GTE Communications Transmission Systems

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DEMODULATOR

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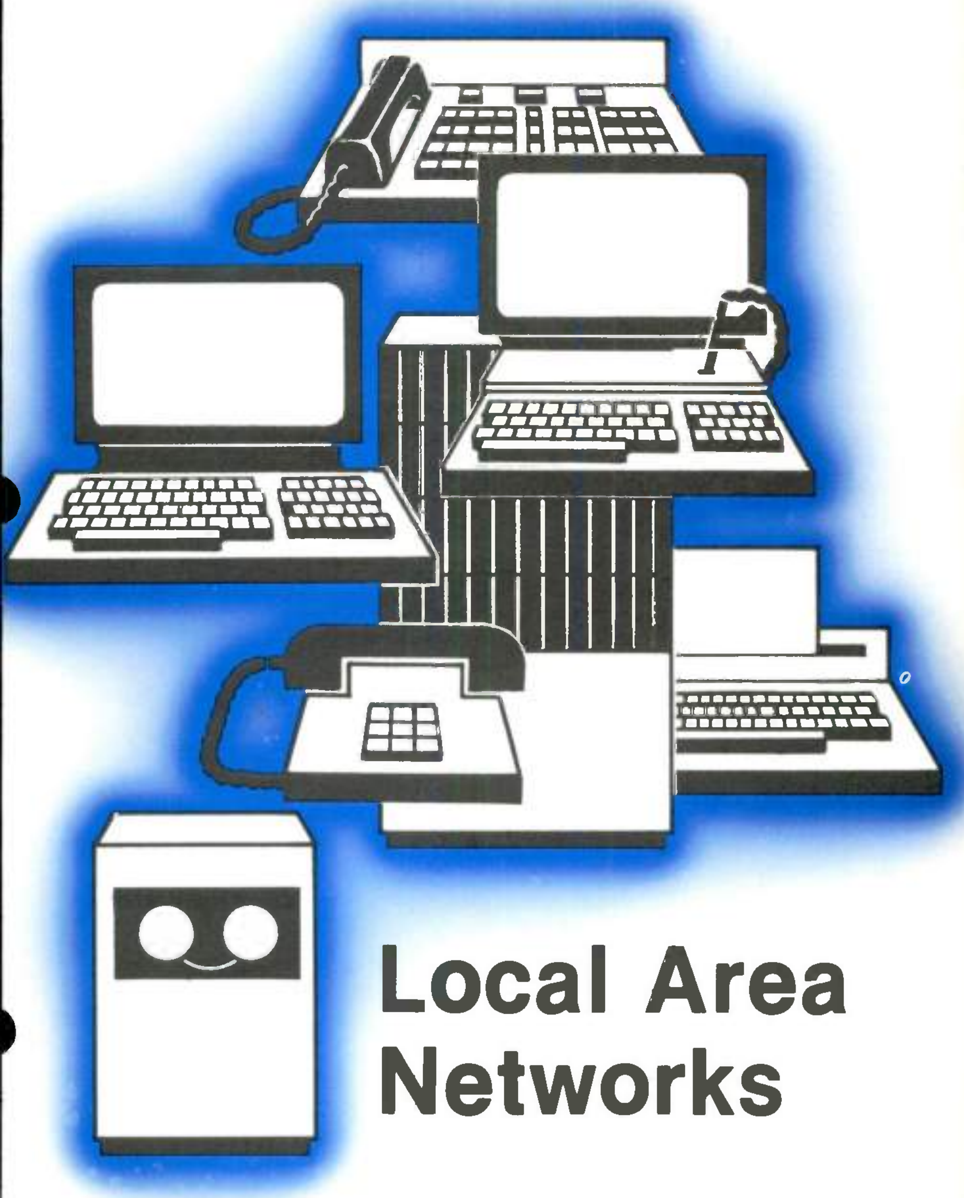

Local Area Networks

Ongoing efforts to improve productivity through automation have established a need for communications networks between computers and other business machines. There are several technical approaches to providing such networks. Some of these approaches are discussed in this issue of the Demodulator.

The "information explosion" has created a need for a means of transmitting, storing and manipulating large volumes of information. To meet this need, many businesses, manufacturers, government agencies and institutions are establishing local area networks (LAN's). These networks provide communications between computers, word-processors, CRT terminals, TV cameras and monitors, automated machinery and other types of equipment. They also provide means for accessing sources of information.

Local area networks make it easier for users to share expensive facilities such as mainframe computers, providing the users are located within a relatively short distance from the facility. The low-cost and ready availability of microcomputers and the increasing acceptance of distributed data processing has led to a proliferation of small, stand-alone computer installations; even in organizations with large mainframe installations.

Contingent upon the ability to match certain characteristics, an LAN can be used to connect these stand-alone installations into the central data base. The microcomputer can then operate as a terminal as well as a stand-alone device. In the terminal mode, it can input and accept data from the main computer.

The information that may be transmitted over an LAN includes voice as on a PBX network, video as on a TV monitor network, data as on a computer terminal network and images as on a computer aided manufacturing (CAM) network. The transmission media used for LAN's includes twisted-pair cable, coaxial cable and optical-fiber cable. Radio can also be used but so far atmospheric radio transmission applications to LAN have been negligible.

Historically, twisted-pair cable has been used for voice and data traffic with at least one pair allocated to each function and a single coaxial cable has been used for each baseband video signal. PBX networks are the primary example of this type. The maximum transmission speed over twisted pair is about 56 Kbps. Optical fiber networks could handle much higher speeds but they have been slow to develop, due to a lack of suitable splitters taps and coupling devices.

Over the last three to five years, a new kind of network has emerged. These are called Shared Cable or Bus Networks and are divided into baseband and broadband. They use coaxial cable as the transmission medium.

Baseband cable can transmit data at rates up to about 50 megabits per second (Mbs) in a half duplex mode. Broadband can transmit more than 100 Mbs in a full duplex mode. Baseband systems have a distance limit of about a mile. Broadband systems can extend for around 30 miles.

Baseband systems use digital technology including time division multiplexing (TDM). Broadband systems use rf technology including frequency division multiplexing (FDM). Baseband systems do not use a modulated carrier. Broadband systems do use a modulated rf carrier (i.e. the information is used to modulate a carrier).

A network may also be described as belonging to one of four basic topological families; star ring, loop or bus. The following paragraphs discuss each of these classifications in turn.

Star Networks

Star networks, figure 1, provide point to point communications. The network is controlled by a central node which may also provide gateways to other networks. Private branch exchanges, including computerized branch exchanges (CBX), are examples of star networks.

CBX networks generally use a distributed network architecture. A distributed network is an expanded form of star network with several controlling nodes. Frequently, optical fiber or coaxial cable is used in place of twisted pair for the transmission path between the central switch and the control nodes.

CBX equipment may be considered as third generation PBX or PABX equipment. The first generation accommodates only analog voice traffic. The second generation uses digital switching. It is primarily intended for voice but accommodates data through data ports. External, interfacing equipment is usually required between the switch and the data terminal equipment (see Figure 2). The ability to handle voice and/or data is an integral part of third generation CBX design (see Figure 3).

The ability of the CBX to handle both voice and data can be a distinct advantage in certain situations. For example a business may not have sufficient data traffic to justify a communications system but its combined voice and data traffic might provide ample justification. Also a CBX uses twisted-pair telephone cable, which is already installed in many buildings.

A disadvantage of this kind of network is its limited bandwidth. Another disadvantage is that a com-

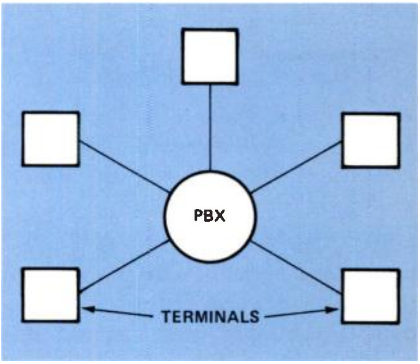

Figure 1. Star Topology — First Generation PBX. The PBX acts as a switch. There is no requirement for intelligence in the terminals.

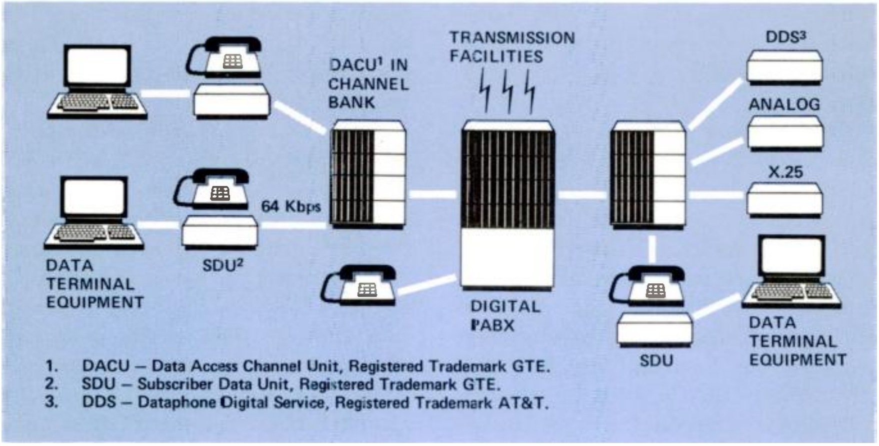

Figure 2. Star Topology — Second Generation PBX digital switching. Data is accommodated through data ports. Some intelligence is in the terminals.

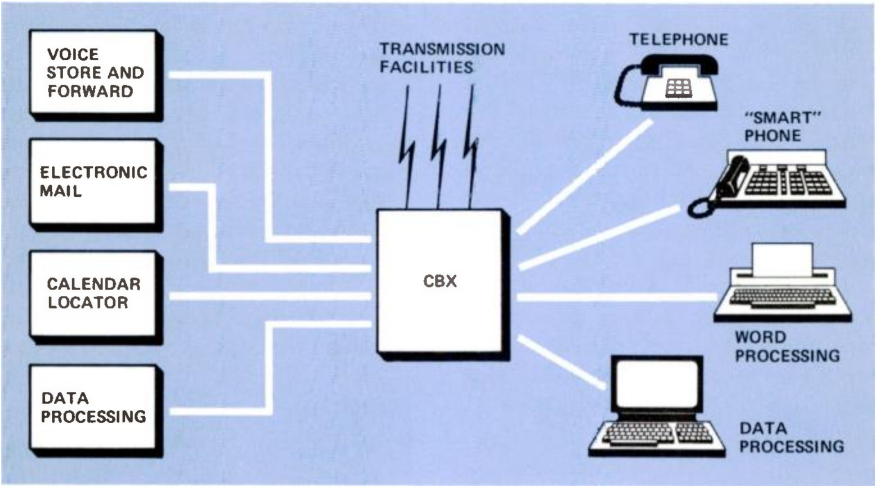

Figure 3. Star Topology — Third Generation PBX. The CBX functions primarily as a switch to connect the user with specialized processors as well as data processors. Speed, code and protocol conversions may also be provided depending on the computer's capacity. Some intelligence is in the terminals.

puter failure could cause an outage of the entire network. However, redundancy techniques can reduce this problem.

Ring and Loop Networks

Ring or loop networks are so named because the transmission medium forms a ring or loop. Ring networks (Figure 4) use token passing for data transmission.

One or more empty packets (tokens) circulate around the ring. A station with something to transmit seizes the first empty packet and replaces it with one containing data.

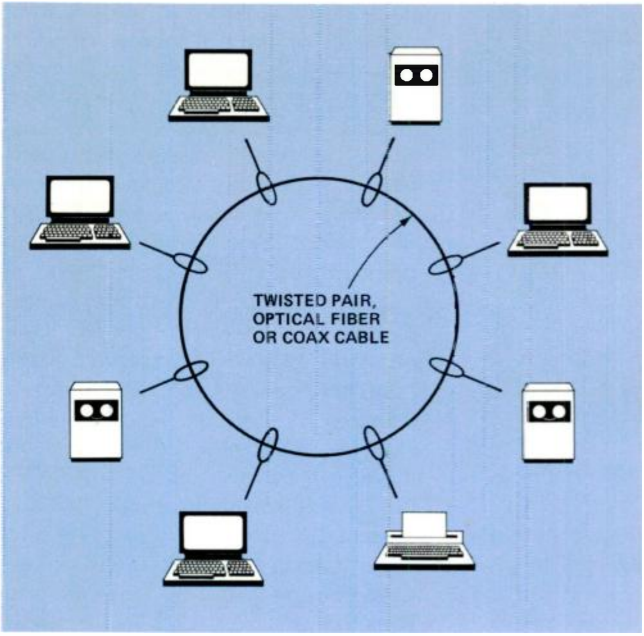

Figure 4. Ring Network

This packet contains destination and source information as well as other data.

When the packet reaches its destination station, it stops and delivers its data. The destination marks the packet as delivered and puts it back on the ring. The packet completes a full rotation, returning to the source.

The source station marks the packet empty and puts it back on the ring. The station cannot immediately reuse its own packet, so a station cannot monopolize the network.

Ring networks are easy to access. Access is assured, even with heavy traffic. However, a special interface device may be required for each station. Another problem is that if one station fails there is a strong probability that it will cause an outage of the entire network. This can be avoided by providing bypass circuitry for each station.

Twisted-pair cable is the transmission medium most commonly used but the ring is the most suitable network configuration for fiber optic cable. Optical fibers are very suitable for transmitting high speed information point to point. What is difficult is to provide multiple access to the fiber because of the optical loss per tap plus the cost and installation problems of the tap.

In a fiber ring network, the ring would be an optical cable. Each ring interface could be used to connect several terminal devices, thereby decreasing the number of taps required. The bandwidth of fiber is sufficient for any kind of traffic.

Loop Networks

Loop networks (Figure 5) use a sequential polling method for communications line discipline. The central computer polls each terminal in sequence to see if it has data to transmit.

The loop network has the advantage of low cost for each connection

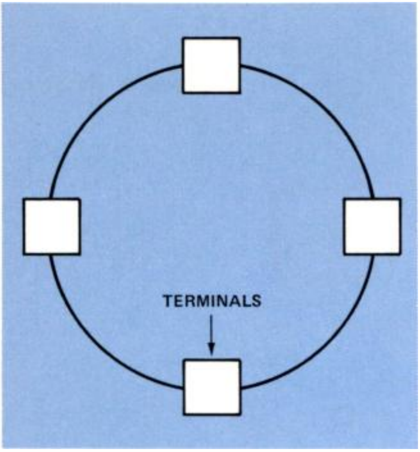

Figure 5. Loop Networks

and the central controller provides a convenient point (gateway) to connect to other networks. A disadvantage of loop networks is that the loop transmission speed is substantially limited to the slowest device in the loop. Another disadvantage is that the entire loop goes down if the controller fails.

Bus Networks

The network control for Bus Networks is distributed with each station having equal control capabilities. Two access techniques are in general use.

One of these access techniques is Carrier Sense, Multiple-Access with Collision Detection (CSMA/CD). A terminal listens to the network, and if no other terminal is transmitting, the listener is free to transmit.

While a terminal is transmitting, its collision detection receiver listens to determine if any other location on the network is trying to transmit. If a collision (interference) takes place, the original transmitting unit jams the network for a prescribed amount of time so that all stations know a collision has occurred. When the jamming signal is removed, each station waits a different amount of time before trying to transmit.

The other access technique is token passing. Token passing for Bus networks is similar to that for Ring networks. A terminal desiring to transmit must remove a passing control token from the network and insert a message packet in its place.

Token passing is much more complex for Bus networks than for Ring networks. Special supervisory functions are required and the adding or deleting of stations becomes more complex. However, token passing is more satisfactory than CSMA/CD for real-time applications of Bus Systems.

As previously stated, Bus Networks are divided into Baseband and Broadband. The following paragraphs discuss each type in turn.

Baseband

Figure 6 is a diagram of a baseband LAN. The network contains coaxial cable, repeaters, taps, transceivers and terminations.

The trunk coaxial cable length between repeaters is limited to 500 meters per section. Normally only two repeaters can be used in a path. Repeaters regenerate the line signal. Their ability to determine the exact space/time position of a pulse is limited by pulse jitter which is more critical at high bit rates.

Optical fiber cable could be used to double the cable length between repeaters, if taps are not required. For example, using optical fiber for the cable between buildings could eliminate the necessity for an underground repeater. This could be advantageous for an LAN installation at a facility where many buildings are spread over several acres.

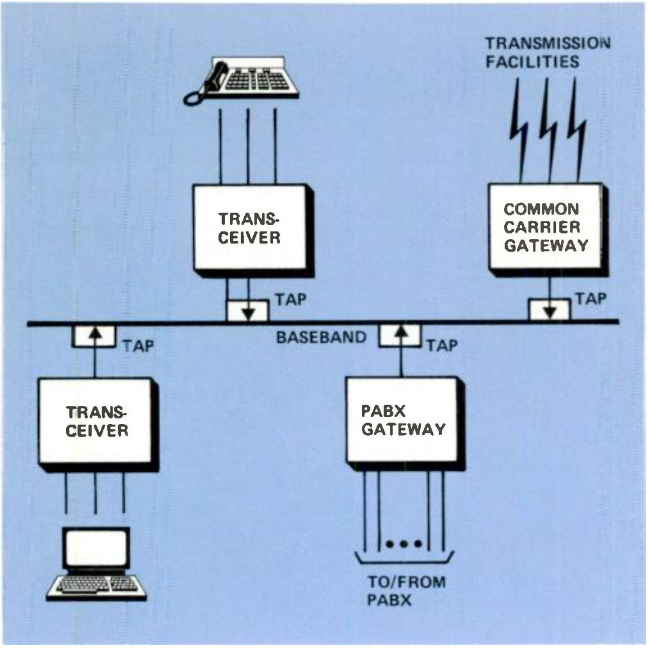

Figure 6. Baseband LAN

The taps are used to connect between the transceivers and the cable bus. A commonly used type is one originally designed for master antenna TV (MATV) systems. It consists of a plastic clamp with a pin which pierces the cable and contacts the inner conductor.

The transceiver interfaces between the cable and the terminal equipment. Transceivers must be located very close to the tap (within 3 centimeters). The cable between the transceiver and the terminal equipment should not exceed 50 meters in length.

The terminations are used to terminate otherwise open cable sections. The terminations match the cable impedance (generally fifty ohms for baseband systems).

Broadband

Broadband networks, Figure 7, include three subsystems, the rf headend, the backbone trunk and the distribution network. As the terminology implies, broadband networks evolved from Cable TV. This points to one advantage of broadband — it is based on proven, well-developed CATV technology.

The rf headend is the point of origin for all forward (downstream) rf signals which are sent to all devices connected to the network. The headend also receives all signals generated by the devices and transmitted over the return (upstream) path. These signals are filtered, amplified and converted to frequencies in the downstream band. The converted signals are retransmitted to their destination.

The system just described is "bi-directional". It uses a single coaxial cable trunk with different frequency bands for each direction of transmission. The two bands provide transmit and receive paths so that two-way

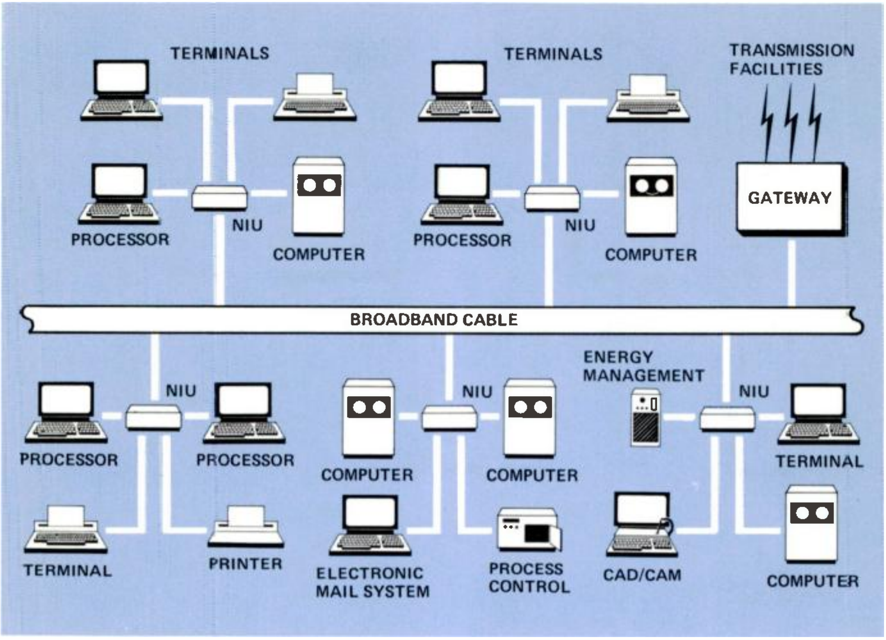

Figure 7. Broadband LAN

communications can be established between any two devices connected to the network.

The backbone-trunk subsystem transports data signals over substantial distances so, high-quality, low-loss cable is used. Trunk amplifiers are used to maintain the signal levels and equalization along the trunk. These high-quality, low-noise amplifiers are the same as those used for CATV systems.

Coaxial cable is bidirectional but amplifiers are not so, separate amplifiers are provided for each direction of transmission. Bandstop and bandpass filters are used to block unwanted signals and pass wanted signals to the amplifiers. Bypass networks are used to route signals around an amplifier where amplification in the opposite direction is not required. These networks are also composed of bandstop and bandpass filters. Equalization networks are sometimes included to compensate for cable slope.

Two-cable systems can also be used for local area networks. A completely dual coaxial cable system provides essentially the same transmission capabilities in both directions. It has the greatest traffic carrying capability but is the most expensive.

The third subsystem in the broadband system is the distribution network. At desired points along the trunk, the line is bridged with distribution amplifiers which feed signals to the distribution cable. When possible, these bridging amplifiers are co-located with the trunk amplifier to reduce the number of trunk cable interruptions.

The distribution cable is tapped close to the using devices to attach them to the network. When necessary, distribution amplifiers are used to maintain the signal level along the distribution cable. Directional couplers are used to connect the drop cable to the distribution cable. The drop cable terminates in a network interface unit (NIU).

A simple cable connector is used to mount the network interface units at convenient wall outlets. The subscriber's terminal equipment is connected to the network through an NIU. An entire building can be prewired to provide a data outlet in every room, just as phone jacks and electrical sockets are provided.

From the foregoing discussion, it is apparent that broadband networks are closely related to CATV systems. The following discussion shows how CATV systems might be used for broadband data transmission.

Data on CATV

Since February 1972, the Federal Communications Commission (FCC) has required new CATV installations, in the top 100 U.S. markets, to provide a capacity for non-voice, return communications from customers locations.

Note that the requirement is for "capacity" rather than "capability". So, some retrofit might be required for a given system to provide a two-way communications capability.

Two methods are used to provide this capacity. One method uses separate cables for each direction of transmission. The other "bidirectional" method uses a single cable, with different frequency bands for each direction of transmission.

The standard CATV entertainment cable, with bidirectional capability, has some bandwidth available for data transmission. A 13 MHz bandwidth, from 107 to 120 MHz, is available for downstream data. A 25 MHz bandwidth, from 5 to 30 MHz, is available for upstream data. Systems where data traffic shares the cable with television should mean lower costs to data users.

In recent years, the local political entities that grant CATV franchises have frequently required the inclusion of institutional networks. These networks are intended for use by hospitals, police departments, fire departments and similar agencies.

Institutional networks using bidirectional cable often use a form of frequency division known as "midband split". The dividing point varies between systems but a typical split provides the following bands:

Downstream:	270 to 400 MHz, 130 MHz bandwidth
Upstream:	20 to 220 MHz, 200 MHz bandwidth

A dual-cable, 400 MHz institutional network provides the same 40 to 400 MHz band in each direction of transmission. Since separate cables are used, there is no interference between upstream and downstream signals. The full 360 MHz bandwidth is available in each direction.

From the foregoing, it is apparent that CATV facilities are quite suitable for broadband local networks. Systems operators could add data capabilities to existing systems at relatively low cost. Manufacturers may find LAN's are a new market for CATV equipment.

Standards

As stated earlier, an LAN can interconnect various computer devices but these devices may not be able to communicate with each other if certain characteristics are not matched. This is largely due to the fact that almost every manufacturer uses their own special, high-level protocol to access their particular equipment.

Several organizations, individually and in collaboration, are trying to solve this problem by establishing standards to which the manufacturers will agree to adhere. Among these organizations are: the International Standards Organization (ISO), the Consulative Committee on International Telephone and Telegraph (CCITT) and the Institute of Electrical and Electronic Engineers (IEEE).

The ISO has defined an "Open Systems Interconnection" (OSI) reference model for data protocol design. The reference model divides, into 7 layers, the logic functions performed to transmit and receive data between two users. The layers are:

1. Physical Layer. Specifies the electrical and functional characteristics to connect or disconnect the station to the physical communication circuit so that data can be transmitted or received.
2. Link Layer. Adds addresses to outgoing messages, decodes addresses of incoming messages, detects and corrects errors.
3. Network Layer. Selects route, specifies network addressing. Works in conjunction with layer 4.
4. Transport Layer. Establishes a data path, from one end point to another, independently of the numerous layers in between.
5. Session Layer. Controls message exchanges between applications programs. Connects user applications.
6. Presentation Layer. Translates and converts formats, i.e. converts transmitted data into a format acceptable to the receiving unit.
7. Application Layer. Generates or receives and interprets messages. This is the only layer seen by the user. In other words, all layers except 7 are transparent to the user.

Virtually all networks accept the layering concept, that is creating levels of protocol that act more or less independently of other levels, but this does not mean that the reference model described has been universally accepted. On the contrary, long-haul network vendors (mostly common carriers) have generally agreed only on levels 1 through 3 and LAN vendors disagree even on those layers. In the context of LAN, the IEEE Committee 802 standard recommendation specifies only layers 1 and 2. The CCITT Recommendation X.25, which specifies interfaces for packet-switched networks, is generally followed so LAN's may be able to interconnect to longhaul networks such as Telenet.

At present there are possibly 150 vendors competing in the LAN market. Therefore, it is improbable that an agreement on standards could be reached at this time. At a later date, when the market is more mature and served by fewer vendors, agreement will be easier to achieve.

Conclusion

Of the technologies we have discussed, the second and third generation PBX's will probably be used in the greatest number of LAN installations over the remainder of this decade. However, coaxial bus type systems will show strong growth rates.

Baseband systems will be used for applications with relatively short transmission paths and less than about 100 work stations. Broadband systems will be used for systems with longer paths and a greater number of stations. Optical fiber systems, using a ring topology or improved taps, will see increasing use toward the end of the decade.

There is a strong probability that very large installations will use a hybrid network or several different networks. A hybrid could provide maximum flexibility and use the most efficient medium for handling each kind of traffic — voice video and data. The Demodulator will continue to monitor LAN technology and report new developments as they occur.

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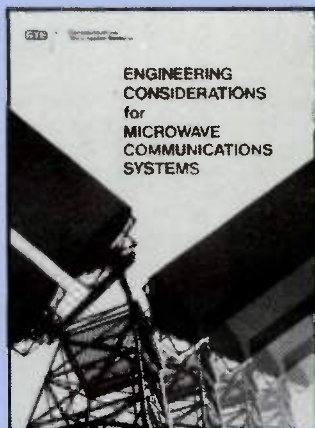

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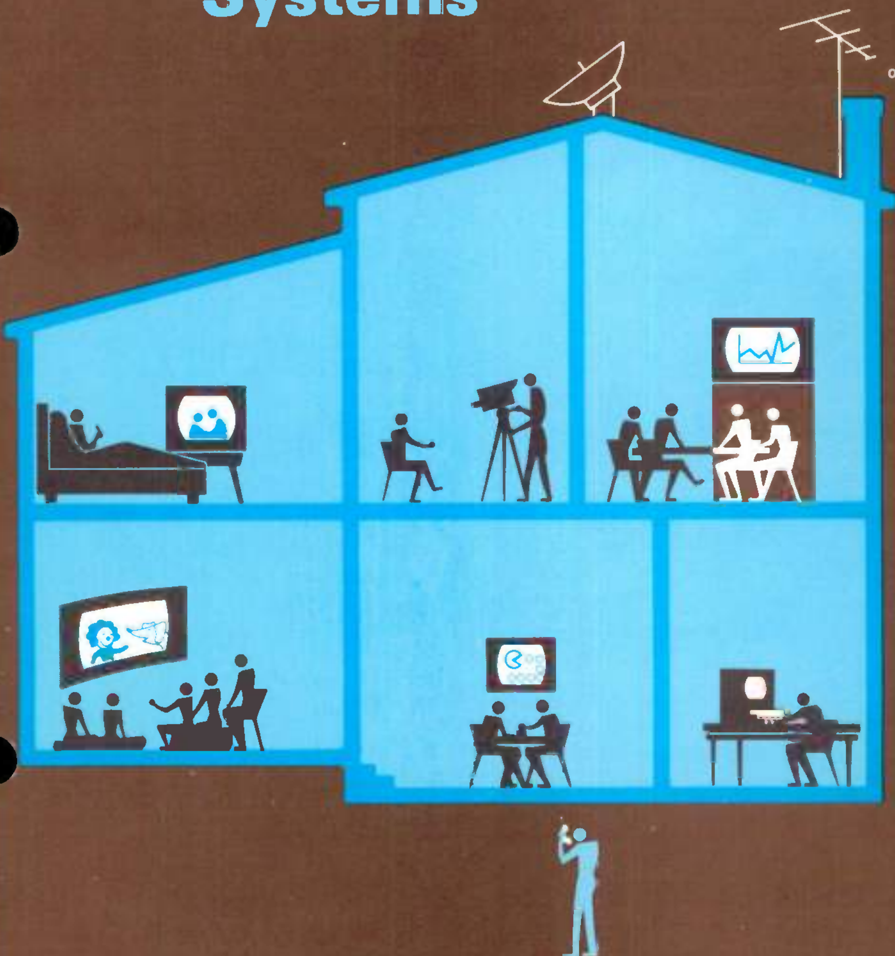
Home Information and Entertainment Systems



The 1980's will see Modular Information and Entertainment systems in American Homes. These systems are evolving from the merging of computer and communications technologies and the integration of several consumer products into a modular home terminal. This issue of the Demodulator describes these terminals and the transmission networks which will deliver information and entertainment to the home.

Consumer products that can be integrated into a home terminal are television receivers, radio receivers, telephones, alarm devices, environmental controls, personal computers and various kinds of recording, transmitting and printing devices. Today, a totally integrated terminal does not exist but all the components listed are available as individual items.

Video Portion

The television receiver will be the foundation for the video portion of the home terminal. In the United States, 85% of the households have television sets. Forty percent of these television households have more than one set and 25% are wired for cable.

Actually, home video centers have been evolving since the mid-1970's when Video Cassette Recorders (VCR's), Video Disc Recorders (VDR's) and video games were introduced. These devices plug-in to the TV set and increase its value. Many home computers also use the TV for display and various decoders may be attached to the set for videotext information and pay television.

Other devices associated with the video portion of the home terminal are large-screen, projection TV and video cameras. These devices are used by a smaller number of TV households because of their higher cost.

Video Games

Video games are among the first TV add-on products to see significant usage. There are several reasons for this. One is the nature of the games themselves; after playing any one game many times, people tend to tire of it for a while, so they purchase another game. Another reason is games make excellent gifts.

Video games are becoming increasingly available from Cable TV services. People only pay for actual use, as in Play Cable. This kind of service offers a wide selection of games without requiring their purchase.

From whatever source, electronic interactive video games will be a large part of the home video center activities, second only to TV viewing itself. Interactive games will lead the public to a broader interest in other interactive communications and information retrieval, although these services may require a more capable TV set than do games.

High Definition TV

Although their primary motivation is not to provide a better display for a home information terminal, several research and development efforts are underway to perfect high definition television systems (HDTV). Receivers with much greater resolution are being developed as a part of these efforts. One prototype receiver uses 1125 scan lines to provide a picture with approximately four times the detail of ordinary color TV.

The new receiver has a display capability equal to the cathode ray tube used for display in a color graphics computer terminal, so it is more than adequate for any home terminal application. These receivers could be available in the next few years.

Of course, a receiver does not make a system. Broadcasting a television signal with the kind of definition just described would require a bandwidth of 27 to 30 MHz. The standard TV broadcast channel has a bandwidth of 6 MHz, so it could not accommodate HDTV.

The signals could be transmitted over coaxial or optical fiber cable or by microwave radio. Current plans are to transmit HDTV by direct broadcast satellite (DBS). This subject will be treated more fully in a future issue of the Demodulator.

Digital Music

Digital Audio Discs (DAD) and players will be introduced during this decade, perhaps by Christmas 1982. In addition to superior sound and reproduction, DAD's have three other advantages. One is the size of the player and disc, which is approximately 1/3 that of conventional LP players and discs. Another is the capacity of the disc which is about twice that of an LP disc. The third advantage is the almost zero disc wear from the audio pickup.

The DAD player uses an optical or capacitive pick-up, so it does not put pressure on the disc. The DAD player also eliminates the expensive pick-up arms and stylus of today's LP players. Digital Audio Players and discs will certainly become part of the home entertainment center and may eventually replace analog recording discs, just a 33 1/3 LP records replaced 78 rpm records in the 1950s.

VCR's and VDR's

Video cassette recorders and video disk recorders combined may see greater use than video games in the home video center. Because of their earlier introduction and greater flexibility, VCR's will be more popular. Also, a portable cassette model is available for use with video cameras. Despite their lower cost VDR's will have a limited appeal until they can record as well as playback.

Home video centers of the future may also have a character generator to produce in-home notices to be flashed on TV screens anywhere in the house. Figure 1 is a diagram of a center. Figure 2 expands the DBS receiver portion.

The video signals will be received by standard TV antennas for broadcast television and teletext; by telephone lines for viewdata, by parabolic, one-meter-diameter antennas for satellite signals and by coaxial cable for basic, pay and interactive cable communications. Later in the decade, telephone and cable companies will be using fiber optic cable.

Information Portion

A home information and entertainment system provides a fast, efficient method for information distribution.

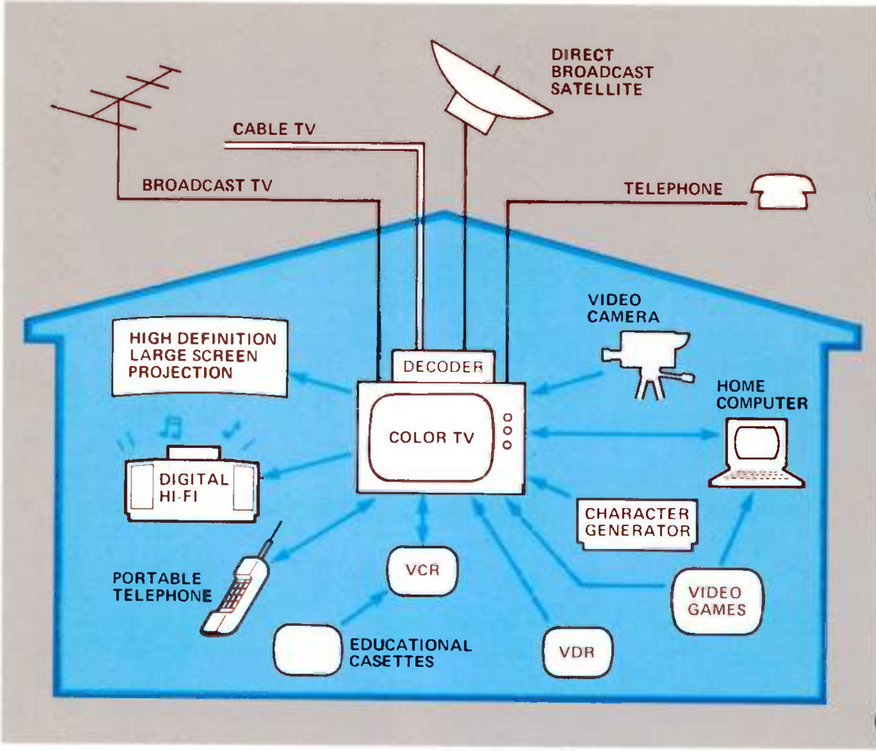


Figure 1. Home Information and Entertainment Center.

Essentially the same information which enters the home today, from a variety of broadcast and published sources, will be electronically transmitted to the home of the future over an information network.

In the home, a terminal will electronically convert the transmission into audible, visual or audio/visual form. At the user's option, this information may be selectively printed out or recorded for future use.

As previously stated, the same kind of information available today will be available in the future but it will probably be in a different format. The real difference will be in the method of distribution which will be totally electronic.

There is certainly no information shortage today. On the contrary, people are overwhelmed by the sheer volume of information. What is required is a means of rapidly accessing and sifting through the available information, to sort out and display what is desired.

Home information systems will provide virtually immediate access to user-selectable information sources. The system may also have electronic scanning and random access memory to provide rapid sifting and sorting.

At present, there are two devices suitable for home use as information retrieval terminals. These are personal computers and terminals specifically designed to receive

Videotext information. Videotext is a term used to refer to both Viewdata and Teletext.

Viewdata and Teletext

Viewdata is the generic name given to systems using telephone lines to deliver text and graphic information from a centralized computer data base to the home TV set. Viewdata does not involve broadcast television signals. Teletext is the generic name given to systems which do use television signals to deliver the information.

Viewdata, is a narrow band, interactive system using telephone or similar networks to transmit information, at relatively low data speeds. Users can directly access a data-base containing a theoretically unlimited number of pages of information. Users can go directly to a desired page without sequencing through previous pages. The requested page is received within 3 to 8 seconds.

Viewdata services were conceived and developed by the British Post Office. Their service is called the Prestel system. Prestel was implemented in Britain in 1976. The purpose was two-fold: to increase the use of the switched phone network and to efficiently and inexpensively distribute information to the population.

Teletext is a one-way system using the unused portions of television signals to transmit information. Users retrieve information with a special decoder attached to or built into the TV set. Hundreds of pages of information are transmitted in a con-

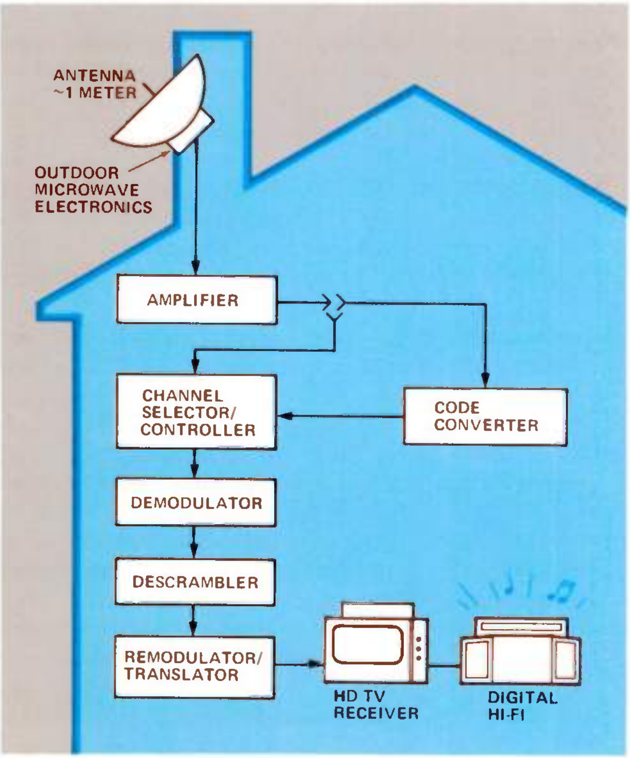


Figure 2. Direct Broadcast Satellite Home Receiver For High Definition TV.

tinuous cycle. The greater number of pages broadcast, the longer a user may have to wait for his selected page to appear. Wait times could amount to several minutes. Wideband broadcast Teletext is similar to Teletext but uses a full video channel for over-the-air transmission of an estimated 50,000 pages of information.

Cabletext is similar to wideband broadcast Teletext but is transmitted over Cable. Wideband two-way Teletext is similar to Cabletext except it has two-way capabilities. This service could be established on two-way Cable systems such as QUBE.

Hybrid Videotext systems involve a number of different technologies and techniques: for example, telephone/Cable TV and telephone/broadcast hybrids. Information is transmitted upstream via telephone lines and downstream via cable or broadcast signals.

Both Viewdata and Teletext systems require decoders which may be connected externally or built into the TV set. The Viewdata decoder must also be connected to the telephone by a coupler or modem which is not required for Teletext.

Delivery Systems

The delivery systems which will distribute home information and entertainment services to American homes include telephone, radio and television (Commercial Broadcast, Cable and Subscription). Direct distribution by satellite will become more readily available later in the decade. These separate networks and combinations thereof called hybrid networks, are or will be used for home information and entertainment systems. For the immediate future, hybrid networks will be the method used for most two-way home information services.

Telephone Network

The portion of the telephone network which connects the individual user's telephone to the local telephone switching office is called the "subscriber loop." These loops are voice grade, and have a limited bandwidth. Consequently, voice grade pairs are suitable for human speech and relatively low-speed data. They are not suitable for high-speed data, music and video.

A complete home information and entertainment system requires a broadband transmission medium capable of passing all kinds of signals. So, the subscriber loop is not suitable for HIES in this respect. However, the subscriber loop is completely interactive, which is another HIES requirement.

The services an HIES system provides can be divided into two categories, special and wideband. Special services include health care, Viewdata, energy management, facsimile, Teletype, Telex and some security monitoring.

Practically all special services can be handled within the nominal 300 to 3000 Hz voice channel bandwidth available to practically every household in America. The ordinary telephone cable pair provides a more than adequate transmission path for these special services. The HIES provides terminal devices incorporating displays, keyboards, microprocessors, and special input/output (I/O) components which are substituted for the telephone set.

The use of telephone lines for these purposes is particularly appealing because they are idle most of the time. In fact many special services are already available over the telephone network.

Wideband services include Television, Cable Television, Videophone, High Fidelity Music, FM programming and high-speed data. All of these require a bandwidth greater than that of a voice channel and generally cannot be transmitted over ordinary telephone cable. FM broadcast radio, television, microwave radio, coaxial cable and optical fiber cable are suitable transmission media for wideband services.

Broadcast Radio and Television

Radio and television networks cover the United States with broadcast stations in all populous areas. These stations are interconnected by transmission facilities which are generally leased from common carriers. The interconnecting links use wire-lines, terrestrial microwave and satellite transmissions. They are generally interactive. However, the broadcast path from the station to the home is one-way.

Some interaction between homes and broadcast studios is possible. The familiar radio "talk show" where listeners phone in questions which are answered over the air is an example. The interaction in this case is very limited and the programs actually have more entertainment than information value.

Broadcast television offers several more sophisticated information systems. Most of these are currently being operated on an experimental basis and use a hybrid arrangement for interaction. That is, the downstream signals from the TV station to the home are broadcast but the upstream signals from the home to the studio are over telephone lines. However, these upstream signals are not necessarily voice. Often some form of alphanumeric keypad is used.

Television broadcasters can transmit large quantities of information "piggyback" on normal television programs without interfering with the regular program. This is accomplished by transmitting the information in the vertical blanking interval which is outside the usual viewing area of the television screen. There are other portions of the composite TV signal which could be used but the vertical blanking interval is best because of its long duration.

Cable Television

Today, highly sophisticated Cable TV systems are operating in large metropolitan areas as well as smaller communities. Cable TV is successfully competing against direct broadcasting networks.

The increasing availability of low-cost earth stations for receiving satellite signals has greatly stimulated Cable TV growth. These stations are known as receive only or ROTV stations.

It is anticipated that by the mid-1980s there will be more than 3,000 ROTV stations serving over 5,000 Cable TV systems. This means a larger number and variety of entertainment and information channels plus other information services will be available to Cable TV operators.

Originally Cable TV systems were owned and operated by small companies who often found it difficult to meet high capital requirements. Recent consolidations and combinations have led to larger companies called Multiple Systems Operators (MSO's). MSO's larger operations have greater capital raising capacity and a larger cash flow.

One-way Cable Systems

All Cable TV systems prior to 1972 were constructed to transmit only from the Cable TV station to the subscriber. In 1972 the FCC established a requirement for new Cable TV systems, in the top 100 market areas, to provide the technical capacity for the return of non-voice communications from subscriber's locations, i.e., two-way communications.

The actual implementation of two-way transmission is quite costly. Therefore new systems in the top 100 TV markets constructed since 1972 have the capacity to be two-way, but most are equipped to provide only one-way transmission.

One-way systems allow viewers to receive information, via broadcast TV signal, Cable TV, or FM multiplexed transmission, but not to communicate with the system operator. These systems include most TV stations, multipoint distribution systems and experimental Teletext services.

Pay TV

Pay television offers special programming to viewers. Cable TV system operators offer Pay TV to their subscribers as a premium service with a monthly rate above the basic subscriber rate. Pay television is available to multiple dwelling units, hotels and motels, and also to public television broadcast viewers. For public broadcast television it is called Subscription Television (STV).

Pay TV programs are primarily feature films and special events such as sports or cultural activities. They are presented uninterrupted and without commercials.

Two-Way Cable Systems

Although there are very few two-way Cable TV systems in operation today, there are a few notable examples of installations for both business communications and home information/entertainment services. An example of a two-way system serving business customers is Manhattan Cable in New York City. They provide data communications and leased channel services to banks and the City Government. The system is bidirectional. Trunks used for this service are equipped with amplifiers for each direction of transmission. It is noteworthy that Manhattan Cable installed fiber optics cable to extend this service.

Another more publicized example of Cable TV's entrance into the wideband and special services market is the Warner Communications Company's QUBE project, first installed in Columbus, Ohio. QUBE is a two-way system where subscribers use simple hand held transponders to reply to opinion-type questions. Extra reply capacity is available for such services as meter reading, burglar and fire alarms, etc. "Pay view" service is also available.

Warner Communications is expanding QUBE service to Pittsburg, Cincinnati and Houston where they have Cable TV franchises. QUBE is proving the technical capability of Cable TV to offer many home information services in addition to standard and premium video entertainment.

The Cable TV industry is expanding. It is anticipated this will continue well into the 1980s. Further expansion is expected in the area of wideband and subscriber services, including broadband, local areas networks for businessess, government agencies. These local area networks will carry data and video traffic. Local area networks will also be discussed in a later issue of the Demodulator.

Subscription TV

Subscription TV was formally established by the FCC in 1968. Technical standards and criteria for

STV applications were adopted in 1969. However, outside of Cable pay TV, STV did not become a commercial success until 1977.

Subscription TV is considered a supplement to conventional television rather than a replacement. There are limitations to the number of subscription TV stations per community and operators must also be a licensee, permittee, or applicant for a commercial television station. Subscription TV decoders may be leased but not sold to subscribers.

STV stations must broadcast a minimum number of hours of non-subscription programming per day and week, just as commercial television stations. In practice this means that feature films and sports events may not account for more than 90% of the program content.

Originally, as with Cable TV, the age of the feature films was restricted, excluding foreign language films. Also as with Cable pay TV, advertising commercials are restricted, except promotions of STV programs before and after the program viewing.

In 1977 the FCC loosened the restrictions by eliminating the film rules for both Cable pay TV and STV. This action stimulated a tremendous growth for STV just as the growth of Cable pay TV was previously stimulated by the availability of Home Box Office and Showtime.

To date all operating STV stations use UHF television. This requires a UHF television receiver and an appropriate antenna. The UHF signal is received with relative ease and most modern home receivers have UHF tuners, so for subscription purposes the transmitted signal is encoded and scrambled. Each subscriber is leased a decoder to unscramble the signal. The decoders used for STV are more complex than those used for Cable pay TV. Most systems use remote control, allowing the STV station to turn the decoders on or off. The technical requirements for STV and Cable pay TV are stricter than for standard TV broadcasts.

Multipoint Distribution Systems

As a non-broadcast, common carrier service, Multipoint Distribution Systems (MDS) are primarily used to deliver special television programs to specific locations. To date, the principal application has been to transmit motion pictures to apartment complexes, hotels and private residences. Special receiving equipment is required to receive the MDS signal and translate it to a form suitable for viewing on a television set. Some Cable TV multiple systems operators use MDS to provide pay TV to areas not served by their regular cable plant. In its present form, MDS is essentially a Subscription TV service.

Recently, the FCC expanded MDS by allocating it additional frequencies. Using the new frequenices, MDS operators could establish broadband local loops in a relatively short period of time.

MDS channels have a 6 MHz bandwidth, so they could easily accommodate high-speed data transmissions. During non-business hours these same channels could be made available for HIES use. Information could be transmitted on the same non-interfering basis as it is on standard TV broadcasts.

Interactive Systems

An information retrieval system is one where the user accesses information by a requesting or interrogating signal, which identifies the information source and the requester. The transmission path for this signal can be very simple. An ordinary telephone line is more than adequate.

However, the information requested may require a more complex signal format for transmission back to the user. The return path may be a telephone channel, a coaxial or optical fiber cable link, an FM broadcast link, a television link or any combination of these. Many of these transmission facilities are in place and have the capacity to serve central information sources. However, the origination of similar transmissions from every subscriber, which is implicit to a completely interactive system, is a different matter.

A completely interactive system, capable of handling all kinds of traffic, requires a wideband, two-way, transmission network such as coaxial or fiber optical cable. The network might also include terrestrial and satellite microwave links as well as cable.

In fact a satellite network, using orbital antenna farms constructed in space could play an important part in such a system. Two-way Cable TV systems, using coaxial cable for both directions of transmission, are suitable for completely interactive systems. Optical fiber cable, which has broadband capabilities is particularly suitable for digital transmission.

The network will probably be all digital. Today, the telecommunications industry's movements toward all digital networks and wideband transmission paths are easily discernible. The increasing demand for high-speed data communications and the economies of digital switching assure that this trend will continue.

Aside from the transmission path, a completely interactive system would require the subscriber to make a substantial investment in transmission and ancillary equipment. This investment is not economically feasible for the average householder. What is feasible, and already in place in most American homes, is the television receiver and telephone.

The modern television receiver with remote control and video input jacks meets the essential requirements of a display unit. The modern telephone set with touch-tone dialing meets the essential requirements of an alphanumeric keypad and voice input/output devices.

Today's video games and video cassettes are the forerunners of tomorrow's input devices and applications programs. The video input jack will become a multiple input point for numerous devices requiring video display. The Cable TV converter, which converts many channels to a single channel input to the television set, can be modified and installed between an antenna and television set input to perform the same kind of signal conversions for many over-the-air signals.

Telephone handsets for home installations are providing a host of new features. Telephone operating companies are providing a number of special services and are capable of providing many more when the demand arises. The telephone set and television receiver will eventually merge to form the home terminal and transmission facility.

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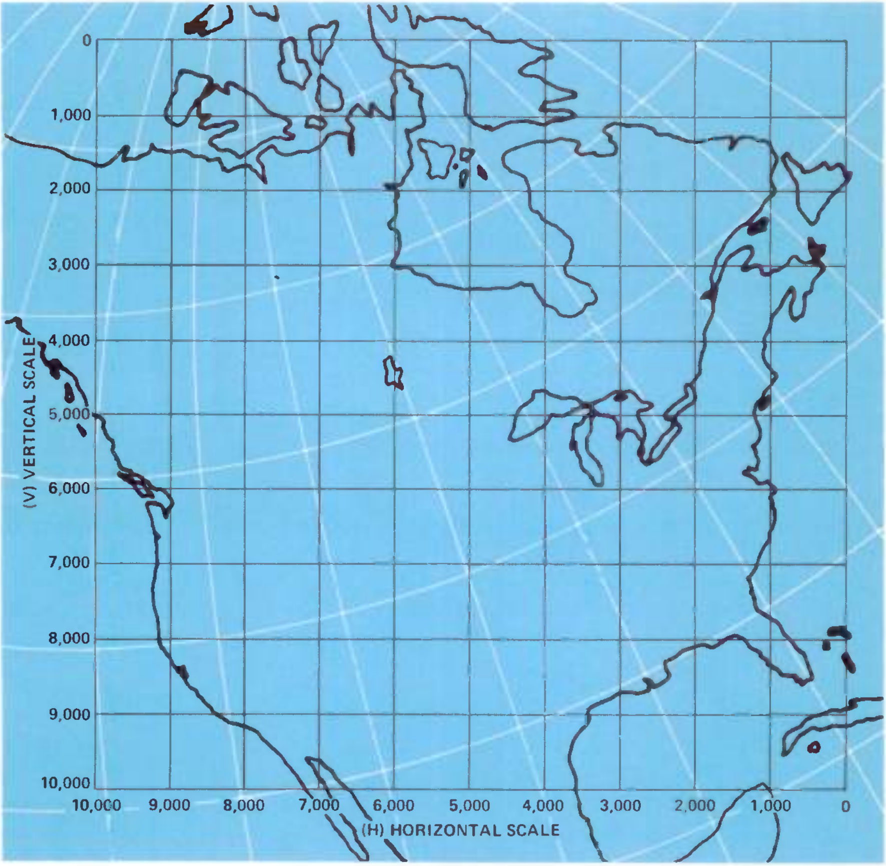

CORRECTION

Figure 5. Bell System's V-H Coordinates Map. This drawing was inadvertently omitted from the January/February issue of the Demodulator. The map is for illustrative purposes only. It is not accurate enough for actual measurements or calculations. We regret any inconvenience the omission may have caused our readers — The Editor.

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GTE Lenkurt 2, 6 and 8 GHz 700 Series RF Repeaters

GTE Lenkurt has developed two new RF repeaters to supplement its highly successful 700F1, 2 GHz model. One new repeater, the 700B1, will operate in the 6.425-7.125 GHz band. The other new repeater, 700C1, will operate in the 7.125-8.5 GHz band.

These repeaters are particularly useful for providing microwave routes through difficult terrain and provide a viable alternative to complex passive repeaters. The repeaters for all bands will be available in six basic configurations ranging from single channel, unprotected to Y-junction, protected. Monitoring and alarm circuitry will also be provided. The 700F1 is currently available. The 700B1 and 700C1 will be available in the first quarter of 1983.

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