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Introduction to local area network concepts and terminology : a special report developed for CPAs; Management advisory services special report

American Institute of Certified Public Accountants

A Management
Advisory Services
Special Report

An Introduction to Local Area Network Concepts and Terminology

A special report developed for CPAs seeking to become familiar with the use and technology of LANs, which permit the linking of diverse electronic equipment to provide an integrated system for enhancing office automation and communication.

AICPA American Institute of Certified Public Accountants

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Preface

Linking devices within an office or building complex through a local area network (LAN) is a very useful office automation technique. Uses and benefits of a LAN include working in electronic form, exchanging data, and communicating with others.

This special report provides practitioners with information about selecting and implementing a LAN. Because of the proliferation of personal computers and growing microcomputer technologies, an increasing number of MAS engagements may involve LANs in some way, and many CPA firms may find LANs useful in their offices as well.

Contents

Introduction

A local area network (LAN) is a communications system designed to meet the unique needs of a specific work area by interconnecting existing equipment and allowing for the addition of new equipment. An understanding of basic LAN concepts and terminology may enable a practitioner to assist clients and the CPA firm in improving the effectiveness and efficiency of office operations.

This report provides an overview of LANs and includes a glossary and bibliography. The types of LAN systems it describes are generally owned and used by one organization. Most commonly, they operate in a single building, but they can be effective within a fifty-mile radius.

Currently, organizations can acquire a variety of compatible electronic devices intended by their manufacturers to be interconnectable and form a network. Generally, the term *LAN* is not used in such cases, although the resulting network is a LAN. *LAN* more often identifies a system interconnecting diverse equipment that was purchased over a period of time and that may not have been designed to be linked. The feasibility of such a linkage may be limited, however, and LAN advantages and disadvantages will differ for each case.

Since LAN hardware and software are changing rapidly, and the systems solutions that are best at this time may not be best in the future, this report describes LAN concepts without advocating a particular hardware or software solution. Practitioners need to stay current to maintain their technical competence.

Defining a Local Area Network

A LAN is a system of multiple, interconnected electronic devices. It integrates different equipment (microcomputers, minicomputers, mainframe computers, word processors, telephones, and so on) and various manufacturing types (mixed or single vendor environments). LANs may use video and voice transmission, including transmission over telephone lines without the limitations of telephone transmission. For example, *digital** signals do not have to be converted to *analog* signals, as is normally the case over telephone lines. Thus, LANs greatly expand communication potential.

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*Italicized words throughout the text of this report are defined in the Glossary.

Each user in a network can process data independently and can communicate with every other user. All users can share data under the control of appropriate LAN software, although some current technology limitations may exist. As in other EDP applications, the development or acquisition of required software is essential.

In summary, LAN systems link diverse or similar hardware already in place, and new hardware can be added as it is acquired. Once cables are in place, further changes to a network can be made easily with little incremental cost.

Benefits of a Local Area Network

The benefits of a LAN system include sharing data files and resources, communicating electronically with other office staff, and interconnecting existing equipment. Following are some examples of how a LAN may be used:

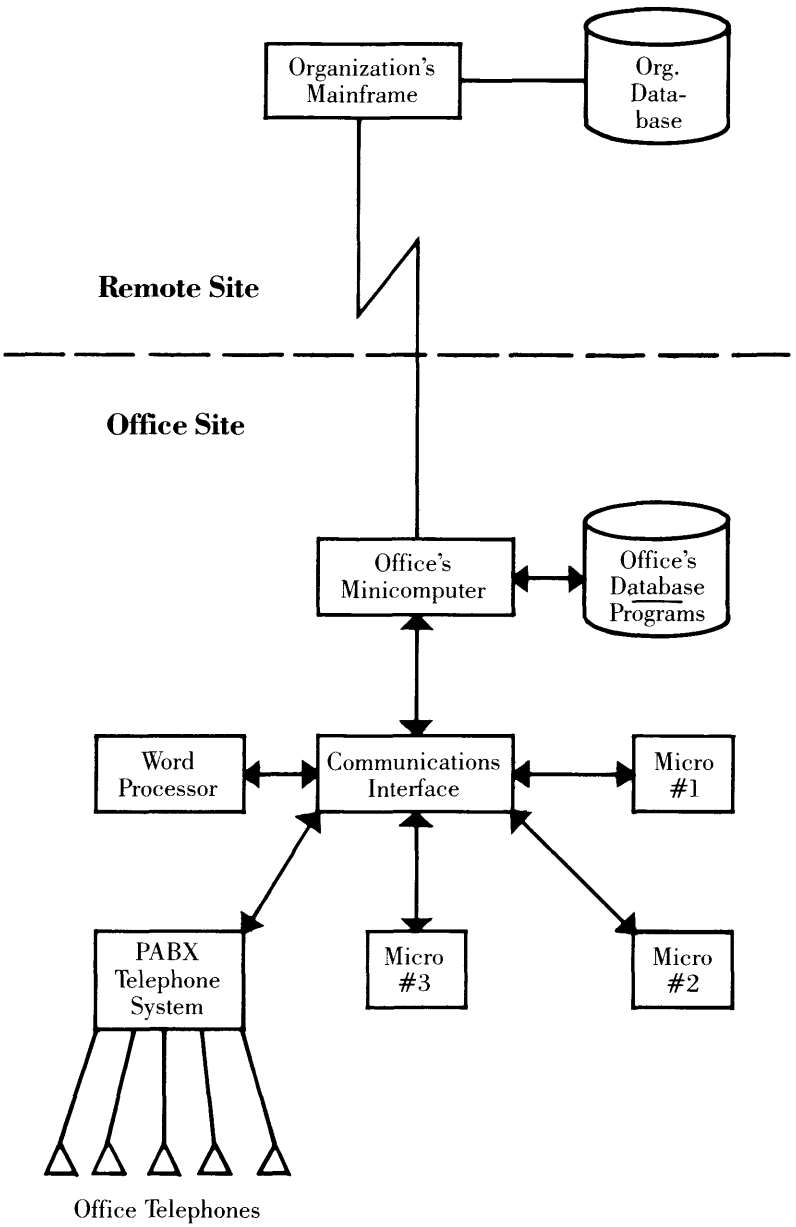
- A personal computer user can develop a projected cash flow model by using spreadsheet software and the organization's latest financial statement data stored in the office minicomputer. A LAN is one method of permitting the personal computer to access the minicomputer's data file, copy the original general ledger data, and store the results of the spreadsheet work in a separate data file in the minicomputer without changing the data content of the original file.
- An office can use a LAN to improve efficiency by implementing an electronic mail and calendar system. For example, appointment calendars of office personnel can be entered into the system, enabling others to determine whether an office member is available for a planned meeting and if not, to make alternative plans. Likewise, a notice for an office picnic can be entered into the word processor and "mailed" via the computer to all the network stations designated to receive it.

Applicability of a Local Area Network

Using a LAN in general business data processing may allow workstations to access shared resources and application programs and to communicate with each other. By doing so, it provides distributed or shared data processing capabilities. A LAN can link diverse applications, such as electronic mail, word processing, spreadsheet programs, decision support systems, and telephone switching, into an integrated system. Exhibit 1 illustrates such a configuration.

Exhibit 1

LAN Configuration



Using a Local Area Network in a CPA Firm: A Case Study

A local CPA firm with three partners used a minicomputer to provide general ledger services for its clients and to perform time and billing and word processing applications. After three years of system operations, the firm's annual revenues increased from less than $100,000 to $1 million. At that time, the firm provided write-up services to over eighty-five business users. The partners attributed a great deal of their success to the minicomputer system's ability to handle the increasing client load.

A few years later, inexpensive computers became available with spreadsheet software that could provide cash flow projections, loan amortization schedules, tax planning, and other analyses not available from the firm's existing system. To remain competitive and continue providing efficient, quality service, the firm acquired three microcomputers with word processing software, a spreadsheet program, and a tax planning package. Rather than duplicating the minicomputer's data files (client financial results, standard forms and letters, and so on) for each of the personal computers, the partners decided instead to install a LAN so that the minicomputer could store data and share it with the microcomputers.

The firm acquired, through the original hardware supplier at a nominal cost, the LAN installation needed to link data files on the minicomputer to the three microcomputers and to permit communication between the different devices. Staff accountants using the write-up system were able to prepare financial statements on the minicomputer. They then transferred the data from the minicomputer to a microcomputer and produced ratio and analytical review analyses by using the spreadsheet program. The resulting data were used with a graphics program to prepare charts and graphs showing key relationships. Comparing the results with preprogrammed ranges, the word processing program (1) addressed a letter to the client and (2) selected and then incorporated specific stored comments into a standard preformatted letter that explained the results of operations. The system performed the final two steps automatically after the staff selected the program and provided some additional program command statements.

Success forced the firm to search for new office space, and it entered into a lease commitment for a building under construction in the city. In anticipation

of the move, the firm installed a *coaxial cable* throughout the walls of the new office while it was under construction, since cabling costs are lower during construction. During the construction period, the firm purchased an "electronic office" package that provided electronic mail, calendaring, and software inter-device connection capability, as well as a reliable network management (LAN and operating system) and security system. The firm is rapidly becoming "paperless" and is well positioned for productivity into the 1990s.

Technical Alternatives

A practitioner generally provides data and recommendations to aid a client in making LAN installation decisions. Key factors are the appropriate *topology* for the LAN, present versus future user requirements, and the capabilities of available systems compared to the potential of emerging technologies.

Generally, the potential LAN user faces several technical alternatives in four areas:

1. Topology (architecture)
2. Transmission media
3. Network-accessing techniques
4. Interface methods/Communication standards

The potential user's goal is to choose the best combination of alternatives. Being aware of industry standards in the four areas listed above will aid in the process.

Topology

In LAN terminology, *topology*, or *architecture*, refers to the physical design, or shape, of the communications network. The four common network shapes are star, ring, bus, and tree.

Star Network

In a star network, processing is centralized in one device acting as a central *hub* through which all communication passes. (See exhibit 2.) Performance depends on the reliability of the central processing unit.

Ring Network

A ring network has stations organized in a circle and distributes communication control among the stations (*nodes*), each of which has equal standing within the network. (See exhibit 3.) A message is passed from node to node in one direction until it reaches its destination. If one node fails, the message is passed in the other direction. This feature increases reliability because two nodes would have to fail to interrupt the entire network.

Bus Network

In a bus network, linear cable links each user *tap*. Communications are broadcast down the entire length of the cable to the user devices. (See exhibit 4.) Each node listens for any message addressed to it, accepts the message, and signals the original sender that it received the message in good order.

Tree Network

A tree network is similar to a bus network but has multiple workstations attached at each node. (See exhibit 5.)

Transmission Media

An understanding of the different transmission media available is needed to select and install cable for a network. Three alternatives are as follows:

1. Twisted-pair wire
2. Coaxial cable
3. Fiber-optic cable

Twisted-Pair Wire

Transmission using *twisted-pair wire* supports all topologies and can connect up to two hundred users within twenty miles. "Repeaters" strengthen the single-channel, one-direction signal by amplifying it every mile of cable or so. It generally is a low-cost installation method but does have limited *bandwidth* and is susceptible to noise and cross talk.

Coaxial Cable

Familiar to most as cable TV, coaxial-cable transmission is available in two forms, baseband and broadband, and is most often used with the bus and tree topologies.

Baseband. The *baseband* signal transmission uses only one bidirectional channel and usually operates within a ten-mile range. It is easy to install and the cost is relatively low. But to remain stable, it can carry only about a 40-percent load and is subject to noise interference that can slow processing speeds and cause data errors.

Broadband. The *broadband* form has multiple channels and can support over twenty thousand users on a one-direction signal per channel. The method is usually used within a fifty-mile range. It can support voice, data, and video

applications at the same time; it uses 100 percent of the bandwidth and is not as susceptible to noise as other transmission methods. However, installing it and adding users to it may be more expensive.

Fiber-Optic Cable

Transmission using fiber-optic cable is probably the method of the future. It supports the ring and star topologies but currently can accommodate only a limited number of users. It has a one-signal channel that is unidirectional at a point in time. Its advantages are reliability, a high resistance to noise and interference, and the ability to run different applications simultaneously. At this time it is expensive, requires skilled installation, and must be considered an experimental but promising technology.

Network-accessing Techniques

In addition to topology and transmission media, ease of user access to the network is important to consider. Factors that affect network access as well as the performance of a LAN include—

- Determination and distribution of communication priorities.
- Throughput (influenced by number of nodes), network length (transmission or cable distance), communication priorities, network overhead, and data transmission rates (speed).
- Access time (waiting to enter the network), error detection and recovery, and systems software capabilities.
- Number of stations (nodes).

There are several types of network-accessing techniques that have significant differences, including polling, token passing, and contention.

Polling Access

Polling is a centralized access method usually found in a star network. The central processor continually calls each station to determine if a message or instruction is waiting. The calling method can be ordered in any sequence or time interval so that frequent or important users can have priority access. Data collisions are avoided with this centralized method.

Token-passing Access

Token passing is a point-to-point (node-to-node) network control used in both baseband and broadband bus networks as well as in ring networks. A stream of

Exhibit 2

Star Network

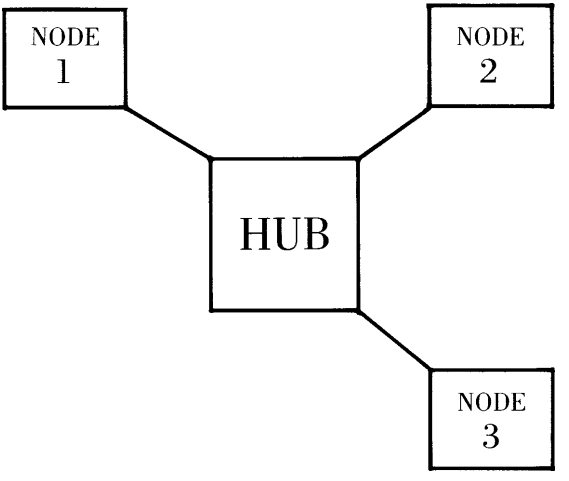


Exhibit 3

Ring Network

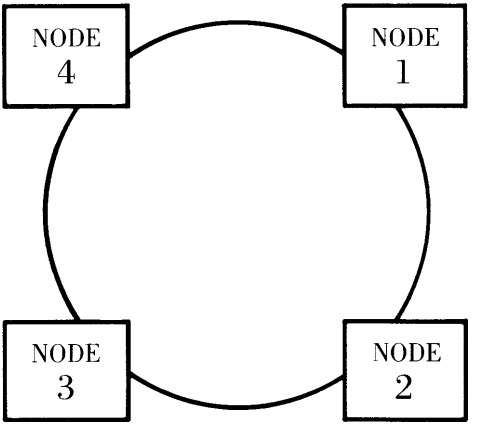


Exhibit 4

Bus Network

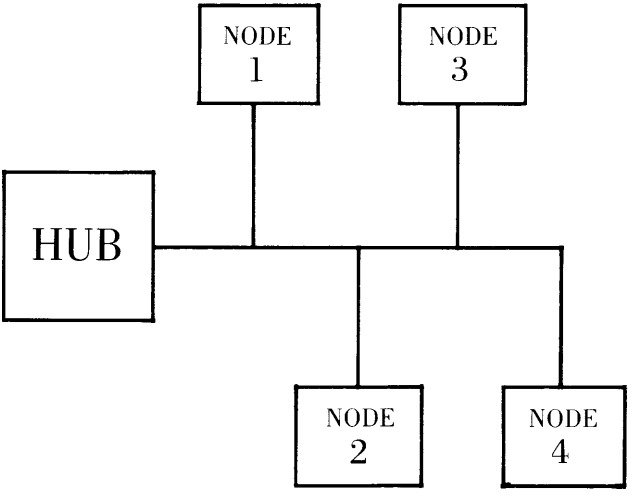
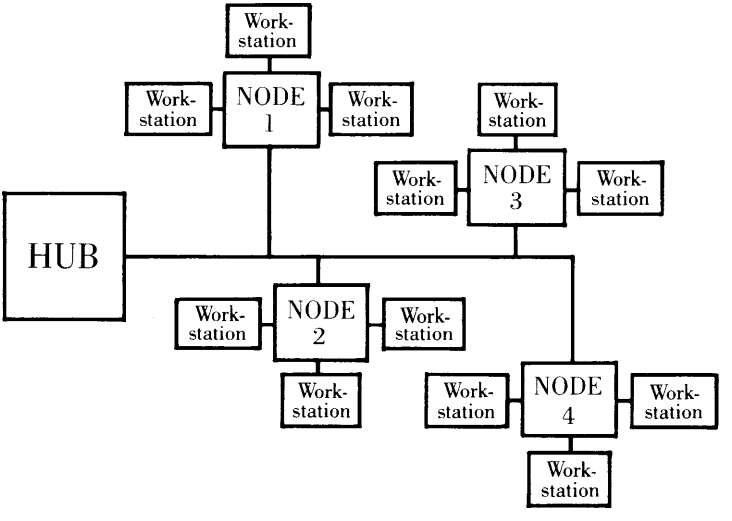


Exhibit 5

Tree Network



tokens (a unique *bit* pattern) is continuously sent along the network. To transmit an instruction or message (*packet*), a station must first "take" one of the tokens from the network stream. When this happens, other stations cannot take tokens. Only a station with a token can transmit. When a station completes a transmission, it breaks the connection and puts the token back into the network stream, thus giving other stations the opportunity to transmit.

Contention Access

Contention access, usually called *CSMA/CD* (Carrier-Sense Multiple-Access with Collision Detection), is a method of network control in which a station listens to the network channel to determine if any other station is sending a message. If no other message is heard, the station transmits a packet. When the packet is properly received, an answer is sent back to be *parity* checked. If a "collision" occurs because two or more stations send a message at the same time, no answer is received. Each station will then automatically retransmit its message. To avoid chaos and minimize collisions on the network, transmission is done at random or predetermined intervals.

Interface Methods/Communication Standards

Potential LAN users need to relate (interface and interconnect) different hardware devices. Essentially, this is done with *file servers*, *gateways*, nodes, and operating system capabilities. In general, electrical interfaces are currently standardized by using *RS-232* connections, and control codes are established by using *ASCII* file characteristics.

Selection Considerations for a Local Area Network

Specific user requirements should determine which type of LAN, if any, is installed. The technique and concepts used in selecting a network are similar to those used in selecting a computer. The basic considerations are as follows:

- Traffic
- Reliability
- Protocols
- Expansion
- Functions

Traffic

The LAN must be able to meet the expected use, or traffic load. Potential peak load must be calculated to determine hardware requirements.

Reliability

The LAN should be accurate, quickly accessible, and have little down time. Therefore, a potential buyer must consider system maintenance as well as the error rate in transmissions.

Errors are of two types, detected and undetected. Detected errors are discovered by the network and corrected, usually by a retransmission of the message. However, retransmissions create additional system use (overhead) and slow the transmission rate (operating speed). Undetected errors are unknown until something external to the network alerts the user to a problem; for example, accounts payable do not balance or an employee does not get a paycheck.

A system with good hardware reliability and an acceptable undetected error rate is essential. Vendors can provide technical data to support claims about these factors.

Protocols

Protocols, involved in *handshaking*, are rules that govern how devices or systems establish and break connections, exchange data, and so on, based on sequences of control characters. An example is the sequence for exchanging characters between a computer and a remote terminal.

Exhibit 6 shows the seven-layer communication standard of the International Standards Organization. The *X.25* protocol conforms to the three bottom layers. The protocols for the LAN in use will determine and may limit the ability to add new devices to the network.

Expansion

A potential buyer should anticipate future network growth. Such growth includes new LAN applications (word processing, electronic mail, calendars, tax return preparation), additional user stations (more employees), and new equipment (copying machines and phone systems). Both hardware and software should be able to meet expansion needs at a reasonable cost. The system's ability to use standard protocols and conform to *IEEE* specifications also requires evaluation.

Functions

In choosing a LAN, the potential buyer needs to answer a number of questions, for example:

- Will the network serve one building or several?
- Will multiple networks in separate buildings be linked?
- How and where will the transmission medium (cable or wire) be installed? If required, is there an existing conduit?
- Where will the equipment be placed, what kind of equipment is it, and how compatible are the components?
- What kind of information will be transmitted over the network? Will the data types, communication requirements (transmission and presentation protocols), and equipment interface?
- Is there an appropriate security system available (for example, read only, read/write, or read/write/delete) to prevent unauthorized system access?
- What kind of control and monitoring will be provided? (The system software should control the network by making connections, setting priorities [for example, for stations, users, and applications], and providing security author-

izations and clearances. The system manager should be able to make on-line inquiries about the number of users, error rates, hardware status, and so on.)

Exhibit 6

Seven-Layer Communication Standard

Level 7—Application Layer	Identifies users; initiates data transfers; handles flow conversion and recovery
6—Presentation Layer	Makes data available to application layer (protocol conversion, data translation unpacking, encryption)
5—Session Layer	Sets up and breaks communications; multiplexes and demultiplexes; serves as a buffer; manages priorities
4—Transport Layer	Connects network entities; controls errors
X.25 PROTOCOL	
3—Network Layer	Determines message path and sequencing
2—Data-Link Layer	Forms, addresses, and error-checks data packets
1—Physical Layer	Electrical and mechanical interfaces

Source: International Standards Organization, Open System Interconnection

Conclusion

A LAN can provide many benefits by improving data processing efficiency and effectiveness. However, the decision to install a LAN, the choice of system, and its implementation require careful planning.

The case study on pages 5–6 illustrates the level of knowledge needed to make decisions about LANs. For example, when the partners first acquired a minicomputer system that distributed data in the usual star network topology, they considered the available industry standards for electrical connections (RS-232), control files (ASCII), and protocols (X.25).

As more software and thus more applications became available in the microcomputer field, the partners acquired and interfaced microcomputers by using the minicomputer as a *host* to share data files. A file server and operating system provided a gateway for interdevice connection and consequently permitted access to and between system users (nodes).

When they moved to a new building, the partners decided to increase communications and system capabilities by using their new telephone system (*PABX*) and coaxial cable. The resulting system linked voice and data through a digital signal.

In the case study the electronic office truly exists, and the firm provides its clients with graphic presentations of financial statements, performs audit work (for example, lead schedules) on portable personal computers, and uses text-management techniques in its new "paperless" environment.

Practitioners who wish to assist their own firms and clients in achieving similar results need to gain and maintain technical competence in using LANs and specific pieces of equipment. To stay current with rapid changes, practitioners can monitor emerging technologies that could affect the status of LANs. For example, a merging of data processing, voice, and video technologies is occurring. Companies are developing products that will deliver all three. This special report provides only an introduction to the subject of LANs.

Local Area Network Glossary

accessing technique In the LAN context it refers to the method of determining which device has access to the transmission medium at any instant. **CSMA/CD** is an example of network-accessing techniques, which are governed by communications software that includes some **protocols*** for exchanging data and constructing files.

analog Transmission methods developed for voice signals. These methods were designed only for the **bandwidth** of the human voice, which restricts their ability to transmit high-speed **digital** signals.

ANSI The American National Standards Institute, a body that develops and publishes standards for codes, transmissions, and signaling schemes.

ASCII The American Standard Code for Information Interchange is a method of coding **digital** signals. The ASCII character contains seven **bits;** an eighth bit is often added for **parity** checking.

asynchronous A transmission method in which the time intervals between characters need not be equal. "Start" and "Stop" **bits** are added to coordinate the transfer of characters. This method is used for relatively slow systems, for example, time-sharing with keyboard input.

bandwidth The range of frequencies a circuit will transmit. The square waves of **digital** signals can be distorted by inadequate bandwidth. The faster the digital signal rate, the greater the bandwidth requirement. **Analog** circuits are typically limited to the bandwidth of the human voice (about 3 KHz). Fiber-optic and **broadband** cables are **wideband** media.

baseband A transmission medium that sends signals without modulation. In a baseband LAN, **digital** signals (1s and 0s) are impressed directly onto the cable, which is generally used only for data transmission.

baud A measure of transmission speed in bits per second. It is roughly proportional to characters per second in a ten-to-one ratio; for example, 300 baud equal roughly 30 characters per second.

bisynchronous A transmission method in which the time intervals must be equal. It is generally used to transmit large quantities of data.

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* Boldfaced words in the text of the definitions are defined elsewhere in the Glossary.

bit The smallest unit of information, either 0 or 1.

block A number of characters transmitted as a group.

broadband A transmission medium capable of passing **wideband** signals. It is used to transmit voice and video.

byte A group of eight **bits**.

carrier A radio frequency or light wave that is transmitted over a cable and modulated with a signal.

CATV Community-antenna television, which is based on **broadband coaxial-cable** technology.

coaxial cable An electrical transmission cable with a center conductor and an outer electrical shield. It is used in both **broadband** and **baseband** systems. Broadband cable has better shielding than baseband cable.

contention The condition occurring when two or more stations attempt to use the same channel at the same time.

CSMA/CD Carrier-Sense Multiple-Access with Collision Detection is a network-**accessing technique** by which stations sense the absence of a **carrier** on the medium and begin to transmit. If two stations transmit simultaneously, they detect the collision and cease transmitting. Each waits a period of time determined by special noninterference techniques before initiating transmission again.

digital A transmission method developed for numerical signals in a binary code.

download/upload Data transfer between computer devices. Data is *down*loaded from a central computer (**host**) to local computers or terminals; data sent in the opposite direction is *up*loaded to the central computer.

duplex (1) In communications circuits, the ability to transmit and receive at the same time, also called *full duplex*. *Half-duplex* circuits can receive and transmit only at alternate times, for example, send/receive/send. (2) In terminals, a choice of displaying locally generated characters, echoed characters, or both.

EBCDIC Extended Binary-Coded Decimal Interchange Code is an eight-**bit** code used primarily on IBM business computers.

field A particular position within a message frame. Positions are labeled as the control field, flag field, and so on. **Bits** in a particular message have a specific meaning for stations on the network.

file server The device designated to make file data available to other devices on the network.

gateway A device that connects two systems, especially if the systems use different **protocols**. For example, a gateway is needed to connect two independent local networks or to connect a local network to a long-haul network.

handshaking Exchange of control codes or specific characters to control the data flow.

host The computer whose function is to provide services such as database access, computation, and special programming languages to other devices on the network.

hub One of the LAN stations that acts as a central receiver and sender of messages.

IEEE Institute of Electrical and Electronic Engineering.

message switching A switching technique using a message store-and-forward system. No dedicated path is established. Rather, each message contains a destination address and travels from source to destination through intermediate **nodes**. At each node the entire message is received, stored briefly, and then passed on to the next node.

modem Stands for *modulator/demodulator*, a device that transforms computer (**digital**) impulses to telephone (**analog**) impulses and vice versa.

node Each LAN station at which a device sends and/or receives messages.

PABX A private automated branch exchange is a telephone communications system serving a specific location, such as an office or building. The word *automated* indicates that users may place and receive calls with little or no operator assistance. Modern PABX systems may be able to switch and pass **digital** signals.

packet A string of characters that includes the source address, the destination address, and the message itself. Different systems utilize different-size packets.

packet switching A method of transmitting messages through a communications network in which long messages are subdivided into short **packets** with a maximum length. The packets are then transmitted as in **message switching**. Usually, packet switching is more efficient and rapid than message switching.

parallel transmission A method of sending data whereby all component **bits** constituting a character are transmitted simultaneously.

parity In **ASCII**, a check of the total number of 1 **bits** in a character. A final eighth bit is added so that the count, when transmitted, is always even or odd. This even or odd state can easily be checked at the receiving end.

polling Controlling the transmission sequence of communicating devices by asking each device if it wishes to transmit.

protocol A set of rules governing the transmission of information over a data channel.

RAM Random-access memory. Also known as *read/write memory*.

RS-232 An electric standard established by the **IEEE** for connecting equipment, for example, a printer to a computer. It is used for serial ports.

serial transmission Data transmission in which several component **bits** constituting a character are transmitted in sequence.

tap A prewired hookup point that simplifies the process of adding devices to a LAN.

token passing In ring networks, an allocation scheme that passes a very short all-clear message (token) around the network until a station catches it and changes it to "Here comes a message." In bus networks, each station must know who is next on the network in order to pass the token.

topology An information industry term denoting the physical design or shape of a system. Common topologies are the star, ring, bus, and tree.

twisted-pair wire An electrical cable used for communications. It is often used in **PABX** systems.

wideband A channel or transmission medium capable of passing more frequencies than a standard 3-KHz voice channel.

X.25 A **packet-switching** standard adopted by the **IEEE** and CCITT. It defines the physical interface level, the data-link level, and the network **protocol** level of the system.

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