Digital believes the information in this publication is accurate as of its publication date; such information is subject to change without notice. Digital is not responsible for any inadvertent errors.

The following are trademarks of Digital Equipment Corporation: ALL-IN-1, DEC, DECmate, DECnet, DECnet-11M-PLUS, DECnet-RT, DECnet-VAX, DECnet/E, DECnet Router, DECnet Router/X.25 Gateway, DECnet/SNA Gateway, DELNI, Terminal Server, DECsystem-10, DECSYSTEM-20, DECsystem-10 and -20, Digital Network Architecture (DNA), the Digital logo, Internet, Packetnet, PDP, P/OS, Professional 325 and 350, PRO/Tool Kit, Q-bus, Rainbow, RSTS, RSTS/E, RSX, RT-11, TOPS-10, TOPS-20, UNIBUS, VAX, VAXcluster, VAXELN, VMS, and VT.
Table of Contents

Preface  i

Chapter 1. Introduction  1
What is a Network? What are its Benefits?  2
Factors to Consider in Choosing a Network.  3
How Networking Evolved.  4
Illustrative Networking Applications: Inventory Control, Electronic Mail, Funds Transfer.  5
One Flexible Network to Encompass Varying Applications.  9
Choosing the Right Vendor.  14

Chapter 2. Local Area Networking  17
Why a Local Area Network?  18
What to Look For in a Local Area Network.  18
The Importance of Standards.  19
The Ethernet Local Area Network.  22
Baseband and Broadband Local Area Networks.  22
Network Topology.  24
Local Area Network Topologies.  31
Ethernet Configuration—Simple and Cost Effective.  33
Channel Access on an Ethernet LAN—CSMA/CD.  37
An Illustrative Local Area Network.  38
Bridges.  41
Chapter 3. Wide Area Networking  45
WAN Communication Media.  46
Communication Media and WAN Configuration.  48
An Illustrative Wide Area Network.  49
A Single Flexible Network of Many Components.  51

Chapter 4. What Makes Digital the Vendor of Choice?  53
Commitment to Multivendor Communication; Flexible Products.  54
As Many as One Hundred Networking Products and Capabilities.  54
Compatible Networking Software across Digital Systems.  55
Easy-to-Use Networking Products.  56
User Training and Support.  56
Comprehensive Network Services.  56
Glossary.  59
Chapter 1
Introduction

Increasing numbers of vendors are claiming to offer networking capabilities. In your capacity to approve budgets for your department or company, you may be presented with networking proposals you do not completely see the benefit of. To make a sound business decision about a network investment, you do not need to know the technicalities of networking. But a general understanding of networking concepts will help you answer questions that are critical to your decision-making.

- How will a network help in making timely and accurate sales and marketing decisions?
- How will it improve customer service?
- How will it increase the efficiency of inventory control?
- How will it help improve communication between employees? Between facilities? Between departments?
- How will it help the company maximize its investments?

You will also need answers to questions of a financial nature

- What are the cost-benefits to be realized with a network?
- What will the initial investment be? What are the possible ongoing expenses?
- How much and how long will my business be disrupted while the network is being implemented?
- How easy is to modify and expand the network to accommodate changing application requirements?

Numerous companies are realizing significant cost-savings with appropriate networks for their applications. A knowledge of the important criteria involved in choosing a network can make you feel comfortable about approving a network purchase for your department or company.

[For your quick reference, explanations of italicized terms can be found in the glossary.]
What Is a Network? What Are Its Benefits?

A network comprises two or more intelligent devices (computer systems, intelligent terminals, and intelligent peripherals) linked in order to exchange information and share resources. A device on a network is called a node. Some nodes are called hosts. A host is any network node that individuals can access for resources such as processing power, information files, and user applications. Hosts are general purpose nodes that have not been specifically designed to fulfill network-specific functions. They are distinguished from special purpose nodes, about which you will read later, that serve very specific networking functions.

From the perspective of individual users, the most apparent advantage of a network is that critical information, no matter where it is located, is available to them when they need it. For instance, a company's financial manager preparing a profit-and-loss statement for a fiscal quarter can sit at a terminal and immediately get up-to-date sales and operating cost figures, even if the data resides on two remotely located nodes.

From an organizational perspective, the immediate advantages of a network are efficient use of information and cost-effective use of expensive resources (storage devices such as disks and tapes and output devices such as printers, in particular). Consider four research engineers located in facilities in different cities. Each engineer is designing a separate aspect of a product. Through a network, the engineers continually share their findings, thereby speeding up development of the product. In a publishing house, for example, a network enables editors in several departments to share an expensive printer.

Ultimately, the benefit of a network lies in the increased effectiveness of a company's employees. Networks help individuals make intelligent and timely decisions by giving them quick access to critical information. Timely decision-making helps increase a company's effectiveness.
Factors To Consider in Choosing a Network.
Before making a investment, you may want to conduct a pilot plan to evaluate the impact of a proposed network. In making your final decision, you should keep in mind the following points.

Your company or department should have the option to start with as small a network as it needs, without having to spend millions of dollars to wire an entire building. At the same time, this network should be easy to expand to keep pace with growing application requirements. It is not always possible to predict today what your application needs will be two years later. Your network should be flexible enough to accommodate this uncertainty in your business.

In addition, the networking strategy in which you invest should be able to encompass new developments in data communications. Data communications technology is moving at a very rapid rate, and today's cost-effective technology may be displaced by a new one three years from now.

Your company should be able to manage its applications and networking technology independently of one another. Applications are an expensive investment and play a critical part in keeping the company competitive. Efficient management of communications costs is a significant factor in controlling the company's operating expenses. A modification or growth in applications should not entail disruption of your existing network. Similarly, a migration to more cost-effective technologies in your network should not require a change in your applications.

Finally, if your company has computers from different vendors, your networking strategy should enable multivendor communication. The networking vendor you choose should be committed to the international standards that make possible multivendor communication.
How Networking Evolved.
To make intelligent decisions and be effective in their jobs, individuals have always needed relevant information quickly. In the past, however, information was not always readily available to those who needed it when they needed it. An inventory control manager who wished to know the inventory level of a product in a remotely located warehouse could not expect to have that figure immediately. Computers were large and expensive machines located in isolated rooms and operated only by highly trained specialists. Individuals took their questions to these experts who then fed the problems to the computer. After a substantial delay, the computer would have the answers. These answers may not always have been completely accurate since they would probably have been based on data that was not entirely up to date.

VLSI technology made possible a dramatic reduction in the size and cost of computers. The smaller computers of today are many times more powerful than the large machines of the past. In addition, VLSI technology has made it possible for dumb devices such as terminals and peripherals to acquire intelligence. In today's corporation, there is an abundance of departmental minicomputers, intelligent terminals and peripherals, and personal computers.

The primary advantage of this proliferation of computers and intelligent devices is that computing power is available to individuals at their work site, be it an office, a lab, or a factory floor. A major disadvantage of such proliferation is duplication of effort. Every departmental computer requires its own database of information, as does every personal computer. Users have to build and maintain these databases, and this takes considerable time. Multiple copies of the same data exist, and this presents updating problems. For
example, sales and distribution data resides not only on sales department and distribution department computers, respectively, but also on a computer in the finance department, where these figures are needed to prepare financial statements. To ensure that the data remains useful, the finance department has to update its database periodically. This might involve manual transportation of storage media from the sales department and inventory department computers to the finance department computer. This assumes that the three computers accept the same kind of storage media, which they might not. In that case, updating becomes further complicated and time consuming.

Networking helps eliminate this inefficiency in data storage and maintenance. There is no need to create multiple copies of the same data because users on a network can share information. A financial manager needing sales and inventory figures sits at a terminal and has immediate access to the sales department and distribution department nodes (provided the manager has a valid user account on both computers). Similarly, other users have access to information they need when they need it. With a network, maintaining data becomes simple because there is only one copy of data to update. Sales figures reside only on the sales department node, inventory figures only on the inventory department node. Networking enables a company to derive the advantages of the proliferation in computing power rather than suffer the disadvantages.

**Illustrative Networking Applications: Inventory Control, Electronic Mail, Funds Transfer.**

All applications discussed in this section and elsewhere in the book are representative of networks that are currently in operation in various companies.
Inventory Control
Inventory control becomes very efficient with networking. A manufacturing company has a distribution center located in one city and warehouses in several cities across the country. Each warehouse has its own minicomputer with a database of local inventory details. The central distribution facility has a master database of the inventory figures on all the warehouses.

Whenever a warehouse receives an order or makes a shipment, an operator at the warehouse updates the local database. At the same time, the order or shipment information is sent over the network to the computer at the distribution center to update the master database.

Thus, at any time, a distribution manager at the central facility can check on the current inventory level of any warehouse. This up-to-date information enables the manager to maintain adequate inventory levels where needed and to reduce inventory levels where they are too high. The benefit to the company is the increased profitability resulting from appropriate stocking of inventory. In addition, day-to-day inventory information enables the company to adjust the manufacturing of its products to reflect demand, thereby controlling excess production of goods with slow sales. Again, the savings are considerable.

Current inventory information also enables the manager to respond in an effective manner to day-to-day problems. For example, a very large shipment depletes a warehouse's inventory. To ensure that the customer does not receive a partial shipment, the distribution manager consults the master database to find a warehouse with available inventory of the product required for the shipment.
Electronic Mail
Electronic mail helps individuals save valuable time. Employees linked on a network by electronic mail do not have to waste time trying repeatedly to reach one another on the phone. Instead, they can sit at their terminals, type a message (of any length), and send it over the network. Within seconds, the message arrives at its destination, be it an office in the next aisle or one on the other side of the globe. The ability to communicate across time zones is invaluable, since individuals located in different countries and with different working hours could spend days trying to make phone contact. The advantage of electronic mail is that both sender and receiver can work at their convenience and still communicate with one another.

Funds Transfer
Banks that are linked by networks can electronically transfer funds among themselves. This capability enables banks to serve their customers with increased efficiency. Corporate clients are among the primary beneficiaries. A corporation can conduct transactions involving transfers of large sums of money between geographically separated banks, without experiencing inconvenience and costly time delays.

A company in San Francisco makes a purchase worth $4 million from a manufacturer in Boston. The purchasing company agrees to make an immediate payment of $1 million and to meet the difference upon delivery of the goods. Accordingly, the company authorizes its bank in San Francisco to transfer $1 million to the manufacturer’s account at a Boston bank.
The electronic transfer of funds can take place in one of two ways. If the two banks have a correspondent/respondent relationship, the San Francisco bank can inform the Boston bank, over a network linking them, of a credit of $1 million to the manufacturer’s account. The credit to the seller’s account and the debit from the buyer’s account take place almost simultaneously. Either bank can verify the status of the two clients’ accounts and confirm the transfer. Through the network, the entire transaction can be completed in a few hours.

If the banks involved do not have a correspondent/respondent relationship, the Federal Reserve Banks in San Francisco and Boston enter the picture. The bank in San Francisco informs the local Federal Reserve Bank, over a network linking them, of the need to transfer $1 million to the bank in Boston. Through a network linking the various Federal Reserve Banks in the country, the Federal Reserve Bank in San Francisco informs its counterpart in Boston of the required transfer. This information is passed on by the Boston Federal Reserve Bank to the seller’s bank over a network linking them. Within a few hours, the transfer is effected through the two Federal Reserve Banks.
One Flexible Network to Encompass Varying Applications.

Applications as diverse as inventory control and electronic mail often run on the same network. The network supporting the inventory control application described above could support an electronic mail application as well. The distribution manager would use the electronic mail application to communicate with the warehouse operators. A network is primarily a means of transporting information from a source to a destination, regardless of whether the information takes the form of memos between users or files from a database on one computer to a database on another.

A large company usually has many potential networking applications. Ideally, all of these should be able to run on a single network that is flexible enough to accommodate varying application requirements. There are several advantages in having a single network rather than many. First, configuring and implementing one network are simpler and less expensive than configuring and implementing several networks. Second, it is easier to maintain one network rather than many. Third, it is easier and cheaper to expand one network rather than several. Finally, it is simpler to incorporate technological developments in one network rather than in many.
A Flexible Network That Includes Local Area Networks and Wide Area Networks

A network can comprise two computers or many thousands. It can span a building, a country, or a continent. The terms local area networking and wide area networking primarily draw attention to the geographical area a network covers. Local area networks (LANs) span a limited geographical area, such as a building or a cluster of buildings, while wide area networks (WANs) cover large geographical areas, extending across several cities or even countries. (Recent developments in LAN technology have vastly expanded the reach of LANs, thereby blurring the distinction between LANs and WANs. For an explanation of these developments, see the brief discussion on bridges following Chapter 2.)

In many applications, LANs and WANs are part of a single network. Figure 1-1 depicts the network of a Company X. This network includes a local area component, a wide area component, and a component involving communication between computers of different vendors.

Company X is a relocation services firm, with large corporations for clients. When employees of these corporations are transferred from one city to another, relocation specialists at Company X help the employees find their new homes. Company X is headquartered in Connecticut with branch offices in seven major cities. Each location, including the headquarters, has a local database (residing on a minicomputer) containing a list of available homes in that region. In addition, a mainframe at Connecticut stores billing information on every client.
Figure 1-1
One Flexible Network Comprising a LAN, WAN, and Intervendor Communication
Relocation specialists at Connecticut sit at any terminal T and access or update the local database over the LAN. In addition, they can access any of the remotely located branch office databases over the WAN through a special purpose system that converts the message-format of the LAN to a format recognized by the WAN. There are several types of special purpose systems, performing different network-specific functions. The special purpose or dedicated system in this case is a Router/X.25 Gateway. This system enables communication between the LAN and WAN over a packet-switched data network (PSDN). (PSDNs are public data networks owned and operated in this country by private vendors and in Europe by the national Post and Telegraph departments. Customers connect their computers to the PSDN. The PSDN is made up of communicating nodes that switch or transport the data between the customers’ computers. In order to communicate over a PSDN, computers have to use the X.25 protocol of data transfer. The major difference between a network owned by a customer and a PSDN is that in the former the customer owns the switching or transporting nodes and in a PSDN, the PSDN vendor owns them.) Given Company X’s application, a PSDN provides the most cost-effective way of configuring the WAN. PSDNs are the best solution for applications with moderate amounts of data flow because PSDN tariffs are based on the volume of data transferred rather than on the distance or connect time between communicating computers. PSDNs are cost-effective solutions in a majority of cases because most applications involve medium
volumes of data flow. Relocation specialists at each of the branch offices can access any of the other databases, including the one at Connecticut, over the WAN. Thus, at any time, relocation specialists, regardless of their location, can see what homes are available in any part of the country.

In addition to database access and update, relocation specialists also have to enter billing-related information for their clients. The mainframe that supports the billing application is not from the same vendor as the minicomputers on the LAN and WAN. However, the node on the LAN supporting the local database also runs appropriate software to enable it to communicate with the mainframe. Thus specialists at Connecticut access the mainframe for data entry through this node on the LAN. Relocation specialists at the remote offices access the mainframe by first getting on the LAN through the Router/X.25 Gateway and then going through the LAN node supporting intervender communication.

The single network at Company X, with its many different components, fulfills the company’s business requirements in a comprehensive fashion. Company X’s clients benefit because every relocation specialist has access to the total picture of available homes. Further, billing is made efficient because the relocation specialists periodically enter and update billing information on their clients. With three separate networks, relocation specialists would not have had the same kind of easy access to every database.
Not every company requires a network of many components. Applications dictate network configuration. Some companies need no more than a LAN, others require just a WAN. Whatever its initial configuration and size, a network should be easy to modify and expand as application requirements change and grow, and there should be little or no disruption in existing network operation.

**Choosing the Right Vendor.**
One of the most critical aspects of investing in a network is choosing the right vendor. Your company’s investment should be protected against inefficient and unreliable products and against technologies that rapidly become obsolete.

A vendor should have a proven record in the networking business and should offer a comprehensive range of networking products and capabilities to meet a variety of application needs. In addition, a vendor should offer the following services
- Consulting Services—Trained personnel assess your department or company’s networking requirements and recommend the right configuration (whether this be a LAN, a WAN, or a configuration including both).

- Installation and Implementation Services—The vendor installs the network and ensures that it is operating correctly.

- Educational Services—The vendor trains users, regardless of their level of familiarity with computers.

- Maintenance Services—The vendor responds rapidly to solve hardware or software problems in network operation.

- Performance Monitoring Services—To ensure that your network is performing at the optimal level, the vendor should have facilities to monitor performance and remedy problem areas. In addition, performance monitoring services should be able to detect potential problems and correct these before they begin to affect the network adversely.
There are many hundreds of local area networks in operation today and the number is expected to increase to many thousands over the next three years. A local area network

- covers a limited geographical area such as a floor in a building, an entire building, or a cluster of buildings.

- can encompass over a thousand nodes.

- uses the kind of physical medium and communications technology that enable large volumes of data to be transferred at very high speeds.

In the past, one of the most expensive components of data communications has been the physical connection between nodes. Communication media, be they leased lines, cables, or satellite links, are expensive, and in large networks connection costs can be very high. Local area networking technology vastly reduces communication costs by simplifying the connection between nodes. In the most cost-effective configurations, all the nodes on a LAN are linked by a single high-speed continuous cable, called a bus.

In Chapter 1, you read about the proliferation of intelligent devices in today’s organization and for the need to link them in order to avoid inefficient data storage and maintenance (see How Networking Evolved, Chapter 1). A LAN is a cost-effective means of linking the numerous mainframes, minicomputers, personal computers, and intelligent terminals and peripherals in a local environment. A LAN can be configured to include just two nodes and expanded to include over a thousand. A LAN in one area can communicate with a LAN in another area so that the effective reach of both LANs is greatly extended.
Why a Local Area Network?
A general rule of information use holds that communication within a local environment is far more intensive than communication across widely separated geographical areas. Eighty percent of the information used in a local environment is generated from within the environment; only 20 percent comes from the outside. Likewise, of the information generated within a local environment, 80 percent is used in the environment; only 20 percent is sent outside. A LAN is the most effective way to handle this heavy flow of information within a local environment.

What to Look For in a Local Area Network.
A LAN should be fast, support a large number of users, and be reliable and simple to maintain. It should be easy to configure, install, and expand, and support a wide variety of equipment.

Network users expect quick responses to their requests for data. In a LAN, speed is a particularly important consideration because the requested data, be it a large file of numbers for a graph or a short memo, travels within a local environment, and users therefore have a very low tolerance for delays. In addition, network response time should not suffer with increasing numbers of users. There could be many hundreds of users on the network at any given time. The LAN should accommodate their demands in such a way that the users do not perceive any decrease in the speed with which they can access data.

In order to be a truly useful means of information exchange and resource sharing, a network should be available for use at all times. LAN components and operations must be very reliable to provide a consistent high level of service. Node and network hardware, transmission media, and the network in general should be designed
so that if a node or component fails, the fault is localized to that particular unit and the rest of the network is not disrupted. In addition, a LAN should be easy to maintain, with little or no interruption of network operation. Faults should be easy to locate and correct.

It is difficult to predict the rate and nature of change and growth in a work environment. LANs should therefore be easy to configure and the configurations should be easy to modify and expand. Nodes should be able to be located where users need them and moved when necessary.

In any environment, there is a large variety of computer equipment such as mainframes, minicomputers, word processors, personal computers, workstations, high-resolution graphics plotters, intelligent copiers, high-speed printers, and intelligent storage devices. A LAN is useful only if it enables easy and transparent data transfer among these various types of devices. User transparency in a network means that users do not have to know how the network functions. They merely request the information they need, without having to be aware of how the information gets to them. A truly universal LAN enables communication between equipment of different vendors.

**The Importance of Standards.**
There are thousands of computer equipment manufacturers today. Enabling multivendor communication is one of the most formidable tasks of data communications engineers. Unless the many manufacturers adopt common standards of communication, multivendor exchange of information could be impossible. Customers would be locked into one vendor or, if they already have equipment from different manufacturers, be unable to link these devices in efficient resource sharing networks.
Communications standards are recommendations or sets of rules defining and describing the concepts and technicalities associated with communication between intelligent devices. Communication is possible between the equipment of vendors who adopt the same standards.

*The ISO Model of Open Systems Interconnection*

The most comprehensive of communications standards is that recommended in 1978 by the International Standards Organization (ISO). This recommendation has become the de facto standard for communications, with all but a few vendors adopting it. Known as the ISO model for Open Systems Interconnection, the recommendation is in the form of a seven-layer model for network architecture.

Each layer of the hierarchically designed model (see Figure 2-1) provides a certain subset of services to the overall set of network functions.

*Figure 2.1
The ISO Model for Open Systems Interconnection*

<table>
<thead>
<tr>
<th>Layer</th>
</tr>
</thead>
<tbody>
<tr>
<td>Application</td>
</tr>
<tr>
<td>Presentation</td>
</tr>
<tr>
<td>Session</td>
</tr>
<tr>
<td>Transport</td>
</tr>
<tr>
<td>Network</td>
</tr>
<tr>
<td>Data Link</td>
</tr>
<tr>
<td>Physical</td>
</tr>
</tbody>
</table>

The lower layers, the Physical Link Layer and the Data Link Layer, define the electrical and mechanical aspects of connecting to a physical medium and establish an error-free communications path between network nodes over the physical channel, respectively.
Together, they make it possible for devices to connect to a physical medium and to send and receive data over the channel. The upper five layers of the architecture are responsible for the higher levels of communication such as setting up links between programs in different nodes, addressing information so that it arrives at the right destination, sending data so that it arrives in the right sequence, and providing the user with an interface to the network's capabilities.

The upper layers are critical to the interpretation of data. Without them, information exchange is meaningless. Two computers could exchange data over a wire or cable, but unless their networking software included the functions provided by the upper layers of the architecture the information they received would remain unintelligible to the user. The upper layers process received data and interpret it so that the user understands the information.

The Relationship between LAN Technology and the ISO Model
Most of the discussion of local area networking technology focuses on the two lower layers of the ISO model. LAN standards are specifications describing the mechanical and electrical connection of devices to a cable and the transportation of data over this cable. These standards do not include specifications for the higher levels of network functions. Thus, although computers from different vendors can be part of the same LAN and exchange information, they will not be able to interpret and use the data they receive if they do not have requisite higher-level networking software. (An analogous situation occurs when you are in the same room as another person who speaks a foreign language you do not know. You hear the person—that is, you receive data—but do not understand what the person is saying because of your ignorance of the foreign language).

Local area networking capabilities must therefore operate in conjunction with software that interprets the data computers receive over a network in order to provide meaningful information exchange and resource sharing capabilities.
The Ethernet Local Area Network.
In 1980, Digital Equipment Corporation, Xerox Corporation, and Intel Corporation collaborated to come up with a specification for the Ethernet, a local area network optimized for the high-speed exchange of data between intelligent devices within a moderate sized (2.8 kilometers long) geographic area. The Ethernet specification was issued to encourage a standardized approach to the design of local area networks and to maximize communications between the great variety of equipment available from different manufacturers.

The specification provides precise, detailed design information on how to connect devices to a coaxial cable (the physical medium of communication of an Ethernet LAN), the pattern of configuration of nodes, the maximum number of nodes, and the minimum distance between nodes. The specification includes details on how the nodes share the cable to transmit data. In addition, the specification defines the interface between the Data Link layer and the higher-level functional layers of a network architecture and describes two interfaces in the Physical layer that ensure compatibility between equipment used in different Ethernet implementations. Vendors who adopt the Ethernet specification can connect their equipment to the same Ethernet LAN and exchange information among themselves.

Baseband and Broadband Local Area Networks.
Baseband LANs use a single physical transmission medium that carries data only. All nodes on a baseband LAN transmit data at the same frequency and therefore have to wait their turn to use the communications channel.

Broadband LANs also use a single physical channel, but the channel is subdivided into a number of independent frequency channels. These
subchannels transmit different forms of information—voice, data, and video—simultaneously. Broadband LANs are thus useful in security operations that require video monitoring and in teleconferencing applications. Teleconferencing can help a corporation realize dramatic cost savings by eliminating the need for executives to travel long distances to attend meetings. Universities are also realizing the benefits of broadband LAN technology. A lecture is conducted simultaneously in several classrooms. The professor’s voice, image, and lecture material are transmitted over the LAN and appear on screens in the classrooms.

On broadband LANs, the physical channel can be divided into many frequency ranges such that different varieties of video, voice, and data equipment can transmit over the channel. For instance, a variety of data equipment, operating at different speeds and conforming to various electrical standards, could participate on the same broadband LAN. Some of the capacity of the physical medium could be unused or reserved for expansion of the network with growth of existing applications or addition of new ones.

Baseband and broadband LANs use different capacities of coaxial cable as their physical transmission medium. Coaxial cables are popular as LAN transmission media because of their large capacity (allowing for large volumes of data transfer), low error rates, and configuration flexibility. Ethernet operates over a coaxial cable. Although the Ethernet specification describes the rules for design of baseband LANs, Ethernet can operate on the data subchannel of broadband LANs, as well.
Network Topology.
The topology of a network is the geometric pattern in which its nodes and physical lines are arranged or configured. Figure 2-2 depicts several types of network topologies.

Figure 2.2
Network Topologies

Star Topology
Bus Topology

Unconstrained Topology
Network planners make their choice of topology on the basis of how they wish to assign control of information flow over the network. Control can be centralized or distributed. With centralized control, access to the network (which nodes can send messages and when) and allocation of the channel (how much of the physical channel a node can use and for how long) are controlled by one node. When control is distributed, all nodes have equal privilege to transmit and receive information and do not have to wait for a control node to grant them their turn.

There are two kinds of links that serve as the building blocks of network topologies—point-to-point and multipoint. A point-to-point link is a circuit that connects two nodes without passing through an intermediate node. See Figure 2-3(a) for illustrations of nodes connected by point-to-point links. A multipoint or multidrop link is a single line that is shared by more than two nodes (see Figure 2-3b).
Fig. 2.3b
Multipoint Link
Routing is a concept basic to topology. Every network transfer of information involves a source node, which sends a message, and a destination node, for which the message is intended. In some instances, the destination node may be adjacent to the source node and be connected to it by a point-to-point link. More often, there are many intermediate nodes on the path between a source node and a destination node. Intermediary nodes that direct information from the source node to the destination node are said to have routing capability. They pass on messages not intended for themselves.

Each node in a network has a unique numeric address or identification tag. Every message sent on the network has associated with it the address of the destination node. The decision by a node whether to accept a message or route it through to the next node in the path is based on the destination-node address associated with the message. Messages with addresses that do not match the intermediary node's address are routed through.

Without routing capability, a network can be very expensive to configure. Large networks made up of nonrouting nodes can have astronomical configuration costs. Figure 2-4 illustrates a six-node nonrouting network.
Figure 2.4
Nonrouting Network with
Six Nodes
Full communications (the ability of each node to communicate directly with every other node in the network) can be achieved only when each node is connected to every other node by a point-to-point link. A network with six nonrouting nodes needs 14 lines for full communications. Nodes added to the network increase the line count exponentially, in addition to increasing the complexity of configuring the network. Adding routing capability to four of the six nodes decreases the line count from 14 to 5 (see Figure 2-5).

Figure 2.5
Six-Node Routing Network

Multipoint lines can also be used to reduce configuration costs. The six nodes in the example above could communicate by sharing a single multipoint line.
Local Area Network Topologies.
The cost-savings of LANs is one of their major benefits. Usually, all nodes in a LAN are connected to a single multipoint line, thereby eliminating the high cost of multiple connections between nodes. In addition, nodes on a LAN do not have to route messages. (A message, together with the address of the destination node, travels on the common communications line. The node to which the message is addressed recognizes its address and accepts the information. No other node can accept the message.) Thus, the expense of including routing functions on nodes is eliminated.

Bus Networks
Most LANs are configured in a bus topology, where the bus is a single cable to which all the nodes are connected. To facilitate easy communication among nodes and to ensure that users have rapid access to information, control of the bus is distributed. All nodes have equal privilege to transfer information. Ethernet LANs have bus topologies.

Bus networks are easy to configure and expand in most physical layouts such as a room, building, or cluster of buildings (see Ethernet Configuration, below, in this chapter, for an explanation of the simplicity of configuring Ethernet LANs).
Ring Networks
In ring networks the nodes are connected by point-to-point links to form an unbroken circular configuration (see Figure 2-6). Transmitted messages travel from node to node around the ring. Each node must be able to recognize its own address in order to accept messages. In addition, each node serves as an active repeater, retransmitting messages addressed to other nodes.

Figure 2.6
Ring Network

The major disadvantage of ring networks is that they are more difficult to configure than bus networks and the configurations are harder to modify. Every time a node is added to the ring, lines have to be placed between the new node and its two adjacent nodes. Thus it is often difficult to prewire a building for ring networks in anticipation of nodes to be added in the future. Bus networks require very little preplanning, however.
Ethernet Configuration—Simple and Cost Effective.

Ethernet LANs are simple and cost-effective to configure, so you undertake no risk when you invest in such a network. A single coaxial cable takes the place of thousands of wires. Installation of the cable in a building is therefore far less expensive and less complex than laying down innumerable wires. The nodes are merely tapped into the cable, once it is in place, by means of a pronglike clamp that pierces the cable. There are no predetermined points at which the nodes must be placed. Provided there is a minimum distance of 2.5 meters between two nodes, they can be located wherever users find it most convenient. Ethernet LANs are highly flexible and extendible. A network can be configured to serve a small office or building, a complex of buildings, or the offices of a corporate headquarters extending up to 100 floors of a building (see Figure 2-7).
Figure 2.7 (a-c)
Ethernet LANs—In a Small
Building, across a Complex
of Buildings, and at
Corporate Headquarters
An Ethernet LAN is simple to expand. Adding nodes does not disturb network operation. New nodes can be connected at virtually any point without disrupting the running of the network. They can be added and powered on to function immediately. This ease of expansion means that you do not have to know accurately how large or small your growth projections will be. In case of a major change such as a departmental move or a change of company location, the single-cable topology makes it possible for the entire network to be set up or reconfigured with considerably less effort and expense than would be required for transporting and reconfiguring existing wire-intensive networks.

**Channel Access on an Ethernet LAN—CSMA/CD.**
A single Ethernet LAN can comprise up to 1024 nodes. All the nodes share a single transmission channel and, therefore, must have some means of adequate access to the channel. Ethernet LANs use a technique known as *Carrier Sense Multiple Access with Collision Detect (CSMA/CD)* to allocate the common channel among the many nodes.

The *Multiple Access* feature of CSMA/CD lets any node send a message immediately upon sensing that the channel is free of traffic.
Carrier Sense is the ability of each node to detect any traffic on the channel (called listen-before-talking). Nodes defer transmitting whenever they sense that there is traffic on the channel. However, because of the time it takes for a data signal to travel across the entire length of the network, two nodes could detect that the channel is free either exactly at or close to the same time, since each will not yet have detected the transmitting signal of the other. In such a situation, a collision between the two messages will occur.

Collisions are detected by nodes while they are transmitting, by monitoring the energy level (i.e., the electrical signal level) of the channel (called listen-while-talking). Message collisions change the energy level on the channel. Collision Detect is the ability of a transmitting node to sense a change in the energy level of the channel and to interpret it as a collision.

Upon detecting a collision, each node involved backs off and abandons its transmission, waits for a brief interval, and attempts to transmit again. The period before retransmitting is either fixed (at a unique interval for each node) or random. In the case of a random interval, a node experiencing successive collisions will interpret the phenomenon as a particularly busy channel and wait a longer period each time.

Owing to the ability of nodes to listen before and during transmissions, the number of collisions can be quite low, and successive collisions between nodes are rare. CSMA/CD is therefore a highly efficient form of shared access to a channel.

An Illustrative Local Area Network.
An internationally known manufacturer based in New England uses a variety of computers from Digital Equipment Corporation at one of its manufacturing facilities. Approximately a dozen VAX and PDP-11 production systems manage the flow of raw materials making up the company’s product. All the systems on the production floor are linked in a process control network configured as an Ethernet LAN.
To monitor and control the manufacturing process, the systems on the LAN use data collected from more than 8,000 points throughout the facility. Program development and analysis of production data also occur on some of the systems.

The network, says a company official, has dramatically increased the efficiency of the manufacturing process. The company is now able to produce a high quality product at low cost, thereby gaining a competitive advantage in the market.

Until this past year, the production systems were physically connected in a star network configuration (see Figure 2-2) that was subject to certain bottlenecks. The trouble with such a configuration was that failure of any link interrupted data flow. Although the network manager had reconfigured the network to minimize the impact of line and node failures, it was impossible to eliminate entirely the interruption of data flow due to such failures because there were at least two points in the network where two nodes had to be daisychained.

The company has a three-shift manufacturing operation in which production downtime causes a critical setback. The network configuration was thus changed from a star to an Ethernet bus topology. Because each system in a bus topology is connected directly to the Ethernet cable, failure of a node is confined to its location and does not disrupt network operation.

The Ethernet LAN has brought other advantages, as well. Since each system is connected to the Ethernet bus by means of a single cable, the company has realized substantial savings in communications hardware costs. The high bandwidth of the Ethernet LAN has resulted in faster transfer of data than in the previous configuration. Expanding an Ethernet LAN is also easier than expanding a star network.
The company is realizing still other benefits from the new network. Program development is now simpler. In the previous network configuration, routing overhead was held to a minimum by having programmers keep multiple terminals on their desk, each terminal connected directly to a different node on the network. In the present network configuration, programmers no longer suffer the inconvenience of having multiple terminals on their desks. They can connect to any node on the LAN with only one terminal on their desk.

The company also plans to add terminal servers to reduce terminal processing overhead in network nodes. In most network configurations, each terminal gains access to remote nodes through a local node. A significant amount of the processing power of nodes is therefore taken up in establishing connections between local terminals and remote nodes. In an Ethernet network, terminal processing can be offloaded onto special purpose systems known as terminal servers that free the network nodes of the task of establishing terminal-to-node connections. A terminal server provides high-speed communications from up to 32 terminals to any node on an Ethernet network. By connecting multiple terminals to the entire network through a single communications line, the terminal server reduces line costs.
Bridges, recent technological developments in local area networking, have made it possible to link widely separated LANs so that they appear to be one large network (see Figure 2.8).

Figure 2.8
Bridges Enable Communication between Widely Separated LANs
The most significant aspect of the bridge is that it permits communication between LANs of different vendors in a manner that is transparent to the nodes in both LANs. In other words, the nodes are not aware of the presence of the bridge. Each node merely addresses its message to a destination node. If the destination address lies on the remote LAN, the local bridge passes the message to the remote bridge, which then places it on the remote LAN. To the source node, the destination node appears to be located on the local LAN.

Another important feature is the filtering capability, which enables a bridge to ensure that messages addressed to local nodes remain on the local LAN and do not get on the transmitting medium connecting the two LANs. Only messages addressed to remote nodes are allowed to pass through the bridge onto the connecting medium. This capability prevents local traffic on one LAN from congesting the interconnecting medium and the remote LAN.

Bridges vastly extend the reach of LANs. Satellite or terrestrial links between bridges connect LANs that are separated by thousands of miles.
LANs and WANs: Is the Distinction Valid?
In earlier chapters you read that LANs span limited geographical areas and WANs can extend over many hundreds or thousands of miles. LANs and WANs also differ in the type of communication media they use and in the manner in which they transfer information between nodes.

These differences will soon not exist, however. Already, bridges are eliminating one distinction between LANs and WANs by linking widely separated LANs so that they appear to be a single network spanning a large geographical area. Future developments in networking technology will render obsolete other differences between LANs and WANs.

For the purpose of discussion, this book draws a distinction between LANs and WANs in terms of geographical area covered and communications media and technology used. Network users do not have to be aware of these distinctions, however. From the users’ perspective, a network should merely be a means of accessing critical information, regardless of whether this information resides in the next building or in another city.
A wide area network (WAN) covers a large geographical area: the nodes may be distributed across several cities or countries. Many large companies, with offices in different locations, are realizing the benefits of WANs. An electronic mail application running on a WAN enables employees in widely separated facilities and in different time zones to communicate with the ease and immediacy of being in adjacent rooms. A WAN-based inventory control application enables a company to serve its customers with increased efficiency because, at any time, a distribution manager at a central distribution facility can determine the current inventory status of any remotely located warehouse. As you read in the introductory chapter, the network may be set up so that each remotely located warehouse has its own computer with a database of local inventory details and the central distribution facility has a master database of the inventory figures on all the warehouses.

Access to critical information, no matter where it is located, is immediate. A financial manager who is preparing a report on a certain division's performance for the quarter can sit at a terminal and access from different computers in remote sales offices up-to-date invoice, backlog, and bookings data. Such information helps the business manager of the division to forecast and plan for the next quarter's business with increased timeliness and efficiency.

The banking industry is fast becoming increasingly dependent on a wide area network linking international banks worldwide. This WAN enables, among other things, speedy electronic transfer of money between banks that are located in different countries. Bank customers who wish to conduct international transactions involving large sums of money no longer have to suffer costly time delays.
**WAN Communication Media.**
Nodes on a wide area network may be linked by various types of communication media, depending on the volume of data flowing between the nodes. WAN communication media currently in use include leased lines, dialup lines, packet-switched data networks (PSDNs), and microwave links. A single WAN may include one or more of these media.

**Leased Lines**
A *leased line* is a communication line that the customer leases or rents from a phone company. The connection between nodes linked by a leased line is always “live”; in other words, whether or not the nodes are in the process of communicating with one another, the connection between them is permanently open. Because the customer is paying a phone company for a permanently active connection, a leased line makes economical sense only when data traffic between nodes is heavy and continuous. An example of an application using leased lines is one in which test-stand computers on a manufacturing floor continuously transfer test data to a remotely located computer for analysis.

**Dialup Lines**
In principle, a *dialup line* is similar to the connection you get when you pick up your phone and dial a number. The connection is made when you dial, and you pay a phone company for the length of time you stay on the line and the distance of the connection. When two nodes linked by a dialup line wish to communicate, the source node “dials” the destination node and activates the line. At the end of the communication, both nodes “hang up” and the connection is severed. The customer is charged for the length of time the nodes communicate and for the distance between them.
Dialup lines are a good solution for applications in which data traffic between nodes is short, intermittent, and of relatively low speed. Electronic mail applications, in which users send relatively short messages among themselves at random intervals, usually include dialup lines.

Packet-Switched Data Networks (PSDNs)
A PSDN is a vendor-owned and vendor-managed network to which customers connect their computers. The fundamental technology operating in PSDNs is called packet-switching. With it, user data and the accompanying control information needed to ensure delivery to the correct destination node are formed into discrete entities or packets. The nodes making up the PSDN dynamically interleave the packets of many users and route the packets to their destinations. The vendor or carrier operating the PSDN is responsible for ensuring that users' messages arrive at the proper destinations and in the proper sequence.

Computers connected to a PSDN must use the X.25 protocol. In the context of networking, a protocol is a set of specific formats and rules for exchange of messages between two communicating devices. You read in the introductory chapter that the X.25 protocol is a series of recommendations developed by the International Telephone and Telegraph Consultative Committee for standard communication protocols to be used by common carriers to provide data communications services. Computers of different manufacturers, provided they "talk" X.25, can connect to the same PSDN and exchange data among themselves. PSDNs only transfer data among various systems, however. Once data arrives at a destination node over a PSDN, the software on that node must interpret the data to make it readable by and comprehensible to users.
Tariffs for PSDN use are based on volume of data transferred, rather than on the distance or connect-time between communicating nodes. Thus, PSDNs make economical sense for applications with medium volumes of data traffic between nodes.

PSDNs in the United States are privately owned. In Europe and Canada, they are owned and operated by the government Postal Telephone and Telegraph departments. Commonly used PSDNs include Telenet™ and TYMNET™ in the United States, Transpac in France, Datex-P in Germany, PSS in the United Kingdom, Datapac in Canada, DNI in Holland, and Telepac in Switzerland.

Microwave Links
Like radio waves, microwave links operate through the air. A transmitting station or facility at the source converts the messages into microwaves, and a receiving station at the destination captures them and returns them to a form in which they can travel over physical lines. Usually, a cable or other terrestrial line connects source and destination nodes to the transmitting and receiving stations, respectively.

Microwave links are practical when the source and destination nodes are many thousands of miles apart, such as in applications involving transatlantic communications.

Communication Media and WAN Configuration.
Applications determine the type of communication media to be used in configuring a network. A networking vendor should provide customers with the most cost-effective and efficient connections. Some parts of a network may work well with dialup lines; other routes may function more effectively with leased lines. Communication media may need to be changed as patterns of data flow alter and as new nodes are added. A vendor should offer you the flexibility of making these changes when necessary.
The geometric arrangement of nodes and communication media or lines in a network is known as topology. Some of the questions network planners must ask themselves in considering network topology include

- What is the pattern of communication between the nodes? Will all nodes communicate equally with all other nodes, or will some nodes have most of the traffic directed to them?
- How important is it for every node to have immediate access to every other node? Is time a critical factor?
- What is the size of the network today? How will this application grow? Will it be necessary to add nodes frequently?

**An Illustrative Wide Area Network.**

Employees at Digital Equipment Corporation use a wide area network that currently spans over 225 facilities across the United States, Europe, Australia, and the Far East. The corporate wide area network, known as Easynet, was first set up in 1978. At that time, it consisted of less than ten nodes. Today, Easynet comprises over 4600 nodes, of which 2400 nodes can be reached at any given time. Easynet includes every type of system manufactured by Digital: the DECSYSTEM 10 and 20 mainframes, the VAX superminis, the PDP-11 minis, the MicroVAX and Professional 300 workstations, and the Rainbow personal computer.

Employees with various levels of computer expertise use Easynet for a variety of different purposes. Digital develops its software products in a modular fashion, the various modules being designed and engineered in different facilities. Easynet is indispensable in coordinating product development. Engineers use the network to exchange technical information and to keep themselves informed of the development status of the various modules. When all the modules have been developed, the engineers transfer them via Easynet to a central point where the modules are integrated and the final product tested.
Engineers also use Easynet in Computer Aided Design/Computer Aided Manufacturing (CAD/CAM) applications, either by submitting data they enter on local systems for analysis to remote systems running CAD/CAM software, or by logging on to remote systems and making use of CAD/CAM resources on those nodes.

Easynet plays an important role in the manufacturing and distribution of hardware and software products. Employees in materials planning, manufacturing, and distribution, who are often located in widely separated facilities, communicate over Easynet to ensure that products are ready to be shipped and available for delivery on schedule.

Software distribution personnel use Easynet to distribute Digital-developed software for installation at Digital facilities. Electronic distribution of software from a central location to various remote locations dramatically minimizes the time spent in and inconvenience of manually transporting storage media from one computer to another.

Digital's employees use Easynet's electronic mail application to communicate with individuals located in Digital's facilities throughout the world. A Videotex application on Easynet enables employees anywhere to access a central database of general information.

Trade show demonstrations are yet another use of Easynet. Employees at trade show sites who wish to demonstrate new communications products to prospective customers can dial in to specific nodes on Easynet that support the products in question.

The task of managing the over 4600 nodes on the Easynet is the responsibility of a central group of ten individuals. This small group works in combination with local support groups at the various Digital sites that the network spans and manages the network in a cost-effective manner.
A Single Flexible Network of Many Components.
You read in an earlier chapter that this book differentiates between LANs and WANs for the purpose of discussion. However, network users do not have to be aware of whether their access to critical information is made possible by a LAN or WAN. From their perspective, all that matters is that the information be available to them when they need it regardless of where it is located. A good network is transparent: users don’t have to concern themselves with how the network operates. They merely sit at their terminals and request the information they need.

A network is a solution that improves communication and use of information and resources in a company. In some instances, a WAN may be the best solution, in others, a LAN. Some applications may require networks that include a WAN and a LAN component, as well as a component that enables multivendor communication. The application determines the type of network.

Ideally, a network should be flexible enough to fulfill a variety of application requirements. A company may start with a small LAN and a year later decide to expand to a WAN. Rather than having to maintain two separate networks—the existing LAN and the new WAN—the customer should be able to incorporate the LAN and the WAN as part of a single network. Then every node on both components of the combined network will have access to every other node, thereby enabling widespread information exchange and resource sharing. Any future added application, such as multivendor communication, should be incorporated as a component of the same network. (See the introductory chapter for a discussion of a multi-component network at company X.)

™ Telenet is a trademark of GTE Corporation.
TYMNET is a registered trademark of TYMNET, Inc.
Digital offers as many as one hundred networking products. It has today the capabilities and services that many networking vendors can only claim for the future. Its products are flexible, simple to use, and can be easily adapted to continuous changes in your needs. Whatever your application requirements, Digital helps you gain a competitive advantage by configuring the most suitable network to move information quickly and smoothly through your company.

Why should you buy your network from Digital? The corporation has been in the computer business for over 25 years and in the networking business for over 10 years. As a networking vendor, its strengths include

- Commitment to multivendor communication, so the various departments in your company don’t have to sacrifice the flexibility of purchasing computer systems from different manufacturers.
- Flexible products that enable you to take advantage of developments in communications technology without having to incur the expense of rewriting your applications or disrupting your day-to-day business.
- Up to 100 networking products to configure networks to suit every customer need.
- Compatible networking software across all computer systems from Digital so users in various departments with different computer systems from Digital can easily exchange information and share resources.
- Easy-to-use networking products that enable even users with virtually no computer experience to realize the benefits of networks.
- User training and support to make users productive in a matter of hours, whatever their level of experience with computers.
- Network services that start from the moment you decide your company needs a network and continue through the planning, installation, and maintenance of your network to ensure that your employees always have quick and easy access to the information they need.
Commitment to Multivendor Communication; Flexible Products.
Digital designs and develops all of its communication products within a sophisticated and flexible networking model known as the Digital Network Architecture (DNA). DNA is compatible with the architectural model recommended by the International Standards Organization for open systems interconnection. Other vendors are expected to implement network architectures that are compatible with the ISO model, as it becomes more completely defined in the future. When this happens, systems of vendors who implement ISO-compatible network architectures will be able to communicate with each other.

DNA is an open-ended architecture designed to absorb new and increasingly efficient communications technologies. These technologies can be incorporated into DNA without affecting your applications. For example, about four years ago, Digital incorporated the Ethernet protocol in the Data Link layer of DNA. The incorporation gave customers the option of running their existing applications on local area networks (LANs). Those customers with configurations using dialup or leased lines could now move to the more cost-effective LAN configuration without having to alter their applications in any way or retrain users. DNA absorbed the new protocol in a manner that was transparent to applications and users.

As Many as One Hundred Networking Products and Capabilities.
Your company can choose to configure a simple network of two nodes or a complex multicomponent network of over a thousand nodes. Your network can be localized in one department, can extend through a building, span several buildings, or stretch across several cities and countries. Whatever the size of your network, Digital has all the products and capabilities to put it in operation. Should your application needs change, Digital's products can be easily adapted into new network configurations.
The corporation has as many as 100 networking hardware and software products. Among these are special purpose router systems that enable communication between LANs and WANs, bridges that link widely separated LANs into a single network, and gateway systems that enable communication between networks of Digital systems and networks of IBM systems. (A gateway is a special purpose system that converts the functions of one vendor's network into functions recognizable by another vendor's network. Its function is similar to that of a translator who enables two persons speaking different languages to understand each other.) Products are available that enable communication between systems from Digital and systems from IBM, as well as several other major computer manufacturers.

**Compatible Networking Software across Digital Systems.**

Digital manufactures a wide variety of computer systems to suit the needs of different users. The various departments in an organization use those systems from Digital that are optimized to serve their application requirements. For example, managers in the finance department may use the Professional or Rainbow personal computer. In the engineering department, individuals may use the MicroVAX personal workstation. The engineering department may run all its applications on a computer of the VAX family. The manufacturing department may run its applications on any one of Digital's several families of computers.

All of the systems from Digital—the VAX family of computers, the DECSYSTEM 10 and 20 family of computers, the PDP-11 family of computers, the MicroVAX personal workstation, the Professional personal computer, the industry-standard Rainbow personal computer, and the IBM PC—support Digital's DECnet networking software. Thus, the various departments in an organization with different systems from Digital can be linked into one single network.
Users in one department can access information that resides on a computer in any other department provided they have the required accessing privilege. DECnet enables easy interdepartmental information exchange and resource sharing.

**Easy-to-Use Networking Products.**
DECnet networks are user transparent. Even users with almost no computer experience can sit at their terminal and access information from anywhere or send information to anywhere in the network without having to know how the information arrives at its destination.

**User Training and Support.**
Digital helps your employees gain the benefits of networking, whatever their level of familiarity with computers. User training, tailored to meet the varying experience of individuals, ensures that your employees become productive on the network in a few hours.

**Comprehensive Network Services.**
Digital's comprehensive network services program ensures that your decision to invest in a network entails no risks. The many facets of the service program include planning for current and future network configuration, installing, managing, and maintaining the network.

Even before you make the final decision, experienced consultants from Digital can guide you in making a sound investment. They analyze your company's information flow requirements and suggest the best networking solution in terms of design and cost. They will also help you in planning for network expansion and modification as your company's needs increase and grow.

Once your decision is made, Digital takes care of all aspects of your network's operation. Trained personnel plan the configuration and physical layout of the network. They prepare the worksite and
install the network completely. Software specialists install the software, verify its operation, and ensure that the network is operating smoothly.

One of Digital's major service strengths is the sophistication of its network management software. This software, which is easy to use, can monitor the network continuously. At any time, the status of every line and node is apparent. Network monitoring software identifies potential problem areas in the network, such as defective lines. It also identifies bottlenecks or network paths with heavy loads of traffic flow. Such information enables you to avert network failure by correcting minor faults before they become crises. Network monitoring software also gives you the information you need to reconfigure the network to improve patterns of data flow and increase network productivity. In addition, you can plan for future network growth based on day-to-day variations in the pattern of network use.

Network maintenance services include preventive and corrective measures. You automatically receive upgrades to hardware and software. If required, Digital will install the upgrades. You can opt to have experienced hardware and software specialists make onsite visits to ensure that all network components are operating efficiently. In the event of a failure, a trained person will arrive to correct the problem and stay onsite until the network is operating smoothly once again.

Digital ensures that your employees’ experience with the network is positive, productive, and successful, and that your company's network investment will result in a competitive advantage.
address: The unique numeric identification of a network node.
baseband LAN: A local area network using a single physical medium that transmits data only.
bridge: A device that links two widely separated local area networks so that they appear to be one network spanning a large geographical area.
broadband LAN: A local area network in which a single physical medium is subdivided into many frequency sub channels that carry voice, video, and data simultaneously.
bus: A high-speed high-capacity cable.
Carrier Sense: The ability of each node on an Ethernet LAN to detect any traffic on the channel.
Carrier Sense Multiple Access with Collision Detect: The technique by which nodes on an Ethernet LAN share the transmission channel. See also Multiple Access; Carrier Sense; and Collision Detect.
coaxial cable: Physical transmission medium in baseband and broadband LANs. Coaxial cable has large capacity, low error rates, and is easy to configure.
Collision Detect: The ability of a transmitting node on an Ethernet LAN to sense a change in the energy level of the channel and to interpret the phenomenon as a collision.
configuring a network: The process of deciding where network nodes will be located and how they will be interconnected.
CSMA/CD: See Carrier Sense Multiple Access with Collision Detect.
database: An organized collection of data on a computer storage device. The application determines the manner in which information in a database is structured. Users should be able to view this information in a manner pertinent to the application. Updating a database means deleting from or adding information to the database to ensure that the data is current.
**DECnet™**: Networking software designed and developed by Digital. DECnet runs on all of Digital's computer systems.

**destination node**: A network node to which a message is addressed.

**dialup line**: A type of communication line in which there is a temporary connection established between two communicating nodes. The connection is made by the nodes when they wish to communicate, much like dialing a phone number, and terminated by them when the information exchange has been completed. A phone company charges the customer for the length of the communication and for the distance between the nodes.

**Digital Network Architecture (DNA)**: The ISO-compatible architectural model within which Digital designs and develops all of its communications products.

**gateway**: A special purpose network node that enables the networks of different vendors to communicate by converting the functions of one vendor's network into functions recognizable by the other vendor's network. A gateway serves the same function as a language translator, who enables persons speaking different languages to communicate.

**host**: Any network node that a user can access for processing power, information files, and applications. Hosts are general purpose nodes that are not designed to perform network-specific functions.

**ISO**: International Standards Organization.

**leased line**: A communication line providing a permanent connection between two nodes. The customer leases or rents the line from a phone company.

**listen-before-talking**: See Carrier Sense.

**listen-while-talking**: See Collision Detect.
local area network: A network spanning a limited geographical area, such as a building or cluster of buildings, and using new technologies of data transfer such as high-speed buses.

microwave link: A connection between two nodes established through the air. A transmitting device at the source-node end modifies the data into microwaves that travel through the air. At the destination-node end, a receiving device converts the microwaves back into a form in which they can travel over a cable or other terrestrial line.

multidrop link: See multipoint link.

Multiple Access: The ability of any node on an Ethernet LAN to send a message immediately upon sensing that the channel is free.

multipoint link: A single line that is shared by more than two nodes.

network: Two or more computers or intelligent devices linked via physical communication media (cables, telephone lines, or satellites) for the purposes of information exchange and resource sharing.

node: An intelligent device on a network.

packet: A unit of information comprising user data and the control information needed to ensure that the data arrives at its proper destination.

packet-switched data network (PSDN): A vendor-managed network that uses the X.25 protocol to transport data between customers' computers connected to the PSDN. Tariffs for PSDNs are based on the volume of data sent rather on the distance or connect time between communicating computers.

packet-switching: The communications technology operating in packet-switched data networks. The PSDN nodes interleave the packets of many users and direct them to their destinations.
point-to-point link: A line connecting two nodes only.

protocol: In a networking context, a set of rules and formats for the exchange of messages between communicating devices.

Router/X.25 Gateway: A special purpose system that enables communication between nodes on a LAN and those connected to an X.25 PSDN.

routing: The capability that enables an intermediary node on the path between a source node and a destination node to pass through messages intended for the destination node.

source node: A network node that sends a message.

terminal server: A special purpose device on an Etherent LAN that enables up to 32 terminals to be connected to the Ethernet cable via a single physical line. A terminal server frees network nodes of the burden of establishing connections between local terminals and remote nodes. Terminals connected to the terminal server have access to all nodes on the network.

topology: The geometric pattern in which the lines and nodes of a network are arranged.

user transparency: The quality in a network that enables users to access and transfer information without having to know how the network operates.

wide area network: A network spanning a large geographical area, such as several cities, countries, or continents.

X.25 protocol: A protocol recommended by the International Telephone and Telegraph Consultative Committee for data communications over common carrier lines such as a PSDN.