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EVALUATING AND SELECTING A LOCAL AREA NETWORK

INTRODUCTION

As you analyse the features of candidate LANs, you need to consider their ability to handle not only your present needs but your future needs as well. An accurate assessment of present needs requires a detailed understanding of the problems you are trying to solve. Assessing future needs requires that you put your networking requirements into the context of your business or organisational plan, especially with regard to the need to transfer and process information. A network represents a sizable investment and should be one that can grow with your computer applications. Think about growth in areas such as the number of network nodes, capacity of disk storage, number of print servers, and the size of the physical area covered by the network. Also, if you will be using off-the-shelf software, how much software is available for the network you choose? The network vendor or your dealer may be able to provide you with a catalogue of currently supported software applications.

GENERAL

Cost is always an important consideration. PC networking is a competitive business, and advances in electronic technology are currently driving costs down. Highly integrated designs are reducing the number of parts required on a network interface card. Follow two rules of thumb: choose a vendor who is actively working with new technology so that expansion of your LAN in the future will benefit from reduced costs, and do not buy more hardware than you need as long as prices continue to fall over time.

Ease of installing and using the network should be a major factor in your selection. The software used to initialise and manage your network is the biggest factor in this respect. Do not be fooled by the simple appearance of the floppy disk your network software comes on, compared to the pages of impressive-sounding specifications describing the hardware. The hardware must be right for you, but the software is even more important. The discussion here will help you learn what to look for in network software and you should plan to spend more time evaluating the software than the hardware in your network purchase.

You should evaluate your network vendor and its local representative to assess the support you will get during the planning, installation and use of your network. Truly useful service requires expertise and time, so be wary of assurances that all the help you need is free. A certain amount of consulting and assistance may be covered in the cost of the sale, but free long-term assistance is probably either nonexistent or of low quality, or the assurance of such assistance a signal that the provider is new in business or would not be around very long. Reliable references from previous sales should be requested and checked. You should also request references before hiring a consultant to help with any phase of your network installation.

Once the network is installed, you and your end-users will need training. You should evaluate your own situation and decide if you your staff and your users need to attend classes. If so, see if your dealer offers them, how much they cost and when they are given. Unless you have considerable in-house expertise or a lot of patience, you should not plan to depend entirely on reading the manuals, figuring it out for yourself and training your end-users. If your programmers are going to be modifying software for the network, consider the availability of technical documentation and training for them. Your network dealer or vendor should be able to assist you in locating these.

Maintenance of your system may be a critical factor. More productivity depends on your network being up and running, hence it is vital that you have fast, dependable service for it. The same consideration also applies to any other computer equipment. If you are used to a single-user PC environment, you may not be prepared for the way a network increases the dependency of many users on a single piece of hardware. For example, if several point-of-sale computers or a classroom full of student PCs all depend on a network disk server, the failure of that disk server may require that service be quicker than would the failure of a single PC. Many service options exist, ranging from on-site service within a couple of hours of the failure, through mailing the suspected component away for a couple of weeks. You must consider the options and make sure the appropriate ones are available for the system you select.

APPLICATIONS

The most important consideration in selecting a network is its ability to solve a problem, increase productivity or enhance the operation of your organisation. The first step in choosing a network has little to do with the network system itself. You must carefully determine what you want the network to achieve and what application software can be used to meet these goals. It may be off-the-shelf software from a third-party vendor or it may be custom written by your programmers or a consultant. Your PC network should be chosen for its ability to run this software.

EXISTING SOFTWARE

If you are networking a group of PCs that are already in use, you need to analyse how existing software will function in the network environment. Even if you decide that existing software will be used in the same way as before and will not take special advantage of the network environment, you must still be sure it does not conflict with the network in any way. In some cases a software package or hardware card may be unable to run at all on a workstation that is equipped with a network connection. You dealer, network vendor or application software vendor should be able to tell you what will and will not work together.

If you want to take advantage of the network with existing software, you should check the same sources to see if the version you own supports the network you want to install. You may have to purchase an upgraded version of the software that incorporates network support. Make sure the software works with the network in the way that you need it to.

If your applications are written by your own programmers, you need to understand how this software will function on a network. The same considerations apply as for outside-developed software, but you cannot turn to an outside vendor for answers. It may be necessary to consult with the vendor of the programming language your applications are written in. Some implementations of programming languages work with networks, while others have problems. In any case, if you decide that achieving the desired results requires that your applications be modified, you or your programmers must first review the network to make sure that it supplies the functions you need. This phase of network selection is very technical and must be done by someone familiar with your applications and with multiuser programming environments, which present a new set of problems compared to single-user environments. You must perform a similar analysis if you need new, custom-written applications for your network. You may have more freedom of choice for a programming language for a new application.

NEW SOFTWARE

If one reason for buying a network is to run new applications such as shared database applications or electronic mail that require a network, you may find a suitable off-the-shelf package from an outside software vendor. The vendor can tell you what networks the package supports, and you can evaluate the features of the package rather than its ability to run on a network.

LAN EVALUATION

The LAN shopper has many networks and a wide range of features, components and prices from which to choose. This variety tends to complicate the selection process but also enables users to design systems ideally suited to their particular needs. Before the network is actually up and running, many components must be evaluated- applications, software peripherals, workstations, servers and LAN hardware. We concentrate on the components of the basic system. In most cases, the selection process should be based on the intended applications and environment in which the network is used. The first stage in the evaluation process, therefore, should be a careful description of the LAN functions and the physical site.

Any network you evaluate has three main components: workstations, servers and connections. Most networks support only a limited number of choices in these three areas, so although you must evaluate your network selection in all three dimensions, you will probably have to make trade-offs in deciding which network system most closely meets your requirements.

Following is a list of questions that should be answered:

PHYSICAL SITE

1. What is the maximum distance between workstations?
2. Can you use existing cable?
   - A. No requirement
   - B. Telephone wire (twisted pair)
   - C. 3270 cable (RG-62)
   - D. Others (specify)
3. What is the workstation distribution?
   - A. Clustered
   - B. Distributed
4. What types of workstations will be used? (brand and model)

FUNCTIONS

1. How many workstations?
2. How many hours will each workstation be in use?
3. List each workstation's applications (word processing, data entry, and so on).
4. List the percentage of workday devoted to each application.

PERFORMANCE

1. What is the desired response time? (Select comparable)
   - A. XT floppy drive
   - B. XT hard disk drive
   - C. AT hard disk drive

2. Which is the primary consideration?

   A. Cost

   B. Performance

Answers to these questions will help determine the right LAN system for a particular site. Following are some examples of how the site definition is used.

THE PHYSICAL SITE

Physical site requirements help determine what network cable and topology are best. Each type of cable has inherent distance limitations. Twisted pair supports short runs. Baseband coaxial supports longer runs. Broadband coaxial and fibre optics support extremely long runs. Transmission speed is limited by cable, too, with fibre optics being the fastest, followed by baseband coaxial, broadband and twisted pair.

Matched against the cable characteristics are the types of available cable. You may be able to take the cable that is already installed and use it on the LAN. Twisted-pair and 3270 cabling (RG-62) are often available and can be used for LANs, provided that the cable meets the transmission speed requirements.

Before you decide to use installed telephone wire (twisted pair) for a LAN, you should carefully test its condition and suitability. Voice transmissions are much more tolerant of media imperfections than are data transmissions. Barely audible noise on the line that is only annoying during a telephone conversation often prevents successful data communication. Telephone systems often are a collection of old and new wiring and switches and this medium frequently fails during high-speed data communication. The higher the data transmission rates (in excess of 1 Mbs) and the longer the distances between communicating devices, the more likely the failure.

But telephone wire systems are being used successfully for LANs in many buildings - and with a considerable saving in cabling costs. Do not reject the idea without testing its feasibility.

Existing broadband cable systems can be used for new LAN installations, provided that the existing installation supports two-way communication. Many corporations and campuses have a broadband cable system that was installed for cable TV transmissions. Converting a cable TV system to support broadband data transmission is seldom practical because the initial cable TV installation was designed for one-way communication only. LANs are two-way communication systems. Installing new broadband cable usually is cheaper than converting the existing system. Due to the large potential savings of using an existing cable system, its feasibility for a particular site always should be analysed by an expert.

Cable selection has long-term implications that are especially significant in large installations. If properly chosen and installed, LAN cable can give satisfactory service for 10, 15 or more years before it has to be replaced or upgraded. Because the cable and cable installation costs typically are 50 percent of the cost of the entire installation, careful planning is well worth the effort.

Network topology should be matched to the site layout. Topology affects the amount of cable that must be purchased and installed. Even the cable bulk should be considered. Some cable trays may not have room for three or four more wires that may be required by some topologies. If workstations are clustered, a star topology is ideal. If they are distributed through individual offices, a linear bus topology is good. The distributed star topology is a natural choice when connection must be made to small clusters of workstations distributed through several offices. The star-wired ring (IBM cabling system) was designed as a wiring scheme for large buildings, so this system uses a star topology for individual floors and connects the floors with a single high-speed cable - a good strategy for large buildings.

NETWORK FUNCTIONS

Network functions and performance are closely related. Looking at the checklist, you may realise that the proposed network has a current need for eight workstations. If you add three more workstations within a few months, include those also as current workstations.

Long-range growth should be considered and included in your overall network strategy. But because of the flexible architecture of networks, you usually do not need to install a high-performance system in anticipation of a future need.

The number of workday hours a workstation is in use (question 2 on the checklist) is a factor in determining the station's impact on the network. For example, a workstation may be used by outside salespeople for an average of three hours a day, or it may be used a full eight hours a day. The types of applications and their percentage of the day's activity also will affect the network. Word processing is a light user of a network because most processing is done locally. Database work is a heavy user of a network because data continually must be sent back to the network to update the shared hard disk.

WORKSTATIONS

If you need to use non-IBM PC workstations on your network, you must select a network vendor that supports different types of computers on a single network. Make sure you understand how the different kinds of computers need to share such network resources as disk storage and printers, and be sure that the network you choose permits the right degree of sharing. For example, some networks may let you connect two different kinds of personal computer workstations to the same cable, but may require that each have its own separate disk server, and there may be no way to exchange data between the two computers.

The workstation hardware requirements that you need to evaluate include:

* Amount of random access memory (RAM) required,
* Amount of local disk storage required.
* Compatibility with other workstation hardware.

You should also consider whether the number of workstations supported by the network meets your current and projected needs. Your greatest evaluative effort should be spent on the workstation software, concentrating on such things as:

* Ease of installation and use.
* Number of needed functions supported.
* Ability to run application software.
* Performance.
* Flexibility and ease of modification.
* Security.

EVALUATING NIC

All the components in a LAN have the potential to affect the LAN's performance, yet no classification scheme is commonly available to rate LAN component performance. Because performance ratings are not available, you have to use what statistics are available to estimate performance.

The network interface card (NIC) has four characteristics that typically are used to predict NIC performance. These are:

1. Bit rate
2. Access method
3. On-board processor
4. NIC-to-host transfer

The bit rate often is referred to as the speed of the LAN. LANs are rated according to the speed of data crossing a clear piece of cable. Most of the LANs have bit rates from 1Mbs up to 10Mbs. Actual throughput is never 100% of the bit rate because of other LAN performance factors. And because of individual NIC design factors, one 10Mbs NIC may have very high throughput, whereas another may have very low throughput. Therefore, bit rate is a poor way to compare LANs, especially when the bit rates of the systems being compared are close.

Bit rate, however, should be considered in the selection process. Although a high bit rate does not guarantee high throughput, a low bit rate does guarantee low throughput. A 1Mbs LAN might get 80 percent of the bit rate as throughput. But that amount is only 0.8Mbs or 100 kilobytes per second throughput. A 10Mbs LAN might be much less efficient, getting perhaps 40 % of the bit rate as throughput. Yes that 40% would amount to 4Mbs throughput.

The cable access scheme of a NIC tells virtually nothing about its actual performance. Theoretically, a token-passing access scheme is more efficient in high-traffic situations than a contention scheme (CSMA-CD, and so forth), but the NIC's design can overcome limitations in the access scheme.

The on-board processor is another poor way to judge NICs. Logically, an on-board processor should make for a faster, more efficient NIC. In practice, though, the firmware used to control the on-board processor often is inefficient and that factor increases system overhead.

The NIC-to-host transfer method - the fourth of the NIC evaluation features - is the most valuable for making comparisons. The width of current transfer buses usually is 8- or 16- bits. A NIC with a 16-bit-wide bus interface transfers data twice as fast as an 8-bit-wide interface.

Three methods are used to transfer data: shared memory, I/O port and direct memory access (DMA). Shared memory is the fastest because it involves no data transfers. DMA is the slowest because all data must be transferred into a contiguous area of memory to be read.

One other criterion that should be considered when evaluating NICs is the types of workstations the NICs support. The IBM PC bus is a standard, and most of the NICs can be plugged into PC or PC-compatible buses. Additionally, many LAN companies make NICs that also support one or more different buses. If your company wants to network different types of PCs, bus compatibility becomes an important issue.

EVALUATING SERVERS

Many computers can act as network servers. Most are AT-compatible machines; however, several machines have been designed especially for use as network servers. The criteria used to describe network servers are the primary ones used in evaluation. They are:

- Processor
- Clock cycle speed
- Wait states
- Memory (max)
- Expansion bus
- Bus width

Processor is the most commonly understood performance factor. Anybody who has ever used an 8088 workstation and then switched to an 80486 workstation knows the effect of faster processors.

Processor speed is rated according to how much data a processor can process and transfer in a single block. The Intel 8088 processor, which is used in the PC- and XT-compatible machines, processes data 16 bits at a time and transfers data 8 bits at a time. The Intel 80186 processes and transfers data in 16-bit blocks. Intel's 80286, used in AT-compatible machines, also is a 16/16 processor. The Motorola MC68000 processor processes data 32 bits at a time and transfers 16 bits at a time.

The processor is driven at a set speed by a component called a clock crystal.

Faster clock cycle speeds result in faster performance. An 80286 machine with a 16 MHz crystal, for example, might be able to perform a task in one second but, with an 20 MHz crystal, could do the same task in 0.6 seconds.

In computers, circuitry performance and processor/clock crystal performance must be balanced. A processor that runs faster than the circuits can support must be slowed down. This is accomplished by placing wait states between the processor and the circuitry. One wait state is a period of time equal to one cycle of the clock crystal. Wait states cause a delay in the delivery of data to the circuitry so that the flow of data matches the capability of the circuitry. A machine with one wait state is slower than a machine with zero wait states, all other things being equal.

Memory maximum refers to the total amount of random-access memory (RAM) supported in the machine. Available RAM can be used in a server to cache or store temporarily, data in electronic memory. Because accesses to electronic memory are much faster than accesses to a physical disk, available RAM does affect performance.

Expansion buses, which allow computers to adapt to changing technology, affect both performance and adaptability. Machines with expansion buses, such as AT-compatible machines, generally transfer data slower than machines that use proprietary buses. But expansion buses often are desirable. For example, new generations of NICs generally outperform old NICs. The old NICs can be replaced provided that the machine has an expansion bus. Moreover, an expansion bus permits the machine to serve multiple networks when that capability is supported by the network operating system.

The bus width involves the same issue as the NIC-to-host transfer width discussed under network interface. A 16-bit-wide bus transfers data twice as fast as an 8-bit-wide bus.

Most vendors of IBM PC networks let you use IBM PCs as servers as well as workstations — at least to provide disk and print service to the network. Many vendors also provide proprietary hardware-based servers, usually claiming higher performance than can be had from PCs. Your choice of server can, therefore, extend beyond the issues mentioned under workstations to include the choice of the hardware itself.

Some networks offer you a choice between dedicated and non-dedicated servers. A dedicated server is useful only as a server, while a non-dedicated server can also be used simultaneously as a workstation. This is a cost/performance trade-off, for such use of a server as a workstation almost always diminishes its performance as a server except possibly if it was being given very light use in either capacity. Another consideration is the vulnerability of a server used as a workstation: the workstation user should be running only well-tested software in a stable configuration, since any crashes or "hang ups" of this software can adversely affect a whole community of users with work in progress on the server.

Another choice must be made between multipurpose and singlepurpose servers — between, say, use of a single PC/AT as both a disk and print server and use of two PC/ATs, one functioning as a disk server and the other as a print server. Again, this choice usually presents a cost/performance trade-off. Two PC/ATs cost more than one, but if both functions are used heavily enough you will get better performance from two than if you try to implement both these functions on a single PC/AT. If you decide to try a multipurpose server or a nondedicated server, you should set up an experimental configuration and see if the performance meets your needs before you order a full network configuration based on that choice.

Disk Servers. Some of the factors to consider when evaluating network disk storage servers are:

* Number of mass storage servers supported.
* Number, capacity and speed of hard disks per server.
* Method of splitting disks up between workstations.
* Provisions for multiuser file sharing and locking.

You may have to choose between a file server and a disk server. The difference between the two is pretty technical, and you need not be too concerned about it as long as your applications work properly and you are satisfied with performance. The distinction has to do with the nature of the information that passes between a workstation and the server. Figure 7.1 shows a simplified view of a workstation application package accessing a disk drive through MS-DOS (Microsoft Disk Operating System). The goal of any PC network is to allow the application to access the disk on a remote computer as if the disk drive were on the local computer. Thus, network software must first intercept the application's request to read or write a local disk file and send that request to the remote disk or file server for processing; it then must get the result that is returned from the remote server and pass it to the application, just as if it had come from the workstation's MS-DOS.

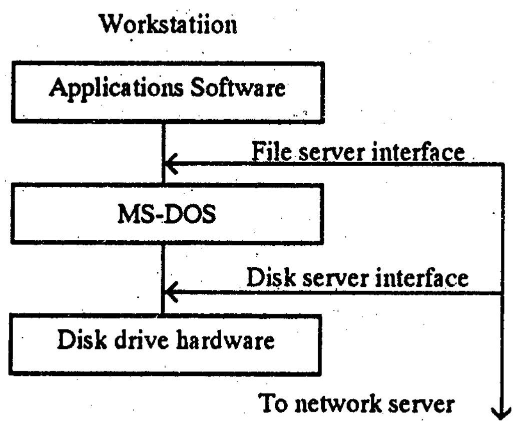

Fig. 7.1 : Difference between file server and disk server

With a disk server, interception occurs between MS-DOS and the local disk drive. When an application requests a block from a file that is on a network disk server, the workstation MS-DOS does most of the work. MS-DOS computes the location of the disk block and requests it from what it treats as a local disk drive. The network system software intercepts this request and sends it to the disk server, which reads or writes the appropriate block on the server's disk.

With a file server, the workstation MS-DOS does not become involved with a network disk file access. The network system software intervenes before MS-DOS can receive a network disk file request. Instead, the entire request is sent over to the file server, which processes it and sends back the results.

Sometimes a single application request to read or write a file block can result in several disk input or output operations between MS-DOS and the disk drive. In such cases, using a disk server may generate more network traffic than using a file server; the file server sends the initial request from the workstation to the server and the server sends back only the final result; by contrast, the disk server sends the intermediate results back and forth, since the MS-DOS on the workstation must process the extra disk blocks.

You should try to find objective performance information comparing data access speeds for the networks you evaluate. The performance of the network disk or file server will have a strong effect on the performance of many applications and on the number of workstations you can connect.

Print Servers. Print servers, like disk servers, may be implemented on proprietary hardware or on IBM PC compatible computers. Some considerations when selecting a print server are:

* Number of printers supported.
* Interfaces supported, serial or parallel.
* Printer models supported.
* Print server software.

In addition to letting you share a printer among several workstations, a print server usually stores print output on a server disk drive and sends it to the printer as fast as the printer can accept it. This capability, called **print spooling**, means that the print server must have adequate disk storage to handle the volume of files your users will send to be printed. You will probably need a hard disk and perhaps should consider using a disk server as a print server too. The software used to control the print server may vary from vendor to vendor and you should be sure that it provides the functions you need.

Other Servers. Disk and print servers are the most widely used network service, but there are others that your applications may require. Some of the most common are:

* Backup servers.
* Gateway servers.
* Remote communication (modem) servers.

You must plan for the backup of your network mass storage. Tape cartridges are a popular medium for storage, since you can often back up an entire hard disk on a single cartridge. You may prefer cartridge disk servers, or even a duplicate hard disk server that can hold as much as your primary network disk.

Gateways, used to connect dissimilar networks, are discussed in more detail later. Remote communication servers are useful if the network needs to be accessed from a remote site over a phone line using a modem (modulator-demodulator), a device that converts data into tones that can be transmitted over the phone. Two computers connected to the phone with modems can send files and other information back and forth. A good remote communication server lets you use the network from a remote site just as if you were connected with a local workstation. Peformance is usually slowed down by the limits of the phone lines. Another seeming use of a modem on a network, for sharing information among workstations, usually does not work out well because little of the PC communication software is adapted to this environment.

EVALUATING OPERATING SYSTEMS

The choice of network operating system, perhaps more than any other LAN component, will determine the success of the LAN. Some of the important criteria for judging network operating systems are ease of use, data safety, support for standards, cost, performance, security, and functionality.

The relevant standards today are DOS 4.1 and NETBIOS. An operating system must support these application-to-network interfaces to have access to the large number of software packages and hardware devices being developed for the standards. People with non-standard products argue that you usually need no more than a few applications, not thousands. That is true. If, however, the products you choose are standard products, they will offer you a better migration path and probably lower cost.

Cost also applies to the network operating system itself. Cost should be considered closely with performance. A high-performance network operating system can support more workstations and is, therefore, more cost effective for large or growing installations.

PC Network Programme is the slowest operating system because it uses DOS as an integral part of the network operating system. DOS's performance is adequate in a single workstation, but it cannot provide high performance in a multiuser network environment.

3+ is faster than PC Network Programme. 3+ gains the speed advantage by using a DOS-emulation programme instead of DOS itself, and the emulator is enhanced with performance features.

Netware is the fastest of the DOS-compatible operating systems by a factor of 200 to 300 percent. Rather than using DOS or emulating it, Netware is built on a special operating system designed specifically for network and shared disk management. This strategy has a limitation in that some hard disks are not compatible with NetWare. NetWare supports all IBM PC-compatible drives and many other major drives. If you already have a non-IBM PC type disk drive and want to use it on your network, however, you should verify the disk drive's compatibility.

Network system security is implemented through one of two methods. Security is based either on a name/password that's associated with network objects or on user profiles. In a name/password system, every directory must be accessed with a name and optional password. With user profiles, after the login name and password are entered, all directories authorised to that user can be accessed with normal directory and path commands.

The name/password system is more difficult to set up and maintain than the user profile system. Both security schemes, however, are easy to use. In the name/ password system, you can store names and passwords in a batch file to eliminate the need to remember them at each log-in. Unfortunately, when the names and passwords are stored in batch files, they can be accessed at the workstation and read with simple DOS commands, so the system loses its security.

Functionality is different among the network operating systems. A quick way to evaluate functionality is to compare the lists of network commands.

CONNECTIONS

It is ironic that the components most readily identified with a network cables and network interface hardware are in many respects the least important components. The applications supported by the network and the network-management software are what you use the most. The performance limits of the server software or hardware are usually reached before the limits of cable bandwidth (which is the data transfer speed) or network-interface hardware design can be approached. Still, there are many important choices to make with respect to connections, especially relative to costs.

There are three main areas to consider in choosing a network connection scheme: the cable type, the topology (or physical layout)and the low-level network protocol used to transmit data. Each LAN vendor usually bundles together a solution that addresses each of these three areas, so you do not have to decide on them individually.

Cable Types. The choice of a LAN limits your cabling options. Many LANs are designed to work with only one type of cable, although some can accommodate two or more types. In many cases the wiring is the most expensive part of installing LAN, and the importance of this aspect of the cabling choice is clear. You must be sure you know the details of each LAN's requirements before you estimate cabling costs. The most common cables are twisted-pair and coaxial cable commonly called "coax". Each of these is available in different grades at different costs per foot.

Twisted-pair, the least expensive medium, is simply two wires twisted together and covered with an insulating sheath. Twisted-pair has another cost advantage over coax — most buildings are already wired with twisted-pair for their phone systems. Networks that can use this existing cable can, often be installed at significantly less cost than systems that require new wiring. The disadvantges of twisted-pair include greater sensitivity to noise, possibly resulting in the repeated transmission of network messages to correct transmission errors; shorter distance coverage than coax for some networks; and lower data rate than coax on some networks.

Coaxial cable is very commonly used in LANs and it comes in several varieties, offering a range in terms of:

* Cost per foot.
* Thickness and flexibility.
* Ease of installation.
* Usable lengths.
* Bandwidths.

Network connections can be categorised as **baseband** or **broadband.** Baseband supports fewer channels of information than broadband; the connection is usually less expensive and the installation less critical. Ethernet and the IBM token-ring are examples of baseband networks. A broadband network cable is physically capable of carrying other signals such as video, voice and security information as well as network data traffic. However, appropriate hardware and software is needed to take advantage of this low-level physical capability. The IBM PC Network is an example of a broadband network.

Fibre optic cables are by far the most expensive medium, but they are also the most resistant to noise and interference and thus have a very low error rate. There are fewer vendors of fibre optic LANs than there are of electrical wire-based systems, but commercial products do exist and are in use. If very high noise immunity is important to you, it may be worthwhile to investigate this choice further.

Repeaters. Cabling distances vary with cable and network card choices. If you expect to expand your network you should determine whether the maximum cable length supported is enough for your needs. Some networks can employ repeaters: hardware devices that considerably extend the maximum usable length of the cable. A repeater works at the physical level; that is, to the network software it is not distinguishable from the cable.

Bridge. Another way to extend networks is with a bridge. A bridge connects two identical networks and passes messages between them. However, it is a bit smarter than a repeater; it only sends messages to the other network that are destined for it, while a repeater transfers everything back and forth, just like a cable. Bridges can cut down on total network traffic by splitting up your network into clusters of those workstations and servers that most often talk to one another. Since the messages local to the cluster stay within that part of the network and do not go past the bridge, the amount of irrelevant network traffic on the other side of the bridge is reduced. However, a bridge can become a bottleneck if it is slower than a simple piece of cable or a repeater and if you put it in the wrong place, such as in between two or more network nodes that communicate heavily.

Topologies. Your choice of a network also involves selecting a layout of physical connections, or topology. The most common PC LAN layout is the bus structure, shown in Figure 7.2: a single cable is routed everywhere a connection is needed, and workstations and servers are connected to it. Some networks, such as Ethernet, let you make the connection with a tap that does not cut the wire in two. You can connect a new workstation to the LAN or remove an existing one without disturbing the workstations on either side or shutting the LAN down during the operation. A bus usually results in a shorter total cable length than the other topologies. It has the disadvantage that a single break in the cable may bring the entire network operation to a halt.

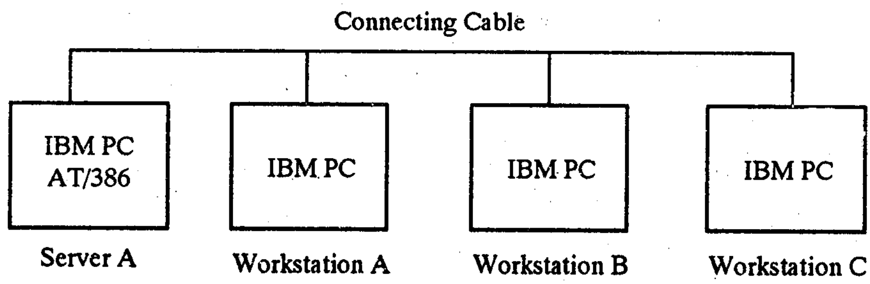

Fig. 7.2 : Bus network topology

The second major cable layout, the ring, is like a bus structure with its ends tied together, as shown in Figure 7.3. One of the technical disadvantages of a ring is that at some level each node in the ring has to handle all the data being transferred in the network. For example, in Figure 7.3, for A to pass a file to C, B must handle the file as an intermediary. Failure of a single node can disrupt the entire network's operation. The main advantage of this topology is that it is more deterministic than a bus (explained below under the discussion of protocols).

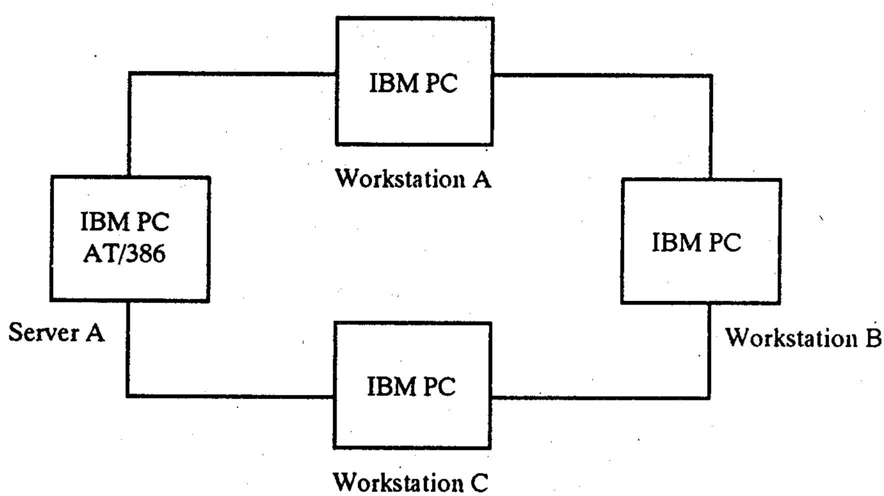

Fig. 7.3 : Ring network topology

The star topology, shown in Figure 7.4, resembles many traditional multiuser or time-sharing systems: a central computer with separate lines to each workstation. This layout usually requires more total cable length than the bus or ring. Star networks often terminate each line with a cluster controller, a specialised computer capable of handling several workstations, thus improving the economy of the wiring. Furthermore, star configurations often use twisted-pair — the least expensive cable. Since each line is dedicated to carrying information between only two nodes, it can be of a lower bandwidth than a bus, which must handle traffic for all the nodes.

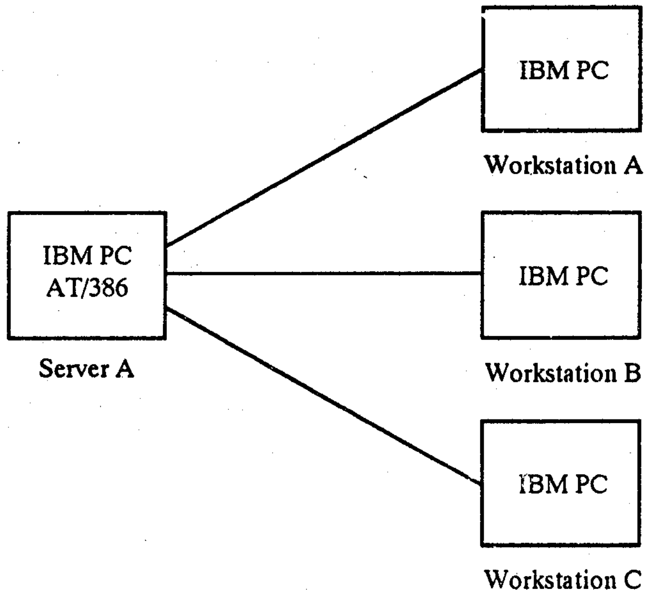

Fig. 7.4 : Star Network topology

Some star networks have been designed to take advantage of electronic telephone switchboards, or Private Branch Exchange (PBX) systems, sharing this wire with the phone system and providing a great saving in the time and cost of installing a LAN system.

There are many variations on these three topologies. IBM's Token-Ring Network improves on the basic ring topology with redundant connections to reduce the likelihood that a single failure will knock out the whole system. The IBM PC network has a hierarchical layout.

Protocols. You can select a network with very little consideration of the protocols used to manage the network connection. Nevertheless, this topic still seems to come up often enough that it is useful for you to know what some of the common terms mean. The fundamental problem that network protocols solve is the sharing of a single wire — the network cable, among many workstations and servers, all of which may need to use it at any unpredictable time. The most popular network protocols are **token passing** and **carrier sense multiple access/collision detection** (CSMA/CD). In brief, token passing is an orderly method of sharing a cable, while CSMA/CD lets every node use the cable when it needs to and handles collisions on the cable when they occur.

In a token-passing system, information is passed around the network from node to node. Messages are linked together and the last message is followed by a special message called the **token**, which signifies the end of the group of messages. As each node is passed, it removes from the group any old messages that it sent, since if it is seeing them again, they must have gone all the way around the network. the node reads any messages addressed to it and marks them as having been read, then passes them on to the next node. When the token is seen, any new messages to be sent are added to the end of the group, then the token is passed.

The CSMA/CD protocol is an entirely different means of regulating message traffic on the cable. Each node monitors the network and waits to transmit until the level of network traffic has subsided. If two nodes try to talk on the network at the same time, a collision occurs — it is sensed by the transmitting nodes, and they wait a randomly selected interval before trying again. To avoid continuous collisions, each node waits for different amounts of time before retransmitting.

CSMA/CD is used widely in PC LANs, the best-known example being Ethernet-based systems such as 3COMs. It is also used in the IBM PC Network product. Its main advantage is ease of reconfiguration — you can add a new workstation or server to a bus-based system at any time without shutting the network down. It is efficient under light use, but starts getting bogged down under heavy use because of the time spent recovering from collisions.

Token passing's main advantage is that it is "deterministic": each node gets a chance to transmit a message within a fixed amount of time. This feature is especially important in many manufacturing applications where a guaranteed response time is critical.

Token passing is also efficient under heavy use. Since there are no collisions, the bus cannot be overloaded. However, you cannot remove a workstation or server from the system without shutting down and reconfiguring, since removal of a node breaks the ring and the token stops in its tracks. It also takes some clever network software to recover from the loss or garbling of the token; in this respect token passing is more vulnerable than CSMA/CD.

In most cases, topology and protocol are not nearly as important factors as systems and applications software. Figures 7.5 to 7.8 presents comparative analysis of various network features by topology, media and protocol.

	Small	Medium	Large	Very Large
Topology :				
Bus	X —	—	X	
Ring			X —	X
Star		X —	X	

Media :				
Twisted Pair	X————	————X		
Base band				
Coaxial	X————	————X		
Broadband				
Coaxial		X————	————X	
Fiber Optic			X————	————X

Fig. 7.5 : Distance Compared by Topology and Media

	Low	Moderate	High	Very High
Media :				
Twisted Pair	X			
Base band				
Coaxial	X————	————X		
Broadband				
Coaxial		X————	————X	
Fiber Optic			X————	————X
Protocol :				
Contention	X			
Token Passing			X	
Polling		X		

Fig. 7.6 : Network Traffic Capacity by Media and Protocol

	Easy	Moderate	Difficult
Topology :			
Bus	X		
Ring		X	
Star			X
Media :			
Twisted Pair	X		
Base band Coaxial	X		
Broadband Coaxial		X	
Fiber Optic			X
Protocol :			
Contention	X		
Token Passing		X	
Polling		X	

Fig. 7.7 : Expandability by Topology, Media, and Protocol

	Low	Moderate	High	Very High
Cable:				
Twisted Pair	X			
Base band				
Coaxial	X			
Broadband				
Coaxial		X		
Fiber Optic		X———	———X	
Installation :				
Twisted Pair	X			
Base band				
Coaxial	X			
Broadband				
Coaxial		X		
Fiber Optic			X	

Fig. 7.8 : Media Cost Comparison

ESTIMATING HARDWARE PERFORMANCE

Performance on a network is best expressed as throughput: How long does a request take to make its way from the workstation through the network to its destination? The two key hardware elements in that throughput are the NIC and the server.

A particular NIC-server combination can develop a maximum amount of throughput for a LAN. If that throughput is expressed in kilobytes per second, the NIC-server combination can put only a certain amount of kilobytes per second on the network.

Each network user shares that network throughput. If your NIC-server combination can deliver 300 kilobytes per second throughput and you are the only active user on the network, then potentially you could receive data at 300 kilobytes per second. If two other people are using the network at the same time, the total throughput now is divided among three users. Each could get a maximum of 100 kilobytes per second.

One other factor is significant: how much throughput a single workstation actually can handle under a particular NIC-server combination. Because of workstation limitations, that figure usually is going to be less than maximum NIC-server throughput.

Therefore, to calculate the probable throughput available to each workstation for a given NIC-server combination, you need to know three things:

1. The maximum throughput
2. The single station throughput
3. The number of users

Of these variables, quantifying the number of users is the most difficult. The type of application and the number of hours per day devoted to that application will decide the actual load on the network. For example, you might have a ten-station network, but one workstation is in the boss's office and is never used. Obviously when you are calculating the number of people that divide up the available NIC-server throughput, you divide by nine workstations, not ten, even though the network actually is connected to ten workstations.

But that example is rudimentary. The number of users needs to be defined much more carefully. For an accurate approximation of user activity, categorise users into five groups. The physical site questionnaire mentioned earlier will help in user definition.

A type 1 user uses the network very lightly, mostly for local processing applications, that is, word processing and spreadsheets. This person is classed as a 1 to 5%user of the network, depending on how many hours a day the user spends utilising the network.

A type 2 user is more active, utilising applications that require more disk access. This type of work includes light database activity or mail merge. This person is a 5 to 10% network user.

A type 3 user must frequently access the shared disk for such applications as heavy database or mail-merge work. As a general rule, applications for this type of user spend about the same amount of time accessing the shared disk as they do manipulating the data at the workstation. This person is a 10 to 20% user of the network, again depending on the number of hours spent using the application.

A type 4 user is a very heavy user of the network, doing applications that require a great deal of disk access. Such applications include reservation systems. The type 4 user is a 20 to 40% user.

A type 5 user is someone who constantly demands as much throughput as the station can deliver. Continuously copying files from the shared hard disk, as in a back-p operation, or performing compiles in a programme development environment are examples of this type of user's applications. A type 5 user is a 40 to 100% user.

The formula for estimating system throughput is

$$T = M/U$$

T stands for available throughput per-workstation , M for maximum network throughput, and U for 100% users. A 100% user is a person running an application that uses the network to the maximum possible from a single workstation.

The figure for 100% users is developed by adding the percentages together for all users on the system. A sample site might have the following users:

		Total
5 Type 1 users each with a weight of	.04	.20
10 Type 2 users each with a weight of	.10	1.00
1 Type 3 user with a weight of	.20	.20
	Total	1.40

STANDARDS

Depending on your needs, standards can be of the greatest importance or may be only a minor consideration in your choice of a network. Standards are likely to be of more importance if you:

* Plan to expand your network.
* Need to connect to other networks.
* Plan to run applications from several vendors.

Standards are of least importance if you are buying a small configuration that will remain fairly static and will not need to be connected to other networks, use devices from other vendors or run many different applications programmes.

There is more standardisation among network hardware components than among software applications. You can probably find many more hardware products from different vendors that can physically coexist than software products that can share information. For example, you could buy a workstation and a print server from two vendors that claim. Ethernet compatibility, find that they can be connected to the same cable without physical interference, but discover that you cannot use the print server from the workstation because the two are incompatible in ways the Ethernet standard simply does not address. You must check very carefully for compatibility before you select network components from more than one vendor.

SOFTWARE

The ISO Open Systms Interconnect (OSI) model is a framework for describing network standards, rather than a standard itself. If you want to mix network components from different vendors, they must be compatible at some common OSI layer. Most of the current standards address only the lower levels of the OSI model. Applications software generally interfaces to the network at the highest levels, where there are very few widely accepted standard interfaces. This is one reason why applications software often needs to be modified for a specific network before it can run on it.

MS-DOS 6.0 and MS-NET. Although formal standards for network applications software may still be in the future, there are some promising de facto standards. Support for these standards may be important in your choice of a network, especially if you require wide availability of applications software.

Microsoft set a major standard in the personal computer world by releasing the

MS-DOS operating system, called PC-DOS on the IBM PC. MS-NET, Microsoft's network software, appears to be having a similar impact in the networking world. IBM PC Network provides an implemention of MS-NET, and many computer and LAN vendors are adding MS-NET or MS-NET-compatible interfaces to their products. MS-NET is accessed via a set of system calls provided in MS-DOS Version 6.0, and these calls provide several important network programming functions. More and more software is being adapted to run under MS-NET and MS-DOS 6.0, so the increasing support for these interfaces may influence your choice of a network.

NETBIOS. Another important PC networking software industry standard is the OSI session level NETBIOS interface, first presented by the IBM PC Network system. Many other LAN vendors have since provided a compatible interface with their systems, and IBM itself has provided this interface to its Token-Ring Network.

Application packages are more likely to use the simpler, higher-level MS-NET and MS-DOS 6.0 interaces than NETBIOS. The NETBIOS interface is especially important for systems-level network software, such as programmes for network servers. Unless you need to run a specific application that requires NETBIOS, it may be of slightly less importance to you than MS-NET compatibility. However, because it is supported in several IBM products, it is likely to be used more as time passes.

HARDWARE

Hardware standards are most important in the fundamental parts of your network such as cable type and the low-level network protocols. If you choose a non-standard, proprietary cable and protocol offered by only one vendor, you may be locking yourself into that vendor for all your future networking needs. A network conforming to one of the IEEE 802 standards opens the door to a broader choice of vendors.

IBM. IBM offers three networking hardware choices. The industrial token bus is designed for factory automation and process control. The PC Network uses broadband technology. The Token-Ring Network is an evolving system intended for use in large corporate networks, and is the basis for the IEEE 802.5 standards committee work.

IBM has suggested that, in an office environment, the broadband PC Network should be used to connect a small number of PCs together. The token-ring is seen as the building-wide network used to tie a large number of machines or clusters of machines together. A gateway product provides the connection between the broadband LAN and the token-ring. You can also use the token-ring as a local PC network, omitting the broadband network entirely. The Token-Ring Network runs the same software as the broadband PC Network. It supports the MS-DOS 4.1 and NETBIOS interfaces mentioned earlier. It can run over IBM's coax or the less expensive twisted-pair that meets telephone installation standards. Both wiring choices provide a bandwidth of 4 million bits per second, although you can connect more nodes and go a greater distance using coax.

The Token-Ring Network may be appropriate if you are planning to connect a large number of systems, including other IBM computers. IBM has expressed its intention to provide a complete corporate computernetwork hook-up, although the details for connecting together more than just PCs are being released very slowly.

Ethernet. The Ethernet standard is supported by many computer vendors, and several variations in cabling have evolved to reduce the relatively high cost of the original specification. Electronic devices called 'transceivers' can be used to connect the different cabling schemes. The choice of cable generally has no impact on applications software, and is a trade-off between cost and performance, with respect to speed and maximum cable length.

Standard Ethernet requires a heavy trunk cable and a transceiver for every workstation. The transceiver connects to the trunk cable, and a wire runs from the transceiver to the workstation or server. Cheapernet uses lighter, less-expensive cable and has the same 10 million bits per second capacity as Ethernet, but does not use an outboard transceiver and cannot support as long a cable as Ethernet.

StarLAN. AT&T's StarLAN is a competitor to IBM's token-ring in the coporate network arena. It uses a standard Ethernet trunk cable connected by a device called a 'hub' to clusters of workstations. The workstations connect to the hub with standard telephone company twisted-pair. You can connect hubs to hubs, increasing the number of workstations supported in a cluster and giving you more flexibility in wiring them together. StarLAN operates at a bandwidth of 1 Mbs.

MAINFRAME CONNECTIONS

If you are selecting a PC network for use in an installation where there are other computers (especialy, minicomputers or mainframes), you should think about how you could connect your network to them even if you see no immediate need to do so. There are several classes of connection that may be important for you:

* Message and file transfer.
* Terminal emulation.
* Programme-to-programme communication.
* Remote job entry.

Making a good selection requires technical expertise. You need to understand the host computer application, data-file structure and communication connections, as well as the gateway connection between the host and the PC network, the PC network hardware, and the software that runs on the PC workstations to access the host.

GATEWAYS

Figure 7.9 shows one means of connecting a mainframe to a LAN. The interconnection is via a gateway, which is a server designed to pass information back and forth between two dissimilar networks. In this case, an Ethernet PC LAN is connected to a 4300 series IBM mainframe with a gateway processor. The gateway translates low-level protocols and handles the speed differences between the two networks. Since all traffic between the two networks must pass through the gateway, you must carefully evaluate the performance capability of the gateway in the light of the amount of the data you expect to transfer through it. If it does not have enough capacity it will become a bottleneck.

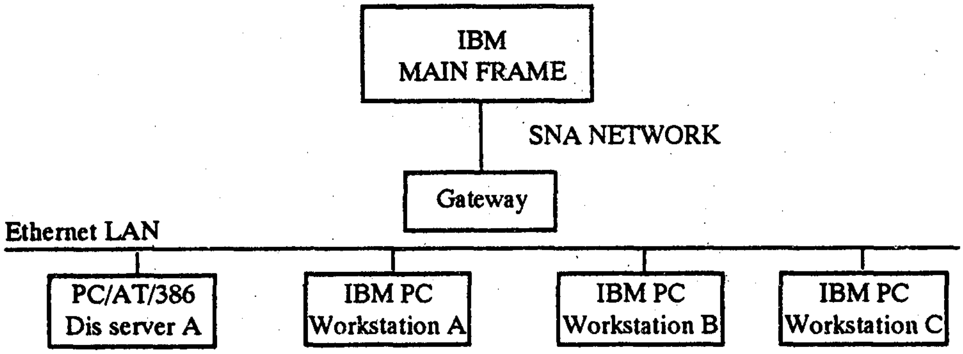

Fig. 7.9 : A geteway connecting a LAN to a mainframe

Most major PC network vendors offer gateways to IBM SNA networks, and some offer gateways to other popular PC networks. You may have a choice between a dedicated gateway server computer and an add-on board for a PC. The trade-offs are similar to those between a proprietary disk or file server and the use of a PC to do the job. You should examine price and performance as you make your evaluation, as well as the software provided to make the connection between the two networks.

DIRECT CONNECTION

An alternative means of connecting to a minicomputer or mainframe host is to run a direct connection from each PC on the LAN to the host computer. Many add-on cards are available to connect to host computers via most of the communication protocols available. However, this approach usually costs much more than the gateway approach and it makes little or no use of the PC LAN. For the extra cost, you may get more performance or more consistent performance when you access the host, since there is a dedicated connection rather than a shared connection through a gateway.

MESSAGE AND FILE TRANSFER

Message transfer and file transfer refer to electronic mail and document transfer, respectively. Many different kinds of electronic mail systems are in use today, and there is not yet a standard. Some systems cover only workstations connected to a common network and others connect also to public electronic mail services to cover a very wide area. The usefulness of electronic mail increases with the increase in the number of people you can communicate with, so be sure to consider ways to connect your PC workstations to electronic mail systems if appropriate.

There is not yet an official standard for document transfer either, although IBM's DISOSS standard is widely supported. If you need to share documents with a DISOSS system, examine whether the network of your choice can do so.

TERMINAL EMULATION

Terminal emulation is a very common approach to connecting a PC to a host computer. To the host your PC appears to be a terminal, and the host lets you do whatever a terminal can do on it, such as accessing existing applications on the host which is often very important. But with straight terminal emulation you cannot do anything that takes advantage of the fact that you are using a PC. If you want to do terminal emulation, you should examine the available options with respect to:

* Faithful emulation of desired terminal.
* Ease of use (how keys are mapped onto PC keyboard).
* Performance (how fast the emulator can receive data from host).

DATA EXTRACTION

Another way of accessing the host from a PC on a LAN is to extract data from host databases and move it to the PC for processing. This is another highly technical area, and to do a proper evaluation you need an excellent understanding of the software that runs on both ends of the connection. The software that extracts data from the mainframe database must have a detailed understanding of the host data-file layout, and it is possible that a revision in host software will change something in the layout and cause the extraction software to stop working. If the data extraction software is not updated for a period of time, you may be unable to run your application until it is updated. If you can find data extraction software from the same vendor as for the host database-management software, it may be more likely that the extraction software will be updated concurrently with the database software — although there is no guarantee.

REMOTE JOB ENTRY

Submitting jobs for processing on the host computer is another common need of PC users. A gateway or direct connection can provide the necessary data link for this remote job entry to take place, but PC software is also needed to do the actual job submission and control. Ease of use and match-up of functions against your needs list are the most important criteria.

PROGRAMME TO PROGRAMME COMMUNICATION

A relatively new area is programme to programme communication. IBM has introduced a standard called LU 6.2, and the full implications are still unfolding. Not much PC software is available that takes advantage of programme-to-programme communication, but as more software gets written for networks, this capability will grow in importance. The goal is to let a programmer set-up two or more programmesthat can execute on two different computers and pass information back and forth as they are running.

SECURITY

You should closely examine the security provided by software used to connect networked PCs to a mainframe. In most cases the mainframe data files were created before the PCs has access to them, and security may not have been a big consideration when the files were first stored. It is very easy to miss a security problem when security is an afterthought rather than something designed into an application. In addition to straightforward security issues, such as who can access which files, there are more complicated ones to consider, such as the ability for any authorised user to access host data and store it on the local network hard disk. Without the appropriate additional security, other network users may be able to access your data. If any PC on the network has a modem and is used to receive incoming calls, then anyone who can call the PC may be able to "break into" your mainframe.

HARDWARE COMPATIBILITY

Before choosing your mainframe connection equipment, be sure any hardware cards that must be added to network PCs are compatible with other cards that you plan to have in the PCs. Communication cards are among those more likely to have incompatibilities with network interface cards than other types of cards. A complete list of the cards going into the workstations and servers should be checked out with your dealer and the board manufacturers.

WHAT DO YOU WANT FROM A LAN?

LANs serve a wide variety of functions and it is important that the prospective user is clear about what he requires from a LAN. For example it may be used to provide any or all of the following functions and many others:

File serving

Print serving

Process control and monitoring

Electronic messaging

Distributed processing facilities

Remote links to mainframe processors

Conferencing

Video transmission

Electronic office functions

LAN applications are limited solely by the imagination of the user. Very few systems can do all of these, and some LANs because of their nature will only perform a few of the functions well, so it is useful to examine the system requirements for each type of application. In general the following rules hold:

1. **File and print servers:** These are installed to spread the cost of expensive peripherals for groups of micro-computers and mini-computers; low interconnection costs are very important, with speed of operation being less so, particularly in the case of print servers.

2. **Process control and monitoring:** The vital factor in this application is the speed of the system response. The delay between the initiation of a command and its execution, or between the monitoring of an event and its acknowledgement by the process controller must be short and fixed, so that the controller can make allowances for it. Thus a network with guaranteed access and short transmission delays is essential. Interconnection costs and equipment costs are not the overriding factor when the plant to which the LAN connects costs a great deal - much more than the LAN itself.

3. **Electronic messaging:** This function will normally be an addition to local functions provided by small business computers and so must be compatible with them. Network traffic will be light compared with other applications and so a low speed network without guaranteed immediate access is indicated, as a time delay of a few seconds is not important in this application.

4. **Distributed processing:** This is common in scientific and engineering work, where terminals, workstations and various sizes of computer are connected together in order to share software and hardware facilities. As programmes and large batches of data need to be transferred from device to device at regular intervals, high speed bulk data transfer is the network's primary aim. Interconnection costs are not of primary importance, as the value of the attached equipment is usually relatively high.

5. **Remote mainframe links:** If this is the main purpose of the network, and a number of terminals wish to gain access to a single mainframe, network usage by each individual terminal will be low, and mainframe response time is likely to be much greater than network access time. A low speed network with variable access time will suit the application.

6. **Conferencing:** This application implies transmission of voice signals, as well as data, and therefore requires a network where speech can be transmitted in an analogous form, e.g. PABX-based network, or one where speech can be digitised and then transmitted, without interrupting data transmission, e.g. broadband network.

7. **Video transmission:** If video signals are to be transmitted as well as data, and possibly voice signals, the network must have a very high bandwidth and the ability to separate the various types of signals or the video signal will be of unacceptably poor quality. This requires some sort of broadband system.

8. **Electronic office functions:** This covers a wide variety of functions including some mentioned above and so needs a reasonably high performance network to fulfil its requirements.

In addition, system limitations will affect the choice of LAN for many applications. For example, the following questions must be kept in mind when examining a LAN:

1. Can it support the number of nodes required? Most LANs have an upper limit on the number of devices that can be simultaneously attached to the network.
2. Can it cover the physical area of the site? Most types of LAN have an upper limit on the lengths of connecting cables. Some can be extended with repeater units but this will be an added expense.
3. Can the LAN cope with the maximum amount of traffic envisaged for the system in an acceptable manner? This question is less straightforward to answer than the previous two but ignoring it may prove more costly to rectify.
4. Can it be connected easily to the equipment with which it is to be used? LAN suppliers normally offer a variety of plug-in interface units for popular computers and peripherals, which make interconnection much simpler than would otherwise be the case.

SPECIFYING A LAN

So far, we have thought about the purpose of the LAN and the types of system that will fulfil a particular purpose, but in a very general, broad way. It is now important to specify, in detail, without reference to any available commercial system, the network that is required. This is necessary at this stage to ensure that the network eventually purchased will meet the requirements of its users.

The best way to start is to follow this set of rules:

1. Draw up a list of the physical and logical requirements of the system:

    Number of nodes

    Area covered

    Maximum rate of data transfer

    Types of devices to be connected to the network

    Number of each type of device

    It is also worth drawing a plan of the lay-out to give a clearer idea of possible difficulties.

2. Find out from the potential users what they intend to do with the network and sort their responses into two types - essential requirements and optional extras.
3. Have a clear idea of the funds available, and the possibility of further funds for upgrading the LAN system at a later date.

Following these rules should provide clear specificationsto present to any supplier of LANs and this is the most important stage in finding a system to suit your specific requirements.

However, at this point it is wise to consider whether a true LAN is the answer to your problems, or whether one of the various types of devices performing related functions might be a more cost-effective solution. It is unnecessarily expensive to pursue a high-tech solution when there is a low-tech one available.

For example, if the requirement is simply for a number of terminals or similar devices to be connected together, so that one device is only connected to one other device at any one time, in the manner of a telephone system, then an Intelligent Switch might be the answer, particularly if the physical distances are small.

A LAN is probably the right answer if one or more of the following points are valid:

1. A wide variety of connections which change with time are required.
2. Cabling costs look like being a substantial portion of system costs. LANs use the transmission medium efficiently and do not require multiple cables.
3. A large percentage of nodes in the system require regular access to other nodes, i.e. most of the nodes have something to say at regular intervals.
4. Both point-to-point and broadcast data transmission are required within the network. LANs need no alteration to physical connections to provide both.

MATCHING LANS TO USERS

We may split LAN users into the following groups:

Scientific and engineering

Office automation

Industrial automation/process control

Education

Home/interest

We now examine their requirements and see which types of LAN serve them best. It is important to note that no two applications are alike and that the network should serve the user, rather than dictate what the user can and cannot do. For example, a network used for scientific or engineering purposes may well need to provide some services associated with office automation work, such as printing from a control station.

The three Tables 7.1 to 7.3 give comparisons of features for LANs assessed by transmission medium, accessing method and topology. Table 7.4 lists the features you must look for while evaluating a LAN. By listing the features most important for a particular application, it is possible to go a long way toward picking the most suitable type of LAN. The following two examples illustrate the process.

TABLE : 7.1 : Comparison of transmisssion media

Trans-mission Medium	Band-width	Ease of Connect-ion	Distance	Suitability for differ-ent Topolo-gies	Ease of Install-ion	Noise Immun-ity	Cost
Twisted Pair	Low	Good	Low	High	Average	Low	Low
Baseband Coaxial	Ave-rage	Good	Average	High	Good	Average/ Good	Average
Broadband Coaxial	High	Good	High	High	Good	High	Average/ High
Optical Fibre	Very High	Poor	Very High	Poor	Average	Very High	High

TABLE : 7.2 : Comparison of Access methods

Access method	Nature	Bandwith	No. of Nodess	Distance	Delay	Cost per Node
CSMA/CD	Random	High	Average	Average	Unlimited	High
Token Passing	Deter-ministic	Average	High	High	Low	Average
Register Insertion	Dete-ministic	Average/ low	High	High	Average/ low	Low
Empty Slot	Deter-ministic	Average	High	High	Low	Average
Time-Division Multiplexed	Deter-ministic	Low	High	Average	Low	Low

TABLE : 7.3 : Comparision of topologies

Topology	Cost	Complexity at interface	Flexibility and Expandability After Installation	Reliability
Bus	Low/Average	Average	Good	Good
Ring	Average	Low	Average	Good
Star	High	Low	Poor	Average

TABLE : 7.4

What features you must look for while evaluating a LAN ?

*	**Topology**	-	Bus, Star, Ring etc.
*	**Protocol**	-	Token Passing, Carrier Sensing Time Division, Multiplexing
*	**Max No of Nodes**	-	Normlly 64-255.
*	**Cabling Technology**	-	Co-axial, Twisted Pair, Fibre Optics etc.
*	**Data Transfer Rate**	-	Expressed in Million Bits/ second (1-2.5)
*	**Distance**	-	Normally 1.2 Kms-64 Kms.
*	**O/s Compatibility**	-	Whether multiple o/systems can be suported simultneously (eg. DOS and UNIX)
*	**Security Features**	-	By Password, by User, by Directory etc.
*	**File Server**	-	Whether dedicated or can also be used as a node.
*	**Driverless Workstations**	-	Availability of Nodes without peripherals.
*	**System Supported**	-	PC/XT/AT/386/68000 Series etc.
*	**Lan cost**	-	Cost Per Node
		-	Cost of cabling
		-	Cost of Dedicated Resource Server, if any.

Example 1: A network based in a college classroom, connecting a number of personal computers to a master computer, and to a print-serving device and a file-serving device and operated by the teacher in-charge. The master computer would not be in continuous communication with the rest but would need to access any of them from time to time. All would use print and file servers. The desired characteristics would be:

Transmission medium bandwidth	- low/moderate
no. of nodes	- low/moderate
distance	- low
ease of installation	- low/moderate
noise immunity	- low/moderate
cost	- low:the most important factor
Accessing method control	- distributed (all intelligent nodes)
bandwidth	- low/mediu

no. of nodes	- low/medium (dependent on class size)
distance	- low
degree of contention	- low
degree of determinism	- high
degree of flexibility	- low
delay time	- low/moderate
Topology interface complexity	- low (to keep costs low)
flexibility	- low
expandability	- low
reliability	- moderate to high
cost	- low: most important item

Comparing the requirements with the tables suggests a bus or tree system with some sort of deterministic accessing scheme using twisted-pair cables. However, the evaluations in the tables are relative and it may prove that because of the relatively short distances involved, the extra cost of a different type of transmission medium may be negligible in comparison with the system cost. Similarly, the time delays involved in using a non-deterministic access method may be acceptable when considered in comparison with the speed with which the users interact with the various computer/ nodes in the network.

Example 2: A network for a modern business office, where the current requirements are mainly linking an assortment of workstations, word-processors, print and file-servers but provision must be made for possible future expansion, and where links to the company mainframe and a video network are envisaged. Bearing in mind the final functions the LAN may have to perform, the desired characteristics would be:

Transmission medium bandwidth	- high (to accommodate video)
no. of nodes	- high (future additional nodes)
distance	- moderate (except for main-frame connection)
ease of installation	- moderate
noise immunity	- moderate
cost	- low: not most important factor
Accessing method control	- distributed
bandwidth	- high
no. of nodes	- high

distance	-	moderate
degree of contention	-	moderate
degree of determinism	-	low
degree of flexibility	-	high
delay time	-	low and fixed (because of video)
Topology interface complexity	-	can be high
flexibility	-	high
expandability	-	high
reliability	-	high
cost	-	low (in comparison with system)

The network fulfilling most of the conditions in this case would be a broadband coaxial, random access, bus or tree system, such as the commercial Ethernet LANs now being sold for office automation by a number of suppliers. There is however one problem: video transmission would require low, fixed time delays in transmission, to avoid unacceptable degradation of the reconstituted video signal at the receiving station. This factor suggests that a deterministic access method i.e. some form of token-passing system, should be adopted to ensure future video compatibility despite the reduced performance of the LAN in other areas that this choice of accessing method would imply.

On the subject of cost, cheaper is always better, but must be considered in terms of the cost of the system the LAN is to serve. One LAN may cost twice as much as another for a limited increase in facilities, but where this extra cost is only a few percent of the total system cost, it may well be acceptable.

Having decided which types of LAN will suit the specification, it is important to balance the trade-off between costs and features of suitable networks. It is rare that a LAN will provide everything its prospective users want at a price they are willing to pay and so some order of priority should be given to the various features in the specification. Beyond this point it is unwise to be specific as each application has its own pitfalls. The only sure result is that the final system will have some unnecessary features and not have some necessary ones, so allow for a certain amount of flexibility in your specification.

PURCHASING A LAN

Having discovered a number of networks which seem to fulfil most or all of the specifications, the problem of choosing one to buy arises. A number of practical points can affect this decision.

1. **Complete package or components?** In other words, do you buy a 'turnkey' system from one supplier or various bits and pieces from different people and

then try to make them work yourself? The first course should guarantee a working system without too many problems, but will undoubtedly cost a great deal more than the latter option. Self-installation, in comparison, could be fraught with practical difficulties. In brief, do-it-yourself is only recommended if every penny counts, and there is adequate technical back-up to solve the problems.

2. **General compatibility:** This is really part of point 1, but worth looking at separately. A number of manufacturers supply LANs complete with workstations of their own design but do not provide interfaces for other popular makes of computer (e.g. IBM PC) or standard peripheral connections (e.g. Centronics interface, RS232C port, etc.) Purchasing this type of LAN is a quick way to get a network up and running but may make your current equipment redundant, or tie up expensive workstations as interface units to the equipment you wish to keep. In general, these packaged LAN-and-workstation systems are a good thing if an installation is being built from scratch, rather than networking existing devices. Most such LAN packages offer a standard operating system, such as CP/M or MS-DOS, on their workstations and so a certain amount of software compatibility is catered for.

3. **Timescale for delivery and installation:** This can vary widely from supplier to supplier and a more expensive or less versatile LAN may be a better buy if it can be installed now, when the delivery time for your first-choice LAN is six months or a year.

4. **Where more than one LAN seems to fit the specification:** Try to get the competing systems installed for a short time for evaluation purposes. Most suppliers will consider this if they feel it will lead to a sale. Despite matching your specifications to the suppliers', there is no substitute for the 'suck it and see' approach in assessing the usefulness of any piece of equipment.

5 **Component costs may affect a decision:** For example, if two LANs, one with coaxial cable and the other with fibre optic cable, suit your application and cost approximately the same amount, the component costs for future expansion are likely to be much greater for a fibre optic system than for a coaxial system. In this case, the coaxial cable system would be a better solution.

LAN ACQUISITION STRATEGIES

When seeking the perfect fit for your network, ponder on these questions before you decide where to buy:

1. What problems do you wish to solve with the LAN?
2. What are the design requirements?
3. What sort of functionality do you intend to provide to the user?
4. Are you building a PC-only LAN or an Enterprise Wide Network?
5. What are your performance expectations?

6. What are the availability expectations?
7. Flexibility. Is your organisation stable or in constant movement?
8. What is your management strategy? Autonomous or Centralised?
9. Security. Highly sensitive data?
10. What is the size and complexity of your network?
11. How many locations do you have?
12. How fast does your network have to grow?
13. Is it heterogeneous or homogeneous?
14. Is the nature of the problem physical or logical?
15. Do you need to make LAN-to-WAN connections?
16. Do you need to make LAN-to-host connections?
17. What are your uptime availability requirements?
18. What are your security needs?
19. Do you have a network management strategy?
20. What are your staff resources?
21. How are your current supplier relationships?
22. What are your time and price requirements?
23. What do you need in the way of on-going service and support?