9

PLANNING AND INSTALLING A LOCAL AREA NETWORK

INTRODUCTION

Installation of the physical components of a LAN is the single, most time consuming, expensive and difficult part of making a local area network part of your business. If you are installing a LAN into an existing office, you can expect disruption at the very least. While the steps involved are not much different from thosefor the installation of any other data processing equipment that requires cable linkto each workstation, that only means they are roughly equal in the amount of trouble thay cause.

Fortunately, with proper planning and some application of technology, the disruption and difficulty can be reduced significantly. The fact remains, though, that the LAN's support equipment will still require space, and the cable will have to be somewhere. How difficult the process is depends on you, to some extent.

Once you have selected a network vendor and system, you need to make a detailed plan of your specific configuration and then install the system according to the plan. The discussion here deals with planning and installing a local area network. After it is installed and running, you can use it and must manage it. Most of the work involved in managing a network is similar to the installation process; some additional management responsibilities are discussed later.

Although the installation process of each local area network is unique, there are many similarities among networks from different vendors. Hardware installation varies the least from one network to another; methods of cabling are generally the area of greatest difference. Software installation varies in its specifics, but several general concepts hold across most networks, and understanding these concepts helps smooth planning and installation. The discussion here provides an overview of the installation process so you can decide whether you want to attempt it yourself, and if so, to give you hints to make things go more smoothly.

If you plan to install a moderate-to-large network using hardware or software that is new to you, it is recommended that you build a very small experimental network first. Many network vendors sell "starter kits" containing everything you need to connect two PCs together. A few days of experience with a couple of workstations and a server can teach you a lot about your particular situation. This small-scale experiment can also help you during the planning phase to make a better detailed plan and to purchase the right equipment when you order the bulk of your network hardware and software.

If your potential network users, who will share peripherals and information, are well familiar with the use of PC, try setting a couple of them up with a server and your intended software configuration. If your network will be used to manage the operation of a business, it may be harder to set up a trial network. Use recent or dummy data for your network applications and have some of the eventual network users spend a few hours working with this data as they would with the real thing.

Figure 9.1 shows a sample checklist of things to evaluate after finishing the network trial. Note that it is only a sample — you should tailor it to your own environment and needs. When considering the items, also discuss them with the network users.

Disk storage
- Performance
- Responsiveness (delay from request to action)
- Transfer speed (time to load and save files)
- Consistency (variation in performance)

File placement
- Convenience (ease of locating and accessing)
- Usability (able to access disk from all applications)
- Volumes (correct things on public and private volumes)

Print service
- Performance
- Usability (print from all applications)
- Spooling (time workstation is tied up while printing)

Job management
- Sharing (distribution of printers to users)
- Separating (distinguishing different users' print-outs)
- Forms (need to change print forms often)

Systems software
- Operating environment
- Understanding (quality of training)
- Ease of use (ease of doing necessary tasks)
- Functionality (can do all necessary tasks)
- Reliability (as compared to single-user PC)

Security
- Functionality (keeps unwanted users out)
- Convenience (not cumbersome for authorised users)

Application software
Personal programmes
Usability (can use programmes on network as desired)
Licensing (do users understand license issues)
Multiuser network applications
Sharing (any problems with concurrent data access)
Functionality (does intended job)

Fig. 9.1 : Checklist for trial network evaluation

You will probably modify several aspects of your network configuration after the trial run. If this experiment seems to use more time than you would like to spend, consider the likely results of implementating a full network without the benefit of a trial. Unless you are exceptionally skillful or lucky, you will lose time in many ways:-

* Users' time wasted running in a suboptimal configuration
* Your time spent reconfiguring all the servers and workstations
* Users' time wasted while you reconfigure the network

Even worse problems are possible from an improperly installed network, especially if it is used to run a business — you could lose money, irritate customers and upset employees. Of course, none of these potential problems is unique to local area networks; they can arise from any change in data processing equipment or procedures.

PLANNING THE INSTALLATION

There is an old saying that if you plan to go nowhere in particular, you are bound to get there. Although your needs — the components and how you should arrange them — may seem obvious to you, writing them down into a plan will probably reveal additional things you will need.

The complexity of your plan and the time you should devote to it will vary with the size of your network. A few hours to a day of planning may suffice for a network composed of four or five PCs run by knowledgeable computer users sharing a network disk and printer, while it may take months to plan for a hundred or more workstations running several different multiuser applications sharing a dozen network servers and linked to a corporate mainframe. If you are faced with such a complex task, do not hesitate to engage an experienced consultant to help with your planning.

Modern programming practices generally stress the importance of planning "top-down" and implementing "bottom-up." Planning and installing a network should be approached the same way. Briefly, top-down planning means starting with a high-level description of the overall task you are trying to perform. This description should help you see the separate components of a large, complicated problem. It is easier to deal with these components separately than trying to solve the whole problem at once. If the interfaces and connections between the components are well-defined and

understood, you should be able to work out the details of each separate component by itself without concern for the details of the other components until you get to them.

Each individual component can be treated the same way: broken down into smaller pieces that can be separately considered. This process is called "successive refinement." You eventually reach a level of detail that cannot be further refined, and you have solved the problem. You are then ready to implement the solution — in this case, purchase and install the network.

Bottom-up implementation means you install the simplest, lowest-level pieces of your design, test them to see if they work as planned, then add the next level and test it, repeating the process until the entire network has been installed. Each successive level of implementation adds more function to the network, and is built on a previously tested foundation. This approach is very important, since problems are more easily found than if you wire an entire network together, load all the software, then try to determine why something does not work.

The discussion here is oriented towards the above approach to planning and installing a network. The highest-level description of the network is at the applications software level. What are your end users going to do with the system? This question generates a list of needs, from which a description of the required application and system software configuration follows. The software configuration in turn suggests your server and workstation requirements, from which it is fairly simple to see how to cable them together.

This whole process requires that you have a good understanding of your application needs and use that understanding to select the right network software and hardware. Two critical skills may require a consultant's help: one is studying a system and turning that analysis into the right applications software set-up — the job of a systems analyst; the other is determining a good network hardware and software configuration to support the applications software — best done by a local area network specialist (who could very well be the same person as the systems analyst). Make sure your in-house person or consultant has the right mix of experience and skills to make your installation a successful one.

SOFTWARE PLANNING

Although the analysis of your application needs from a systems viewpoint cannot be covered here in its full scope, some of the special needs from a network perspective will be discussed. Before you start planning your network installation, you should have selected the applications software for your network on the basis of the considerations listed in Figure 9.2. Without a good understanding of the applications you will run, you cannot possibly plan the requirements or configuration of your network.

Business
- Problems to solve
- Improvements sought
- Conservation from existing system
- Financial resources to purchase system

People
- End-user computer sophistication
- End-user need and ability to modify applications
- In-house or outside custom programming availability
- Network management responsibility

Software
- Applicability to problems at hand
- User interface suitability
- Integration with other applications
- Shared database access across network
- Custom programming requirement
- Ability and need to modify source code

Fig 9.2. Application software selection considerations

Your hardware and software plans are interdependent. As you work through your software plan, you will gather information that will shape the hardware plan. You may need to make a couple of passes through both plans, modifying earlier decisions as you gain a greater understanding of the interdependencies. For example, the number of servers you need in order to support your workstations depends on the applications software that will run on your network, and also on how that software is installed and used in conjunction with the network. Some software can be set up to make very little demand on the network, while other packages use the network constantly and heavily.

Figure 9.3 diagrams a piece of a network from a user's perspective. This viewpoint is helpful to guide in top-down planning of your LAN. You must determine:

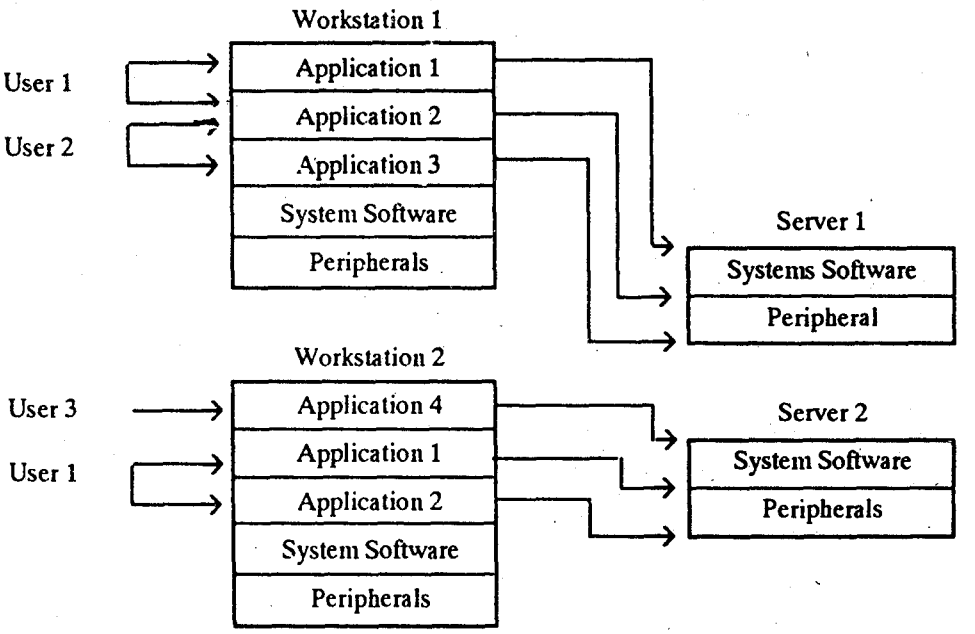

Fig. 9.3 : Network Usage Diagram

* Who your network users are?
* Which applications each user runs on each workstation?
* Which servers each application uses from each workstation?

As you can see in the diagram, the relationships may be complicated. A workstation may be used by more than one user, and a user may use more than one workstation. A workstation can run more than one application, and an application may be run on more than one workstation. The applications may use one or more servers.

To simplify this picture, identify the major components of your network and study each individually:

* Users
* Applications software
* Systems software
* Workstations
* Servers
* Connections

Figure 9.3 also shows peripherals, such as disk drives, printers and modems. They should be considered part of the workstation and server plans.

Refining your understanding of each of these areas will yield insights that will help improve your understanding of the others. To best use this information, you should keep notes as you go; a worksheet helps to keep things organised. Figure 9.4 is an example of a worksheet that you can use for each user of your network. In addition to name, network log-on ID and password, you need to know which applications this person uses, and from which workstations they are run. This use pattern, together with knowledge about the applications themselves, determines the workstation configuration you will need.

User Information Worksheet

Name_____System Manager Privilege (Y/N):_____
Network log-on ID:_____Password:_____
(Repeat log-on ID and password for each account used if more than one)

Network Usage

List each application used by this individual along with the workstation number it is used on :

Application Name	Workstation Number
_____	_____
_____	_____
_____	_____
_____	_____

Fig 9.4. User information worksheet

Applications Software. You need to understand the demands that each of your applications places on the workstation, on the servers and on the connections between workstations and servers. Figure 9.5 shows a basic applications software information worksheet that you can use to analyse your applications. It does not address connection requirements, since the larger context of applications, workstations and servers determines these. This worksheet concentrates on the individual application characteristics, independent of context.

Application Software Information Worksheet

General Information

Application programme: _____ Version #: _____

Vendor : _____

Workstation Requirements

Microcomputer vendor and model: _____

DOS version #:

Lowest: _____

Highest: _____

Display adapter:

(monochrome, graphics, special): _____

Monitor type:

(monochrome, B&W composite, colour composite, colour RGB): _____

Random access memory:

Shared memory in kilobytes: _____

Unshared memory in kilobytes: _____

Disk storage:

Floppy drive A: storage needed in kilobytes: _____

Floppy drive B: storage needed in kilobytes: _____

Hard drive C: storage needed in kilobytes _____

Number of files used: _____

Printers:

Type of printer 1: _____ Forms for printer 1: _____

Type of printer 2: _____ Forms for printer 2: _____

Plotter:

Type of plotter: _____

Modem:

Type of modem: _____

Pointing device:

(mouse, digitiser): _____

Other peripherals:

_____

Server Requirements

Server vendor and model: _____

DOS version #: _____

Random access memory:
Shared memory in kilobytes: _____
Unshared memory in kilobytes: _____
Disk storage:
Shared read-only in kilobytes: _____
Shared read/write in kilobytes: _____
Unshared read-only in kilobytes: _____
Unshared read/write in kilobytes: _____
Number of files used: _____
Printer:
Type of printer 1: _____ Forms for printer 1: _____
Demand on printer 1 (% of capacity): _____
Type of printer 2: _____ Forms for printer 2: _____
Demand on printer 2 (% of capacity): _____
Plotter:
Type of plotter: _____
Modem:
Type of modem: _____
Other peripherals:

(Repeat server information for each server accessed by application)

Fig. 9.5 : Appliction software information worsheet

You should fill out one of these worksheets for every application you will run on your network. Some applications may be thought of as a single large unit that may be run as a collection of separate smaller components. For example, your accounting system may have been purchased as a single software package, but it may contain separate modules for accounts payable, accounts receivable, general ledger and payroll; different users may run different subsets of this accounting package, perhaps not even all on one workstation. If the modules put different demands on the system, each should be considered separately.

Often, the same workstation can satisfy many requirements of both single-user PC and multiuser versions of an application. The DOS version number you use should be within the range you have marked on the worksheet to indicate the lowest and highest revision of DOS that the application can run under. The need to display graphics or text and the subsequent choices between display adapters and monitors are familiar problems faced by all PC buyers. Some applications can run on any monitor; if this is the case, indicate so by writing "any" in the blank. Application memory requirements are mostly independent of use in a network, although some applications may require additional space to manage multiuser access to data. Indicate the minimum memory required by your application, or if you know from experience that you need more than the minimum to obtain satisfactory performance or functionality, use that amount.

Disk storage questions must be reviewed in light of the network environment.

Many applications can be run completely from the network's disk storage and need no local storage. Some of the most common reasons for requiring local workstation storage are listed below:

* Copy protection requires local disk drive to start programme.
* Programme is incompatible with the network software and can only be run locally.
* Programme is hard-coded to use local drive letters. A: or B:
* Security considerations prohibit putting data on network disk drives.
* Performance is improved by local storage of data or programmes.

Performance considerations are hard to generalise, but how long it takes to access data depends on where it is stored. The storage options considered here are RAM disks, hard disks and floppy disks. A **RAM disk** uses random access memory to emulate a very fast disk drive. Some networks support all three options in both the workstation and the server; others support a subset of them in one place or the other.

The graph in Figure 9.6 shows the relationship between network load and the data access speed of these storage options. No one graph can accurately depict the performance relationships under all conditions. For example, on a particular network, it may always be faster to get data from a local hard disk than from a server's RAM disk. Nevertheless, the following rules usually apply:

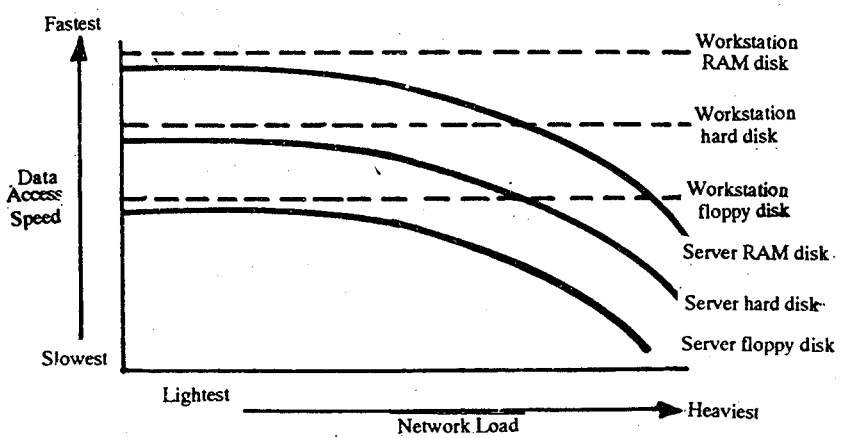

Fig. 9.6 : Access speed versus Network Load

* Workstation storage access speed is independent of network load.
* Given equally fast floppy disk drives and hard disk drives, data can be accessed more quickly from a local device than from across the network, even when the network is lightly loaded.
* Network data access slows as network loads increase.

The last point is critical, as Figure 9.6 demonstrates. Network load refers to

the drain on the server from all the competing workstations. If you stored frequently accessed data on a network hard disk and the network load was light (on the left side of the graph), performance would be somewhere between that of a local hard disk and a local floppy disk — probably quite adequate. But if the network load turns out to be heavy (on the right side of the graph), the data access speed may be considerably slower than a local floppy disk — possibly inadequate. In most cases, the limits of the server will be reached long before you use all the bandwidth of the connecting cable.

Performance considerations encourage storing not only some data on the local hard disk, but other software elements as well, including programme overlay files. The WordStar word processor, for example, includes two such files, WSOVLY1.OVR and WSMSGS.OVR. Overlay files contain programme subroutines that various applications commands require. The application (in this case WordStar) loads part of the file to get the appropriate subroutines. If these must be loaded over the network each time they are used, there will be a delay of several seconds each time while the overlays are read into memory from across the network. If this delay is not acceptable, consider storing the overlays locally, or copying them from the server to a local RAM disk at the beginning of each session with the application. An MS-DOS batch file should be used to automate the process. Remember, however, that some software licenses prohibit this practice.

You also need to know the maximum number of disk files your applications have open at any one time. The workstation must be set up to allow for the right number of files, which also affects the amount of workstation random access memory you will need. There is more information about this topic later. You should carefully evaluate the application's use of printers with respect to how your network is used. The trade-offs between attaching a printer to the workstation and using the network printer are mostly between cost and convenience. A local printer may be needed if your application requires:

* Immediate printing
* A specialised printer not suitable for other users
* Preprinted or multipart forms that must stay loaded in the printer

For example, if your workstation is used as a cash register and prints multipart invoices while the customer waits, it may be best to dedicate a printer to that workstation. On the other hand, use of a shared printer on a network server may be in order if your application specifies:

* Infrequent use of a printer
* That delays in printing are acceptable
* An expensive printer (which must be shared to justify cost)

Plotters and other output devices can generally be analysed by the same methods as printers. Some applications require modems — devices that connect your computer to a telephone line for transferring data between the workstation and a remote computer

not on the network. If your application requires a mouse, digitiser, or any other workstation peripheral, note that on the applications worksheet, too.

Next you need to determine the requirements each application places on network servers. If a specific type of server is required, that fact should be noted. Many applications can be used with any network server, but some require specific server features — such as an application that is split into two parts, one running on the workstation and the other on the server. Such an application may also make a demand on the server's random access memory, and that requirement should be noted.

Server disk requirements depend on the decisions made earlier regarding how the programmes and data will be partitioned between the server and workstation. Network server disks may be the storage option of choice when:

* Many users use a programme or data file
* Only one user needs the file, but from different workstations
* Network disk capacity is greater than local capacity
* Network disk speed is greater than that of local disks

Once you have decided what to place on the server, you also must decide whether to place it in shared or unshared, read-only or read/write storage. Most network systems require you to categorise the server's storage according to these or similar terms. If the data is accessed by more than one user at a time, it must be stored as shared data. If it is not only read but also modified, it must be read/write. Shared files may include applications programsme, DOS utilities, network utilities and multiuser databases.

It is usually only necessary to keep one copy of a shared file on the server. For example, the network software may include utility programmes to display and modify the print queue for network printers. Rather than storing copies of this utility on every workstation, you can place one copy of it in shared storage on a network disk. Unshared storage is typically used to hold files pertaining to a single user, such as:

* Private data files
* Single-user licensed applications
* User profile information
* System management files
* Software under development.

On the worksheet estimate the shared and unshared, read-only and read/write server disk space required under each of these categories. If your applfications require a certain number of files to be open on the server, note this fact also. Refer to your network documentation for more details, since some network servers handle network file opening independently of the MS-DOS file system, and the MS-DOS CONFIG.SYS FILES parameter (explained soon) is not the way to control this operation.

Next you must determine print server requirements for the application. In the previous discussion you saw that your application needs guide your choice between a local printer and a shared printer. If this application will use a network printer, you should estimate the percentage of the printer's capacity that the application will use from each workstation. For example, if a printer can print 100 plane tickets an hour and a ticketing agent's workstation can handle 20 customers per hour, each workstation may use up to 20% of the printer's capacity. You would expect that the printer could handle a maximum of five workstations. It may be appropriate to perform a more detailed analysis taking into account such things as the time it takes to turn the printer off-line while removing a ticket, reloading forms, and so on.

You should fill out an application software information worksheet for every application that will run on the network. Be sure to include network utilities and special applications such as electronic mail. From your information about all the applications that will run on the network, and about which users will run which application, you can derive the system software, workstation and server configuration of your network.

Systems Software. System software integrates the applications software with the network hardware. Your systems software plan is determined by the applications you will run, the needs of the users who run the application, and the exact configuration of servers and workstations you choose. Since you have planned only the first two items so far, you can not complete the systems software plan until you have determined the workstation server configuration. Since doing so is easier if you understand the basic principles of your network's systems software, it is important to review the documentation and make sure you understand the areas discussed in the following sections as they are implemented in your network.

One piece of important systems software probably does not come from your network vendor. Most PC networks use the MS-DOS operating system on the workstations and on the servers. In most respects MS-DOS is used in a LAN environment exactly as a stand-alone PC, but some issues should be considered, especially performance and ease of use.

The exact details of how to configure MS-DOS for your LAN PCs vary from network to network, and you must follow the directions supplied by your vendor. Two important MS-DOS system files usually come into play: CONFIG.SYS and AUTOEXEC.BAT. These files contain plain ASCII (American Standard Code for Information Interchange) text and can be created and modified by most text editors, such as the EDLIN programme that comes with MS-DOS.

CONFIG.SYS contains system configuration information that can affect network performance. One important entry is the BUFFERS parameter. A line in the CONFIG.SYS file like:

BUFFERS=20

tells MS-DOS to allocate 20 buffers in RAM for storage of disk blocks. These buffers fill up with blocks read from disk. If a programme accesses a block that is

already in memory, that data is available at memory speeds much greater than disk speeds. However, allocating too many blocks can have a detrimental effect, since the blocks must periodically be written back to disk for permanent storage, and there can be quite a pause while this happens if you allocate a large number of buffers. Additionally, each block takes 512 bytes of workstation memory, which is subtracted from memory that would otherwise be available for applications and systems software.

Another important CONFIG.SYS file entry is the FILES parameter. Structured like the BUFFERS entry, it tells MS-DOS how may files can be open at a time. For example,

FILES=20

tells MS-DOS to allocate enough local memory and DOS file control information to allow 20 files to be open at once. To set this parameter correctly, you must understand the needs of your application and systems software.

The AUTOEXEC.BAT file is used to automate the set-up of a workstation or server running under MS-DOS. All the commands it contains are automatically executed every time you start the PC. Each LAN vendor's software puts different requirements on the contents of this file, and some vendors even custom-build the file for you automatically. Using this file enables all the network software to be loaded and an application to start running before the end-user touches the keyboard.

During planning you must also determine what version of MS-DOS you will run on your workstations and servers. Many networks let you mix different revisions on the same network, but the safest course is to use only one version everywhere. Using the applications software information worksheets, you will determine the lowest and highest acceptable revision levels for MS-DOS on your system, it is advisable to use the highest revision level uniformly across the network.

Most of the new systems software you have to deal with controls the network itself. It is easiest to plan to install this software as two components: the workstation component and the server component. In each case there are two further major subdivisions to consider: resident operating software and utilities. The operating software is the part that must be configured and installed. It controls the network hardware for you while you are using the network, just as MS-DOS controls your PC's disk drives and other devices. The utilities are used to configure, extend and maintain the network. They are programmes that you run briefly to do a specific operation, like the MS-DOS FORMAT command.

Which systems software to install on the workstation varies from vendor to vendor. Generally, you need to know which network resources, especially disks and printers, you will be using from each workstation. In some cases, you just install an all-purpose software driver, and the resources you can use from that workstation depend on the user account established for you on the server. Occasionally you need to know whether the users of this workstation will be using such network applications as electronic mail, and adjust the workstation software accordingly.

In any event, you need to consider this software in the light of overall workstation

requirements. The application software information worksheet (Figure 9.5) contains most of the relevant questions that you need to answer. Your network documentation probably describes how much overall software support, with respect to memory, disk and printer, is required by the network software that runs on the workstations. Using this summary information, fill out an applications software worksheet so the needs of the network software can be factored into the workstation configuration. This single sheet can probably be used for most of your workstations. If workstations differ in the applications they run (for example, some have electronic mail privileges and some do not), you may consider those applications separately, creating a worksheet for each.

Most LANs come with a variety of utilities used to configure and operate the network. Referring to the network documentation, determine what is offered and what your network users need. This software is a prime candidate to load into network disk storage, since it will probably be used at most workstations. In most cases it includes, at a minimum, software to:

* Connect and disconnect to network disk storage.
* Connect and disconnect to network printers.
* Monitor and modify network print queue status.

You must decide whether it is appropriate for your users to have access to these utilities. In some cases, you may want to provide a batch file that executes the utility in a predetermined way. Consider the sophistication of your users and the possible damage that can be done by accidental or malicious misuse of these utilities. Software that you probably should not make widely available includes network utilities to:

* Create and modify user accounts or user profiles.
* Create and modify network disk volumes.
* Alter network security.

These utilities should be used only by you or the designated system manager, and they should be stored securely so they cannot be misused.

Network software for the server can also be treated during planning as two parts: operating software and utilities for managing the server. The operating software handles workstation requests for server devices such as disks and printers; utilities set up the server so that its resources can be shared with the network. Again, consult your network documentation to see what options are available for configuring the server operating software. In some cases, you simply load it and answer a couple of questions. For other systems you have to make many configuration decisions to suit the type of hardware attached to the server.

If your server is also used as a workstation, make note of any special restrictions in the way it can be used or the software it can run. When configuring the hardware, consider the demands of both workstation and server software. For example, there must be sufficient random access memory to support the memory-resident software of both the workstation and server.

Most LAN software controls network disk allocation by means of **volumes** or **directories.** Among the many reasons for grouping files in volumes are the following:

* Security.
* Write protection.
* Ease of finding and accessing files.
* Application software requirements.
* Providing personal disk storage.

You must understand your applications with respect to each of these categories. Also relevant is the previous discussion about grouping files according to their being shared or unshared, or read-only or read/write. In many systems these paired categories are mutually exclusive: an entire volume or directory must be declared, say, shared and read-only, or unshared and read/write. Some systems allow a finer level of differentiation, letting you assign these attributes to individual files instead of to the volume or directory. Read your system manuals to see what your network software supports. You should thoroughly understand your applications software needs and systems software capabilities in this area, since making a change usually involves redoing major portions of your installation. The applications worksheets should be re-examined to see if the server disk requirement sections are adequately filled out.

Next examine the network provisions for print service to assess flexibility. In some systems you identify your printer by name and the basic set-up is done automatically. Others require you to use printer control codes to make your printer do things like go to the top of the next page or reset to standard character pitch. You must understand your application's printing requirements, your network software's printing options, and the relationship between the two. Consider the amount of memory that the software on the server needs to drive the printer. Sometimes you can specify a print buffer size; a large buffer may speed network printing out also takes memory away from other server software.

Your network security requirements depend on your user community, the sensitivity of your data, your applications softwareand your network software. In some cases you may plan to install the network with security turned off. For example, an elaborate security system may be more trouble than it's worth in a software development environment where the users are computer knowledgeable, code under development must be shared among all users, and network-licensed compilers are uniformly used. By the time you give everyone the appropriate privileges, everyone may have access to everything anyway.

Even in such an open environment, you may help prevent accidental damage if you use read-only volumes or directories to store compilers and archived copies of the code you are developing. In a different setting, such as a retail store where the network holds the business's accounting system, point-of-sale workstations, and electronic mail between branch stores and the home store, elaborate security may be necessary.

Since the security provided by each network varies, it is difficult to create a planning worksheet that is generally useful. Base yours on the type of security your network offers and fill it out during the planning process. Your network security arrangements could address the particular user on a specific application; or you could save time and effort by assigning the same security arrangement to all users who fit in a similar class, for example, all secretaries may have the same security level, check-out clerks another level, and bookkeepers a third.

HARDWARE PLANNING

Once you have a good understanding of your users, applicationsand systems software, you can derive your needs for workstations, servers and connections. You need to determine the workstation and server hardware configurations and the connection scheme you will use to tie the workstations and servers together.

Your user information worksheets identify all the applications each workstation uses. Collect this information on a workstation configuration worksheet so that you can determine what hardware the workstation needs. By analysing all workstations, you determine the number of servers needed to support your workstations and the hardware configuration of each server. Finally, on the basis of your network's data dependencies — that is, which workstations communicate with which servers — you must build a connection plan for your cables and network transceiver cards. This plan is usually the most straightforward and is dictated by the architecture of the network system you choose.

Workstation Planning. The configuration of your workstations is determined by the applications and systems software that run on them. Your user information worksheets tell you who uses what applications software on each workstation. Your analysis of systems software reveals the hardware dependencies it imposes. You now combine this data to determine the workstation hardware configuration.

One approach to collating this information is to use a workstation configuration worksheet, shown in Figure 9.7; it identifies the major hardware requirements of each piece of software that will be run on each workstation. You need such a worksheet for every workstation, although, of course, you can duplicate the same information for workstations with identical requirements. The first two worksheet entries are for the MS-DOS and network software requirements; fill them in now or as soon as you have enough information.

Workstation Configuration Worksheet
Workstation Requirements by Application

Appli	Memory	Usage	Disk	Drive Usage		Files	Display	Printer	Dos Version		other
cation	Unshared	Shared	A:	B:	C:	Used	Type	Type	Low	High	Devices
MS-DOS											
Network											

Workstation Hardware Summary
Memory:
Floppy disk drive(s):
FILES= in CONFIG.SYS:
Display(s):
Printer(s):
DOS version:
Other devices:
Serial ports:
Parallel ports:
Expansion slots:

Fig 9.7. Workstation configuration worksheet

The user information worksheets you completed earlier contain entries for applications and workstations. For each workstation, extract the name of each application run on it and put an entry in the left-hand column of the worksheet. From the applications worksheets transfer the relevant information to the proper line of the workstation configuration worksheet. If you are proficient with a PC database management package, you can automate this process, especially if your package can handle relationships among multiple databases.

Once you have all the information about all the applications that must run on this workstation, you can see what your workstation hardware configuration must be. Analyse the data in each column and enter the results in the summary table at the bottom of the worksheet.

1. RAM must be at least as much as the sum of all the unshared memory plus the largest shared memory requirement that must be in use concurrently. Typically this is the sum of the memory requirements of your network driver software, any memory-resident utility programmes, MS-DOS itself and the largest application programme you run.

2. Some applications may require one or more floppy disk drives. (If this is a hardware expense you would rather avoid, substitute a network shared disk, if possible.) Your total floppy disk space requirements gives you an idea of how to load software on each diskette and how often your users will have to swap them.

3. Some applications may require a hard disk. The minimum disk size needed equals the sum of disk space requirements of all the applications. Again, add this expense to each workstation only after you are sure the network drive is not an option.

4. The total number of files opened by all the software that must run currently gives you the value for the MS-DOS FILES= entry in the CONFIG.SYS file. Consult the MS-DOS manual to determine how much RAM is thus consumed and make sure that figure is included in the MS-DOS memory requirement on this worksheet.

5. For each workstation you assign a video display of the type required by most applications. Determining this demands some non-network PC hardware expertise. If any of your applications require graphics, you will probably need a graphics display adapter and monitor. Most such display devices can also handle your text requirements, although often the quality of text is not as good as on a text-only monitor.

6. If any of your applications require a printer, it must be allocated here. If several of your applications require different kinds of printers, you may want to limit the number of printers you must purchase for each workstation by reallocating applications and users among workstations.

7. The DOS version needed is one between the maximum of the low entries and the minimum of the high entries listed in the workstation configuration worksheet. If the first number is higher than the second number, you have a conflict in DOS requirements and must separate the conflicting applications. Check with the vendor of the software that requires an older DOS revision and see if an upgrade is available for the newer version.

8. Any other special peripherials (such as modems, mice, digitisers or plotters) should be entered in the last column. You will probably need only one each of these but make sure choice is compatible with any two or more applications that require them. For example, if you have two different graphics applications, choose a plotter they both support.

9. Depending on the types of devices you attach to your workstation, you may need one or more serial or parallel I/O ports. This information can be derived from the documentation for the peripherals and your workstation itself. There are many ways to add these ports, and some PCs include them as standard equipment.

10. You must also make sure your workstation has enough expansion slots to hold all the peripherals you want to attach to it. Consult your owner's manuals for the workstation and the peripherals. Most network attachments take up one expansion slot. Make sure you account for slots needed to supply serial and parallel ports and to connect special devices such as mice.

At the completion of this exercise, you should have a good idea of the hardware configuration you need for each workstation. Review the systems software configuration needed to support that hardware, and factor any additional demands on the workstation back into the worksheet. If you can do so without being wasteful, be liberal enough in your figures to make sure your configuration will not fail if some piece of software needs a bit more memory than its documentation states. In performing this analysis for all your workstations, you may also decide that a different grouping of applications on the workstations can reduce cost with no loss of function. But be careful not to sacrifice the problem-solving goals that motivated your installing a network.

Server Planning. The next stage in your plan is the determination of network server configurations. Figure 9.8 shows a server configuration worksheet. If your network is small enough to function with a single server, planning is fairly simple.

If you have dozens of workstations, determining your server requirements not only requires careful analysis but may benefit from some creativity as well.

Server Configuration Worksheet
Server Requirements by Application

Appli-cation	Number in Work-station	Memory Unshared	Memory Usage Shared	Disk Usage Unshared R-O	Disk Usage Unshared R/W	Disk Usage Shared R-O	Disk Usage Shared R/W	Files Used	% Printer type	% Capa-city Used	Other Devices
MS-DOS											
Network											
Workstation Hardware Summary											
Memory:											
Floppy disk drive(s):											
FILES= in CONFIG.SYS:											
Display(s):											
Printer(s):											
DOS version:											
Other devices:											
Serial ports:											
Parallel ports:											
Expansion slots:											

Fig. 9.8 : Server configuration worksheet

To minimise cost, you will probably want to use as few servers as possible. Naturally, you need to know how many workstations a server can support. The right number depends heavily on the type of applications you are running, your pattern of using them and the ability of your network software and hardware to support that pattern. You derive your estimate from experience with your applications and form the network vendor's information. Figure 9.9 gives some very rough estimates of the number of PC workstations that can be typically supported by some of the more common types of servers under varying network loads. Actual rates of use are subject to wide variation according to individual circumstances, so these figures should not be used as the only basis for your estimate.

	Light Use	Moderate Use	Heavy Use
PC/AT server	12-18	8-12	4-8
High-performance server	18-36	12-18	6-12

Fig 9.9 : Typical number of workstations supported by different types of servers under different loads

A light load might consist of word processing or spreadsheet processing during which only data file resides on the server, or execution of an electronic mail programme. A moderate load could consist of interactive database queries and interactive transaction processing. A heavy load would comprise software development or batch database work such as report generation.

These examples are intended to give you a feeling for the problem. The true criterion is really the amount of server access required per minute. If the server is accessed only occasionally and most of the processing is local to the workstation, there is only a light load on the server and it can handle more workstations. If almost every command given on the workstation sends a request to the server, this represents a heavy network load, and the server can handle fewer workstations.

You need to know how many workstations a server can handle for each application you will run. If you need more than one server, you must decide what files and print service to place on each server. There are several reasons for grouping programme and data files on a single server:

* The applications software requires it
* Network loads suggest the configuration
* Redundant storage of the files on other servers is reduced
* All the server resources for a group of workstations are provided, and cabling costs are minimised for that group.

From these and other factors that are important in your environment, you must come up with a trial server configuration, deciding the workstation/application pairs that will use that server for network resources.

After you fill in all the information about your applications and the network software, you can analyse the worksheet in Figure 9.8 and at the bottom write your estimate of the server hardware required. Note that this worksheet tells you only what is necessary, not what is sufficient. Performance considerations determine the latter. Here are some things to consider during your analysis:

1. Server memory should be at least equal to the sum of unshared memory times the number of workstations requiring it plus the largest programme that can use shared memory at any one time. If more than two or more shared-memory programmes can run at once, you must sum their memory requirements together. Your network software documentation should help you determine this requirement.

2. Network disk capacity must be large enough to hold all the unshared files,times the number of workstations requiring them plus the total amount of shared disk storage used.

3. The maximum number of files in use at any one time determines the FILES= parameter in the MS-DOS CONFIG.SYS file. Some network software opens multiple-user files as a single MS-DOS file, so you should consult your network documentation when computing this value.

4. Your server needs one printer of each type required by the workstations. The printer's use rate is the sum of the percent of capacity used by each application, times the number of workstations running that application at once. If your use rate exceeds 100%, either your server needs more than one of that type of printer or you need another print server.

5. Other devices such as modems, tape drives and communication gateways should be noted in the server configuration. Make sure you have a way to back-up the disk storage for the server.

6. Using your projected configuration, you can ascertain the number of serial and parallel I/O ports your server needs, and you can determine the number of expansion slots required to hold all the peripheral adapter cards.

If the summary turns out to be a realistic configuration, go on to the next server. If you find you require more of some resource than can be configured on a single server, you need to rethink your allocation of servers to workstations.

Connection Planning. The final major step in your plan is usually the most straightforward. You need to determine how you will connect the workstations and servers of your network. Connections are needed whenever data must flow between two network nodes. For example, a connection is needed if an application needs to get a data file from a disk server, send output to the printer on a print server or send a message to another workstation by electronic mail.

A connection can be physical or virtual: a physical connection is a direct one by connecting cable; a virtual connection is one achieved by routing the data through one or more intermediate nodes. Be sure you understand the possibilities implicit in this distinction, since virtual connections add no cabling costs, although they may extract more of a performance penalty than a direct connection.

Different networks have different connection rules. The exact details of your network must guide your choices. In any case, you should start with a logic diagram showing the data dependency paths of your network, such as in Figure 9.3. From this diagram, your network cabling rules and your physical site map, you can construct a connection blueprint for your LAN.

Site planning for the workstations and servers themselves is usually no more complex than planning for stand-alone PCs. Adequate power typically requires no more than a convenient wall outlet with stable power, and adequate cooling usually requires only comfortable temperatures. Cable stringing is another matter, and can quickly get you involved with local safety and building regulations. Your best bet is a good electrical contractor with some previous experience in installing LANs. In addition to following electrical codes for safety, LAN cabling needs to conform to the vendor's rules regarding:

* Minimum separation between connections to the cable.

* Maximum lengths of cable runs.

* Proper termination at the ends of the cable.

* Use of drop cables from the trunk to a workstation or server.
* Repeaters to boost the signal over long distances.
* Routing away from sources of electrical interference such as AC wiring, motors and fluorescent light fixtures.

Finding the problem with an improperly laid cable can be frustrating and time-consuming, so you are well advised to learn the rules of the LAN in advance and make sure you follow them. A carefully worked out map of your site drawn to scale and showing all workstations, servers and connecting cables is a must. Study the map and make sure all the length constraints are met. Leave some room for expansion in your cable runs. For example, allow a workstation to be moved from desk to desk within a room if possible. Run bus cables near enough to potential future network node sites so you can easily add the node later.

You must also be sure to follow the cable length rules that pertain to the exact type of cable you are using. Different cable grades with compatible basic electrical characteristics may have different signal-loss rates, meaning that you may be able to use 5000 feet of one type of cable but only 2000 feet of another. Different network topologies can result in radically different cabling diagrams for the same siting of workstations and servers. For example:

* A bus may require one cable strung past all the nodes.
* A bus with drop cables sends a single cable into each office; one not using drop cables may appear to send two cables into each office (it's actually the same cable entering and leaving the node).
* A star may require much more wire than a bus, especially if the workstations are closer together than to the server at the hub

Once your cable diagram is drawn, you can decide whether to use precut cables or custom-made ones. You must balance the cost of the unused lengths of the precut cables against the labour costs of making exact-length custom cables. In many areas this difference may be slight, since the labour costs of running a single cable far exceed the material costs. If you decide to use precut lengths, be sure they also meet your cabling rules — as far as the network rules go — 20 feet of excess precut cable in a 1-foot diameter coil still counts as 20 feet.

DOING THE INSTALLATION

If you have built a trial network to learn about your system and carefully analysed your network as described here, the actual installation is a matter of executing your plan. You should build your network in testable sections, making sure each one functions according to your expectations before continuing with the installation. For example, you may install one server and its workstations and make sure they work together before adding another server.

The order of installation may be dictated by your network vendor, but it typically follows a sequence such as:

1. Set up the server and workstation hardware.
2. Make sure the combination works stand-alone.
3. Install the network cards and cables and connect them.
4. Install the system software on the server and test it.
5. Install the system software on the workstation and test it.
6. Bring up your applications and test them.

You can see that the order of implementation is practically the reverse of the order of planning and design. You start implementation with the lowest-level components of your network, make sure they work, and then build on that foundation, testing each successive layer to make sure it works too.

HARDWARE AND SOFTWARE INSTALLATION

If you are reasonably sure about your network layout you can run cables at the same time you set up workstations and servers. Make sure that the cables you need first for system testing are installed early enough. If you are unsure about your network in any way, for example, whether it will have adequate performance, run only enough cables to perform a test. String more cables when you are satisfied with your design.

Set up the servers following the instructions provided by the server and network software vendor. Connect all the peripherals identified in your server worksheet and make sure the minimum requirements for memory and disk storage are met. Workstations should be set up the same way. In most cases you can test the workstations to see if they function as stand-alone PCs. You can frequently also test the server this way, especially if it is a PC/AT.

Next, the system software should be installed on the servers and workstations configured as the documentation and your worksheets suggest. The worksheets should greatly assist you in the areas that might otherwise require a lot of guesswork, such as allocating server storage to volumes or directories, making different network resources such as printers available to your end users, and setting up system security.

Cable your server and workstations together and start testing the system. Your LAN documentation probably suggests some simple tests you can perform to make sure the basics are functioning before you start trying you applications. When you are satisfied that all is well you can start loading and testing the applications.

DIAGNOSING PROBLEMS

If all does not go well, consult your network documentation and look for an explanation of common problems or interpretation of error messages. Building and testing you network in small pieces should help you to locate the point at which things stopped working. Like most system problem-solving, half the battle is isolating the problem to a small part of the system, then fixing the faulty part or replacing it with a good part. A network has many parts, possibly strung out across a large area, and

can be formidable to debug. Some techniques for isolating problems follow:

1. Make sure every workstation and server works alone, outside of the network environment.
2. Test network connection cards with loopback plugs, if they are available, or hardware diagnostic software.
3. Test cables for short circuits with an ohmmeter. There should be no direct connection between the network cable conductors. Short circuits may be induced by a kink or pinch in the wire.
4. Test applications software on local disk drives and printers, if possible.

Try to narrow down the number of system components whose working status is unknown. Do this by swapping in components known to work. Consider using this technique with server and workstation PCs, network connection cards, cables, and even application packages that use the same or similar server resources as the suspect applications. It may be difficult to swap a cable strung through the wall or ceiling, so if you suspect it is bad, try moving the workstation or server to another location with a known good connection on the network and see if it works there. If it does, your suspicions about the cable should be heightened.

TRAINING NETWORK USERS

Once you are satisfied that your applications are installed and working, you need to train the users of your network,tuning the training to their needs. Technical users may just want copies of the network documentation and they will learn what they need to know when they need to know it. End-users who do not care at all about system implementation or utilities may only need to be trained on the applications. In any case, you should plan for some time to be spent on training and if your system is installed by or with a lot of help from a consultant, plan for that consultant to spend several days at your site to answer questions and make adjustments in the initial configuration.

MANAGING THE NETWORK

Every network needs a manager who is responsible after the installation. If your network is fairly static in the applications it runs and its configuration of workstations and servers, it may be enough to assign a non-technical user who can handle daily back-ups of the servers, answer questions about the applications and assign new user accounts as needed. A consultant can be called in when network management needs go beyond these simple ones.

If your network environment is dynamic (new applications are frequently brought up, new workstatons and servers added, security requirements undergo change, and the like), you may need an experienced person in-house or a consultant on call. Many management tasks can be handled by someone who is not a computer expert but who has received the proper training on the network.

COMMON PROBLEMS IN PHYSICAL INSTALLATION

Despite the best intentions and efforts of everyone involved, the installation and use of any high technology item of equipment rarely goes as planned. The variation between theory and practice can be a small nuisance or a huge, expensive disaster.

In this section, we will look at some of the more common difficulties encountered when installing a LAN and try to indicate how these can be avoided. Many of the problems described are common to all sorts of high-technology equipment and may well be worth remembering in other circumstances.

The gap between theory and practice occurs when the assessment of technical suitability fails to take into account the problems involved in installing the particular hardware (and possibly software in a modular system) which is required by the LAN, or when the operating conditions of the LAN deviate from the original specifications.

The problems break up into two main groups, as previously mentioned. The most common group is that produced by an inadequate original specification for the system. It is important to remember that items such as cabling are an integral part of the system and should be investigated and specified properly before a network is purchased. The main problem areas relating to poor specifications are:

1. Cabling: In the area of cabling, the physical constraints imposed by the premises become immediately apparent. The network cables, either twisted pair, coaxial or fibre optic, must be routed to conform with current provisions for cables and in the case of the electrical conductors, be well clear of any electrical noise sources. This may well mean that it is difficult or impossible to have the cables emerging where they are required. Some of the coaxial cables, e.g. Ethernet, are very stiff as they have a solid outer conductor, and are therefore restricted in the amount they can be bent. This may cause difficulties in installing them in standard cable ducts.

Positioning for the cable tap points, where the network nodes are attached to the cable, must be considered carefully to avoid problems. They should be placed as close to the networked equipment as possible, without interfering with associated equipment. However, spacing between the cable tap points may need to be maintained, depending on the type of network, and so more than one node may have to share the same cable tap point. Where a number of networked devices stand in the same area, they may overload the physical connection facilities of the network at that point.

At the other end of the scale, some nodes may be too far from the main network to be connected without exceeding the allowed distance for cabling. In some networks, this problem can be overcome by adding an extra length of cable and a repeater to boost and reconstitute the network signals but in others, it may be necessary to have the remote node as a separate system with a special connection to the main system. In either case, connection will be expensive, but there are ways of getting round these problems if they can be identified at the planning stage.

The distance limits set by manufacturers and suppliers for the full extent of their standard networks (typically 1/2 - 1 km) may seem much greater than the user's needs,

but the practical difficulties involved in installing a network will very quickly use up the available cable. By planning the optimum layout for the cable, the user can include a much greater area within the network. See Figures 9.10 and 9.11 for an example of optimising the cable layout for a bus LAN within a single multi-storey building.

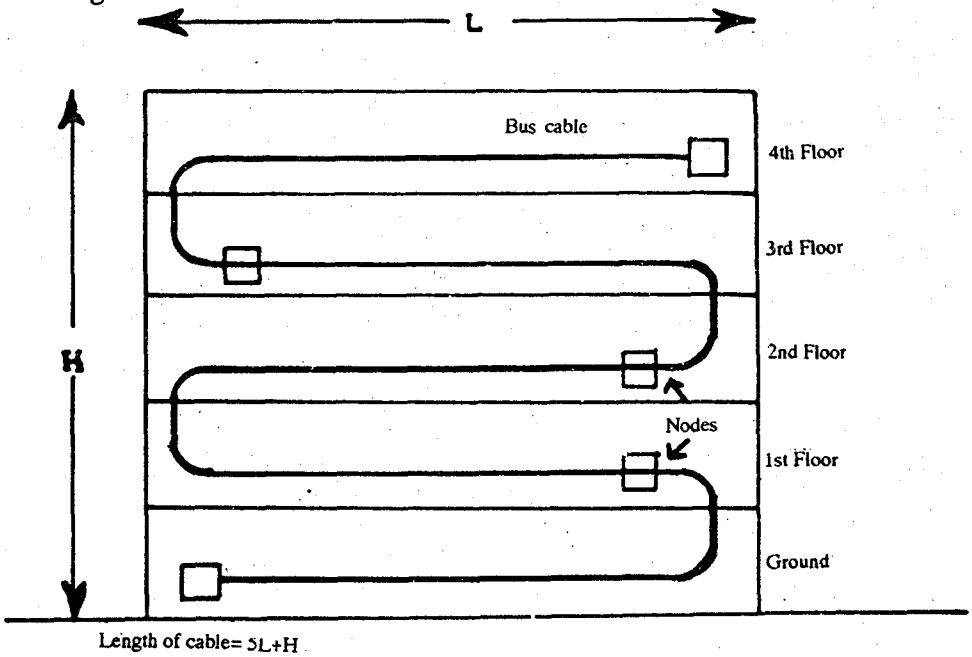

Fig. 9.10 : Cable layout for five-storey building

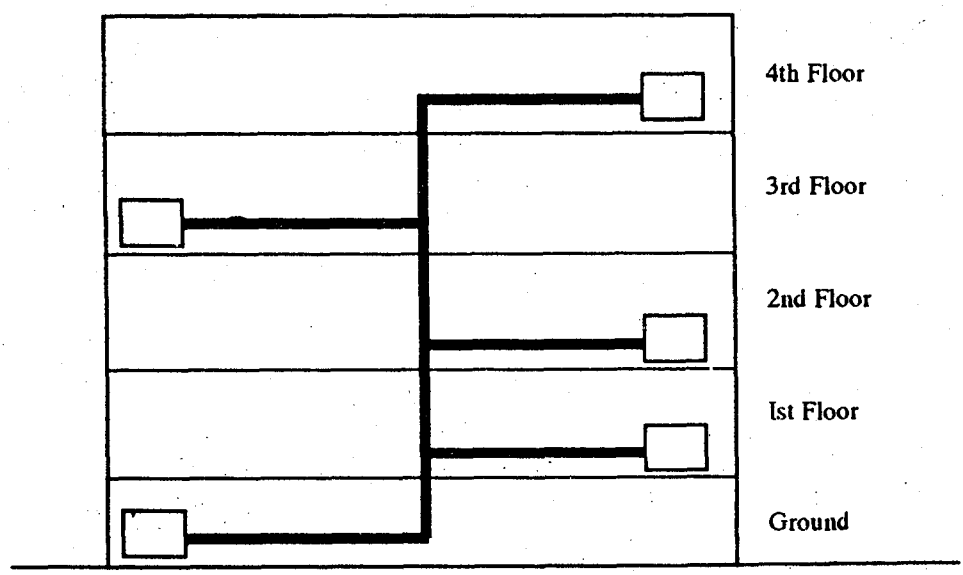

Fig. 9.11 : Alternative cable layout to Figure. 9.10

Finally, on the subject of cabling, there is the matter of the robustness of the cable. In some situations, the cable may be exposed to damp and extreme temperatures, particularly where the network connects separate buildings. More commonly, it may be prone to mechanical damage where it is not protected by suitable cable ducting. The only answer in both these cases is to determine the possible dangers, minimise them as much as possible, and protect the cable or ensure that it can withstand any remaining dangers. It is difficult to be more specific but awareness of the dangers is the most important step towards averting them.

2. Operating Software: Software to operate the network, or rather the lack of it, is becoming less and less of a problem as more manufacturers offer a complete 'turnkey' system, which includes all the necessary hardware and software. With this type of LAN, it is only necessary to ensure that the software, like the hardware, will do all that is required of it. This can normally be determined at an early stage by discussing the specifications with the supplier. After this, any inadequacies in the software will be due to inadequate specifications, or must be rectified by the supplier.

LANs constructed from component parts produce a different set of problems, and are particularly prone to software difficulties. Software from two different suppliers arenotoriously difficult to persuade to communicate with each other and this single problem of incompatible software may be the greatest hurdle in getting a LAN into operation. Again the only way to avoid this is to specify the operating parameters of each software package exactly and, where possible, test the software in advance under realistic conditions. There is no substitute for seeing a version of the network you are interested in working under similar circumstances to your own projected requirements.

In general, it is best to avoid any system where the software must be tailored to operate as required. Even if the user can do this job, the time and expense involved make it an unattractive proposition unless there is no other possible solution.

3. Expandability: Again, the lack of this facility may create problems once the system is installed, particularly if the network performs well. It is always desirable to increase the usage of a LAN if it is seen to be successful and provision should be made at the planning stage for any possible extra uses of the system after it is commissioned. Expansion difficulties may be caused by any or all of the following:

a. Lack of physical access points, i.e. the number of cable tap points and positioning of the cable may be inadequate to allow extra devices to be connected to the network.

b. Lack of logical access points, i.e. the system operating software may not provide sufficient logical nodes or unique addresses for all the devices requiring access to the LAN. This is a serious potential hazard if the software cannot be altered to suit an expanded network and prospective users should ensure that a network can provide access for all their future needs. Manufacturers' specifications for the maximum number of nodes allowed vary tremendously but usually increase in proportion to system cost.

c. Lack of data-carrying capacity, i.e. the network may be able to support extra devices but adding them to the LAN degrades its performance to an unacceptable level. This will happen in any LAN as the actual combined data transmission rates of the attached nodes approaches the quoted data transmission rate of the network. As this point is reached, more data is being generated by the nodes than the network can transmit, and so the data must join a queue until the network is ready for it. This phenomenon is familiar to users of large mainframe computers, and when the computer is overloaded serious delays can result which makes the system difficult to use.

All three points mentioned here must be noted if the network is to be expanded successfully in the future. Additionally it should be possible to add extra cabling to the system without unnecessary expense or difficulty. This will allow both for expansion and for alternative uses of the network, when equipment is moved and used in new locations.

4. Standardisation: Where the LAN is supplied complete with workstations, standardisation of interface will not be a problem. If however, you are looking for a LAN to interconnect existing equipment, it is vital that the LAN nodes should be capable of connecting to the equipment without difficulty. This implies some sort of standard interface unit compatible with the interface units on the existing equipment.

There are a number of standard, or rather generally accepted, forms of connection available on the types of equipment likely to be used as workstations, file servers or print-servers in the network. The most common will be some form of serial data link using RS232C/V24 protocols, simple 8-bit parallel data links like the Centronics interface standard, or more complex 8-bit parallel data links like the IEEE488 interface bus. The last is very common in programmable test and measurement equipment.

If the LAN under examination is to be used for a variety of equipment and does not provide interfaces for some or all of the standards mentioned above, it is unlikely to be suitable.

A number of commercially-available LANs are designed for use with specific microcomputers, such as the Apple or IBM PC, and include interface units that plug directly into the expansion sockets in the microcomputer. These networks normally allow other devices to be attached via interfaces in the microcomputer and are thus versatile in terms of the range of compatible equipment. However, each extra device attached to the network requires a microcomputer to act as an interface unit; and so adding new items is an expensive proposition, as extra microcomputers will be tied up in servicing these. See Figure 9.12.

In general, standardisation of interconnections can be a serious problem for modular LANs used to interconnect existing equipment, but is unlikely to be a significant installation and operation problem in turnkey systems.

As use of the network changes, other difficulties may arise. Matters such as expandability and overloading have already been touched upon as consequences of poor specifications but they will become acute if the way the network is used changes

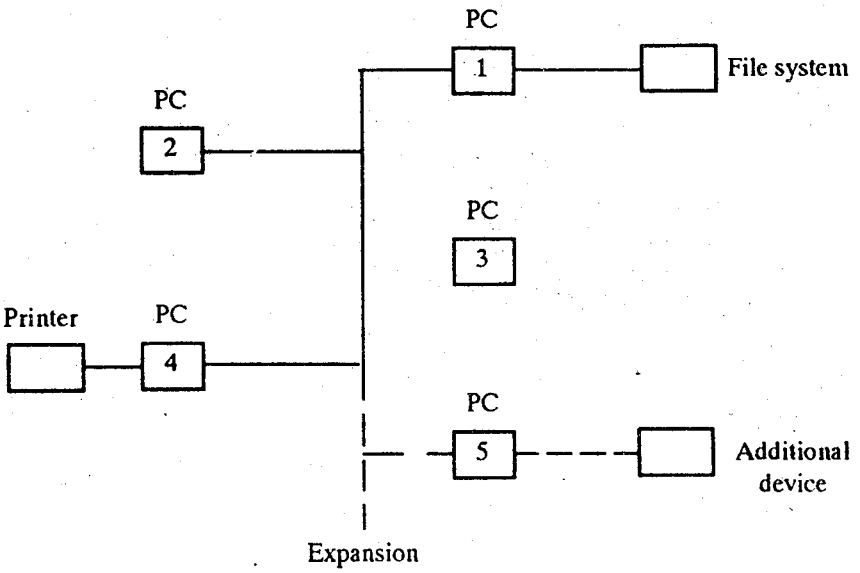

Fig. 9.12 : Problems inherent in LANs dedicated to single types of microcomputers

with time, particularly as more potential users see the advantages of applying the installed LAN to their requirements. It is therefore vital that manufacturers and suppliers provide technical support both during installation and operation of the LAN. A good supplier should be happy to have a representative on-site throughout the installation period and to continue to make engineers available if there are any problems after installation is complete.