Communications Infrastructure for Buildings

BUTLER COX FOUNDATION

Research Report 62, February 1988

BUTLER COX
FOUNDATION

Communications Infrastructure for Buildings

Research Report 62, February 1988

Butler Cox & Partners Limited

LONDON
AMSTERDAM MUNICH NEW YORK PARIS

Published by Butler Cox & Partners Limited
Butler Cox House
12 Bloomsbury Square
London WC1A 2LL
England

Availability of reports

Members of the Butler Cox Foundation receive three copies of each report upon publication; additional copies and copies of earlier reports may be purchased by members from Butler Cox.

Photoset and printed in Great Britain by Flexiprint Ltd., Lancing, Sussex.

BUTLER COX FOUNDATION

Communications Infrastructure for Buildings

Research Report 62, February 1988

Contents

BUTLER COX FOUNDATION

Management Summary

A Management Summary of this report has been published separately and distributed to all Foundation members. Additional copies of the Management Summary are available from Butler Cox

Chapter 1

Building wiring: the need for action now

In the past, organisations have taken quite different approaches to the different types of communications wiring installed in their buildings. The PTT or telephone company has prewired the building for telephony. The site-administration department has installed the wiring used for environmental-control purposes and for security locks and cameras. Wires for data communications have been installed in an ad hoc manner by the data processing or telecommunications department. As a result, some organisations, especially in the financial sector, have more than a dozen different types of wiring supporting specialised services such as stock-market information and dealing, radio paging, and public address, not to mention several varieties of digital data transmission.

Many organisations therefore find themselves with a complex, often unmanageable, collection of wiring that is difficult and expensive to maintain and extend. Some have even begun to talk of installing 'one of everything' in their new buildings — Figure 1.1 lists the eight separate cabling systems installed in one new office building. The 104 Foundation members that replied to our enquiry at the beginning of the research, had, on average, each installed four different kinds of wiring. Figure 1.2 shows the types of wiring that were reported, and the percentage of respondents that had installed each type.

Organisations have begun to realise that the high costs of ad hoc approaches to wiring, and of the subsequent rewiring that may be necessary, are unacceptable. Often this realisation comes as an organisation contemplates the move from dumb terminals, each with its own cable, to intelligent workstations connected via local area networks. Organisations are therefore beginning to recognise that the provision of an appropriate communications infrastructure within their buildings is a strategic issue. The lack of an appropriate infrastructure can delay, or even prevent, the introduction of new communications facilities, or can make it very expensive to provide them. On the other hand, if buildings have been prewired with an appropriate communications infrastructure, new facilities can be introduced with the minimum of cost and disruption.

Many Foundation members believe that wiring is a strategic business issue, as the response to the

Figure 1.1 Eight separate cabling systems have been installed in one new office building in the City of London

Cabling system	Use
Unshielded twisted pairs	Telephony
Optical fibres	Financial information services
Broadband	TV distribution and as Ethernet backbone
Baseband Ethernet	PCs
Wang coaxial	Wang office automation systems
IBM Cabling System (type 2)	Terminal support
Screened multicore	Various, including financial information services and dealing systems.
Other	Security systems

Figure 1.2 Types of wiring used by Foundation members

Use	Type of wiring	Percentage of responses
Telephony	Twisted pair cables	100
Data	IBM 3270 coaxial cables	64
	Ethernet coaxial cables	38
	Optical fibres	28
	Other proprietary cables	28
	IBM Cabling System	21
	Broadband coaxial cable	17
	Other (mainly IBM twin-axial 8100 loop)	12
Environmental control	Separate cables	47
Security	Separate cables	54

(Source: Survey of 104 Foundation members) questionnaire we sent out at the beginning of the research shows (see Figure 1.3).

However, this recognition is not often matched by any marked change in practice. Only a few of the organisations that responded to the questionnaire had prewired any of their buildings, and there was little correlation between the attitudes expressed and the wiring practices actually used.

Major computer and communications suppliers have responded to the growing complexity of wiring needs by announcing 'integrated' or 'universal' wiring systems, and innovative suppliers have increased the uses to which standard telephone wiring can be put. And local area networks, once seen as a technology looking for an application, are now central both to the communications architectures of major suppliers and to the systems plans of user organisations. Local area networks can also now operate on a much wider range of wiring schemes than they could before.

The suspicion arises, and it is clearly shared by some Foundation members, that the current attention to wiring is simply a new fashion, or yet another ploy by suppliers to lock in users in the name of flexibility and openness. However, our research shows that most organisations should now be taking action on wiring if they have not already done so. Wiring is out of control in many organisations, but, by prewiring new buildings, and by taking a rational approach to upgrading wiring in existing buildings, the situation can be brought back under control.

Building wiring is certainly a strategic issue for the systems department because attention and investment are needed now in order to secure future benefits, many of which cannot be precisely identified. But it is not, we believe, usually strategic for the business in the sense of either enabling or constraining major business decisions. If the wiring is unsuitable, however, then the implementation of major business decisions may be expensive and troublesome. The resulting problems will reflect badly on the systems department and can be avoided only by effective preplanning and prewiring.

Figure 1.3 Many Foundation members believe that building wiring is a strategic issue

Perceived importance	Number of responses
A strategic issue for the business	48
A strategic issue for the systems department	23
A tactical issue for the systems department	24
A strategic issue for the communications department	0
A matter for the site services department	5
A matter for the PTT	0

Members were asked to categorise the importance of building wiring. One hundred replies were received. Some respondents ticked several boxes on the questionnaire, and their replies have been included in the category that accords wiring the greatest importance.

RESEARCH ACTIVITIES

The conclusions and recommendations set out in this report are based on a research programme carried out during 1987, led by David Flint, a principal consultant with Butler Cox in London. They are also based on the practical experience of the Butler Cox Building Technology Group, under the management of John Lane. This group has carried out many consulting assignments concerning the information technology aspects of company relocations to new and refurbished buildings. Research assistance was provided by Simon Forge, a senior consultant with Butler Cox in Paris, and Bo Loven of Statskonsult, the Foundation's agent in Scandinavia.

The research included:

- A questionnaire distributed to all Foundation members with the document describing the scope of the research for this report, to which 104 members responded.
- A very detailed questionnaire about building wiring sent to those Foundation members that indicated they wanted to be involved in the research. Fifteen responses were received.
- Desk research to derive lessons from previous research and consultancy.
- Interviews both with managers responsible for building wiring and with product managers in leading suppliers of wiring schemes and computer systems.
- Study of suppliers' literature.
- Cost modelling, especially to determine the value of prewiring.

The research covered Europe, the United States, Australia, and the Far East.

WIRING IS OUT OF CONTROL

In many organisations building wiring is not under effective management control. This situation has arisen because of the piecemeal approach to wiring over many years, particularly for data communications, by both suppliers and users. It is the resulting complexities and inconsistencies that create the present problems.

In the case of data communications, most organisations have used a different cabling system for each type of terminal equipment, and, usually, a new cable has been installed for each new terminal. There are several reasons for this. Although standards do exist, many suppliers seem to have taken an almost perverse delight in ignoring them, preferring to develop their own data communications protocols. Even individual suppliers have specified a variety of differing cables and signalling systems, depending, it seems, on the preferences of individual designers. And designers of communications systems have not paid sufficient attention to the practicalities of wiring systems, which has led to some extremely inconvenient pieces of equipment. For instance, Ethernet transceivers are too big to fit into the ducts in many buildings.

Furthermore, the wide variety of local communications systems has demanded a corresponding variety of technical knowledge and skills. (At one point, the author of this report identified more than three dozen different local area network technologies.) The high rate of innovation has quickly made these skills obsolete, leading to a shortage of skilled staff. And the absence of accepted standards has made it difficult for skilled staff to record their knowledge for the benefit of others with less experience.

A much more rational arrangement has applied in the area of voice communications (essentially telephony), with similar telephone wiring schemes being used in most countries. Moreover, there has been a general expectation (which has not always been fulfilled) that new equipment and PABXs would be compatible with older wiring (and vice versa). The installation of new telephone equipment has not usually required new cables, and, where new cables and sockets have been required, installing them has usually proved to be fairly inexpensive and straightforward. This rationality stems from the existence of PTT monopolies or dominant suppliers and from the suppliers' interests (because of their responsibility for the telephone wiring installed in buildings) in having wiring that is convenient to maintain. However, even the highly regulated telephone environment has not ensured complete compatibility between wiring in different countries. Nor has it ensured compatibility between telephones and PABXs from different suppliers for the more sophisticated kinds of interworking.

More recently, the appearance of proprietary digital feature phones (especially those from non-traditional suppliers) that require extra pairs of wires in the telephone cable has begun to undermine this beneficial arrangement. The telecommunications wiring situation is thus becoming more complex just when the benefits of standardisation are becoming apparent for nonvoice wiring.

A further complication arises from the rapid expansion of both data and voice communications. This has required the installation of many more cables and has led to congestion in the spaces in which the cables run. Of the organisations that answered the question about cable congestion in our detailed survey, 38 per cent reported that riser space was either very tight or completely inadequate, and 46 per cent gave the same answers for horizontal space. ('Risers' are shafts connecting the floors of a multistorey building through which building services are run. 'Horizontal space' is the space on a single floor through which services are distributed from the risers to the places where they are needed. These and other cabling terms are illustrated and defined in Figure 1.4 overleaf.)

The lack of control of wiring is identified by these symptoms:

- Costs are often not properly known and, where they are, are often higher than they need be.
- There are often serious delays in moving terminals and other IT equipment.
- Technical mistakes are common.
- Many organisations depend on external contractors to make changes and extensions.

COSTS ARE NOT KNOWN AND ARE HIGHER THAN THEY NEED BE

In our work in this area we have been repeatedly surprised by the lack of information that organisations have about the costs of moving and installing IT equipment. Many of the respondents to our questionnaires were unable to provide a breakdown of these costs. In many organisations the total costs of moving and adding workstations are not known because the separate cost components, such as planning, materials, and labour, are assigned to different cost centres and have not been collated. Some organisations base their costs on a fixed amount, although the amount often seems to have been devised purely for bookkeeping purposes rather than to reflect the resources and staff used.

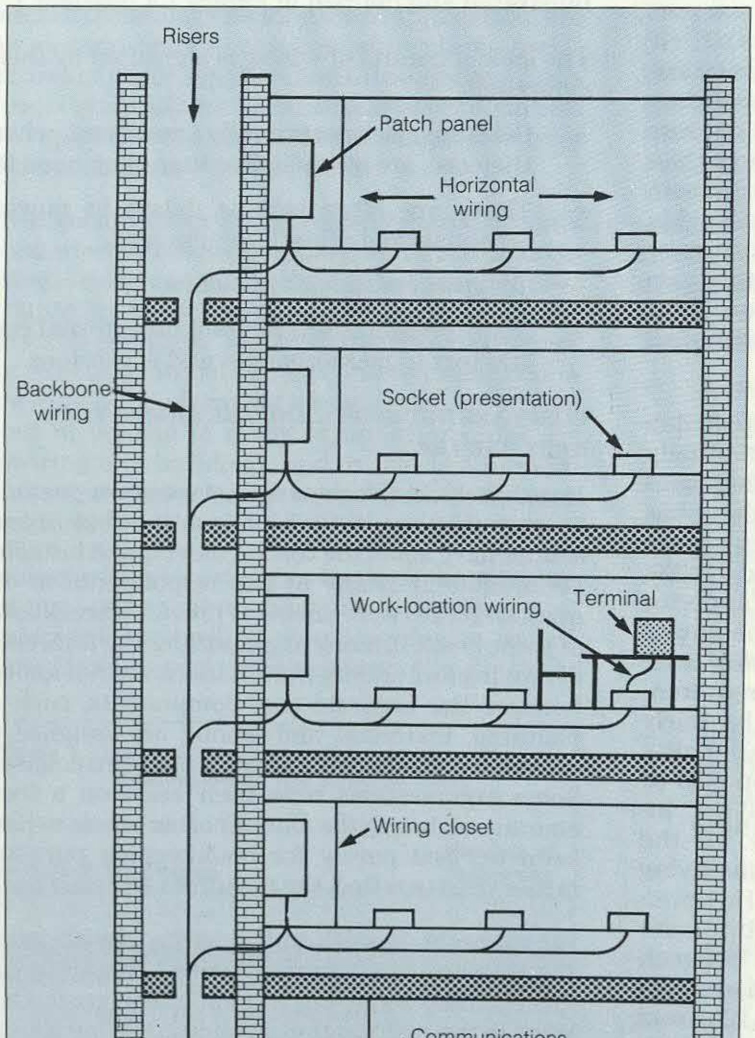
For example, in a UK public utility the standard charge for moving a workstation is £100 ($185), but this excludes some, but not all, labour costs. Cost levels in this organisation are monitored but are not collated across sections and are not allocated to individual jobs, or types of job. A 1987 survey showed that, of six financial institutions that had recently installed dealing rooms, two could not quote the costs of installing cables and another two could provide only incomplete costs. Only one was able to give the requested breakdown of costs. Another example is provided by a large insurance company that did not know the costs of connecting terminals for the four different methods used. Until

Butler Cox performed a consultancy study, this company had not recognised that one method (data-over-voice to a local multiplexor) was less expensive and could be installed more quickly than the others.

Even where costs are available, they are not always complete. Thus, the quoted cost of wiring a new building may exclude the costs of trunking and floor traps if these are accounted for in a different budget (for instance, if they are installed by the electrical contractor, but the voice and data wiring is not). In practice, these costs may exceed the cost of installing and terminating the cables.

The cost of installing and moving terminals is obviously of concern to Foundation members, as is shown by Figure 1.5, which shows it was rated the most problematic area by those that completed our detailed questionnaire. The figure also shows that telephone wiring was not considered a problem, being rated overall as less than minor. Data wiring problems are rated overall as being less than significant. Interestingly, the problems were rated in

Figure 1.4 Building wiring schematic



It is usual to divide building wiring into four zones:

— Computer room, if present. (Computer room wiring is outside the scope of this report.)

— Backbone wiring, from the computer room and main communications distribution frame to the floors.

— Horizontal wiring, from the backbone to the work locations. This usually terminates in a socket, which is often known, together with any supporting structure such as a floor trap, as a 'presentation'.

— Work location, from the socket to the device.

On large campuses with many buildings there may be a separate 'site backbone' system, usually carried in buried ducts.

Backbone wiring usually runs in 'risers', which are shafts connecting the floors of a multi-storey building through which building services are run. In large, low buildings, the backbone wiring system may have horizontal elements that are housed in large underfloor conduits or carried overhead on trays in the ceiling voids. In small installations there may be no separate backbone zone.

'Horizontal wiring' is used to distribute services from the risers to the places where they are needed. The alternative spaces that can be used to house horizontal wiring are:

— Above a false ceiling.

— On trays suspended below the ceiling.

— In wall trunking, which may be at waist level or just below the ceiling.

— In special furniture that incorporates cable ducts as an integral part of its design.

— In skirting board trunking.

— Under the carpet, using flat cables.

— Buried in the concrete floor screed, using screed-depth trunking or conduit.

— Under a false floor.

— In the ceiling void of the floor below, with the wiring presented through holes in the floor.

Horizontal distribution tends to be the most expensive part of a building wiring scheme, and installing horizontal wiring causes much greater disruption than any other kind of wiring.

The 'work-location' wiring is usually supplied by the supplier of the equipment and is often the least tidy part of the installation. Again, work-location wiring may be enclosed in special system furniture.

Figure 1.5 Members' rating of building wiring problems

Problem	Rating for telephony	Rating for data devices
Excessive cost of moves	0.9	1.5
Excessive cost of additions	0.9	1.5
Excessive cost of maintenance	0.75	1.3
Delay in moving a device	0.8	1.2
Delay in connecting additional devices	0.8	1.2
Lack of cable documentation	0.8	1.2
Disruption when adding or moving devices	0.6	1.2
Lack of bandwidth for new device	0.6	1.0

Members reported the severity of their wiring problems on a four-point scale:
0 Negligible
1 Minor
2 Significant
3 Serious
The above figures tabulate the average responses.

(Source: Detailed survey of 15 Foundation members)

the same order of severity for both telephone and data wiring, with cost being perceived as a greater problem than delays and disruption.

Our research also seems to indicate that some organisations are paying too much. The wiring costs reported varied greatly — the cost of moving a mainframe terminal ranged from as little as $36 to as much as $900. Some organisations obviously regard these higher costs as acceptable, as excessive cost of moving or adding a terminal was rated as being merely somewhere between a minor and a significant problem. We find this surprising because these costs are much higher than those for telephone wiring and higher than they need to be.

Installation costs are usually in the range of $200 to $500 per data socket installed, although in some cases they are much higher:

— One financial institution in the City of London claims it spent £5 million ($9 million) on wiring up 500 dealer desks, each with three screens.

— The Paris head office of a large systems house spent FFr38,000 ($7,000) per office on wiring. Every office was provided with two special nine-socket faceplates costing FFr4,000 ($750) each. Each faceplate was connected to a wiring closet by a mixture of coaxial television cables and 32-pair unshielded cables at a cost of FFr15,000 ($2,800) per faceplate. (The high costs reflect to some extent the 18th-century origin of the building.)

— The installation of IBM's Cabling System in American Express's New York office cost more than $1,000 per socket.

Some surprisingly high costs of moving a terminal were also reported:

— In a large UK manufacturer, the average cost of moving a terminal is £400 ($750). The same cost was reported by a local government body, currently occupying an old building.

— A Dutch systems house reported an average cost of G500 ($270) for each terminal move. However, since only one-quarter of the moves required wiring changes, the costs of those moves were clearly much higher.

These costs seem very high compared with the lowest costs reported:

— At an Italian bank, the cost of moving either an IBM 3270 or an asynchronous terminal was only $95.

— In one office of a large public utility, prewiring with an inexpensive proprietary local area network meant that the cost of moving a terminal was only $36.

— At the head office of a large manufacturer, the wiring scheme allows terminal and PC moves to be carried out by computer operators in the overlap period between shifts. As far as this organisation is concerned, it costs nothing to move a terminal.

— In a large financial institution, the wiring scheme installed permits users to move their own networked PCs in many cases, so that no direct costs are incurred.

MOVES ARE OFTEN DELAYED

The delay between a request to move a terminal and the work being done is often many weeks. The table in Figure 1.6 shows some examples. In the case of the building society, the delay is caused by the need for British Telecom to change the main distribution frame and by planning and reconfiguration work within the society. In the public utility, moving a terminal requires work to be carried out by three

Figure 1.6 The delay in installing or relocating a terminal can be several weeks

Organisation	Delay
UK building society	8 to 10 weeks
Public utility	4 to 6 weeks
Airline	6 to 8 weeks
Manufacturer	More than 4 weeks

different departments — computing, engineering, and premises, each of which reports to a different director. Although a move could, in principle, be completed in just one day, the need to coordinate the work of several departments means that it usually takes weeks, or months in a really low-priority case. Tasks are grouped together for the convenience of the tradesmen who do the work and for the purposes of economy, not to provide a good service.

We were surprised at the lack of concern shown by many communications staff about these delays, which they often seemed to feel were beyond their control.

TECHNICAL MISTAKES ARE COMMON

In the research for this report, and also in our consultancy in this field, we have been surprised by the apparent frequency of technical mistakes. Some examples of mistakes we have found are:

- A newly installed floor trap that was too small to take the required plug (the socket had to be mounted at an angle to solve this problem).
- Floor traps that were too small to take the size of power plug provided by the main supplier of IT hardware.
- 'Metal' conduit, part of which was made of plastic, and which was therefore not providing electrical shielding.
- Newly installed telephone wire that was not earthed according to the relevant national standard.
- Newly installed telephone wire in which spare pairs had been neatly cut back so that they could never be used.
- Two sets of local area network wiring that were so poorly installed that they had to be completely redone within a few months.
- Concrete floor screed that was too thick (due to inadequate quality control during construction) to install conduit conveniently.
- Trunking installed in a small underfloor space that had only one compartment for power cables. This meant that electrical power points were available only on one side of the trunking, effectively preventing workstations being installed on half the floor.

These examples, and we could cite many more, show the crucial importance of good 'hands-on' technical management of wiring.

DEPENDENCE ON EXTERNAL CONTRACTORS FOR EQUIPMENT MOVES

In many countries, the PTTs have, at least until recently, been the main source of supply for building wiring. Some organisations have taken the view that since the PTT has to install and maintain the telephone wiring, it might as well look after the data wiring as well. The effect of this is to put control of the building wiring outside the organisation. This inevitably leads to delays, because the PTT will schedule work according to its own priorities, which may not be those of the organisation.

A similar problem can arise when the organisation is dependent on external contractors. One large insurance company has all its cabling work done by a contractor whose staff have to travel over 200 km to reach its offices. The company explains that it has to use this contractor because there is little documentation about the wiring and only that contractor is familiar with the building. To avoid paying repeatedly for the high travel costs, the company only calls the contractor in when it has several jobs to do, thus guaranteeing delays for some of the work.

A further problem is the uncertainty of costs. In some countries, the PTTs have traditionally carried out wiring work at low rates. In the United Kingdom, liberalisation has encouraged many ill-prepared contractors to enter the field, so that work carried out at apparently low rates may turn out to be faulty and have to be put right at much greater cost. Liberalisation in other countries may produce the same result; on the other hand, 'fair competition' rules and commercial pressures may eliminate discounting by major contractors.

THE POSITION CAN BE IMPROVED

Our research has shown that the best way of ensuring that the most appropriate communications infrastructure is installed in buildings is to:

- Plan for flexibility, in particular by involving the systems department as early as possible in the planning of building services.
- Prewire new buildings for voice and data, and prewire an existing building during major refurbishment.
- Adopt a rational approach to improving existing wiring.
- Manage existing wiring in an active way.

The early involvement of the systems department in building planning can avoid later difficulties with cabling and other IT matters. As we show in Chapter 2, the systems department should ideally be involved from the building-design stage onwards. Chapter 2 also identifies the major areas of uncertainty that create the need for a flexible communications infrastructure.

In Chapter 3, we identify and compare the various technical options for building wiring. In particular, we compare the IBM Cabling System (which is based on shielded twisted pairs) with proprietary wiring schemes based on unshielded telephone cables. We conclude that, in most cases, schemes based on telephone wiring cost less than the IBM Cabling System and will be able to meet most local communications requirements for the foreseeable future. In the longer term, however, building wiring will be based on optical fibres.

The benefits of prewiring are discussed in Chapter 4. These benefits are significant and include:

- Improved control of wiring by the systems department.
- Easier moves into new accommodation and subsequent moves within the building.
- Increased speed of response to requests for additional equipment and for moves of existing equipment.
- Fewer faults.
- Cost savings.

Similar benefits may be obtained if a building is prewired during a major refurbishment.

Significant benefits can also be obtained by taking a rational approach to improving existing wiring systems. Taking a rational approach does not necessarily mean comprehensive rewiring. It may, depending on the circumstances, involve the installation of a local area network, the use of a digital PABX for data transmission, or the use of multiplexors to extend the usefulness of existing wiring. These options are discussed further in Chapter 5.

Finally, active management of the wiring system can both maintain the benefits achieved by prewiring and increase the value of an existing wiring system. This is the subject of Chapter 6. Neglecting basic wiring-management practices such as labelling, testing, and record keeping will mean that it will become increasingly difficult to maintain the wiring system. As a result, costs and delays will increase and, if the neglect continues for long enough, it may be necessary to rewire the building completely.

THE NEED TO TAKE ACTION NOW

In this chapter, we have highlighted the importance of wiring and have drawn some conclusions about how wiring issues should be addressed.

During the next five years or less most Foundation members will install as many terminals and workstations as they have done in the last twenty years. These devices will have substantial communications requirements, and their users will become even more dependent on them than they are at present. If systematic solutions to the wiring problems are not found quickly, ad hoc solutions will be used instead, leading to further problems and making it even more difficult to adopt systematic solutions later.

The action that needs to be taken will depend upon the organisation's particular circumstances and will range from improved control of changes made to existing wiring to complete refurbishment. Some Foundation members have already resolved the issues raised in this report, and we have benefited from their experience. Those who have not yet addressed this issue should do so now.

Chapter 2

Plan for flexibility

Because of the long period for which it will be used, installing a wiring scheme is more like installing a database management system or a network architecture than a computer terminal. A terminal is rarely expected to last more than five years and is often replaced sooner than that. A wiring scheme will have to last for many years. Despite this, many systems departments choose their wiring scheme on the basis of the terminals currently installed.

During the lifetime of a wiring scheme there are bound to be large increases in the numbers of terminals and workstations. There will certainly be a move away from dumb terminals to intelligent workstations and a consequent adoption of local area networks as the central technology for office communications. (Quantitative evidence, based on the responses to our surveys, for the speed at which these changes will occur is given in Appendix 1, together with Butler Cox's view of the likely trends.) Even so, there are large uncertainties about the communications infrastructure required for future offices. The nature and numbers of future office buildings, office workers, and office systems can only be guessed at. And the architecture of future systems cannot be foreseen in anything but the most general terms.

Optimum communications networks and wiring schemes can be devised only if the requirements are precisely and fully known. Since it is, in general, impossible to know the communications requirements of future workstations and other office equipment, there is a temptation to base networks and wiring schemes on today's requirements. If networks and wiring schemes are optimised for today's requirements, they are almost certain to cause problems in the future.

Therefore, managers should make long-term flexibility their first objective when planning the communications infrastructure for buildings. Often, the lack of flexibility found in many organisations today stems from the fact that the systems department was not involved early enough in planning the building and its infrastructure. A prerequisite for planning for flexibility is thus to involve the systems department at the earliest possible stage. It is also necessary to recognise that a wiring scheme will last for many years, so it is necessary to plan on a long-term basis. Throughout its life, the wiring scheme will need to be able to cope with an ever-changing IT environment and an ever-changing population of devices connected to it, in terms both of the types of devices and of their physical location. It will also have to take account of the uncertainty of the business environment, which may change dramatically even in the short term.

INVOLVE THE SYSTEMS DEPARTMENT AS EARLY AS POSSIBLE

In the past, the space requirements for computer systems, communication systems, and their associated wiring were usually considered only after the architects, space planners, and mechanical and electrical engineers had laid claim to the, often scarce, building spaces. It is still common for the systems department to get just a few weeks' notice of the need to provide a new building with a PABX, telephone wiring, and data communications, with the result that either the move has to be delayed or staff must move in without essential services.

Many organisations now depend completely on their systems, and the planning of those systems cannot be separated from the planning of the business itself. It is not sufficient for IT needs to be considered only after a building has been designed or chosen, or after a refurbishment has been planned, because decisions that will make IT provision difficult may already have been made. For instance, many buildings constructed in the 1960s are unsuitable for IT because of their low ceilings and lack of underfloor spaces. If possible, it is best to avoid these buildings.

The provision of building space and facilities for IT systems cannot be entrusted to nontechnical people (including speculative developers, premises departments, line managers, architects, and space planners) because they often fail to understand the needs of IT systems.

Speculative developers define the base requirements for their buildings to their contractors, covering everything from the grade of structural steel to the quality of sanitary fixtures. Their aim is to obtain the largest possible amount of usable space from their investment and they therefore minimise the amount of space allocated to building services. Some construction contracts contain up to 6,000 clauses, but most of them do not cover the provision of IT wiring.

Line managers who commission new buildings, and the premises departments that advise them, are often equally indifferent to IT requirements. For instance, one large civil service department is currently moving into a building that was originally designed as a hotel. The marble flooring on the ground floor (which is laid on three feet of structural concrete) and inadequate underfloor spaces on the 'bedroom' floors are seriously complicating the wiring task.

Although building design is a well-established profession, it is not possible to assume that architects, engineers, and builders will make the necessary provision for IT. Some, of course, take a broad view of their responsibilities and will seek to involve the organisation's systems department at an early stage. But others do not recognise the need or are unwilling to take account of IT. Two examples serve to illustrate this point:

- The decision to move the systems department of a large manufacturer (30 people and the computer room) to a new building was taken quite late. By the time that the department was first asked about its requirements in the new building, most of the space had already been allocated for other purposes. As a result there are one-metre floor voids everywhere except in the computer room, where they are smaller.
- In another case, the architects did not allow space for enough risers. When this became clear, they marked out new locations for additional risers, and the builders began to cut through the partially completed building with pneumatic drills. The building started to collapse and two adjacent railway lines were closed pending repairs. The computer, already installed on the top floor, had to be removed with a crane.

It is also impossible to assume that adequate provision for IT will result from contractors complying with professional standards. Such standards as do exist deal only with part of the problem — for instance, they may specify safety and electrical properties (though not all countries' standards do both) but provide no guidance on cable routeing or on the number of outlets. In any case, some contractors are ignorant of the standards that do exist. This is especially true for electrical contractors, who are often ignorant of IT wiring practices.

THE ROLE OF THE SYSTEMS DEPARTMENT

The role of the systems department in planning the move to a new building or the refurbishment of an existing building is, of course, much wider than merely providing advice about wiring. The systems department should endeavour to ensure that all IT-related factors that will affect the use of the building during its lifetime are considered fully. These factors include the likely impact of increasing computer use on work patterns, lighting and power requirements, air conditioning, and security.

Thus, the systems department should ensure that the other parties involved in planning and executing a move to new premises recognise the wide range of issues in which the department should have a say. These include:

- Building design or selection: Will the building have enough power, enough cooling, and enough space for cables?
- Space planning: Will the building have space for wiring closets, for departmental computer rooms, for central computer rooms, and for desktop workstations?
- Furniture selection: Does the furniture have space for cables? Will they connect with the ducts that the space planners have provided for cable distribution? Are the work surfaces at the right height for keyboards and screens?
- Lighting: Is the lighting suitable for visual display users?

The earlier the systems department can be involved, the greater the scope it has for influencing factors that could affect the introduction of new IT facilities. Ideally, the systems department should be involved from the building-design stage onwards, allowing it to provide input concerning the size and locations of risers and other cables, the provision of earths and power supplies, space planning, and the selection of furniture.

If the systems department is not involved until the building has been constructed or, worse, fitted out, the facilities may be quite unsuitable. For example, when Bank of America chose a new office in Bromley, London, it found that, although the building was new and generally well finished, the underfloor ducts were quite unable to meet the bank's wiring needs. (The bank has at least as many terminals as staff.) The broadloom carpet already fitted made it impractical to install new underfloor ducts.

At the building-design or selection stage, systems management should specify its space and building-services needs to architects and space planners in terms that they will understand. At this stage, the role of the systems department should be to define the maximum possible requirements for IT equipment in terms of space, power, and cooling. If an existing building is being considered and it is clear that the building cannot meet the requirements without extensive building works, then either another building should be chosen or the systems department may have to consider using unfamiliar technologies. For instance, the use of AT&T's Premises Distribution System (which is based on telephone wiring) rather than IBM's Cabling System will require less space for cables and much less space for wiring closets. (The technical characteristics of IBM's Cabling System and of wiring schemes based on telephone wiring are discussed in Chapter 3.) Equally, wiring schemes based on the use of undercarpet cables or furniture systems that provide space for cables may remove the need to install false floors.

For cabling, the key requirements are the amount and nature of the space to be allocated for:

- The entry of circuits to the building (which may be as cables or through microwave or satellite dishes) and the termination rooms for the circuits.
- Risers.
- Connections to wiring closets.
- Wiring closets.
- Equipment rooms.
- Routes from closets to work locations.

The need to allocate space for termination rooms, wiring closets, and equipment rooms is often overlooked by space planners. In exceptional circumstances, such as the dealing rooms of financial institutions, the space required for these areas may be 25 per cent of the space available, although a much smaller proportion is more usual. For example, some wiring schemes use patch panels that can, if necessary, be mounted on a spare wall area. The areas will also usually need their own supplies of power and air conditioning. (The exceptions are the few cases where the wiring scheme is completely passive.)

The question of cable routes, and the method used to install them, is particularly significant because much of the cost of installing a wiring scheme is determined by these factors. Decisions need to be made about whether cables will be led under false floors, or through trays suspended from ceilings, or in a variety of other ways. A false floor provides a great deal of space and can provide considerable flexibility for the future. On the other hand, false floors are very expensive and it is inconvenient to lift them once the building is occupied. Allowing space for false floors may even require an increased height for the building — adding directly to construction costs.

Allowing insufficient space for the different elements of a wiring scheme, or choosing inappropriate routes and methods for installing the cables, can result in future inflexibility and can mean that substantial additional costs will be incurred. How to avoid these difficulties is discussed in depth in subsequent chapters.

RECOGNISE THAT A WIRING SCHEME WILL LAST FOR MANY YEARS

Today, many wiring schemes are installed on the basis of short-term considerations of cost and convenience. This approach virtually assures that the wiring will be obsolete within just a few years. It will therefore be necessary to supplement the wiring at a later date or even to replace it. Either option is likely to be expensive and will cause significant disruption.

We have already stressed the fact that wiring costs are high, especially the costs of installing the additional cables required when new equipment is installed or existing equipment is moved. In most cases, however, the identifiable direct costs are not as significant as the 'hidden' costs caused by:

- Losses of time, efficiency, and security due to the physical disruption caused by cabling work.
- Delays in the installation of new systems.
- Delays in moving people and equipment.
- The inability to relocate staff within the building.

For example, until 1983 a major retailer used direct wires routed through risers and then over ceilings to connect terminals in one of its main office buildings to its computer system. It was becoming increasingly difficult to move terminals from one part of the building to another and the risers were becoming full. Moreover, the systems department depended on company tradesmen or outside contractors to install new cables. The company was growing rapidly, and flexibility to cope with the expansion and other changes was a key requirement, but cabling problems were beginning to constrain the organisational changes that could be made. In 1983, a local area network was installed to support the terminals and since then the problems have been greatly eased.

Wiring problems are at their most acute where several types of wiring are needed to support different types of equipment. For example:

- Multipair telephone cables for proprietary key telephone systems.
- Twisted pairs for ASCII screens.

- 93-ohm coaxial cable for IBM 3270 screens.
- 50-ohm coaxial cable for Ethernet.
- 75-ohm coaxial cable for video services.

Using several types of wiring increases the likelihood that when a terminal is moved, it will be to a location with the wrong type of wiring.

In general, it is much more expensive to install wiring after a building has been occupied than during the initial fitting-out. The extra cost depends upon the type of wiring, the building, and the circumstances, but is often about three times the cost of initial wiring. Rewiring once the building is occupied is often disruptive as well as expensive. There are particular problems where the cables have to be installed under a false floor. In an occupied office, access to the floor will be impeded by desks, filing cabinets, and staff. If the cable is to be installed overhead or in wall trunking, the changes can sometimes be made without great disruption, although even in these situations the work may have to be done outside normal working hours, adding to the cost.

Wiring is, of course, only one of the services required in a modern office building. Architects distinguish between the various components of a building (shell, services, scenery, and sets), each having its own characteristic life, as shown in Figure 2.1. Major changes to wiring are more disruptive than changes to either scenery or sets. Even if the wiring is carried through special 'system' furniture, changes to the sets will disrupt the wiring — and are therefore often forbidden.

The worst case arises where new cable spaces have to be created by building work such as cutting new channels in the concrete floor screed. In addition to the disruption caused by the people doing the work, the high levels of noise and dust can disturb staff and damage machines. The levels of noise and dust may well be sufficiently great to require the whole area to be cleared before the work can proceed.

Figure 2.1 Different components of a building have different lifetimes

Component	Comprises	Lifetime
Shell	Structure, cladding, roof, foundations	50+ years
Services	Floor, ceiling, lifts, power, air conditioning, telephone wiring	15 to 20 years
Scenery	Partitions, furniture, carpets, office equipment	5 to 7 years
Sets	Arrangements of the scenery items	1 to 2 years

It is therefore necessary to plan for building wiring to be changed as little as possible after it has been installed and for it to last as long as the other building services. For new buildings and major refurbishments, the planned life for wiring should ideally be the same as that for the building services, typically 15 to 20 years. In practice, the likely rate of change and the uncertainties about the future make this an exceptionally demanding objective.

PLAN FOR A CHANGING INFORMATION TECHNOLOGY ENVIRONMENT

It is inevitable that there will be many changes during the next few years in the way IT is used in office buildings, although it is not always clear what form the changes will take. For example:

- Will the trend be towards image transmission, or will the need for image transmission be avoided by the use of intelligent character- and icon-recognition systems?
- Will office systems increasingly be used to control and direct staff, supporting their work but ensuring compliance with the organisation's standards? Or will they be used to support the creative and interpersonal aspects of office work, thereby giving individual workers more freedom?

Even in the short to medium term, there are major uncertainties concerning:

- The degree to which processing power will be distributed to PCs and departmental computers.
- The significance of work-group systems.
- The need for compound documents comprising text, data, and image elements, and for more advanced document-management systems.
- The extent to which videoconferencing will be used.
- The future of telephone systems.

Nevertheless, it is clear that the total number of workstations or PCs installed will continue to increase, and that the dumb terminals already installed will progressively be replaced by more intelligent desktop devices. The inevitable outcome is that there will be a continuing need to reconfigure the communications networks.

A GROWING POPULATION OF INTELLIGENT DEVICES

The growth in terminals and workstations is due to the increasing cost-effectiveness of electronic systems relative to labour. The members that replied to our initial questionnaire had an average of one terminal or PC to every two office staff. Most of them expected this to rise to one for each office employee within five years (and we believe that several of those who forecast a lower ratio have underestimated the probable growth because they had considered only systems that are currently planned). Most Foundation members will therefore have to install on average at least one new terminal or PC for every 10 staff in *each* of the next five years, in addition to catering for changes and renewals.

Furthermore, PCs are expected to form a higher proportion of the total population of workstations — an inevitable outcome of the technical innovations being incorporated into PCs. Figure 2.2 shows the results of our detailed survey on this question. The majority of the respondents reported that, at the end of 1986, between 30 per cent and 60 per cent of all workstations were PCs. By 1992, the majority believe that the proportion will have risen to between 50 per cent and 80 per cent. As the total population of workstations is expected to double by 1992, the total number of PCs being installed in this period will be substantial. (The next Foundation Report will examine future workstation trends in detail.)

Indeed, the dramatic growth in the number of PCs installed is already under way. Figure 2.3 shows the growth rates reported for PCs during 1986. It is much greater than that for workstations generally, with nearly half the respondents reporting that the number of PCs installed increased by more than 100 per cent during 1986. By the end of 1986, these Foundation members reported that they had installed one PC for about every five office staff. By 1992, they expect to have installed at least one for every two office staff.

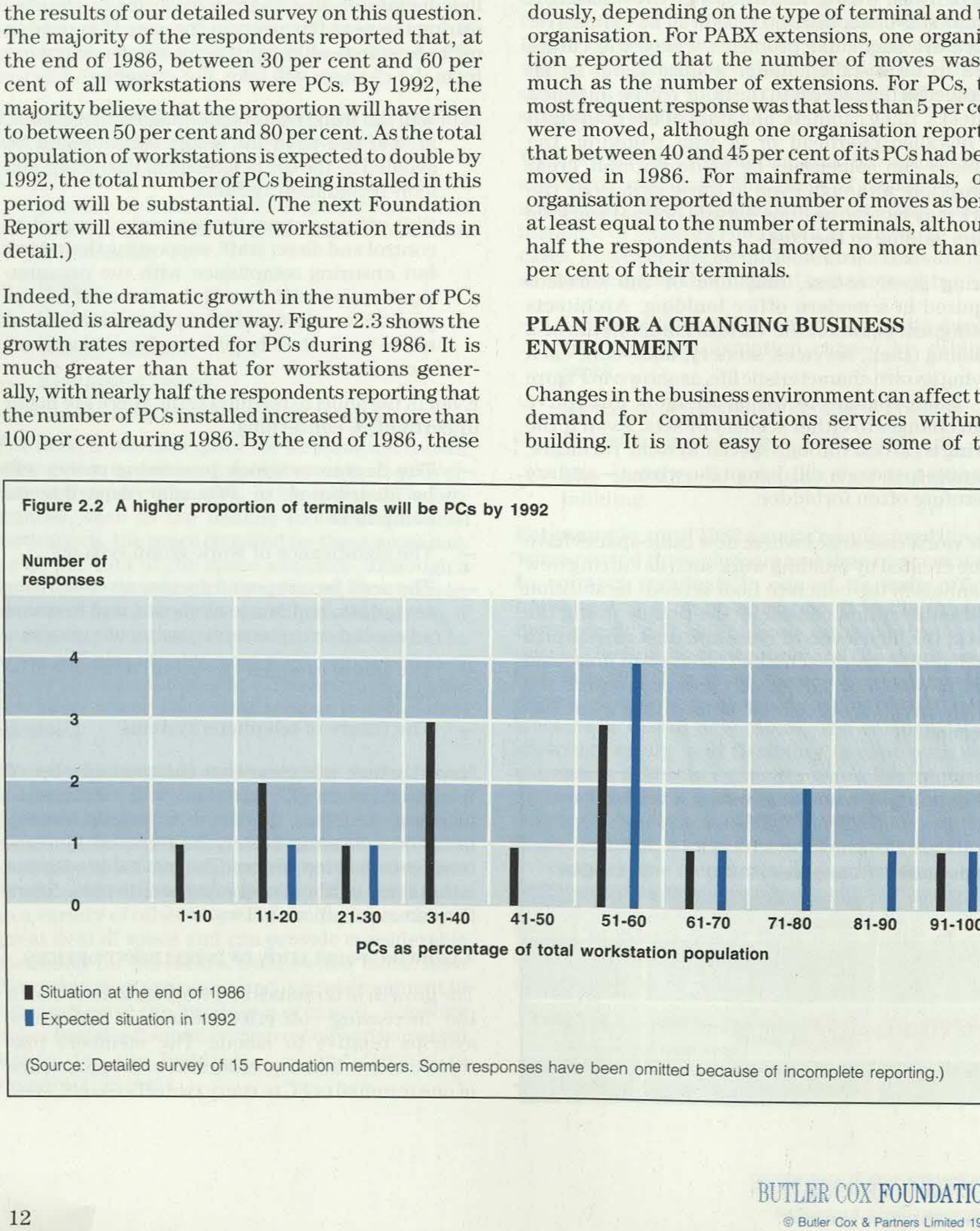
EQUIPMENT WILL BE MOVED FREQUENTLY

Terminals and workstations often need to be moved from the work location at which they were originally installed. The need for such moves occurs both because individuals change desks and, more importantly, because a work group moves to another part of the building. A figure often quoted is that one-third of workstations are moved each year, although as Figure 2.4 shows, the situation varies tremendously, depending on the type of terminal and the organisation. For PABX extensions, one organisation reported that the number of moves was as much as the number of extensions. For PCs, the most frequent response was that less than 5 per cent were moved, although one organisation reported that between 40 and 45 per cent of its PCs had been moved in 1986. For mainframe terminals, one organisation reported the number of moves as being at least equal to the number of terminals, although half the respondents had moved no more than 20 per cent of their terminals.

PLAN FOR A CHANGING BUSINESS ENVIRONMENT

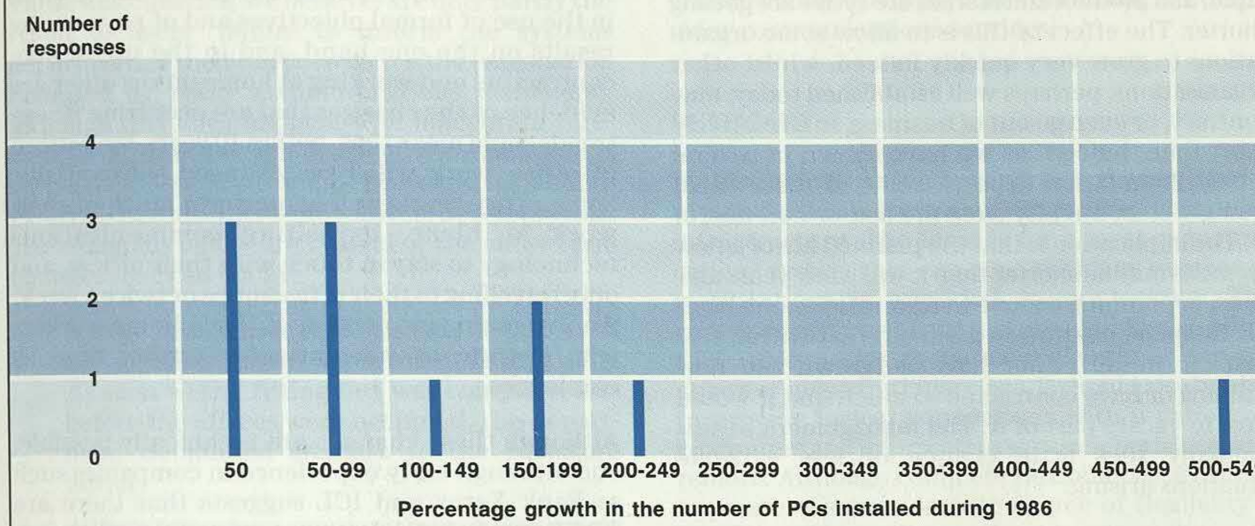
Changes in the business environment can affect the demand for communications services within a building. It is not easy to foresee some of the

Figure 2.2 A higher proportion of terminals will be PCs by 1992



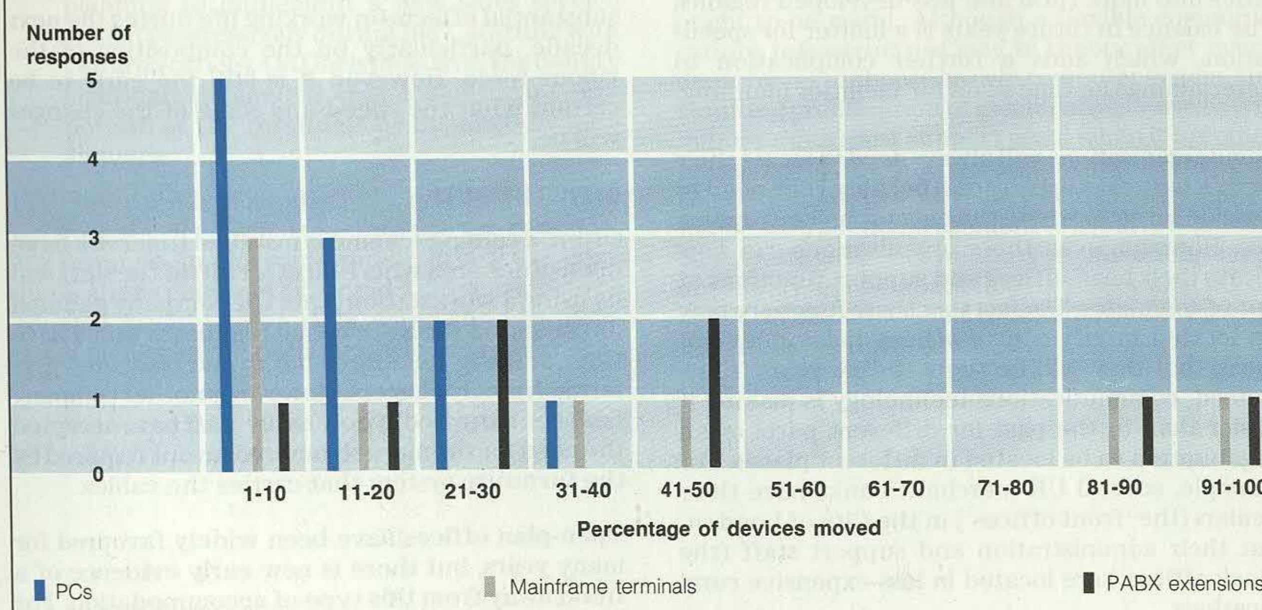
(Source: Detailed survey of 15 Foundation members. Some responses have been omitted because of incomplete reporting.)

Figure 2.3 The number of PCs installed grew rapidly in 1986



(Source: Detailed survey of 15 Foundation members. Some responses have been omitted because of incomplete reporting.)

Figure 2.4 Percentage of devices moved during 1986



(Source: Detailed survey of 15 Foundation members. Some responses have been omitted because of incomplete reporting.)

changes that will occur. Nevertheless, those responsible for planning the communications infrastructure for a building must make an attempt to assess the uncertainties in the areas that could have the largest impact on the demand for communications services. We believe the most important areas are changes in the business itself, major office relocations, the demand for office workers, and changes in office layouts. It is also important to realise that in all of these areas the changes are not restricted to the long term. There are many examples of changes prompted by business requirements happening at very short notice. Without a flexible communications infrastructure it would be impossible to accommodate these short-term changes.

CHANGES IN THE BUSINESS ITSELF

The pace of change in business is becoming more rapid, and product and market life cycles are getting shorter. The effect of this is to allow some organisations to grow very quickly indeed, whilst other organisations, perhaps well established today, may contract, or even go out of business, in a relatively short time. Indeed, as we have shown in several recent Foundation Reports, some of these rapid changes stem directly from the use, or non-use, of IT. The implication is that the planned life of a new premises may be shorter than it was a few years ago. Thus, in planning a move to new offices, one large UK financial institution assumed that within five years it would either have outgrown the new building or have contracted so much that it would have to vacate part of it. The management of this company sees little chance of less extreme situations arising.

OFFICE LOCATIONS

The balance between high-rent city premises and low-rent out-of-town premises continues to fluctuate, but with increasing advantage being seen in the latter. In some countries, government policy encourages organisations to move out of the large cities into more rural and less-developed regions. The balance in future years is a matter for speculation, which adds a further complication to determining the time scale for facilities planning.

Some organisations will always need to locate their 'retail' outlets in urban areas because they need to provide services where the bulk of their customers are. However, even these organisations can now locate their head offices and support functions at out-of-town sites. The fact that these functions may be located in city-centre offices today does not mean that they will be there in five years' time. Indeed, communications technology is making it easier than in the past for different parts of an organisation to be located in different places. For example, several UK merchant banks have their dealers (the 'front offices') in the City of London, but their administration and support staff (the 'back offices') are located in less-expensive rural locations.

DEMAND FOR OFFICE WORKERS

There are also considerable uncertainties about the numbers and types of office workers that will use a building. Several years ago, the top management of one Foundation member declared that a new building would never need to accommodate more than a certain number of staff during its expected 20-year life. Two years later, the board reorganised the company and the building had to accommodate twice that number.

There are increasing signs, modest as yet, of fundamental changes in the way that white-collar workers are employed and rewarded. The growth in the use of formal objectives and of payment by results on the one hand, and in the use of subcontractors and working at home on the other are evidence of the changes that are occurring. These trends could mean that, within 10 years, the pattern of office work will have changed substantially. Some office workers may perform much of their work at home, exploiting communications technology to stay in touch with their offices, and only travelling to their offices once or twice a week. An increasing proportion of these home workers may operate as subcontractors rather than as employees.

Although these changes are technically possible, and although early experience in companies such as Rank Xerox and ICL suggests that there are significant benefits both in productivity and in job satisfaction, they are far from inevitable. Inertia and opposition from staff, unions, and governments may mean that there will have been no substantial change at all in 10 years' time.

In addition, the use of expert systems and other forms of artificial intelligence is likely to have substantial effects on working life during the next decade, particularly on the composition of the labour force. However, it is still too early to be certain what the speed and scale of the changes will be.

OFFICE LAYOUTS

Often, a cabling scheme is installed to serve a large open office area where most (or all) of the staff will be using a workstation. One UK company planned its cabling on the assumption that users would have their desks in neat lines but found that they preferred friendly clusters. However, another company has been surprised at how easily staff have accepted the need for the more structured layout required by the furniture system that carries the cables.

Open-plan offices have been widely favoured for many years, but there is now early evidence of a trend away from this type of accommodation. For example, research by companies such as IBM and TRW indicates that cellular offices seem to increase the productivity of programmers. This is probably also true for other staff who make intensive use of IT. Cellular offices are now the norm in Germany and may become common elsewhere in time.

CHANGES CAN HAPPEN IN THE SHORT TERM

Our research shows that the uncertainties in the business environment are not restricted to the long term. There are also short-term uncertainties. For example, we found many instances where even short-term forecasts of communications requirements had proved to be extremely inaccurate. These inaccuracies, we believe, are only partly the result of users' failure to inform the systems department of their needs (which is the explanation favoured by many communications managers), although this does happen. The inaccurate forecasts are also due to changing needs as organisations revise their objectives and policies and respond to external circumstances and internal developments. The examples below are typical of the short-term changes that can occur:

— A large retail chain refurbished the offices of a head-office buying department during 1987. As soon as the fitting-out was complete, but before the offices were occupied, the department demanded changes to the furniture layout.
— A large insurance company introduced a new system that issued policies more quickly than before. The user department had installed 30 terminals for use with this system, but the system was so successful that the department immediately demanded a further 40 terminals.
— At the end of 1986, a large public utility was planning to implement a new sales service system progressively during 1987, starting with two area offices. On Christmas Eve, the deputy chairman demanded that a significant proportion of the terminals be installed by mid-January.

Inaccurate predictions about the rate at which new network services will come into use are common. For instance, in the same public utility the communications planners expected X.25 services to be adopted rapidly when they wired the new computer facility in 1986. In fact, the take-up of X.25 services has been slower than expected, and this organisation has had to install an additional 48 coaxial cables to support the continuing use of the older communications services.

SUMMARY

In this chapter we have shown that the key need is to plan for flexibility in a building's communications infrastructure. The ideal is for a local communications system that can cope with any number of workstations, of any kind, in any location. The communications infrastructure should also allow the workstations to be moved without causing delays or incurring large costs. It should also be able to provide logical connections with a variety of computers and information services, both local and remote. Although complete flexibility is, of course, impossible, a considerable degree of flexibility is quite possible, and it need not be expensive.

However, in emphasising the need for flexibility, we do need to warn about a potential danger. A key advantage of flexibility is that it allows decisions to be deferred until all the information is on hand to make them properly. But it also makes it easier to postpone decisions beyond the point at which they ought to be made. Although a flexible communications infrastructure may in theory allow every department to choose its own computer system, the resulting proliferation of incompatible systems will impose significant support costs when it becomes necessary to interlink the applications running on those systems. Our advocacy of flexibility should not be seen as encouragement to avoid recognising the trade-offs between, for instance, local autonomy and compatibility, or to avoid facing up to the difficult decisions required to make the best advantage of those trade-offs.

Chapter 3

Wiring scheme options

The need for flexibility in local communications has been argued in the previous chapter. This need can, in principle, be met in one of three ways or by a combination of them. The three ways are a local area network (LAN), a general-purpose wiring scheme, or an integrated services PABX (ISPABX) with its own dedicated wiring scheme. Installing empty ducts to cater for unforeseen requirements also provides flexibility. The particular wiring scheme, local area network, or ISPABX selected will need to be 'universal' in the sense that it can support all the types of device that the organisation might want to install. There are, however, significant problems in relying either on a local area network or on an ISPABX as a universal solution.

We do not recommend the ISPABX option because:

- It is an expensive way of providing wiring support for terminals.
- It provides a limited data transmission rate.
- It tends to bring nonvoice equipment within the telephony regulations, thereby reducing flexibility.

The objections to the ISPABX option were discussed at greater length in Foundation Report 54 — Integrated Networks.

That leaves two main options — local area networks and universal, general-purpose wiring schemes (which are increasingly known as structured wiring schemes). We now discuss each of these options in more detail.

LOCAL AREA NETWORKS

To date there is no local area network that combines good support for data transmission with cost-effective telephony. Local area networks are optimised for the typical pattern of data communications, which usually requires high volumes of data to be transmitted in short intermittent bursts. Because of this, most local area networks have difficulty in handling the continuous (and low-volume, in terms of bits transmitted) nature of telephony. (We exclude the LAN-PABX hybrids such as the CXC Rose system because these systems are not yet available in most countries where there are Foundation members. However, systems of this type will certainly merit attention when they become more widely available.) In addition, we believe there is no local area network that supports all the commonly available data protocols and certainly none that can guarantee to meet new ones in the future. In many cases 'universal' local area networks are an expensive way of supporting simple terminals. A further disadvantage is that a failure in the network affects all the devices connected to it. (Although automatic recovery techniques are available, they are used in very few local area networks.)

Local area networking technology is still developing rapidly. The result is more choice and more options for user organisations, particularly in the cabling that can be used for local area networks. For example:

- SynOptics Communications' LattisNet provides Ethernet connections over twisted-pair networks (this product is discussed in more detail on page 20).
- DEC, which promoted the original baseband version of Ethernet, has now developed broadband and twisted-pair variants.
- Ungermann-Bass, a leading early supplier of Ethernet products, now offers its 'Ethernet' products on baseband, broadband, and optical fibre cables.

At a higher logical level, the suppliers of local area networks are increasingly defining their products in terms of services and protocols, rather than transmission technology. For instance:

- 3Com, the company founded by the inventor of Ethernet, was one of the first to announce that its product would be supported over the IBM Token Ring.
- Ungermann-Bass offers products for Token Ring and MAP networks.

Furthermore, all the local area network suppliers, and PABX suppliers, are actively extending the range of equipment that can be attached to their products — even allowing equipment designed originally for a different cabling scheme and switching technology to be connected. For example:

- Network Systems Corporation can now support IBM 3270 screens on its HYPERbus local area network.
- Intecom can support Ethernet devices and 3270 screens on its integrated PABX, the IBX.
- Wang supports PCs, ASCII terminals, and 3270 screens on its Wangnet broadband system.

The implication is that local area network products and the cabling scheme on which they will run can now be chosen independently.

STRUCTURED WIRING SCHEMES

A structured wiring scheme (sometimes known as 'universal' or 'integrated' wiring schemes) avoids the problems of ISPABXs and local area networks, but it does require the building to be fully prewired. Such a scheme can be defined as one that allows:

- Groups, often pairs, of attached devices to use the same cabling to communicate with each other.
- Each group of attached devices to communicate using a different signalling method.

In practice, of course, most organisations use only a small number of signalling methods.

It is important to realise that structured wiring schemes do not allow incompatible devices to communicate with each other. Device compatibility still has to be achieved through the use of other communications equipment such as protocol convertors.

Structured wiring schemes provide each outlet with its own cable or set of cables. These cables are brought together at a patch panel (or set of patch panels) through which any two cables, and therefore the attached devices, may be connected. Some applications require, and some structured wiring schemes provide for, the connection of more than two devices on the same physical circuit.

In all the major structured wiring schemes, the patch panels (which are known by different names in different schemes) are intended to be installed on each floor, typically serving between 100 and 200 outlets. Figure 3.1 shows the patch panel used with AT&T's Premises Distribution System. Patch panels are interlinked by a backbone wiring system that does not necessarily use the same type of cable as that used to connect the outlets to the patch panels.

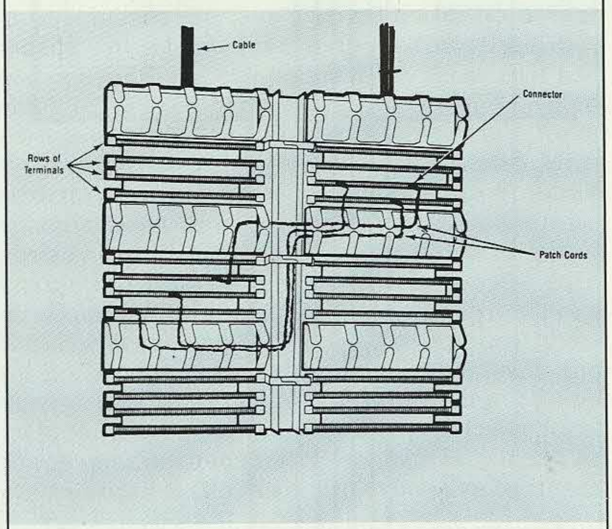
Structured wiring schemes therefore separate the horizontal and backbone components of the wiring, linking the two parts through patch panels. They make it easy to reconfigure the communications network by providing one cable, or in some cases one set of cables, to each work location. Within a single floor each such cable could, in principle, use a unique signalling system. In practice, some might carry RS232 signals to terminals, some might carry 3270 signals to other terminals, and others might extend Ethernet or Token Ring connections to personal computers or workstations. Within the backbone system there might be a mixture of general-purpose wiring and dedicated cables. One such arrangement is shown in Figure 3.2 overleaf.

Commercially available structured wiring schemes are able to support most standard and some nonstandard local area networks and PABXs. Using a structured wiring scheme does not therefore preclude the use of a universal local area network or an ISPABX, although it may make such use more expensive. The use of a structured wiring scheme allows decisions on local area networks and other forms of data transmission support to be deferred.

Thus, structured wiring schemes have two principal advantages — they can support a wide variety of devices and networks, and each particular outlet can easily be switched to a different communications service. For instance, a Token Ring socket can be converted to an Ethernet or 3270 socket in just a few minutes. These advantages are directly relevant to the problems of horizontal wiring, which are the biggest problems in building wiring.

Our research has shown that structured wiring schemes can meet most foreseeable building com-

Figure 3.1 AT&T's Premises Distribution System patch panel



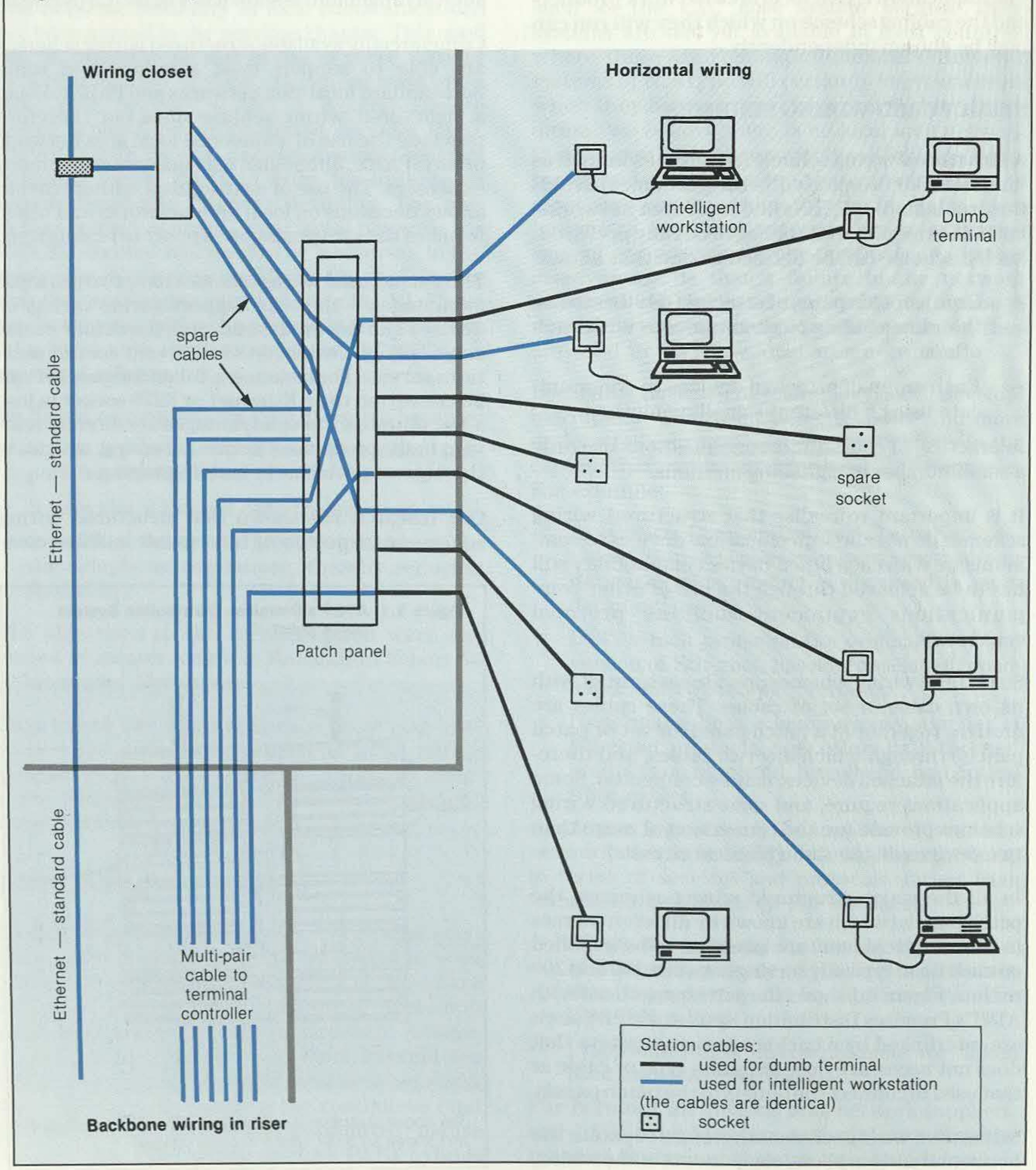
The above illustration is reproduced with AT&T's permission and shows an AT&T type 110 cross connect.

munications needs while leaving options open for the future; they also make reconfiguration easy.

It is quite possible for an organisation to define and construct its own structured wiring scheme, and several Foundation members have done so. They have usually followed this course of action because no proprietary scheme was available or because the proprietary schemes seemed too expensive. Home-made schemes have the advantages of low cost and of being tailor-made for the particular circumstances. Such a wiring scheme can be constructed by selecting inexpensive components from standard catalogues. Bulk purchases can further reduce the price of the components, allowing the organisation to benefit significantly from economies of scale.

However, to obtain the full benefits of a structured wiring scheme, it is essential to ensure that it conforms to industry standards (system suppliers will,

Figure 3.2 An example of a structured wiring scheme



of course, build terminals that can be used with industry-standard wiring schemes). An organisation with suitably skilled staff could certainly devise its own wiring scheme that did comply with one of the emerging standards. This approach, however, would have two disadvantages:

— There would be no external supplier to support the scheme.

— It would be difficult to benefit from industry experience with wiring schemes, most of which would relate to the proprietary schemes.

We therefore regard designing a home-made scheme as a last resort and recommend that a proprietary wiring scheme be used.

PROPRIETARY STRUCTURED WIRING SCHEMES

Several suppliers have announced proprietary structured wiring schemes as general solutions to the problem of wiring buildings for voice and data. The best-known proprietary schemes are IBM's Cabling System, AT&T's Premises Distribution System (PDS), Bull's Building Cabling System, and DEC's DECconnect.

Proprietary wiring schemes have certain common characteristics:

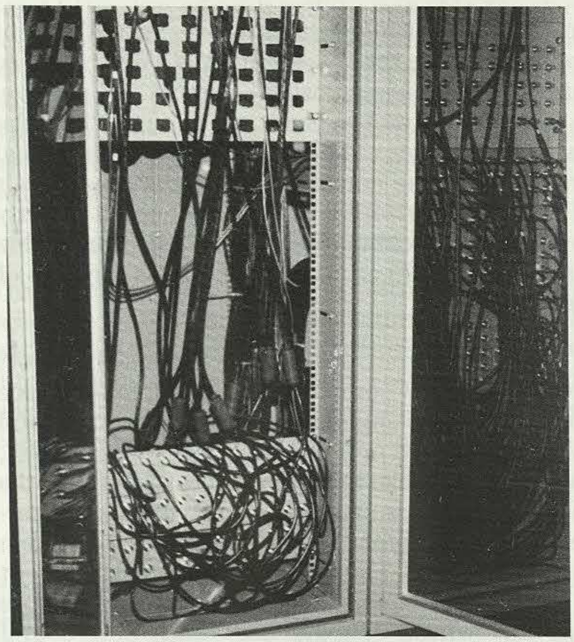
— There is a wiring closet on each floor. (Figure 3.3 shows part of an IBM Cabling System wiring closet installed at a Foundation member's head office. Note that this closet contains a non-standard 3270 patch panel.)
— They provide a high density of sockets, usually at least one per work location.
— They use standard types of cable for both the backbone wiring and the horizontal wiring.
— There is a limit on the length of cable permitted between a device and the wiring closet and between any two devices in one building connected to the wiring scheme.
— Both the backbone and horizontal wiring should ideally be installed when the building is built or refurbished.

With appropriate interface units, proprietary wiring schemes can support a wide variety of equipment types. These include IBM 3270 and System 3x terminals, Wang workstations, and devices with RS232 and RS422 interfaces. Most wiring schemes can also support local area networks complying with the IEEE 802.3 (Ethernet) and IEEE 802.5 (Token Ring) standards.

Structured wiring schemes include configuration rules that limit the lengths of the cables. Most schemes have restrictions on two distances:

— The distance from the device to the wiring closet; 100 metres in the case of the IBM Cabling System.

Figure 3.3 IBM Cabling System wiring closet with nonstandard 3270 patch panel



— The distance between any two wiring closets; 200 metres in the case of the IBM Cabling System.

Various surveys have shown that 80 per cent of terminals are located within 30 metres of a riser, so the first restriction will only be a problem in the most exceptional circumstances. A floor big enough to present such a problem would certainly justify the installation of a second wiring closet. The second restriction would limit a wiring system to a building of no more than about 40 floors — sufficient for the large majority of office buildings.

Most schemes use four-wire cables for horizontal wiring. The schemes can be divided into those that use conventional telephone wire, those that use shielded twisted pairs, and DECconnect — which uses a mixture (see Figure 3.4 overleaf). Note, however, that the telephone wire used with structured wiring schemes is manufactured to strict specifications. Much of the older telephone wire already installed in many buildings has different characteristics and is not suitable for use with structured wiring schemes. Note also that none of the schemes shown in Figure 3.4 uses optical fibres for horizontal wiring, although, interestingly, the pre-release versions of IBM's Cabling System included a 'type 3 station cable' that did use optical fibres, but this is not offered commercially today. At present optical fibres are too expensive because:

— The tight tolerances required for basic system components, and the low production volumes, increase the cost of the components.

- Splicing and terminating fibres is a specialised skill.
- Even low-speed terminals need electronic interface units.

Proprietary wiring schemes use two different approaches to the backbone network used to interlink the wiring closets — active and passive. In a passive system, such as AT&T's PDS, the backbone cables have the same electrical properties as the horizontal cables, and each pair of wires in a horizontal cable is connected directly to a pair in a backbone cable. The backbone cable may consist of 25 or 50 pairs of cables for ease of handling.

In an active system, such as the Ethernet support provided by DECconnect, an electronic interface unit converts the signalling used on the horizontal cable to that used in the backbone. In DECconnect, the horizontal cables are 'Thinwire Ethernet' and the backbone cable is usually ordinary (thick) Ethernet, although a broadband or optical-fibre system may also be used. Figure 3.5 shows a typical layout of a DECconnect satellite equipment room. Note that this wiring scheme uses both active and passive elements. Typically, an installation may use passive patching for telephones and low-speed data links, and an active approach for local area networks.

Proprietary structured wiring schemes have already established a place in the market. Of the 104 organisations that replied to our initial questionnaire, 22 had already installed IBM's

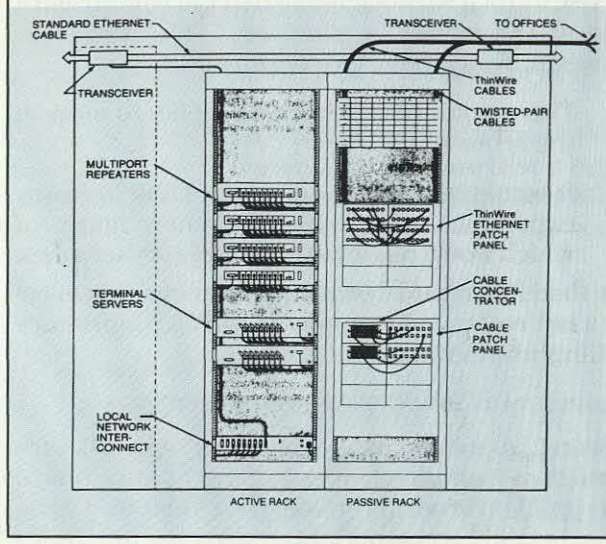
Figure 3.4 Cables used for horizontal wiring in proprietary wiring schemes

Type of cable	Wiring scheme: IBM Cabling System	AT&T's Premises Distribution System	Bull BCS	DECconnect
Unshielded twisted pairs (telephone wire)				
For voice	✓*	✓		✓
For data		✓		✓
Shielded twisted pairs	✓		✓**	
Thinwire Ethernet coax				✓
Video (75-ohm) coax				✓

*Using type 2 cable, which combines telephone and data wires in a common sheath

**BCS cable consists of four twisted pairs in a common shield

Figure 3.5 Typical configuration of a DECconnect satellite equipment room



Cabling System, the first structured cabling scheme for nonvoice applications.

THE USEFULNESS OF STRUCTURED WIRING SCHEMES IS BEING EXTENDED

The uses to which a structured wiring scheme can be put have been greatly extended during the past few years as a result of intensive research and development work. Only a year or two ago there was a general view that ordinary twisted-pair telephone cables could not be used for data transmission in buildings at speeds above about 1M bit/s; and many doubted if even that were possible.

However, early in 1986 SynOptics Communications (formerly Astro Communications) of Palo Alto, California, announced LattisNet, a product that allows the full 10M bit/s of Ethernet to be carried over any IBM Cabling System installation. By the middle of 1987, SynOptics had installed more than 15,000 LattisNet nodes in more than 60 organisations. In August 1987, AT&T announced that it had certified LattisNet as able to operate over any PDS installation. This was followed by announcements from other Ethernet suppliers including Hewlett-Packard, DEC, and 3Com. Beta-test users of LattisNet have described themselves as extremely happy with the product. One, the University of Wisconsin, told us that a 16-node system ran for a month before the first error was detected. The layout of the wiring for a LattisNet implementation is shown in Figure 3.6.

It is too soon to know the ultimate data transmission rate that will be practical over telephone wire. In our view, however, the 10M bit/s achieved by LattisNet is not the limit for data transmission over telephone wire. (We understand that AT&T has a 45M bit/s video system running in a laboratory, for example.)

The usefulness of structured wiring schemes is also being extended as local area network suppliers and computer suppliers adapt their products so that they can be used with the wiring schemes. (Some of the developments were mentioned on pages 16 and 17.)

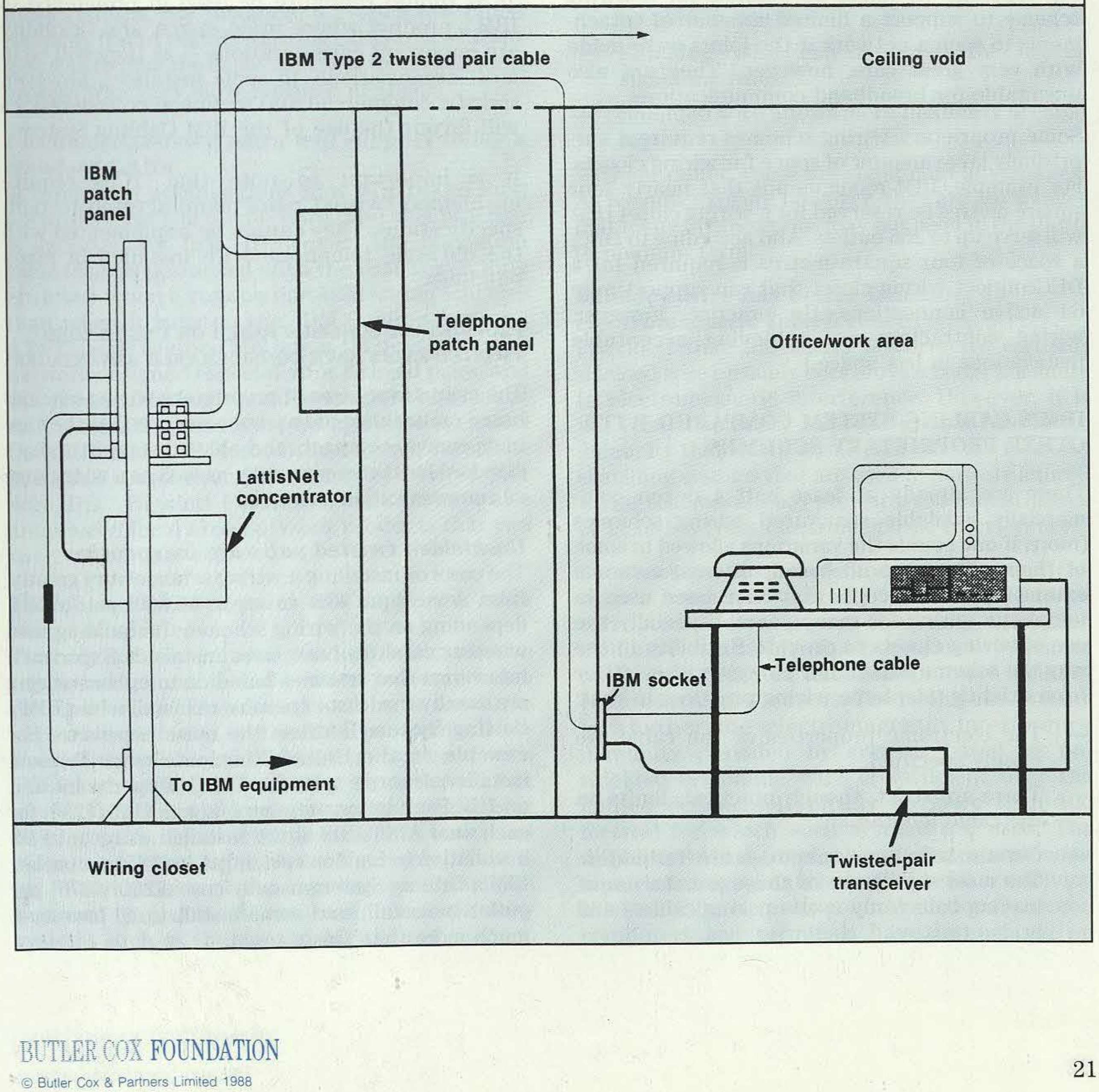
Because structured wiring schemes can support a variety of local area networks and signalling systems, the installation of such a wiring scheme does not commit the user to one particular local area network (unlike the installation of a dedicated wiring scheme). Thus, a DEC user that installs AT&T's PDS still has the option of running IBM 3270 terminals or Token Rings.

As the suppliers continue to develop products to exploit the installed base of telephone cable and other structured wiring, organisations will be offered additional choices. These developments herald the day when it will be possible to select equipment, local networking technology, and cabling schemes separately and independently of each other. Even today, the better structured wiring schemes support a greater range of interfaces and devices than do the standard local area networks.

LIMITATIONS OF STRUCTURED WIRING SCHEMES

The present generation of structured wiring schemes do have several limitations, particularly with respect to video distribution, voice-data integration, and support for certain local area networks. Some proprietary schemes also require considerable space for wiring closets.

Figure 3.6 Wiring layout for a LattisNet implementation



Of the major proprietary wiring schemes, only DECconnect can carry a full broadband signal (because it includes a coaxial cable as part of the wiring scheme). However, baluns (balancers/unbalancers) are available to carry baseband closed-circuit television signals on a variety of cables, including IBM Cabling System and telephone twisted pairs. A structured wiring scheme that uses optical fibres for horizontal distribution could carry video signals to each workstation, but at present such a scheme would be expensive to install and maintain.

Most structured wiring schemes are installed for data transmission purposes only. However, some schemes (in particular the IBM Cabling System) provide the lowest level of voice-data integration by enclosing separate voice and data wires in a common sheath.

In addition, structured wiring schemes are not suitable for certain local area networks, such as Omninet (Unisys's Usernet) that require a single unbroken and unjointed length of wire laid in a bus topology. (It might be possible for a wiring scheme to support a limited number of attachments to such a network if the joints were made with very great care, however.) They are also unsuitable for broadband communications.

Some proprietary wiring schemes require a surprisingly large amount of space for wiring closets. For example, IBM recommends that nearly four square metres be reserved for a wiring closet that will serve up to 256 outlets. And according to DEC, a space of four square metres is required for a DECconnect wiring closet that can support only 64 active connections. (In practice, however, wiring contractors are achieving acceptable installations in less space.)

IBM'S CABLING SYSTEM COMPARED WITH OTHER PROPRIETARY SCHEMES

There are already at least half a dozen commercially available structured wiring schemes (more, if one counts the variations allowed in some of them). They are all based, at least to some extent, on the concepts that have been used in telephone wiring for many years, especially the use of wiring closets to provide flexibility in the way the scheme is laid out. However, they differ from existing telephone wiring practices in that:

— The electronic properties of the cable are closely specified.

— There are strict, though practical, limits on the cable lengths.

— Certain telephone practices are forbidden. The most significant of these are the use of loading coils (only used on long cables) and bridge taps.

The main technological choice with wiring schemes is between those that are based on telephone cables (which we call telephone cable schemes — TCSs) and those based on shielded cables, most notably the IBM Cabling System. TCSs include AT&T's PDS and the Ericsson Cabling System (ECS). The main differences between TCSs and the IBM Cabling System are:

— TCSs use unshielded twisted-pair cables; IBM's Cabling System is based on cables with individually shielded pairs. IBM does allow unshielded telephone cable, which it calls type 3 cable, although it is subject to lower range and transmission-rate limits. However, IBM recommends shielded cables for new Cabling System installations.

— TCSs use telephone components. These are familiar and compact (especially compared to IBM Cabling System components), and have been engineered for low cost and easy installation.

TCSs should therefore be used in preference to IBM's product where price, space, and flexibility are important considerations — as they will be in most organisations. In some instances, however, specific commercial and technical considerations will favour the use of the IBM Cabling System.

It is important to note that TCSs require unshielded twisted pairs manufactured to tight specifications. They cannot be implemented with the old-style telephone wire installed in many buildings.

PROPRIETARY SCHEMES BASED ON UNSHIELDED TWISTED PAIRS HAVE CONSIDERABLE ADVANTAGES

The main advantages of proprietary wiring schemes based on unshielded twisted pairs are that they are inexpensive, compact, and able to support today's standard local area networks, as well as a wide range of communications services.

Unshielded twisted pairs are inexpensive

The costs of installing a wiring scheme vary greatly, from less than $75 to over $1,000 per outlet, depending on the wiring scheme, the building, and whether conduits have to be installed. Experience has shown that schemes based on telephone wiring are usually the least expensive to install whilst IBM's Cabling System is often the most expensive. For example, in the United Kingdom British Telecom installs telephone wire for £50 ($90) per point and one UK Foundation member budgets £125 ($230) for each dual AT&T PDS outlet installed. A recent PDS installation in London cost only £46 ($85) per outlet. IBM's Cabling System usually costs £200 ($370) per outlet to install, and some installations have cost much more than this.

A Norwegian Foundation member found that the IBM Cabling System would cost between NKr4,000 and NKr5,000 ($650 to $800) per outlet, whereas its own telephone-cable-based scheme cost at most NKr2,000 ($325) per outlet.

Unshielded twisted-pair systems are compact
Unshielded twisted-pair cables are smaller than other cables and have small bending radii:

— Standard Ethernet cable is thick, and has a large bending radius. In addition, considerable space is required for cable taps and for transceivers.

— IBM's type 2 cable can be difficult to lay because of its size, especially when it is has to be bent around a corner.

The IBM Cabling System, like DECconnect, requires much more space for satellite wiring closets and for the cables themselves. Because of these characteristics, some organisations have experienced significant problems in installing these systems. For instance, a French insurance company found that its existing cable spaces were too small to take the cable, and that the installation process was very slow because of this.

Unshielded twisted pairs will support today's standard LANs
Several large organisations now run Token Ring networks over telephone wire, and this practice is endorsed by IBM. (However, the maximum cable lengths permitted with the IBM Token Ring are lower when it runs on non-IBM wiring schemes than when it runs on the IBM Cabling System.) AT&T has developed Starlan, a 1M bit/s local area network designed especially for twisted pairs, and this product has been readily accepted because of its low cost. Equipment is now available to extend the IEEE 802.3 (Ethernet) transceiver interface at its full speed over 100 metres of twisted-pair wire. DEC, Hewlett-Packard, and 3Com have also announced local area network products that can use twisted-pair cables.

Unshielded twisted pairs can support a wide range of services
The only communications services that cannot be supported by unshielded twisted pairs are video distribution and broadband local area networks such as those based on the MAP protocols. However, the star-shaped wiring topology used with TCSs and with IBM's Cabling System will not support all types of local networks designed for twisted pairs. Some of those based on buses and rings cannot be supported effectively. This is an important restriction in some environments because it precludes the use of proprietary systems such as Omninet and Videonet.

The range of communications services that can be supported by unshielded twisted pairs will increase as the transmission rate is increased. To date, telephone-wire-based schemes have not been proved to work at more than 10M bit/s, but development is rapid and this limit is bound to increase. Despite repeated requests, various suppliers have been unwilling to divulge their thinking on this topic, and we have not been able to establish the ultimate data transmission rate that can be achieved over twisted pairs.

THE ADVANTAGES PROVIDED BY THE IBM CABLING SYSTEM ARE NOT RELEVANT FOR MOST ORGANISATIONS

Five advantages are claimed for the IBM Cabling System:

— Shielded wire has better immunity to electromagnetic interference.

— Shielded wire emits less electromagnetic radiation.

— IBM will ensure that its future products will be able to use it.

— Shielded wire can be used for higher signalling rates.

— Shielded wire allows more flexibility in cable layout.

Without doubt, these are significant advantages. As we now explain, however, they are advantages that many organisations may not need in the short-to-medium term.

Shielded wire has better immunity to electromagnetic interference
Provided that the shield is correctly earthed, shielded wire certainly does provide better immunity to electromagnetic interference. However, it is not true that every shielded system has better immunity than every unshielded one: the balanced signalling systems that are used in most structured wiring schemes already provide a substantial degree of isolation from electromagnetic interference.

Electromagnetic interference may cause the signals being transmitted over the cable to be corrupted. However, an absolutely error-free medium is neither possible nor necessary because every well-designed data link protocol includes error-control procedures. The main point at issue is whether the electromagnetic interference immunity provided by systems based on unshielded telephone wire is sufficient over the limited distances (typically no more than 100 metres) for which such systems are used. The difficulty is that previous experience with communications systems is not very useful in resolving this issue. In the past, communications between computers and terminals have been based on unbalanced signalling systems such as RS232 (V.24). Unbalanced systems are very susceptible to electromagnetic interference, whereas the balanced systems, such as RS422, and those used between baluns that are coming into use are much less susceptible to electromagnetic interference.

There is a growing body of evidence that unshielded cables can provide perfectly adequate immunity to electromagnetic interference, particularly when they are used in conjunction with balanced signalling systems. SynOptics, for example, claims an error rate of one in 10^{11} bits for its twisted-pair Ethernet system, LattisNet, the same as for the original Ethernet coaxial cable. And there are several cases where unshielded cables are being used successfully for data transmission in industrial plants, where electromagnetic interference is generally much higher than in offices. These cases include Thompson Regional Newspapers in the United Kingdom and Inland Steel at Oakbrook, Illinois.

We therefore conclude that, in most cases, unshielded wire will provide sufficient immunity to electromagnetic interference. If especially high immunity is necessary, unshielded wire can be laid in metal conduits. If this provides inadequate immunity, the best solution is probably to use optical fibres.

Shielded wire emits less electromagnetic radiation

It is generally the case that shielded wire emits less electromagnetic radiation than unshielded wire. But again, the point at issue is whether the emissions from unshielded systems are tolerable. The most recent products for high-speed signalling over unshielded twisted pairs address this problem by 'preconditioning'. That is, they round off the wave, eliminating the higher overtones that would otherwise be present. This technique, which depends on good receiver design, greatly reduces electromagnetic radiation. As an example, the first Ethernet product for unshielded twisted pairs, LattisNet, meets the US emission rules for equipment to be used in commercial premises (Federal Communications Commission Part 15, subpart J, for class A devices) "with substantial margins".

However, there may be some sites where, because of the use of sensitive equipment or because of high security requirements, the electromagnetic radiation from unshielded wires may be unacceptable. (Breaches of security through radiation 'eavesdropping' were discussed in Foundation Report 51 — Threats to Computer Systems.) In these situations, the best choice is to use optical fibres, although in extreme cases the whole building may need to be shielded.

We conclude that unshielded wire can be operated at high signalling speeds without producing excess electromagnetic radiation.

IBM will ensure that future equipment will be able to use its Cabling System

Although it is reasonably safe to assume that future IBM equipment will be able to operate over IBM's Cabling System, it is not absolutely certain that this will be the case. First, there are technical limits on the use that existing IBM equipment can make of the Cabling System, and, second, we expect to see the widespread adoption of optical fibres in the longer term by all suppliers, including IBM. (The pre-announcement prototype of the IBM Cabling System included a wiring scheme that provided optical fibres to every desk, and optical-fibre schemes were installed at beta-test sites such as Carnegie-Mellon University.)

One possibility is that IBM may develop products that require the higher transmission rates available with the IBM Cabling System. In our view, other suppliers would respond to such a move by improving the effective performance of the lower-speed networks and media (possibly by developing unshielded pairs that can be used for higher transmission rates).

Thus, we do not believe that future IBM equipment will be restricted to operating only over the IBM Cabling System. There is plenty of experience of supporting 3270 screens over unshielded twisted pairs, and there are many innovative suppliers with an interest in exploiting the opportunities of using IBM equipment with their products. (They will be helped in this by IBM's layered architectures for workstations, which allows one communications layer to be replaced without changing the others.) Evidence of the trend towards using IBM equipment with other suppliers' wiring products comes from equipment already available. For example, we estimate that there are presently more balun products available for telephone wire than there are for IBM's Cabling System. The only long-term constraint is likely to be concerned with the upper limit on the signalling rate that can be achieved over twisted pairs.

Shielded wire can be used for higher signalling rates

It is not clear whether the limiting data rate is really higher for shielded than for unshielded cable. Neither AT&T nor IBM has published detailed technical research supporting their claims for superiority for unshielded and shielded wires respectively. Our own opinion is that technical superiority depends on whether loss or cross-talk is the key constraint on data communications.

In practice, however, we believe that arguments about the technical merits of shielded and unshielded cable, and about the data transmission rates that can in theory be achieved with both types of cable, are largely irrelevant. We say this because, in our view, the signalling rates that can now be achieved over unshielded twisted pairs will be more than adequate to meet the applications requirements of many organisations for the next 10 years.

First, existing Ethernet and Token Ring systems are, in almost all cases, completely adequate for today's local communications needs. (The exceptions are some groups of software engineers sharing resources between powerful workstations, such as the Sun and Apollo products; these groups are quite atypical of offices generally.)

Second, the workstation of the future will look more like a PC than a terminal. In practice, PCs can rarely transfer data files at more than 100,000 bit/s. Future PCs will be able to use higher rates, of course, but our calculations suggest that rates exceeding 2M bit/s will not be needed for handling office communications (voice, data, or image) in the forseeable future. Thus, the 10M bit/s already available over unshielded twisted pairs should meet most local communications needs for some years to come.

Much higher rates may be needed for special purposes, such as the transfer of moving colour pictures as digital data, although improvements in data compression methods, badly needed to economise on expensive intersite bandwidth, may reduce even this to less than 2M bit/s. If high-speed links have to be provided to individual workstations, this can be done with dedicated channels rather than by a (shared channel) local area network. Such an arrangement would cause no difficulty for a structured wiring scheme based on either kind of twisted pair cable. However, we expect requirements for such high-speed links to be rare for at least the next 10 years.

For an ordinary commercial organisation, therefore, it is reasonably probable that a only a few users will need local area networks providing more than 10M bit/s within the next 10 years. As we show overleaf, we expect optical fibres to be generally used for data transmission rates of more than 10M bit/s in significantly less than 10 years. There is therefore no need to provide for higher transmission rates in a wiring scheme based on copper cables.

There is also a possibility that very high data transmission rates will be required to meet some as yet unforeseen need. Organisations must decide for themselves whether to accept the risk of this occurring or to pay more for a wiring scheme that could meet such needs. We believe that it is very unlikely that such needs will arise within 10 years.

The history of local area networks provides further evidence for our view that existing technology will suffice for the foreseeable future. Local area networks were invented in 1974, but they are only now coming into general use, illustrating the familiar lag between the invention of a technology and its general use. More significant, however, is the fact that most of today's workstations could still be well supported by the very first local area networks — Ethernet 1 and the Cambridge Ring.

Because of the technology-application lag, if much higher transmission rates were likely to be required in 10 years' time, we would expect to see signs today of experimental prototypes able to meet such requirements. We see no such signs.

Shielded wire allows flexible cable layouts

The configuration rules for the IBM Cabling System are less restrictive than those for TCSs. For instance:

- Station cables can be longer.
- Distances between wiring closets can be greater.
- It is not necessary to avoid sources of electromagnetic interference such as fluorescent lights.

These are real advantages but their significance depends on the circumstances in a particular building. For example, the maximum length for an IBM shielded station cable is 100 metres, significantly greater than the 70 metres specified for PDS. In our experience, however, a limit of 70 metres will not be a problem in most buildings. Similarly, there are many cases where the extra distance between wiring closets is of no concern and where cable routes do not run near to fluorescent lights.

A more severe constraint on wiring layout arises if it is necessary to stay within the limits specified by IBM for the operation of its Token Ring Network over unshielded cable. IBM specifies that Token Ring station cables can be no longer than 45 metres for unshielded telephone wire, compared with 100 metres for its Cabling System. However, other suppliers claim that their versions of Token Ring networks can operate on unshielded twisted pairs over greater distances. We believe that the 45-metre restriction specified by IBM is extremely conservative.

USE SCHEMES BASED ON TELEPHONE WIRE WHEREVER POSSIBLE

It is clear that structured wiring schemes based on telephone wire are cost-effective and can meet the local communications requirements of most organisations for the foreseeable future. The installation costs of schemes based on telephone wire can be as little as one-third of the cost of installing the IBM Cabling System, and they have been shown to work at 10M bit/s with the IEEE 802.3 (Ethernet) standard and at 4M bit/s with the IEEE 802.5 (Token Ring) standard. Structured wiring schemes based on unshielded twisted-pair telephone wire should therefore be selected unless there are special reasons for choosing the IBM Cabling System, for example:

- If a site has particularly high levels of electromagnetic interference.
- If there is a need for higher transmission rates than those that can be provided by unshielded twisted pairs.

The level of electromagnetic interference can be established by measurement, and suppliers such as AT&T, DEC, and Hewlett-Packard now offer measurement services for sites and wiring systems. It will be unusual for the level of electromagnetic interference to be high enough to prohibit the use of unshielded cables.

A few organisations may have specialised requirements that preclude the use of schemes based either on telephone wire or on the IBM Cabling System. In a factory, for example, or in an office closely associated with a factory, there will be long-term advantages in being able to support the General Motors' Manufacturing Automation Protocol (MAP). This requires either a broadband cable or, when the standards are fully defined, a MAP optical-fibre ring.

If electromagnetic interference levels are exceptionally high, or if there are very high security requirements, or if the environment may contain inflammable gases, then optical fibres, rather than copper wire, should be used.

A basic unshielded twisted-pair wiring scheme may need to be supplemented with other forms of wiring in order to meet special requirements. In dealing rooms, for example, and, perhaps, in the financial departments of other organisations, it may be necessary to provide separate, special wiring for existing specialised financial services. (The special wiring will often be coaxial cable or optical fibres used to distribute a video signal from a central gateway machine.) However, many of the specialised services are currently being converted to use standard digital network technologies. In general, a broadband cable installation will be required only if there is a significant requirement to distribute television signals.

The installation of dedicated cable may also be justified if the organisation can obtain substantial benefits from a proprietary local area network that cannot be supported on the standard wiring scheme. For example, separate cabling for Ethernet is likely to be justified if the organisation is a substantial user of Ethernet-based equipment and if DEC is the predominant supplier. The separate cable could be a standard Ethernet bus cable or a cable manufactured to the IEEE 802.3 10 base 2 standard (commonly known as Cheapernet), but installed to DECconnect standards.

Ultimately, we believe that all local communications (voice and data) will be based on optical fibres. At present, however, schemes based on telephone wiring are less expensive than optical fibres because of the high cost of the electronics needed to connect a fibre to a computer or terminal and the special skills needed to splice and terminate fibres. In most cases today, optical fibres can be justified for in-house cabling only if there is a need for transmission rates of more than 10M bit/s, if there are special security requirements, or if there is an acute shortage of cable space.

However, we expect the present problems of using optical fibres for local communications to be overcome during the next few years. Thus, as Figure 3.7 shows, fibre will become the preferred medium at progressively lower transmission rates. By the mid-1990s, we believe that optical-fibre technology will have advanced to the stage where metal cables will be preferred only for rates below 1M bit/s.

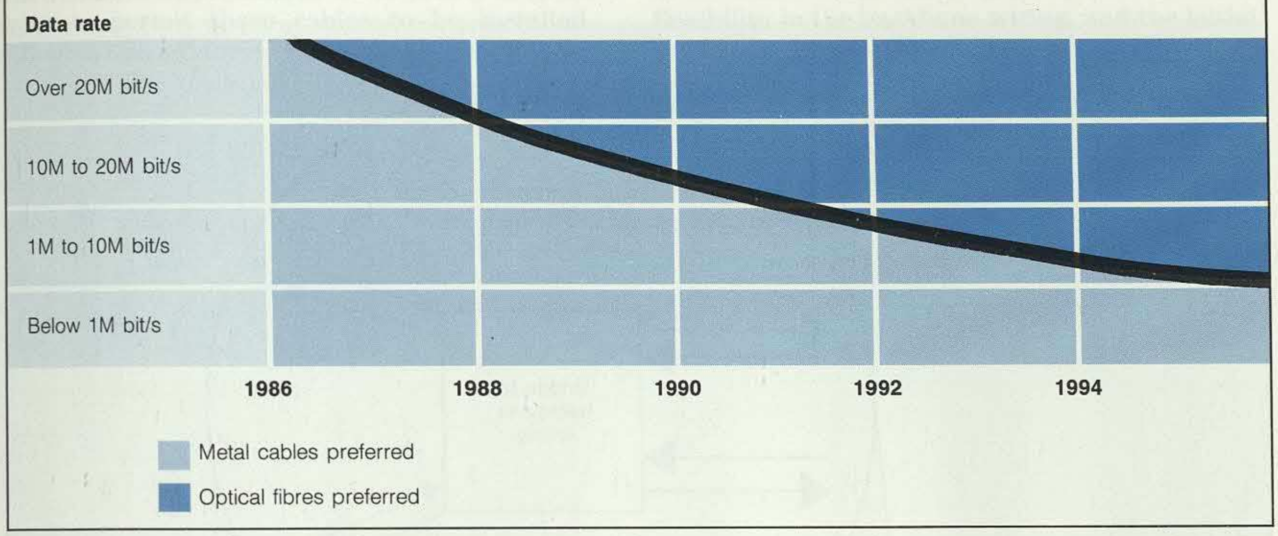
In preparation for the day when it will be necessary to install optical fibres, we suggest that, during any wiring work carried out today, organisations should consider installing empty tubes. Optical fibres can then either be pulled through the tubes or, using a recently developed technology, be blown through them.

SELECTING A SUPPLIER FOR A PROPRIETARY WIRING SCHEME

At present, there are several suppliers of telephone-wire-based structured wiring schemes in Europe, and we expect other suppliers to enter the market within the next few months. In choosing a supplier, an organisation needs to consider three factors:

- The need for technical support during system design. Unless it is prepared to be a pioneer, the organisation should choose a supplier that has significant experience of designing and installing structured wiring schemes and that has skilled staff who can be readily available on site if required.
- The need for skilled tradesmen to install the wiring scheme, preferably employed by an experienced local contractor.

Figure 3.7 Optical fibres will be the preferred technology for progressively lower transmission rates



- The need to stay in line with emerging standards. Many of the most innovative products in this area are being developed in the United States, and, in practice, this means choosing a supplier that can comply with the standards for the IBM Cabling System or AT&T's PDS, at least for cables. It is regrettably the case that quite small changes in certain cable characteristics (the accuracy of the balance in balanced pairs, for instance) may make the difference between a link that works and one that does not work.

In some countries it will be possible to find suppliers who meet all these requirements. In others, some difficult trade-offs may have to be made.

Those organisations choosing to install the IBM Cabling System have no choice in the matter. The components must be obtained from IBM or an IBM-approved supplier, and this will usually be via an installation contractor.

BACKBONE WIRING

So far this chapter has dealt largely with wiring alternatives for horizontal wiring. However most of today's structured wiring schemes use cables of the same type for both backbone and horizontal wiring. As a result, a floor with 200 staff, all of whom might use ASCII or 3270 terminals, may be connected to the computer room by 200 coaxial and 200 twisted-pair data cables. This approach inevitably requires a large number of cables to be installed in the risers, which can lead to weight and space problems in a multistorey building. The problems can be reduced, however, by using cable multiplexing techniques. (These techniques are discussed in Chapter 5 on pages 38 and 39.)

There is another disadvantage of running individual cables from each terminal to the computer room. This arrangement will not work well at high signalling speeds because the signals usually have to be regenerated every few hundred metres (unless optical fibres are used, in which case longer distances are acceptable). The best way of overcoming these difficulties is to base the backbone wiring on a wideband network, probably a local area network.

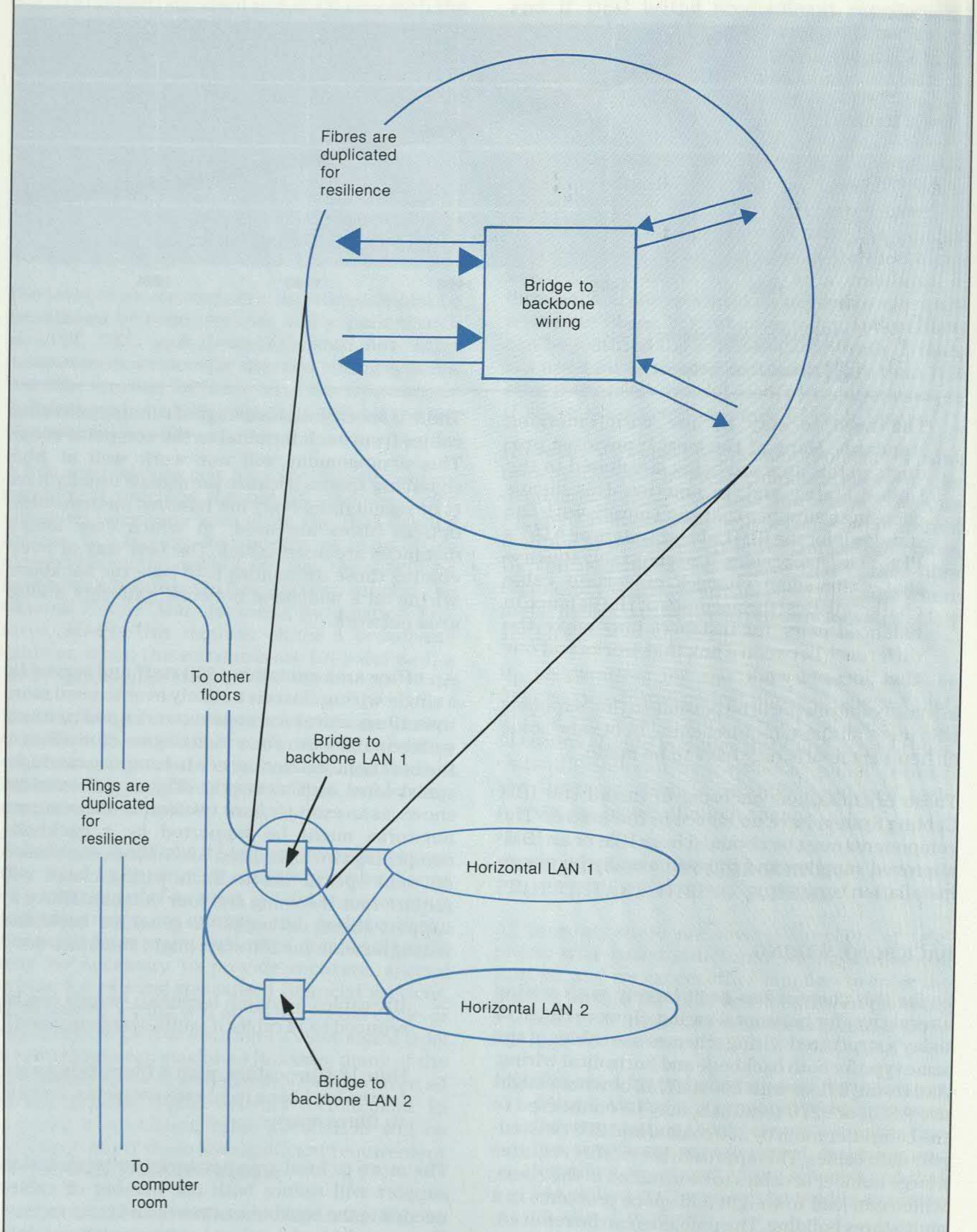
An office area containing 250 staff and served by a single wiring closet is unlikely ever to need more than 10 separate local area networks, and two may well be sufficient. For a high degree of resilience, the backbone network needs to comprise two high-speed local area networks. Figure 3.8 overleaf shows, as an example, how two horizontal local area networks might be supported by a backbone comprising two high-speed Token Rings, each based on dual optical fibres. Each wiring closet will require four incoming and four outgoing fibres to support these networks. A generous backbone wiring scheme for 250 staff might therefore be:

— 100 cables for dumb terminals (which can be reduced to 14 cables if multiplexors are used).

— Four 12-fibre cables, with 8 fibres being used for the backbone local area networks, leaving 40 fibres spare.

The move to local area networks for workstation support will reduce both the number of cables needed in the backbone network and their variety. However, although local area networks will certainly be the dominant local data transmission technology during the next five years, there is always the

Figure 3.8 Configuration of backbone local area networks based on optical fibres



(Note: Backbone wiring is based on duplicate Token Ring LANs.)

possibility that a new technology, requiring more cables, will become popular in the longer term. It will therefore be prudent to leave plenty of spare space to permit these cables to be installed. Although this advice is contrary to that given for horizontal wiring, it is much easier to install new cables in a riser than it is to install many new cables in an office area. Thus, there is less need for flexibility in the backbone wiring, and the initial provision can be less complete.

Chapter 4

Prewire wherever possible

Every organisation gets the occasional opportunity to make a new start on wiring. This opportunity may arise because of a move to a new building or a major refurbishment of an existing building. It also arises, though on a lesser scale, every time the organisation opens a new branch or other local office. Today, the majority of Foundation members, 58 per cent of those that replied to our initial questionnaire, have not prewired their buildings for nonvoice communications. The remaining 42 per cent have prewired to some extent, but this is often restricted to new buildings or, in a few cases, to only parts of their buildings.

Because the installation of wiring in an occupied building is so disruptive, we believe that any opportunity for prewiring should be eagerly seized by the systems director. However, a prewiring project has to be planned carefully. Care has to be taken to ensure that adequate presentations are installed both for voice communications and data communications. It is also important to ensure that the cables are installed in a planned manner so that it will be easy to maintain the wiring system. It is all too easy to create a random jumble of cables where no one knows for certain which cable is connected to which presentation point. The main purpose of prewiring a building with a well-planned, well-laid-out structured wiring scheme is to avoid this.

Enough outlets should be installed at the outset so that when a device is moved to a new location, there is always a conveniently located outlet. The correct density for outlets depends both on the organisation that will occupy the building and on the approach taken to space planning. The following principles should be used in deciding the number of outlets:

- The density should be determined by the maximum number of staff who could be accommodated, not the expected number.
- Different densities will be needed in different parts of the office space, but the difference will not be great.
- The correct density depends upon the method used for cable routeing, being lower if the presentations are integrated with a furniture system or are movable.

Appendix 2 contains detailed advice about determining the number of presentation points on the wiring scheme and about cable routeing. In this chapter we focus on the benefits that can be gained from prewiring a building, particularly on the economic case for installing a wiring scheme. We do this by presenting cost models that identify the payback periods for various types of wiring scheme. We also highlight the need to install separate wiring schemes for voice communications (telephony), security communications, environmental control, and data communications.

BENEFITS OF PREWIRING

From our discussions with organisations that prewired their buildings some years ago, it is clear that substantial qualitative (nonfinancial) benefits can be obtained from prewiring. The major nonfinancial benefits are:

- Improving the control of the wiring scheme by the systems department.
- Facilitating a move into new accommodation.
- Simplifying subsequent moves of people and equipment.
- Improving the speed of response to requests to move equipment.
- Reducing the number of wiring faults.

Substantial cost savings can also be obtained from prewiring. These are discussed in the next section beginning on page 32.

IMPROVED CONTROL BY THE SYSTEMS DEPARTMENT

Once a building has been prewired, most requests for new or altered connections can be satisfied without installing new cables. And even where new cables are needed they will usually be quite short — a few metres at most to connect a device to an adjacent socket. In many situations such cables can be installed by systems staff — there is no need to involve outside tradesmen. The systems department is therefore in control of the wiring scheme and is able to make the decisions about when and how to change the wiring. Such decisions may involve making a trade-off between the cost of changing the wiring and the level of service that is provided. If the systems department is not in control of the wiring scheme, these trade-offs cannot be made so easily.

EASIER MOVES INTO NEW ACCOMMODATION

Moves into new offices are inevitably confused and disorganised. In almost every case, some of the carefully made arrangements for staff, equipment, or procedures will prove to be impractical and will have to be changed quickly. Moving to new accommodation is therefore a particularly testing time for everyone concerned, and because of the growing dependence on IT, the systems department is increasingly involved in ensuring that the right facilities are installed in preparation for the move.

For example, in 1986 one Foundation member moved into a newly constructed head office building in a rural area. Despite its late involvement in planning the move, the systems department was able to have the whole building prewired with the IBM Cabling System. Afterwards, the main board director in charge of the move, a man not noted for his sympathy for IT, was amazed at the speed with which the systems department was able to move in. After inspecting the work, he said, "I never believed this was possible." Speaking to staff in the new building, the chairman singled out the systems staff and praised them for contributing to the success of the move.

SIMPLIFYING SUBSEQUENT EQUIPMENT MOVES

Prewiring a building can make it much easier and quicker to move people and equipment. For example, at CAP Gemini Sogeti's new head office in Paris, the structured wiring scheme (which was designed by the company) allowed 40 Minitels to be installed in a conference room in just two hours.

Prewiring with Racal's Planet local area network at W H Smith's retail head office in Swindon has made it much easier to move people, equipment, and departments. There have been several major moves in the 18 months since the network was installed, all of which have been completed without difficulty.

IMPROVING THE SPEED OF RESPONSE

If a building has not been prewired, the time required to install or move a terminal usually includes the time to install a new cable from, at least, the riser and to terminate it in a suitable socket. In a prewired building, this step is eliminated completely.

Sometimes, the terminal can be moved by the user, in which case the job will be completed as soon as the user moves it and the systems department, or the terminal communications system, has been notified of the new location. For example, at the Abbey National Building Society's head office in Milton Keynes, Usernet (Omninet) PCs can be moved short distances by the users themselves because the building has been prewired with Usernet. However, this procedure is completely straightforward only if the PC is not moved to another local area network. If this happens, the systems department has to change the configuration tables.

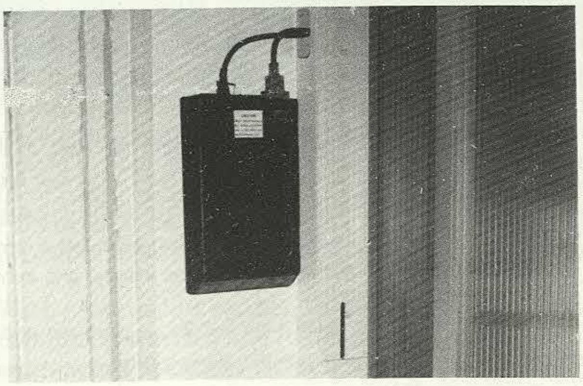
W H Smith's Planet installation provides dumb terminals with access to ICL and DEC computers. The Planet cable is led to sockets installed on every other structural column in the area of the building served by the network. To use the network, an interface box (known as a terminal access point) is installed on the column next to the trunking and is plugged into the socket. The two V.24 cables from the access point are led back into the trunk, down to the floor, and then loose-laid to reach the equipment. It takes about an hour to install a new terminal access point. (Figure 4.1 shows the presentation point installed on one of the structural columns.)

The head office of a major manufacturer has been prewired with IBM Cabling System. As a result, a request to move a terminal which is received by 2 pm will usually be carried out by 4 pm that day.

FAULT REDUCTIONS

When cabling is installed on an ad hoc basis, it is often done in a rush, without proper planning, and is sometimes carried out by tradesmen who do not have proper equipment — especially test equipment, which means that the new cables may not meet all of the required specifications. There is also the danger that existing cables will be disturbed during the work, introducing faults into the wiring system.

Figure 4.1 Planet presentation point



The advantage of prewiring is that it can be thoroughly planned and the work can be carried out by staff with all the necessary equipment, thereby reducing the likelihood of faults in the wiring system.

PREWIRING CAN REDUCE COSTS

Prewiring a building requires a substantial initial investment in a communications infrastructure that will be used for many years. Furthermore, installing a structured wiring scheme is likely to cost more than prewiring with conventional wiring. One large manufacturer estimates that prewiring its head office with IBM Cabling System cost £80,000 ($150,000); wiring with 3270 coaxial cable would have cost only £50,000 ($95,000). However, a French insurance company found that the additional cost of installing IBM Cabling System in its regional offices was only 10 per cent more than the cost of installing coaxial cable.

Prewiring will also cost more than installing wiring on an ad hoc basis, at least for a year or two, but the additional costs will almost certainly be offset quite quickly by cost savings in subsequent years. One simple example is shown in Figure 4.2. Given the assumptions in the example, the figure shows that the cumulative cost of ad hoc wiring becomes greater than the cost of prewiring after three years — well within most organisation's criteria for IT investment. (Although we have not shown the effects of discounted cash flow, it does not affect the results significantly.)

The assumptions in Figure 4.2 will not apply to every organisation and building, but they are not atypical. The payback period will be longer if:

— The growth in the number of new workstations is slower.

— The proportion of workstations needing to be relocated is lower.

— The cost of installing ad hoc cabling is less than three times the cost per outlet of prewiring. This may be true if the prewiring system is inherently expensive, or if the price charged by the contractor carrying out the prewiring does not reflect the costs incurred.

On the other hand, the payback period will be shorter if:

— The growth in the number of new workstations is faster.

— New workstations cannot easily use the existing cables.

— The proportion of workstations needing to be relocated is higher.

— The cost of installing ad hoc wiring is even more than three times the cost per outlet of prewiring. This may be true if a less expensive wiring scheme is used for prewiring.

Figure 4.3 gives a slightly more complex example of the payback period required for prewiring. In this example the total population of workstations doubles over five years, but during this period dumb terminals are progressively replaced by PCs. Each time a PC is installed, whether in a new location or as the replacement for a dumb terminal, a new cable is installed. The example also assumes that the cost of installing an ad hoc cable is the same as the cost of installing a cable with a prewired cabling scheme. Using these assumptions, the investment in prewiring does

Figure 4.2 Prewiring costs can be recovered within three years

	Year 1	Year 2	Year 3	Year 4	Year 5	Total
Wiring changes						
Number of additions	10	10	10	10	10	50
Number of relocations	18	22	24	30	32	126
Ad hoc wiring costs ($000)						
Extra connections	3.0	3.0	3.0	3.0	3.0	15.0
Relocations	2.7	3.3	3.6	4.5	4.8	18.9
Total costs	5.7	6.3	6.6	7.5	7.8	33.9
Cumulative cost	5.7	12.0	**18.6**	26.1	33.9	33.9
Prewiring costs ($000)	15.0	0	0	0	0	15.0

This example is for an office building housing 100 staff. At the start of year 1 there are 50 workstations. The assumptions are:

— Ten new workstations will be installed for each of the next five years, so that at the end of five years there is one workstation per person.

— One-third of the average number of workstations installed will need to be relocated each year.

— With ad hoc wiring, each new workstation will need a new cable, and half the relocations will need a new cable to be installed.

— With prewiring, 150 sockets are installed initially, and subsequent new connections and relocations do not need new cables to be installed.

— Cables cost $100 to install if the building is prewired and $300 each if the work is done on an ad hoc basis.

— All devices installed can use the same cables.

Figure 4.3 Using different assumptions, the cost of prewiring can be recovered in less than five years

	Year 1	Year 2	Year 3	Year 4	Year 5	Total
Wiring changes						
Extra dumb terminals	5	5	0	0	0	10
Dumb terminals replaced by PCs	0	0	17	17	16	50
Additional PCs installed	5	5	10	10	10	40
Terminals relocated	14	16	12	8	3	53
PCs relocated	4	9	16	25	29	83
Ad hoc wiring costs ($000)						
Cost of extra connections	2.0	2.0	5.4	5.4	5.2	20.0
Cost of relocations	1.8	2.5	2.8	3.3	3.2	13.6
Total cost	3.8	4.5	8.2	8.7	8.4	33.6
Cumulative cost	3.8	8.3	16.5	25.2	**33.6**	33.6
Prewiring costs ($000)	30.0	0	0	0	0	30.0

This example is for an office building housing 100 staff. At the start of year 1 there are 40 dumb terminals and 10 PCs. The assumptions are:
- The total workstation population increases by 10 a year, growing to 100.
- After small increases in the first two years, the dumb terminals are replaced progressively by PCs. After five years all workstations are PCs.
- A new cable needs to be installed when a terminal is replaced by a PC.
- Approximately one-third of the installed base of workstations is relocated each year.
- Where wiring is ad hoc, a new cable has to be installed for each new connection and for half of the workstations that are relocated.
- Following prewiring with 150 sockets, neither new connections nor relocations need new cables to be installed.
- Cables cost $200 to install whether they are prewired or installed in an ad hoc basis.

not begin to produce a payoff until some time during the fifth year.

We find that the most critical factor in determining the time it will take to receive a payback on the investment made in a structured wiring scheme is the rate of change that would be required if wiring continued to be installed on an ad hoc basis. The rate of change is determined by the growth in new workstations, and the proportion of existing workstations that have to be relocated and that require a new cable to be installed. It is also affected by the need to replace workstations by another more advanced type that requires a different type of cable. When allowance is made for the number of work locations that will require a new cable, the rate of change will be increased significantly, with a corresponding decrease in the time required for a payback to be achieved from prewiring.

Figure 4.4 overleaf shows the payback periods for various rates of change. Note that the rate of change is assumed to be constant throughout the life of the wiring scheme. Thus a 10 per cent change implies that the total number of cables to be installed during any one year is 10 per cent of the total number of cables installed at the beginning of the year, even though some of those cables may no longer be used.

Figure 4.4 shows two curves — one which assumes that the cost of installing an ad hoc cable is three times the cost of installing a cable during prewiring, and one which assumes the two costs are the same. For a 30 per cent level of change, the payback period in the first case will be just under three years, and in the second case just under six years.

Prewiring can also produce cost savings if it is necessary to install equipment of unforeseen types. Within a year of installing the IBM Cabling System, the manufacturer mentioned on page 32 also had to install several Honeywell systems. Although the Cabling System did not meet Honeywell's specification, it has proved to be perfectly adequate for intercommunications between the Honeywell systems. Installing separate wiring for the Honeywell systems would have cost about £20,000 ($37,000). In addition, a few small Token Rings have been commissioned on the Cabling System, and this has been achieved without the need to install extra cabling and with no difficulties. Thus, for this organisation, prewiring had nearly paid for itself within the first year.

In the example just quoted a rapid payback was achieved even though one of the most expensive cabling schemes had been used to prewire the building. If a wiring scheme based on telephone wire and components had been used, the costs would probably have been much less. For instance, to wire the manufacturer's building with AT&T's PDS to provide one socket per work location would probably have cost no more than £30,000 ($55,000).

With costs as low as this, the company might have thought it worthwhile to install a double socket at each work location (which would have avoided some problems that were actually encountered after moving in). This would have cost about £46,000 ($71,000) — still much less than the £80,000 ($150,000) required to install the IBM Cabling System.

INSTALL DIFFERENT CABLES FOR DIFFERENT TYPES OF COMMUNICATIONS

A great deal has been written and said about the integration of communications. In a recent Foundation Report (54 — Integrated Networks) we concluded that, in preparation for ISDN and other future products, the management of voice and data communications should be integrated and that there were advantages in integrating wide-area networks. We also concluded that the time was not yet ripe for the integration of on-site systems and communications. During the 18 months since the preparation of that report our view has not changed. (We do now recognise that the building space used for wiring is a key resource, however, and should be properly managed.)

For the time being we therefore believe that, within their office buildings, most organisations will need to install separate wiring for telephony, security, environmental-control, and data networks.

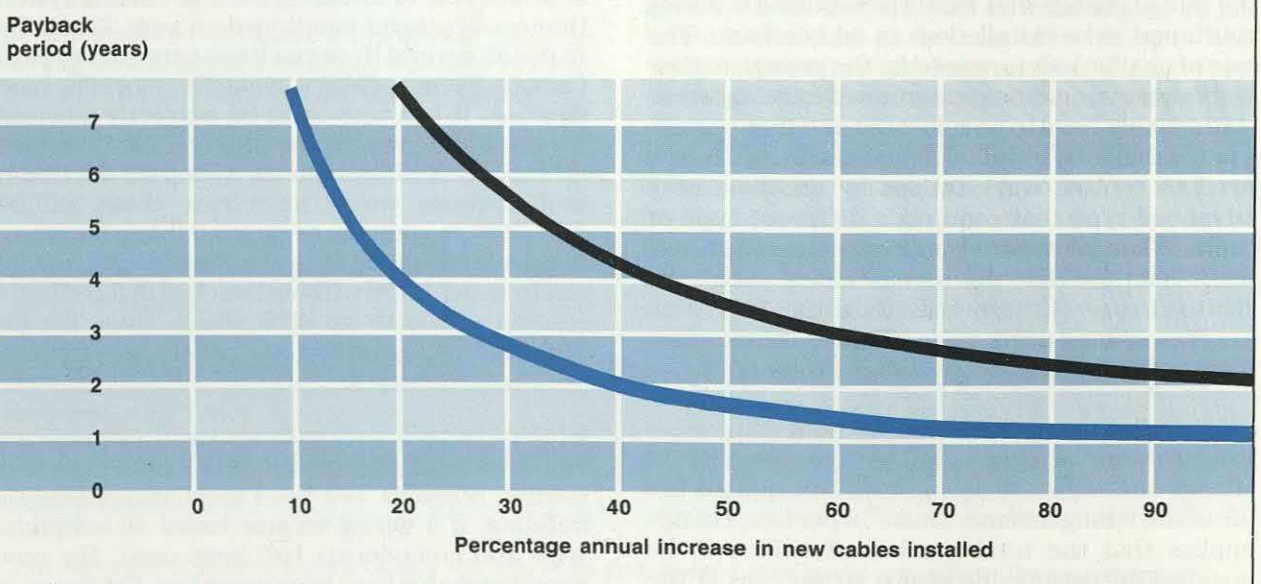
TELEPHONY

In most countries, telephone wiring must be kept separate from other wiring for technical and regulatory reasons. Experience has shown that the 75 volts used for signalling in analogue telephony often interferes with digital signalling and that analogue and digital cables should not be mixed. Digital telephony does not produce interference because of the lower voltages used.

In most countries an integrated wiring system would be subject to PTT control. The most immediate disadvantage of this is the requirement that only PTT, or PTT-approved, tradesmen can work on the wiring system. This requirement will inevitably lead to delays when the in-house wiring system needs to be changed and is one of the less obvious disadvantages of data-over-voice systems. A consequence of the regulatory position in some countries is that nonvoice equipment would require approval before being connected to an on-site integrated wiring scheme, even though it is not directly connected to the public network.

During the past few years, increasing use has been made of existing telephone wiring for nonvoice communications. Indeed, the PTTs are themselves suppliers of IT products and services and have in the

Figure 4.4 Payback periods for prewiring



Shows the situation when the cost of installing an ad hoc cable is three times the cost of installing a prewired cable.

Shows the situation when the costs are the same for installing an ad hoc and a prewired cable.

Assumptions:

1. Percentage change applies to ad hoc wiring and is assumed to be constant throughout the life of the wiring system. It is measured as the percentage increase in cables installed during a year, even if some of the cables in existence at the beginning of the year are no longer used. New cables will be required for additional workstations and for a proportion of workstations that are relocated.
2. With prewiring, new workstations and relocated workstations can always use an existing prewired outlet.

past often used their monopoly positions to exclude competitors. In other cases they have, by setting high, and sometimes unreasonable, standards, prevented innovative nonvoice equipment being connected to their networks. Nonvoice equipment has rarely been as closely regulated as voice, and there is certainly a general trend in many countries towards a more liberalised telecommunications market. However, this trend is in many cases being prompted by political decisions, and a future change of government could reverse the trend. If this were to happen, we believe it is unlikely that existing installations and practices will be outlawed, but it is certainly possible that the expansion of innovative practices might be inhibited.

In some countries today, it is possible to connect without PTT approval a wide range of equipment to an in-house network that in turn is connected to the PTT network. We believe that it is possible that a future political decision might extend the definition of connection to the public network to include such equipment. It might even be extended to include the situation where equipment is not connected in any way to PTT wiring, but where the wiring for such equipment shares the same sheaths as wiring that is connected directly to the PTT network. In our view the possibility of such a change will exist for some years and will only cease once the PTT is comfortable with the idea of a wide range of equipment being connected to networks that are indirectly connected to (or are closely associated with) their own wiring. The possibility will therefore exist until:

- There is several years' experience with integrated wiring systems in the country concerned.
- The PTT has begun to use integrated wiring schemes and to sell them to subscribers.

Therefore, even if unshielded twisted-pair cable is the chosen medium for data communications, users should install two twisted-pair networks — one for PTT services and the other for data and other non-PTT services.

SECURITY

Most organisations prefer to install separate wiring for use with security systems (cameras, remote-control door locks, and so forth). In this way, the security function can have total control over its resources and it will be more difficult for users of other communications systems to gain access, accidentally or otherwise, to the security systems. Moreover, security systems are often installed in locations not served by data and voice networks — for example, on rooftops (for cameras), in plant rooms, and in car parks.

ENVIRONMENTAL CONTROL

As with security, wiring used for environmental-control purposes may be connected to equipment that is not located in ordinary office space. Environmental-control sensors may be located in lifts, in false ceilings, in corridors, and on the outsides of the building. There are no clear standards in this area, but, because the wiring may be connected to large numbers of relatively inexpensive sensors that have little or no inbuilt intelligence, the wiring conventions are unlikely to be the same as those for office, or even factory, communications networks.

However, when a structured wiring scheme is installed, we recommend including some spare capacity that could be used for environmental-control sensors and providing outlets for voice and data services in nonoffice areas, including plant rooms and the wiring closets themselves.

Chapter 5

Upgrading existing wiring

Many organisations are faced with immediate wiring problems that have to be solved in existing buildings. Our research indicated that the main wiring problem for most organisations was associated with the need to move equipment (see Figure 5.1).

Problems with existing wiring may be brought forcefully to management's attention by an IT or other development such as:

— The choice of a new PABX.
— The need to install a new information service, perhaps a financial service for the organisation's treasury function.
— The choice of a new mainframe.
— A decision to adopt a new PC or terminal standard.
— The inability to meet a routine need because the existing cable ducts are full.

Unfortunately, there is no universal solution to the wiring problems associated with existing buildings because of the wide variations in buildings, organisations' policies, and inventories of existing equipment. Replacing the existing building wiring with a structured wiring scheme may sometimes be possible, but there are many circumstances in which it will be too expensive, too disruptive, or both.

Figure 5.1 The main wiring problem is caused by the need to move equipment

Problem	Average ranking	Percentage of respondents ranking this problem no. 1
Equipment moves	2.1	32
Adding equipment	2.4	24
Planning wiring during refurbishments	2.6	19
Planning wiring for new buildings	2.7	25

Respondents were asked to rank a series of wiring problems

(Source: Survey of 104 Foundation members)

However, there is a very wide variety of possible techniques and products available for improving the wiring in an existing building, and we therefore recommend a procedure for dealing with the problem, rather than a universal solution. The procedure has four steps:

— Establish the existing cabling position.
— Identify the approaches to upgrading the wiring.
— Match the approach to the wiring problem.
— Implement the changes.

Even if no wiring problems are apparent, we recommend periodic and careful review of the wiring position. The activity that we describe as establishing the existing cabling position can form the basis of such a review.

ESTABLISH THE EXISTING CABLING POSITION

Before making any decisions about how to improve the existing wiring, it is important to establish the basic facts about the current wiring resources available, the levels of service that are needed, and those that are actually provided. We call this the 'cabling position' and it may be different for each of the organisation's buildings.

The cabling position comprises service levels, costs, staff resources, cables, equipment, and the space required to house the cables and equipment. To put these in a proper perspective, it is also necessary to know the expected lifetime of the building and the state of other building services, including power supplies, lighting, and air-conditioning plant.

SERVICE LEVELS

The service level is an attempt to measure the degree to which users' requirements are met. If there is already a service-level agreement for communications services, this can be used as a starting point. If such an agreement does not exist, the first step in assessing the service level is to identify what the requirements are. The users must, of course, be involved in this process.

At first, users are likely to perceive their communications requirements in very general terms. It will be necessary to translate these perceived requirements into measurable service-related elements — response time, reliability, delay in providing new equipment, delay in moving equipment, and so on — each of which can be related to the level of service available from the wiring infrastructure. Target service levels should be set for each of these elements, and the targets should be used to measure the performance of the wiring system. There will, of course, be other service-related elements (such as access to multiple host computers) that are independent of the wiring.

Identifying users' communications requirements for the purpose of defining service levels does not, of course, identify their future requirements. As we stressed earlier, users find it difficult, if not impossible, to predict what their future requirements will be.

COSTS

At the beginning of the report we showed that systems departments have only a very general and approximate idea of their wiring costs. We have often found that organisations are unpleasantly surprised when they do discover the true costs of wiring. We recommend that systems departments should establish the actual costs of adding wiring for new equipment, the wiring costs associated with relocating equipment, and (where relevant) the wiring costs associated with upgrading equipment. It is important to take account of all cost elements, including staff costs (unless these costs are so modest and widely spread that they cannot sensibly be allocated).

It is unlikely that any of the existing accounting systems will be able to provide the relevant information. The only alternative is to examine invoices and work records, possibly for a sample period. In our consultancy work in this area, we find that the most generally useful presentation of costs is on a per-outlet or per-change basis.

STAFF RESOURCES

An organisation may employ experienced communications staff, yet not have anyone who is an expert in installing large wiring systems. Most organisations seldom install such systems and many communications staff have never had to manage the installation of a wiring system. The systems department should recognise that not all of the required skills may be available in-house and should allow for the costs of external assistance when the options for improving the existing wiring are being evaluated. In-house staff used to dealing with power cables and ordinary telephone wire are unlikely to have the skills required to install the specialised cable used for structured wiring schemes.

EQUIPMENT

The wiring systems in a typical building are difficult to manage because of their dispersed nature and because of the large number of people who have worked on the systems during their lifetime. Unless there are comprehensive records about the cables currently installed, the systems department should determine the amount of cable and associated equipment already in place and the amount of spare space in the risers and ducts.

CABLE SPACES

The spaces in which cables can be installed are a key resource, and, in many buildings, they are already full. The systems department must have accurate records showing the current state of these spaces because lack of cable space will constrain significantly the options available for improving the wiring situation.

OTHER BUILDING SERVICES

There is little point in spending considerable amounts of money on improving a wiring system if the other building services, notably power supplies and air conditioning, will be unable to cope with the larger numbers of IT devices that such a wiring system will be able to support.

In some cases, other building services, lighting especially, can be improved at the same time as the communications wiring is upgraded. It will also probably be necessary to install extra power points, and possibly other electrical services, at the same time.

It is often the case, however, that the existing services, air conditioning in particular, cannot be expanded sufficiently to cope with the new needs. Here, there are two options:

— Adjust the systems policy so that computing needs can be provided in a way that requires less heat to be dissipated in general office areas. This may require PCs to be concentrated in a separate area, the use of off-site computers, or even a change of computer supplier.

— Move to another building. (However, the capacity of the existing building may be sufficient if some, rather than all, the staff move out.)

There is also no point in carrying out expensive rewiring if the organisation intends to leave the building, or to undertake a major refurbishment, within a few years. In this case, the best course of action is likely to be either to bring forward the move or to focus only on the short-term communications needs that have to be met before the move. The long-term needs can be addressed in the new building or during the refurbishment.

IDENTIFY THE APPROACHES TO UPGRADING THE WIRING

A very wide variety of products are available for local communications and, more generally, a wide variety of approaches may be taken to selecting and using those products. In our experience, however, the best approaches are to:

- Rewire with a structured wiring scheme. (Structured wiring schemes were discussed in Chapter 3.)
- Make better use of existing cable capacity. The use of multiplexing techniques often means that extra communications capacity can be provided without the disruption of rewiring.
- Add a new communications infrastructure element such as a local area network or wideband optical-fibre system. With this approach, the organisation installs additional communications capacity in anticipation of future developments.

Making better use of existing cable capacity and adding a new communications infrastructure element are most useful for nonvoice communications. However, these approaches may be used for voice communications if the organisation is able and prepared to use distributed PABX technology.

REWIRING WITH A STRUCTURED WIRING SCHEME

In principle, rewiring with a structured wiring scheme is the best approach, but it is often necessary to expand the cable spaces in order to rewire, partly to provide enough space for the new cables but mainly to reduce the likelihood of damage to existing wiring before the new wiring scheme is ready to use. However, rewiring may be a sensible option if the cable spaces are adequate.

Several Foundation members have tackled the problems of rewiring their existing buildings. For instance, a major retail chain realised that it had a serious problem with the wiring in its London head office. This company is currently rewiring the head office building completely, using telephone wire for voice communications, and the IBM Cabling System for data communications. The total cost of the rewiring project will be not far short of $6 million.

MAKING BETTER USE OF EXISTING CABLE CAPACITY

Most buildings with a wiring problem already have a great deal of communications wire in place — which is often the cause of the problem. In many cases, every existing cable has been installed for a single purpose and supports a single device. The problem can be eased immediately if it is possible to use one of these cables for several purposes or to support more than one device.

However, the additional capacity created by doing this will often be mainly on cables installed in the risers or other main distribution channels. This approach therefore does not necessarily solve the problems of horizontal wiring. For example, where multiplexors are used on 3270 coaxial cables, it will still be necessary to install cables from the multiplexor to the individual devices. On the other hand, horizontal wiring problems can be eased by exploiting the spare capacity in telephone wiring (many organisations have unused telephone wire installed in their buildings). Horizontal wiring problems can also be eased by using data-over-voice systems and integrated PABXs.

The options for making better use of existing cable capacity depend on the type of cable reused.

RS232 or similar data cables

In most cases, multiplexors can be installed to allow additional terminals to be supported by an existing RS232 or similar data cable originally installed to support a single terminal.

3270 coaxial cables

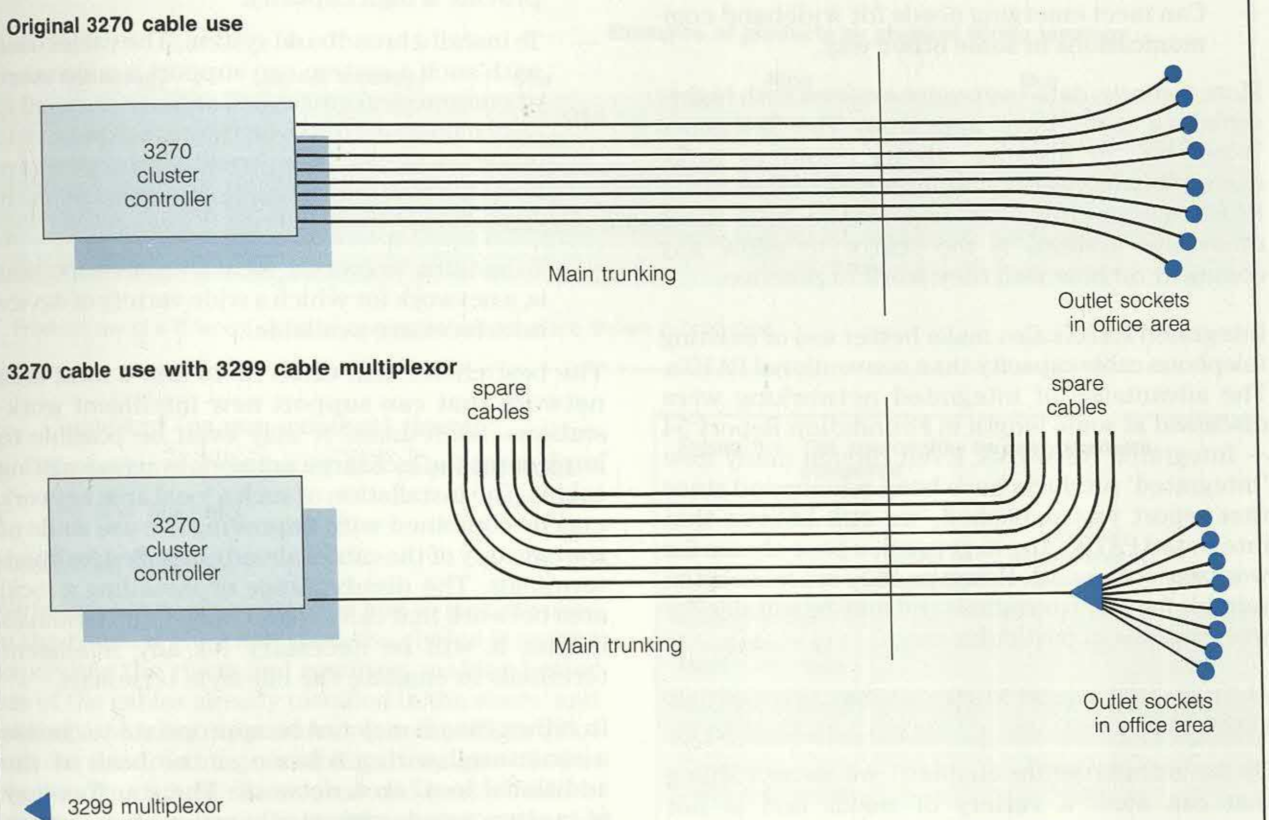
The cable multiplexing approach has been pioneered by suppliers such as Lee Data, although it has subsequently been adopted by IBM. By using IBM 3299 cable multiplexors, or similar products from other suppliers, a single coaxial cable can support eight 3270 terminals.

Figure 5.2 shows how the use of a cable multiplexor can release up to seven cables for other uses. Note that the 3299 multiplexor can be wired directly into the 3274 controller — it is not necessary to install a second multiplexor next to the controller. By going outside of IBM's product range, and installing multiplexors at both ends of the 3270 cable, even more cables can be released for other uses, although two multiplexors will be needed for each link.

The coaxial cables released by the use of multiplexors need not be used for 3270 terminals. They might, for example, be used to support graphics workstations or multiplexors for ASCII terminals. In some cases, the cables might even be used to form part of a broadband local area network. One large oil company is currently wiring 3270s with coaxial cable of a grade that will allow the cables to be reused in this way at a later date.

Some non-IBM multiplexors allow even more options in the uses that can be made of 3270 coaxial cables. For example, Adacom produces a range of

Figure 5.2 Using a cable multiplexor for 3270 coaxial cables can release existing cables for other uses



multiplexors that can use a single coaxial cable as a multidrop line with anything between 4 and 32 multiplexors attached to it. The cost per terminal port with this arrangement ranges from $290 to $670, the higher figure applying to the smaller multiplexors. In addition, a more expensive Adacom multiplexor allows some or all of the devices to contend for a smaller number of 3n74 ports. This is especially useful for PC connections, where the usual communications pattern is a short period of file transfer followed by a much longer period of standalone processing.

Unused telephone wire

Many organisations have unused telephone wire installed in their buildings. By using suitable baluns, in certain circumstances this wire can be used to support many different types of terminal. A wide range of baluns is now available, enabling, for example, Wang terminals, IBM 3270s, and ASCII devices to be supported over telephone wire. However, this approach should not be used if digital signals will be carried on wires that are bundled in a cable together with active telephone circuits. There is a danger that the analogue telephone signals will cause electrical interference that will corrupt the digital signals.

Sometimes, unused telephone wire can be used as part of a local area network. For example:

— Telephone wire is recognised as type 3 cable within the IBM Cabling System and can thus support Token Ring networks.

— IBM (and compatible) PCs can be supported on Starlan, a 1M bit/s local area network specifically designed to take advantage of spare telephone wire.

PABX wiring

Even when it is used for telephony, telephone wire still has a great deal of spare capacity. The easiest way of making use of the spare capacity is by using data-over-voice systems such as Case's Grapevine. Most data-over-voice systems have relatively low data rates, no more than 19.2k bit/s, but they are an effective means of providing a data communications service. The cost of installing a data-over-voice system compares favourably with the cost of installing new cables.

In our view, existing data-over-voice technology should be seen only as a means of overcoming an immediate problem. The point-to-point configuration and low data rates make it quite unsuitable in the long term. However, in the short term it is especially appropriate for organisations that:

— Have a large installed base of dumb terminals and are committed to using dumb terminals for the foreseeable future.

- Expect to move or refurbish their offices within three years or so.
- Can meet emerging needs for wideband communications in some other way.

More recently, data-over-voice systems with higher signalling rates have appeared. The Telegence TokenStar, for instance, allows resources to be shared between personal computers at 1M bit/s over PABX wiring. However, experience with these innovative systems is too scarce to allow any comment on how well they work in practice.

Integrated PABXs also make better use of existing telephone cable capacity than conventional PABXs. The advantages of integrated networking were discussed at some length in Foundation Report 54 — Integrated Networks. Even though many new 'integrated' products have been announced since that report was published, we still believe that integrated PABXs are, in general, a poor choice for workstation support. However, they are more often suitable for dumb terminals and may be suitable for workstations in particular cases.

ADDING A NEW COMMUNICATIONS INFRASTRUCTURE ELEMENT

By an 'infrastructure element' we mean cabling that can meet a variety of needs and is not dedicated to a single application or type of device. In some organisations there is a cabling system that is reasonably adequate for existing equipment, usually dumb terminals, but which is not adequate for new, intelligent, devices. Rather than attempt to support new devices on the old wiring, these organisations will often set about installing new wiring to support the new devices. Significant benefits can be gained if the new wiring is perceived as a new communications infrastructure element rather than as just an ad hoc means of supporting the new terminals. The new wiring should therefore be capable of:

- Providing the capacity to support a high penetration of new workstations.
- Supporting a suitable local area network.
- Meeting the management requirements for a new cabling system.

Unless the organisation expects to leave or refurbish the building within, say, five years, we believe that any new wiring installed should be seen as adding to the communications infrastructure of the building. Ad hoc solutions should be used only if they produce significant cost savings.

The technical options for adding a new communications infrastructure element are:

- To install optical fibres. The advantage of this option is that the cables are physically small but provide a high capacity.
- To install a broadband system. The cables used with such a system can support a wide range of communications types and are reasonably easy to install. However, they are expensive to interface to, and large broadband systems are complex to maintain and require particularly skilled staff.
- To install a 'universal' local area network, that is, a network for which a wide variety of device interfaces are available.

The best choice will often be to add a local area network that can support new intelligent workstations. Sometimes, it may even be possible to implement the local area network by using existing cables. The installation of such a local area network may be combined with improving the use made of the capacity of the cables already installed for dumb terminals. The disadvantage of installing a local area network that can support only dumb terminals is that it will be necessary for any intelligent terminals to emulate the old-style terminals.

In either case it may not be appropriate to choose a structured wiring scheme as the basis of the additional local area network. The star topology of a structured wiring scheme requires much more cable than the physical ring or bus topology that can be used with most local area network technologies. (Figure 5.3 shows the physical topologies that can be used with the most common local area network technologies. Note that the logical topology of the network does not have to be the same as the physical topology.) Buses and rings are therefore less expensive to install and will often cost less to use as well, as long as a convenient means of access to the cable can be provided.

MATCH THE APPROACH TO THE WIRING PROBLEM

The best approach to upgrading wiring for an individual organisation depends on the nature of the communications requirements, on the wiring problem that needs to be solved, and on the building. Communications requirements may in general be divided into:

- Telephony.
- Dumb terminal support (usually via V.24 or 3270 coaxial cable interfaces).
- Intelligent workstation support (increasingly via either IEEE 802.3 or 802.5 local area networks).

The root cause of the wiring problem that is to be solved is usually one of the following:

Figure 5.3 Logical and physical topologies of local area networks can be different

LAN technology	Logical topology	Examples of products by physical wiring topology: Star	Ring	Bus
Contention	Bus	**LattisNet** **Starlan**	— —	Ethernet Sytek LocalNet
Token passing	Ring Bus	**IBM Token Ring Network** **Datapoint ARC**	Prime Ringnet —	**3Com Token Bus** IEEE 802.4
Cambridge Ring	Ring	—	Racal Planet	—

Products using a different physical and logical topology are shown in bold type.

- Congested (or non-existent) risers.
- No horizontal cables of the required kind.
- Too few sockets.

CONGESTED RISERS

Wiring problems are rarely due just to lack of space in the risers. If they are, then the choice is among expanding the risers and rewiring, making better use of the cables already installed in the risers, and adding a new infrastructure element. Figure 5.4 sets out the advantages and disadvantages of each choice. The figure shows that the best choice is usually to add a new infrastructure element in the risers, typically a local area network either to provide better support for old-style terminals or to support new workstations, or both. Expansion of the vertical cable spaces will usually involve major building works to open up new risers, with the attendant nuisance from noise and dust. The routes for the new risers will need to be planned carefully so that they neither weaken the structure unduly nor damage any existing services.

Figure 5.4 The approaches to riser problems compared

Approach	Level of disruption	Level of improvement expected	Cost
Adding a new infrastructure element in the risers	Low	High	Low
Making better use of cable capacity	Low	Depends on technology used	Low
Expanding the risers and rewiring	High*	Reasonably high	Moderate

*Minor compared to the disruption caused by horizontal rewiring

NO HORIZONTAL CABLES OF THE REQUIRED KIND OR TOO FEW SOCKETS

If the wiring problem is caused by a lack of horizontal cables of the required kind, or by a shortage of sockets, the most common approaches to overcoming the problem are:

- To make better use of existing cables.
- To add a new horizontal infrastructure element, usually a local area network.
- To rewire with a structured wiring scheme.
- To expand the space available for horizontal cabling.

Figure 5.5 overleaf lists the advantages and disadvantages of each of these approaches. We have not included the possibility of installing extra cables that would be dedicated to a single service because, for reasons given earlier in the report, we believe that installing a structured wiring scheme is in general a better option.

It is important to recognise that a wide variety of products are available to address horizontal wiring problems. In particular circumstances an option not included in Figure 5.5 may be much more cost-effective than any of those listed.

Better use of existing cable capacity

Even if there are no cables of the required kind, it may be possible to use existing cables to provide the required support. For example, extension cables could be used for data-over-voice systems; 3270, Wang, or Ethernet support could be provided via spare twisted pairs; or cable multiplexors could be used with 3270 coaxial cables. The main advantage of these approaches is that they do not require physical work to be carried out, but they do involve significant costs for the electronic devices. Their disadvantages include:

- The limited bandwidth of data-over-voice systems.
- The requirement in some countries to use PTT staff for wiring changes.

Figure 5.5 The approaches to horizontal wiring problems compared

Approach	Level of disruption	Level of improvement expected	Cost	Wiring closets required?	Horizontal space required?
Making better use of cable capacity	Low	Moderate	Low	Yes	Yes
Adding a new horizontal infrastructure element	High	Moderate	Moderate	No	Modest
Rewiring with a structured wiring scheme	High	High	Low to moderate	Yes	Substantial
Expansion of the horizontal cable spaces	Very high	Moderate	High	Not applicable	Yes

The data-over-voice option can be used only if the limited bandwidth is sufficient and if an appropriate interface unit is available.

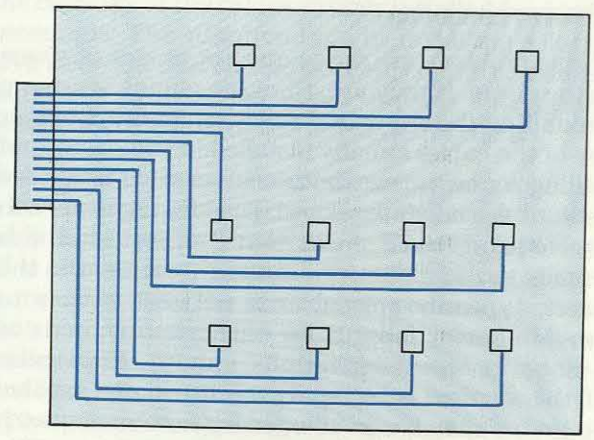
Addition of a local area network
In most organisations, each terminal and workstation is connected to a single network, although a few organisations connect terminals and workstations to two or three separate networks. However, there are now several local area network products that can be used to support each of the common types of terminal. For example, Net/One, Clearway, LocalNet, and Planet can be used for ASCII terminals; and Net/One, and HYPERbus can be used for 3270s. The amount of wiring required for these local area networks is usually much less than would be required to connect each terminal to a shared computer. Furthermore, the capacity of the networks is usually sufficient to allow extra terminals to be attached by adding no more than a work-location cable from the terminal to a socket.

Ideally, the local area network chosen should be able to support future intelligent workstations as well as today's dumb terminals. The intelligent workstations will be connected directly to the network, whilst dumb terminals will usually be connected via terminal multiplexors (often described as 'terminal servers'). In the case of DEC equipment, future product developments will be focused on Ethernet communications, and the most appropriate local area network choice is therefore likely to be Ethernet, even if it is more expensive than other suitable products.

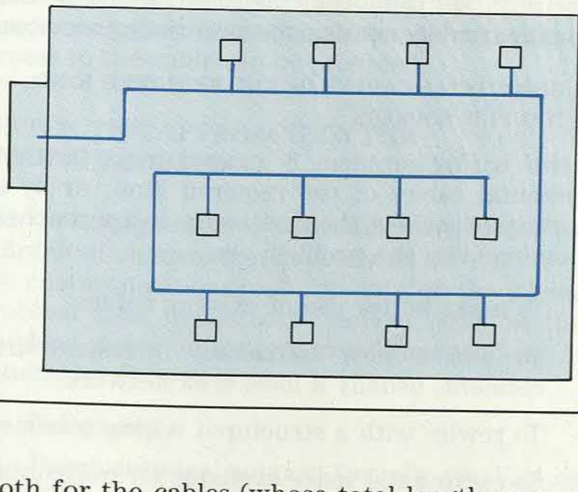
Rewiring with a structured wiring scheme
Earlier in the report we said that installing a structured wiring scheme is the best approach to prewiring a new building or to rewiring during a major refurbishment. By allowing a variety of local networks to share the same cables, a structured wiring scheme provides the most flexibility for the future. However, structured wiring schemes require considerable amounts of space

Figure 5.6 Structured wiring schemes need much more cable than bus topologies

Star topology, used in structured wiring schemes



Bus topology, used in some local area networks



both for the cables (whose total length may, as shown in Figure 5.6, be 10 or 20 times that needed for a bus scheme) and for wiring closets. For this reason, they are often difficult and expensive to install in existing buildings. Even the use of flat undercarpet cable may not make it practical to install a structured wiring scheme.

Wherever possible, however, any general rewiring should be based on a structured wiring scheme unless an alternative approach to solving horizontal wiring problems can provide considerable benefits in the short term. It may sometimes be necessary to install both a structured wiring scheme for long-term flexibility and a solution that provides more immediate benefits.

Expansion of the horizontal cable spaces

Sometimes, horizontal wiring problems may be solved by creating new cable spaces, rather than by using the existing spaces. However, creating new horizontal cable spaces has many disadvantages, and most of the ways of doing this should be avoided if at all possible:

- The installation of a new false floor is expensive, often requires ramps between landings and office areas, and reduces head-room (which is a critical factor in some buildings dating from the 1960s).
- The installation of floor-screed trunking is noisy and dusty, and carpets may be damaged. Use flat undercarpet cable instead (provided that the concrete screed is smooth enough).
- The installation of underfloor cable trays requires that false floors be lifted, and normal work will be disrupted.
- Overhead cable trays are unsightly.

Wall trunking and furniture or screens with built-in facilities for cables are easier to install but also have disadvantages:

- Wall trunking is often unsightly, and the cables cannot serve the parts of open-plan offices that are not adjacent to the walls.
- Screens with cable facilities can impose restrictions on the physical layout of offices.
- Furniture with cable-management facilities requires replacement of the existing furniture, and can also lead to inflexible office layouts.

The use of system furniture (which is discussed in more detail in Appendix 2) is a good way of expanding horizontal cable spaces, but it does require the organisation to accept restrictions on the layout of desks. It may be possible to custom-design a central spine that carries wiring and other services and to fit existing furniture round it.

A possible alternative to creating new horizontal cable spaces is to use flat undercarpet cables. Such cables are now available for a variety of local cabling applications (including some local area networks). Their advantage is that they expand the space available for cables without the cost and disruption of building works. Although some of the older flat-cable designs were unreliable, and some reacted chemically with concrete, many organisations are now using this technology successfully.

In many cases, the best solution to horizontal wiring problems will require a mixture of approaches. For instance, wall trunking could be installed to support users near to the walls. For users distant from the walls, cables might be carried overhead and down pillars, and then out to pedestals in the form of undercarpet cable.

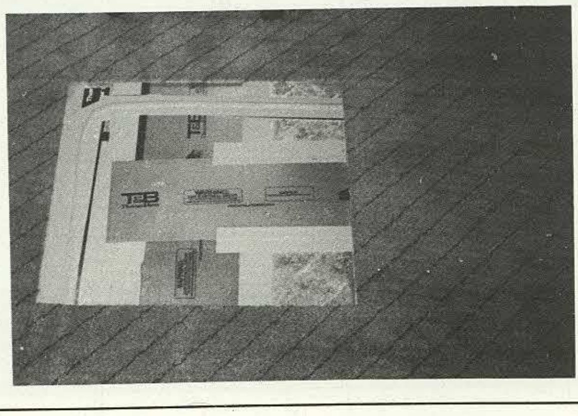
Flat undercarpet cable is available for power, telephony, and a variety of data applications. It is usually less expensive than installing conduits, but special skills and considerable care are required to install it properly. undercarpet versions now exist for a variety of cable types, including 3270 cables, the IBM Cabling System, and Ethernet. One drawback of undercarpet cables is that they have greater signal losses than ordinary cables and can therefore be used only over shorter distances. This drawback is often overcome by combining conventional and undercarpet cables in the same installation. A convenient way to do this is to run conventional cables overhead from the wiring closet to a vertical duct on a wall or structural column, and to use undercarpet cable to carry the signal from the wall or column to a pedestal on the floor.

Care is required in installing undercarpet cables because they are rather inflexible and can be damaged when heavy furniture is moved. A further disadvantage is that the pedestals to which underfloor cables run must be regarded as fixed (although they can be moved if absolutely necessary). Figure 5.7 shows the flat undercarpet cable installed at Woolworth's head office in London. Fixed pedestals are fed with power, telephone, and IBM type 1 undercarpet cables.

IMPLEMENT THE CHANGES

As with installing a wiring scheme in a new building or during a major refurbishment, it is necessary to consider carefully the number of outlets to be

Figure 5.7 Undercarpet cables at Woolworth's London head office



provided when existing wiring is upgraded. It is also necessary to decide on the cable routeings that will be used and to manage the upgrading project.

As discussed elsewhere in the report (in Chapter 4 and Appendix 2), a high density of outlets will be indicated by:

- A high ratio of workstations to staff.
- A high proportion of workstations needing to be moved, especially if the moves are likely to take place at short notice.
- A low cost per outlet installed.
- A high level of concern about the appearance of office space. A low density of outlets will lead to ad hoc wiring 'fixes' and to untidy cables trailing over the floor.
- A long lifetime for the network. This will be likely if the building has a long useful life, if the network has a high signalling speed and complies with emerging international standards, and if the supplier is continuing to develop the network and associated products (such as new device interfaces and file-transfer facilities).

However, in general, it is more expensive initially to install a high density of outlets, and it is sometimes more expensive over the life of the wiring scheme. In addition, dumb terminals often need a different kind of connection from intelligent workstations. For example, a high density of LAN-based V.24 outlets will be of little use in supporting DEC VAXMate terminals or their successors.

It is difficult to give general advice about the cable routes to be used. As a rule, existing spaces should be used wherever possible, and ceilings are usually more accessible than floors. The need to create extra space for cables should be minimised as far as possible. This may be done by using multiplexors with the cables already installed and by using flat undercarpet cables. We believe that there is considerable scope for using both of these techniques to upgrade existing wiring. Expanding the existing cable spaces will usually require building work and is therefore often expensive. And sometimes the cable spaces cannot be extended in a leased building because the owner will not grant permission for the building work to be carried out.

The creation of new cable spaces will seldom be justified when upgrading existing wiring. However, if it is necessary to create new cable spaces, it will be prudent to ensure that the new spaces have spare capacity so that future wiring problems can be minimised.

After the approach to be used for upgrading the existing wiring has been chosen and decisions about outlet density and cable routeing have been made, the systems department must actively manage the project to upgrade the wiring. In Chapter 1, we emphasised that a great deal can go wrong with a wiring scheme if there is insufficient attention to detail. The systems department must therefore make a plan for upgrading the existing wiring, choose a contractor to carry out the work, and then closely monitor the work that is done. If, as is often the case, the upgrading requires a relatively limited amount of new wiring, these activities will be less time-consuming than for a complete new wiring scheme, but they are still important. Attention to detail is the key to success in wiring work.

Chapter 6
Managing the wiring system

The previous chapters have discussed the approaches to installing a good wiring scheme or to improving one already present. By following these approaches, an organisation should be able to establish an excellent wiring system. However, a wiring system, like any other asset, will degenerate unless it is managed properly. In the case of a wiring system, poor management often results in incomplete and inadequate documentation, the use of poor and inconsistent wiring practices, and a general feeling that the wiring is not trustworthy.

We recommend that the systems department should take four actions in order to control the organisation's wiring systems:

— Set wiring standards.
— Establish suitable administrative procedures.
— Manage the work that is done.
— Conduct periodic audits.

SET WIRING STANDARDS

All wiring must, of course, comply with the relevant safety standards and, where wiring is subject to telecommunications regulations, with those regulations. However, in some countries (the United Kingdom, for example) the rules and regulations are not clear-cut and unambiguous, and the legal status of a particular wiring scheme might be determined only after negotiations with the relevant authority. In addition to these externally imposed standards, the systems department also needs to set standards for numbering cables and sockets, for labelling, for documentation, and for the quality of work carried out.

Ideally, there should be a single numbering scheme for all communications cables and sockets. (Today, many organisations have several cable numbering schemes — the most we heard about was six.) The advantages of a single numbering scheme are simplified record keeping and, more important, a unique identifier that can be used when tracing a circuit. However, it is reasonable to have a separate numbering scheme for cables that obviously form a separate wiring scheme — power cables, for example.

Many organisations have separate numbering schemes for data and voice cables. This has been acceptable in the past because different types of cable have been used for these purposes, and they have been presented at different sockets and faceplates. However, the increasing use both of telephone-grade cables for data transmission and of multiservice faceplates has made this practice less appropriate. We therefore recommend the use of a single numbering scheme to cover both voice and data cables.

There should also be a single numbering scheme for presentations (that is, for individual sockets or multiservice faceplates). In addition, cables and presentations should be clearly labelled. (Figure 6.1 provides guidelines for labelling the various elements of a wiring scheme.)

Figure 6.1 Checklist of labels required for wiring schemes

Wiring scheme element	Label position	Type of label
Riser cable	Both sides of fire barrier	Proprietary cable label
	Both sides of wiring closet entry	Proprietary cable label
	On terminal designation strips	Indelible pen
Junction box	On outside cover	Indelible marker
	Inside	Indelible marker
Horizontal cable	On terminal designation strips	Indelible pen
	Inside of wiring closet	Proprietary cable label
	Every 5 metres	Proprietary cable label
	Both sides of fire barrier	Proprietary cable label
	Where cable leaves main tray run	Proprietary cable label
Floor trap	Inside lid	Indelible marker
	On front of socket	Engraved plastic label
	On rear of socket	Indelible marker

Accurate records should be kept of the cables and presentations installed, and these records should always be updated whenever there is a change. Various types of records can be used, but we recommend:

— Floor plans showing cable routes.

— A database of cables, sockets, wiring closets, and so on. This database may also contain other related information — for example, about computer ports, wide-area network facilities, and terminals.

The systems department should define both the content and the format of the records to be kept. Manual records are acceptable for wiring systems with fewer than, say, 100 cables. For larger systems, we recommend that the records be maintained on a personal computer. And for very large and complex wiring systems, a minicomputer may be needed to maintain the records. There are cable-management software packages to help in the task of maintaining records about a wiring system, but they are either specific to a particular wiring scheme or provide limited functions, or, more often, both. Moreover, the links between the graphics and database elements of these packages are often very poor. However, software suppliers are showing considerable interest in this area, and we expect a rapid improvement in the quality of such packages.

Standards should also be set for the quality of the wiring work that is to be done. The particular standards will depend to some extent on the building and the type of wiring, but we recommend that a high quality of workmanship should generally be specified. For example, the standards should specify that cables must be laid so that it is possible to remove one cable from a bundle without unduly disturbing other cables in the same bundle.

ESTABLISH SUITABLE ADMINISTRATIVE PROCEDURES

The installation and movement of cables and presentations will inevitably be driven by the organisation's needs for systems and terminals. Often this results in cable management that is purely reactive, always responding to demands and generally using resources inefficiently. As we argued in Chapters 3 and 4, prewiring with a structured wiring scheme helps to avoid the problems caused by a purely reactive approach; it allows the systems department to respond immediately to many requests for new connections. In some situations, prewiring can even allow some requests to be dealt with directly by the user, who will plug in a new workstation. In other situations, the systems department may have to install an interface device (such as a balun), change the patching in the appropriate wiring closet, and, perhaps, change the configuration tables stored in the network server or host computer.

However, even where the building has been prewired with a structured wiring scheme, there are likely to be some requests for new connections that cannot be met without installing new cables. In order to anticipate the need for such connections, the systems department needs to take three actions:

— Assign one person the responsibility for managing the spaces in a building that could be used for cables, and ensure that he or she takes full account of the competing claims to use the spaces.

— Establish closer liaison with the departments likely to demand changes. This is particularly important in a new building site, or in a building that has previously not been wired for data communications.

— Set up internal procedures to balance the department's need to manage its resources efficiently and the users' needs for rapid response.

The procedures adopted by one Foundation member (Rowntree) to balance the needs of the systems department and users are described in the case history in Figure 6.2.

Figure 6.2 Appropriate administrative procedures can help to reduce wiring problems

ROWNTREE PLC

Rowntree is an international food group that manufactures and retails confectionery, snack foods, and grocery products. The company has several sites, and the building wiring is maintained by the company's own tradesmen.

During 1986/87, Rowntree introduced a new procedure that has eased some of its wiring problems. Under the old procedure, every time a user asked for a new connection or for equipment to be moved, the communications department asked the site services department to carry out the work. The tradesmen typically took between two and three months to satisfy the request, resulting in considerable discontent amongst the users.

The new procedure has involved the establishment of a help desk. Now users contact the help desk, which then initiates the request for a new or changed connection. The network services department collates the requests into groups for a particular building or floor before passing them on. Also, the different communications groups are physically adjacent to each other so the requests circulate faster within the communications department. This procedure makes life easier for the tradesmen, who are now able to respond to a request within a month. Users are satisfied, and everyone in the communications department is better informed about the status of requests.

MANAGE THE WORK THAT IS DONE

It is tempting to delegate wiring work either to the site services department or to an external contractor. Experience shows that doing this significantly increases the chance of the wiring being defective. We have already stressed that many things can go wrong when cable is being installed, that the systems department must actively manage the installation of new wiring, and that attention to detail is essential. There is no substitute for experience, especially where a major wiring scheme is being installed for the first time. If the organisation does not have people with the relevant skills, it should either recruit them (although they will be difficult to find and to keep busy once the initial job has been completed) or use the services of a specialist consultancy.

Managing the work involved in installing a wiring scheme can be divided into four activities:

- Select the contractor(s) carefully.
- Precisely specify the work to be done.
- Inspect samples of the work.
- Proceed in stages.

CONTRACTOR SELECTION

It is vital that a wiring scheme be installed by a contractor who is competent to carry out communications wiring work. In selecting a wiring contractor for a new building or for a major refurbishment, some organisations ask an electrical contractor to take the responsibility for installing all of the wiring, including communications wiring. However, not all electrical contractors are competent to install communications wiring, and this approach can sometimes result in defective wiring. For example:

- In one case, the wiring was installed by an electrical contractor who cut back all nonterminated twisted pairs so they could never be used. The PTT refused to accept the wiring.
- In 1987, a major bank employed a firm of consultants to select a cabling scheme, but the consultancy was not asked to manage the installation of the wiring. Instead, the work was managed by the building contractor, who subcontracted it to a wiring contractor, who in turn subcontracted it to a specialist data wiring contractor. The building contractor and the data wiring contractor each assumed that the other would do the patching. Eventually, the patching was done later than it should have been by the data wiring contractor. As a result, the project was finished later than scheduled.
- In another case, the electrical contractor recognised that he did not have sufficient expertise and employed the services of a 'consultant' (not from Butler Cox) to advise him. Nonetheless, the telephone wiring was installed without a proper earth.
- In another case, there were serious deficiencies in nonvoice wiring: wires were wrongly connected, cables were connected with a variety of different types of connector, and there were no labels. When computers were connected to the wiring, it was found that some of the connections did not work. The faults were put right, at considerable cost, by a specialist firm.

It is obviously critical to choose an appropriate contractor to install a wiring scheme. The contractor must have experience of installing wiring schemes, specialised skills, and the necessary resources. Visits to buildings that have already been wired by the contractor are a very good way of assessing the contractor's work. Inspections of previous work also provide a basis for specifying the quality of the work to be done and can identify areas where the quality needs to be improved.

Before commissioning a large wiring job, the systems department should also inspect samples of the components that will be used. The samples should be tested by, for instance, attempting to pull apart a cable joint. (If you can pull it apart, so can users — and some will.)

These principles should be applied to all the contractors who will work on installing a wiring scheme. For instance, if the floor plans are to be drawn up by a separate company, some floor plans drawn up for other clients should be inspected before the contract is placed.

However, it is not sufficient to select the contractors carefully and then allow them to get on with the job. The systems department, or a skilled and trusted agent, must closely supervise the work that is done.

PRECISE SPECIFICATION OF THE WORK TO BE DONE

The systems department should actively manage the work involved in installing a wiring scheme, deciding exactly where cables should be laid and when they should be laid. In particular, the standard of workmanship should be specified. It is not sufficient to use terms such as 'neatly laid' or 'clearly labelled' unless you are already confident of the contractor's work. Instead, these terms should be defined by reference to previous work carried out by the contractor.

INSPECTION OF THE WORK

Our research has revealed many examples of wiring work that was defective in important and obvious respects, even when it was carried out by reputable contractors. (Several examples were listed on page 47.) Even if the instructions for carrying out the wiring work are complete and unambiguous, it is unwise to assume that the contractors will follow them. The systems department should therefore ensure that the work is checked regularly — even daily whilst the cables are actually being installed. The department should also ensure that all cables are tested once they have been installed and that the continuity of earths is also checked. It is also necessary to check that the wiring installed complies with relevant electrical and safety standards.

STAGE-BY-STAGE PROGRESSION

For a large wiring job, it is sensible first to commission a small part of the work as a trial. When this trial work has been completed, the systems department should review the results with the contractor and agree any changes in procedure for the rest of the work. This principle should be applied to all aspects of wiring work, such as the drawing of plans and other documentation, as well as to cable laying itself.

For major refurbishments, however, care has to be taken to ensure that a staged progression does not slow down the work unnecessarily. For example, during a major refurbishment at a London head office, the contractor initially worked on half a floor at a time, first gutting it and then refurbishing it. This meant that wiring staff could be employed for only half the time, which lead to scheduling difficulties. Subsequently, the contractor worked in parallel on two half floors, gutting one whilst the other was refurbished. This arrangement meant that the wiring staff could be employed continuously.

CONDUCT PERIODIC AUDITS

Even with good management and administration procedures, there is always the possibility of deviations from proper procedures, perhaps as a result of emergency repairs that were not entered into the cable records. The systems department should therefore arrange for periodic audits of the wiring system. These audits should include satellite wiring closet equipment and the configuration of all patch panels. A good cable-management software package should be able to print out the recorded configuration for comparison with that actually in place.

If you feel that an audit is not necessary you should ask yourself: "Would I be happy to cut through any cable that I could not identify?" Only if the answer is an unqualified "yes" are periodic audits unnecessary.

Experience will indicate the necessary frequency of such audits, but we suggest that annually would be a reasonable start. If there has never been an audit of your cabling system, we recommend that one should be carried out immediately — possibly as part of the exercise to establish the present cabling position as described in Chapter 5.

In addition to regular audits, monitoring the trends in wiring costs and in the level of service provided by the wiring system will indicate problems that are occurring, or that are likely to occur.

REPORT CONCLUSION

We have shown that many organisations need to take urgent action about the communications wiring installed in their buildings. The main problem is that the wiring ducts are full of cables that have been installed in an unplanned, uncoordinated way to satisfy ad hoc requirements. As a consequence, wiring costs are often much higher than they need be and the future exploitation of IT is being hindered because it is not possible to install new wiring.

The report has provided advice both on how to upgrade existing wiring and on how to prewire a building with a structured wiring scheme. We have also reviewed the main technological alternatives for structured schemes — wiring systems based on conventional unshielded twisted pairs (as used for telephony), and IBM's Cabling System, which is based on shielded twisted pairs. We conclude that, in most cases, wiring schemes based on unshielded twisted pairs are less expensive and can meet most organisations' local communications needs for the foreseeable future.

The technical advantages provided by the IBM Cabling System (in particular transmission at 16M bit/s, as against 10M bit/s over unshielded pairs) will not be required by many organisations for about 10 years, by which time we expect that twisted pairs of both types will have been superseded by optical fibres.

Appendix 1

Future requirements for local communications

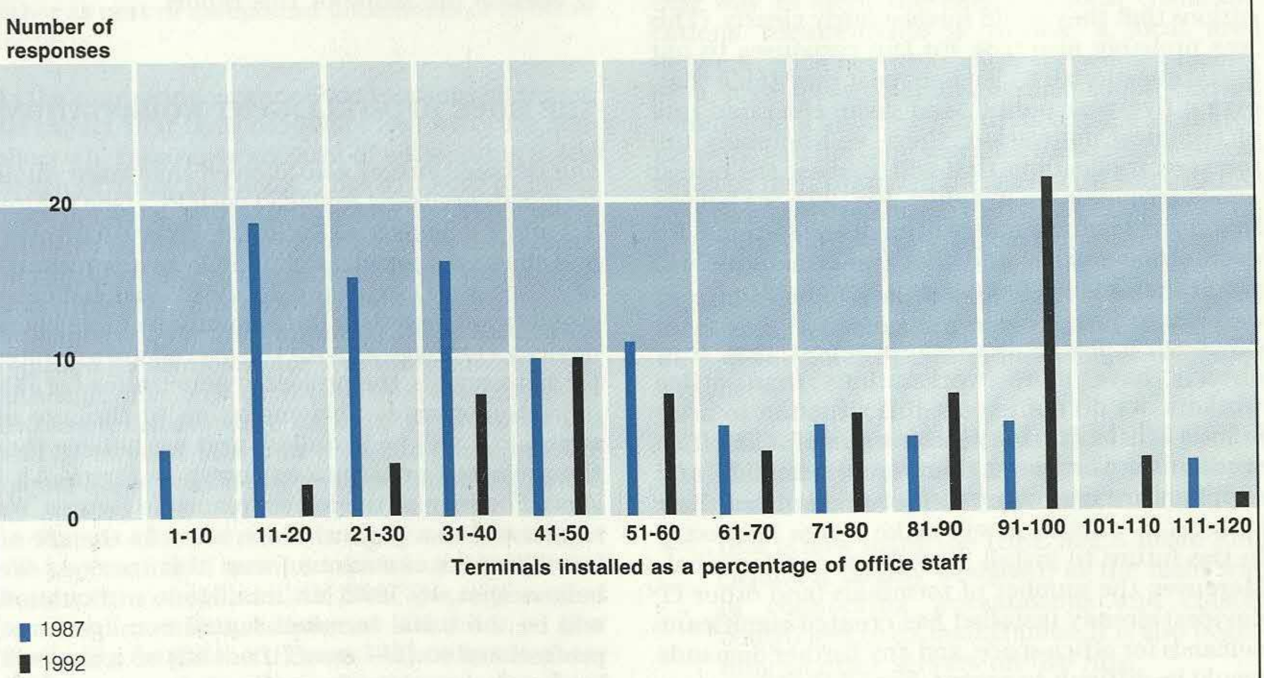
In this appendix we present some of the findings of the surveys we carried out for this report, focusing on the growing population of terminals and the growing proportion of office workstations that will be intelligent devices (PCs) rather than dumb terminals. We then offer our view of what these trends mean for local communications needs and show how these needs will be met progressively by using local area networks.

A GROWING POPULATION OF TERMINALS

In our initial questionnaire we asked about the number of terminals currently installed, the current ratio of staff to terminals, and the expected ratio in 1992. In total, the responding organisations had installed 270,000 terminals and PCs to support more than 600,000 office staff. Thus, the overall penetration of workstations, expressed as a percentage of staff, was 45 per cent, although as Figure A1.1 shows, there were considerable variations. (A few organisations even had more terminals than office staff.) The figure also shows the expected penetration of terminals in 1992. All organisations expect a significant increase, and a high proportion expect to have at least one terminal per office worker by 1992.

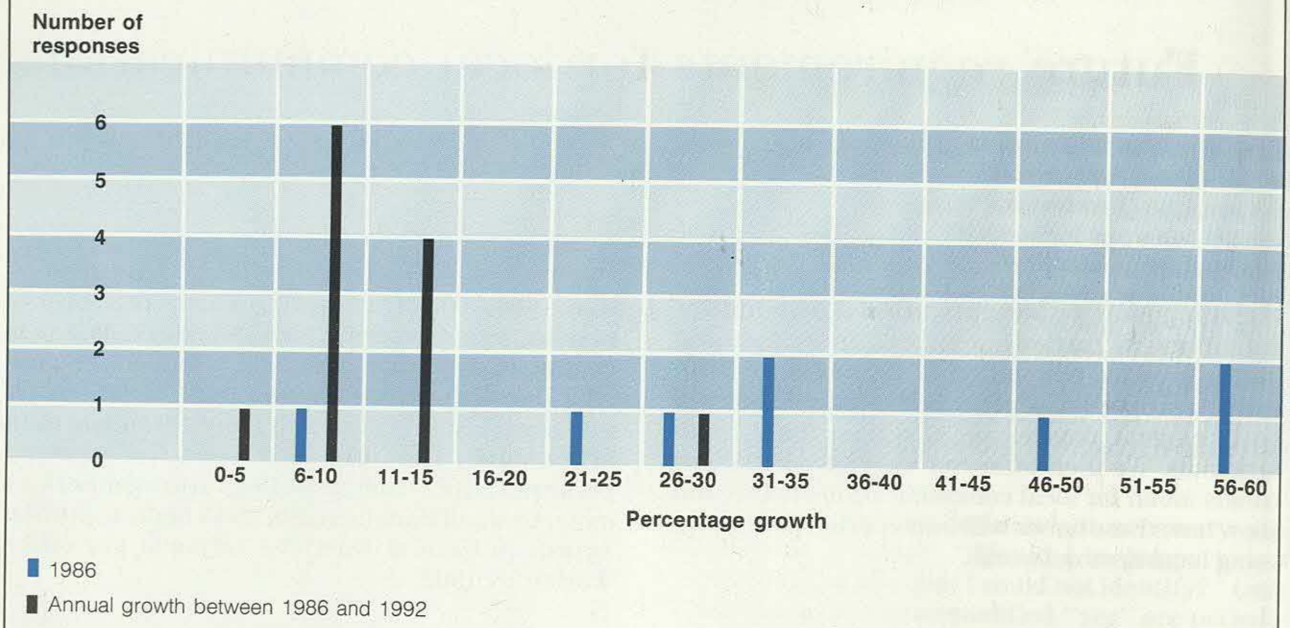
Although these responses indicate a rapid increase in the number of terminals, we believe that they understate the true rate of increase. Fifteen members completed a more detailed questionaire on the communications requirements in selected buildings, and Figure A1.2 overleaf shows their terminal growth rates during 1986 and their expected

Figure A1.1 Terminals installed in Foundation member organisations in 1987, and expected in 1992



(Source: Survey of 104 Foundation members. Some responses have been omitted because of incomplete reporting.)

Figure A1.2 Percentage terminal growth rates in 1986 and the annual growth rate expected between 1986 and 1992



(Source: Detailed survey of 15 Foundation members. Some responses have been omitted because of incomplete reporting.)

annual growth rates for the period 1986 to 1992. (In both cases, some responses have been omitted because of incomplete reporting.)

Further investigation of some of the organisations that were predicting lower growth rates revealed that the respondents had based their 1992 estimates for the terminal population only on applications that they could foresee fairly clearly. (This was probably also true for the responses to our initial questionaire.) We believe it inevitable that, over a five-year period, and given the rapid rate of technical innovation, there will be many unforeseen applications that will increase the rate at which terminals are installed. By 1992, we believe that many organisations will have one terminal for each office worker and that the remainder will reach that level a few years after that.

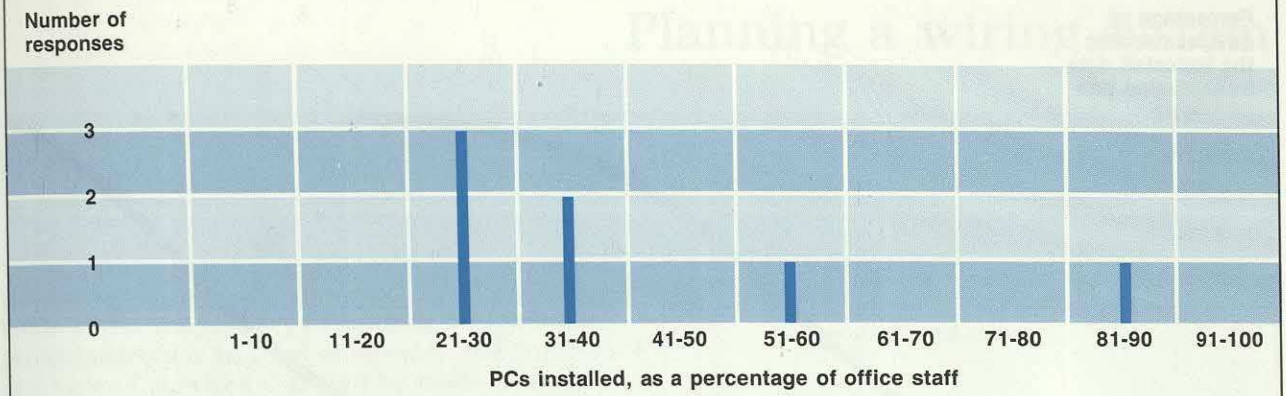
Although a few organisations report that they already have more workstations than office workers, we do not expect this situation to arise in most offices. It is very inconvenient for an office worker to use more than one terminal, and suppliers are improving the connectivity of their systems in ways that will make it less necessary in the future to install more than one terminal. Moreover, the number of terminals (and other IT devices) already installed has created significant demands for office space, and any further demands would be difficult to accept. For all these reasons, we expect terminal penetrations to stabilise at about 100 per cent (except in special cases such as dealing rooms, control rooms, and some systems development units).

Nevertheless, many organisations will continue to buy additional workstations even after they have achieved a 100 per cent penetration. These workstations will be used by staff at home, but this issue is outside the scope of this report.

THE MOVE TO INTELLIGENT WORKSTATIONS

Our detailed survey also showed that many dumb terminals are being replaced with PCs (see Figures 2.2 and 2.3 on pages 12 and 13). Figure A1.3 overleaf shows the penetration of PCs (as a percentage of office staff) expected by 1992, and indicates a significant growth in the population of intelligent devices. However, as with the overall growth rates for all terminals, the projected penetrations of PCs indicate a considerable reduction in the rate at which PCs will be installed, and we believe that the projected penetrations shown in Figure A1.3 should be seen as the lowest plausible figures. We expect to see a general move towards the use of intelligent workstations over this period. We believe that, by 1992, an intelligent workstation will be the usual terminal for all managers and professional staff — most (if not all) of whom will have a workstation of some kind. In some organisations, all office staff will be equipped with an intelligent workstation.

Figure A1.3 PC penetrations expected at the end of 1992



(Source: Detailed survey of 15 Foundation members. Some responses have been omitted because of incomplete reporting.)

After 1992, we anticipate continued increases in the power of office workstations, with many exceeding the power of today's mainframes.

COMMUNICATIONS NEEDS

Intelligent workstations have distinctive communications requirements — notably high data-transfer rates required to download programs and files of data from libraries and databases. However, the average data-transfer rate is low compared with the peak requirement because intelligent workstations will be used for long periods to run the downloaded program or analyse the data. In the future, there will also be a need to transfer images, either as part of compound documents or in other contexts.

As the computing power of workstations increases, we expect that both hardware and software suppliers will take more account of networking in the design of their products. This will lead to closer links between workstations and between workstations and other computers, to greater dependence on networks, and to the removal of the bottlenecks that currently constrain the communications performance of PCs. The communications bandwidth required for workstations will therefore increase, although this will be offset to some extent by increased data-storage capacity at workstations and by improvements in data-compression techniques made possible by greater computing power.

In Figure A1.4 overleaf we show our forecast of the proportion of terminal devices that will need bandwidths of 4M and 16M bit/s. The requirement for local communications at 4M bit/s is now becoming established. From 1991 onwards, there will be an increasing requirement for local transmission at up to 16M bit/s. We do not expect any significant number of office workstations to need higher transmission rates within the next 10 years.

LOCAL AREA NETWORKS

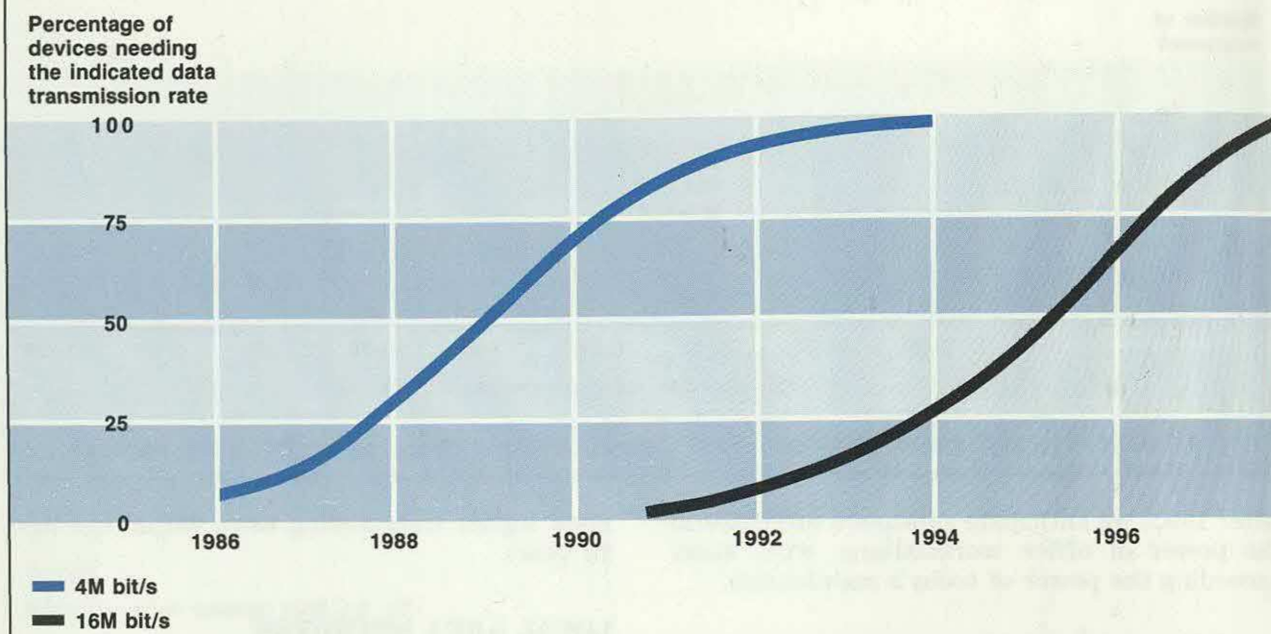
Most older networks cannot meet the emerging need for transmission at up to 4M bit/s. Multiplexor networks are usually optimised for dumb terminals and cannot accept signals at more than 19,200 bit/s. Proprietary terminal clusters, such as the IBM 327x, use high signalling speeds between the terminals and the controllers but usually cannot support the higher speeds between controllers, or between a controller and a host computer.

One way to meet the emerging local communications requirements is to use a local area network. Such networks allow the whole capacity of a high-speed digital channel to be carried throughout a building. (Until recently, a local area network was the only way that these requirements could be met. However, there are now some PABXs that provide comparable functions, often by simulating standard local area network interfaces.)

In addition to their technological advantages, local area networks are now central to the product development plans of most major computer suppliers:

- DEC has standardised on IEEE 802.3 (Ethernet) for workstation and terminal support and for multivendor interworking.
- IBM is now using the IEEE 802.5 Token Ring (which it largely designed) as the main way of connecting workstations and cluster controllers to its mainframes. It is also beginning to offer servers on the ring.
- ICL has developed an 'open' LAN based on Ethernet and OSI protocols.

Figure A1.4 Emerging local bandwidth requirements



- Hewlett-Packard now places great emphasis on Ethernet for office and on broadband LANs for the factory.
- Honeywell Bull now uses Starlan.
- Unisys uses Corvus's Omninet, under the name Usernet, as the basis for its terminal clusters.

Thus, all organisations will find that they will need to install local area networks in the reasonably near future, if they have not already done so.

Before 1987, local area networks required their own special cabling systems. During 1986, however, suppliers began to announce support for Ethernet and Token Ring on the IBM Cabling System and on telephone cables. We expect cabling schemes based on these technologies to be used increasingly as the basis for local area networks.

Appendix 2
Planning a wiring system

Planning a wiring system requires decisions to be made about the density of outlets, whether the presentations will be fixed or movable, the number and type of services that will be made available at each presentation, and the routes that the cables will follow. A wide variety of options exist for each of these parameters (Figure A2.1 lists some of them), but the choices of options cannot be made independently. For example, floor traps require screed-depth trunking or, preferably, a false floor.

In deciding how many outlets to install it is always tempting to choose a number based on the number of staff currently occupying the building. Experience shows that doing this will almost always result in too few outlets being installed. A few examples will illustrate this:

- Management may decide to move a whole new business unit into the building, thereby increasing the number of people occupying the building.
- Some business units may grow rapidly, with a consequent need for additional staff to be housed in the building.
- Staff may wish to rearrange their office space, perhaps to reflect changed working relationships or to make room for new equipment. The sockets may not be situated conveniently for the new or relocated equipment.
- The business units currently housed in the building may be moved out and replaced by units that employ more staff.
- Some staff may need a second telephone or data terminal.

It is clear from these examples that the number of outlets should not be based on the number of staff now occupying the building but on the greatest number that can be accommodated. The best way to approach the problem is first to divide the building into a number of 'planning zones' and then to consider each zone separately. The required density of outlets will depend on the use that will be made of the space in each planning zone and the space allocated to each employee. Space per employee varies enormously, ranging from as little as four square metres to ten square metres or more. The factors that determine the space per employee include legislation, fire regulations, employee grades, union agreements, and management priorities. All of these need to be considered when determining the density of outlets for a particular type of office accommodation. However, they should be used to give an indication of the minimum number of staff that will be housed in a given area. The life of a building is long compared with the foresight of legislators, managers, architects — and even consultants.

Figure A2.1 Some options for service presentation and cable routeing

Characteristic	Options
Nature of presentation	Fixed or movable, single or multiple sockets.
Types of service	Single service, typically provided via a hole and socket. Multiple service, typically provided via a floor trap, floor pedestal, pole, or underfloor box.
Number of services per presentation	One to nine.
Density of presentations	From one per two square metres, to one per floor.
Cable routes	Above a false ceiling — in a tray or conduit, or loose-laid. On cable trays suspended below the ceiling. In high-level surface-mounted wall trunking. In waist-level surface-mounted wall trunking. In system furniture with cable management ducts. In skirting trunking. Under the carpets, using flat cable. In concrete screed, using either screed-depth trunking or conduit. Under a false floor — in trunking on trays or loose-laid. On trays in the ceiling void of the floor below with cables poked through the floor slab.

For the purpose of planning a wiring system, most buildings can be divided into four planning zones:

— General office space.
— Nonoffice space, such as canteens and stores.
— Office space where IT will be used intensively, for example typing pools, telesales areas, and dealing rooms.
— Executive offices.

In most cases, the space used for canteens, stores, dealing rooms, executive offices, and so forth cannot be converted to general office space without major refurbishment. However, what is now general office space may be earmarked for a possible future purpose that would require more intensive use of IT. The cabling for these possible expansion zones should be based on the density of presentations required for the more intensive use, rather than for general office use. For example:

— General office space earmarked for the expansion of a dealing room would need to be fully prewired with video distribution cables and with a large number of telephone circuits.
— Space earmarked for the expansion of a computer room would need raised flooring and provision for high levels of power supply and air conditioning. The telephone wiring would be at general office levels, however.

GENERAL OFFICE SPACE

The correct number of sockets for general office space depends on whether the work-location end of the fixed wiring (the presentation) is in a fixed position, in a movable position, or located in system furniture. In addition, open-plan and cellular offices need to be considered separately.

FIXED PRESENTATIONS

The majority of buildings today have fixed presentations for wiring systems, often in the form of floor traps fed by screed-depth trunking or by a rigid trunking system installed under a false floor. Undercarpet cables to floor pedestals should also be considered as fixed presentations. Even though undercarpet cables can be moved, it is not easy to do this.

With fixed presentations, the density of outlets should be set to ensure that there will always be an outlet close enough to a desk so that safety hazards from trailing cables can be avoided. If the office staff have complete freedom as to where their desks are to be located, one presentation will be required for each two to three square metres. To provide this will be very expensive, however, and it may be possible to install a lower density of outlets by placing some restrictions on where the desks can be located.

MOVABLE PRESENTATIONS

Movable presentations are provided by floor traps that are connected to underfloor access boxes by flexible conduit. (In some countries, electrical safety regulations restrict the length of these conduits.) Alternatively, cables may be run direct from the underfloor access boxes through holes in the floor to the devices. (The floor tiles with holes should be movable and the holes should be closed up when they are not in use.) Figure A2.2 shows a schematic diagram for an underfloor wiring system with movable floor traps designed in 1987 for a UK financial institution.

For movable presentations, the density of outlets can be determined by considering the highest staffing density that the planning zone can accommodate. From this, calculate the maximum number of work positions and provide one presentation for each work position. In addition, approximately 20 per cent more outlets should be provided for shared equipment.

SYSTEM FURNITURE

If the presentations are provided by a furniture system, the density of outlets will be determined by the number of work positions allowed by the furniture system. There is a point of presentation for the services at every possible desk location, and these are decided when the spine of the furniture system is laid out. The cables reach the spine from the riser or wiring closet by whichever route is easiest, often above a false ceiling. Figure A2.3 on page 56 shows an office laid out with a commercially available furniture system, and Figure A2.4 shows the way that power and communications cables are packed into the beams that carry the cables for this furniture system.

The physical structure of a furniture system makes it impractical to accommodate additional staff. Again, however, additional presentations should be provided for shared equipment.

DIFFERENCES BETWEEN OPEN-PLAN AND CELLULAR OFFICES

The density of outlets for open-plan offices should be based on the amount of usable office space left after the space required for lifts, toilets, storerooms, and other nonoffice facilities has been assigned. A further deduction of between 10 and 15 per cent should also be made for 'primary circulation' — that is, for the main routes through the space that cannot be used for desks or equipment. In a cellular office layout where the partitions are fixed, each office should be considered separately and the maximum number of occupants determined.

Figure A2.2 Schematic of an underfloor wiring layout, showing that floor traps can be located anywhere within the radius of coverage

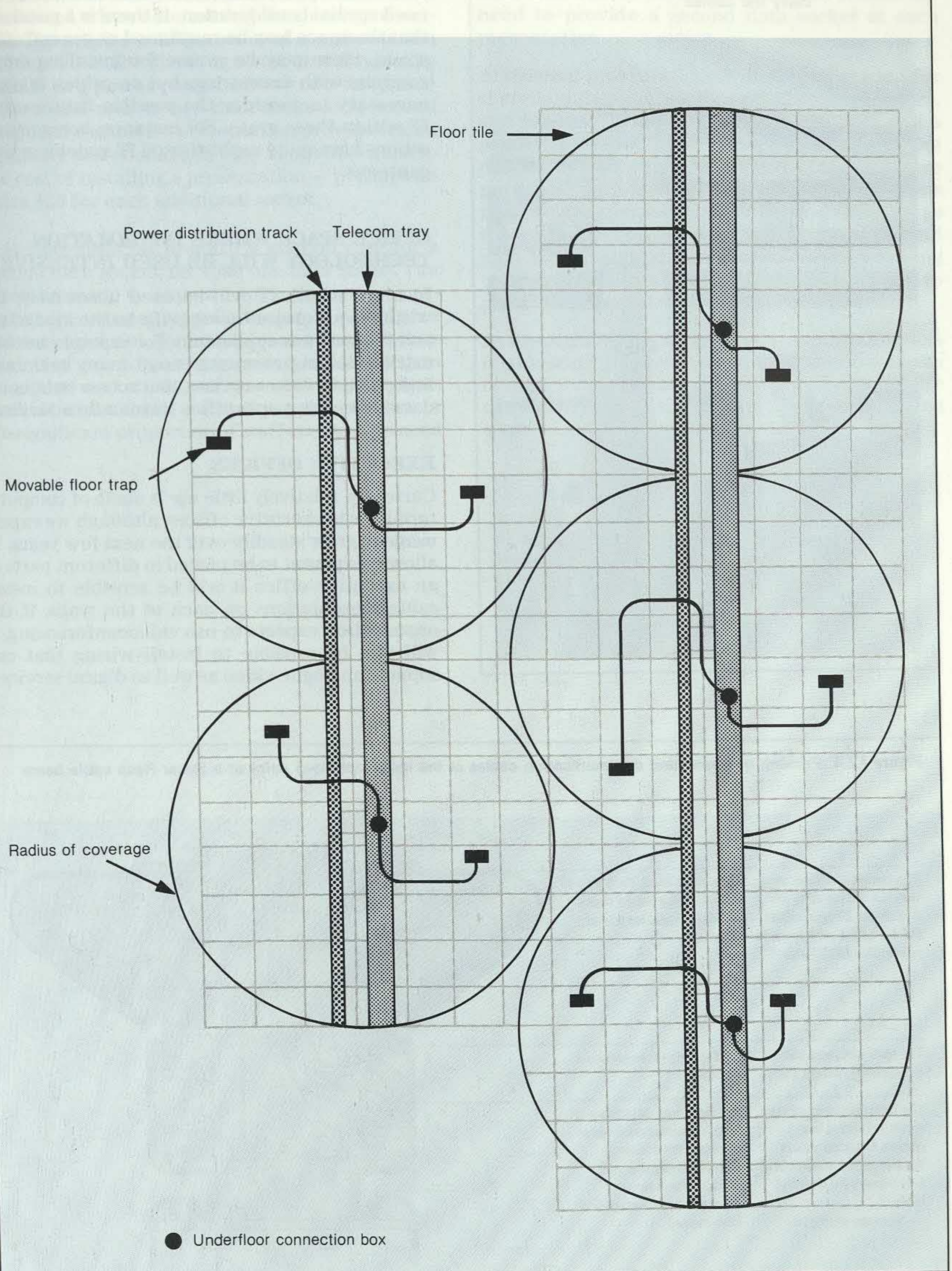
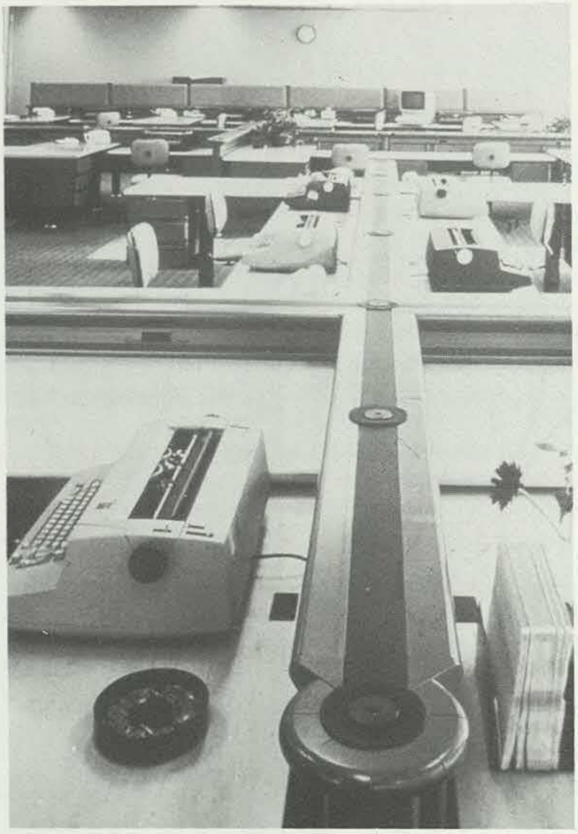


Figure A2.3 Office layout using the Sunar Race furniture system, showing the beams that carry the cables



NONOFFICE SPACE

Non office space, such as canteens and stores, will need special consideration. If there is a possibility that the space may be reassigned as general office space, there may be a case for installing empty conduits with drawstrings but no cables. It is also necessary to consider the possible future use of IT within these areas. For instance, some organisations have quite sophisticated IT systems in their canteens.

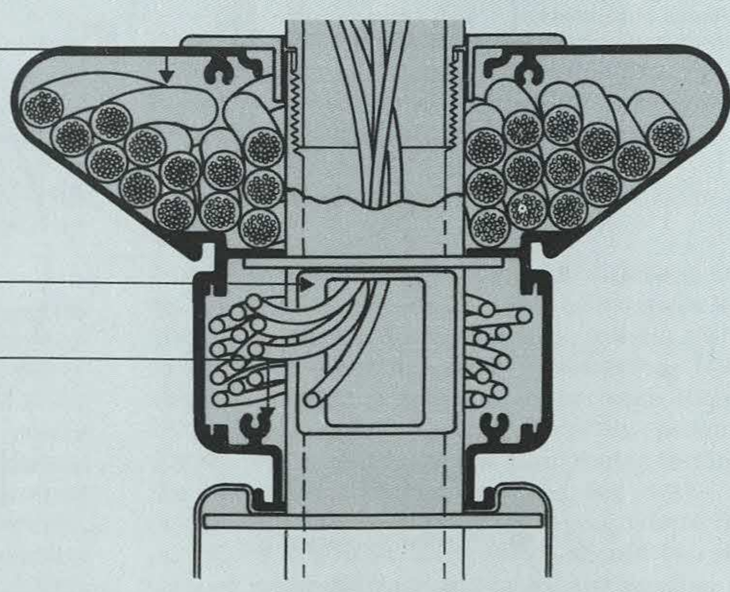
OFFICE SPACE WHERE INFORMATION TECHNOLOGY WILL BE USED INTENSIVELY

In areas where IT will be used intensively, the wiring requirements are specific to the kind of use and the business application. For example, a stock-market dealing room may need many telephone lines, several video services, and access to in-house data processing and office automation services.

EXECUTIVE OFFICES

Currently, relatively little use is made of computer terminals in executive offices, although we expect usage to grow steadily over the next few years. To allow equipment to be placed in different parts of an executive office it will be sensible to install cable presentations on each of the walls. If the organisation expects to use videoconferencing, it will also be sensible to install wiring that can support analogue video as well as digital services.

Figure A2.4 Packing of power and communication cables at the most restricted point of a Sunar Race cable beam



NATURE OF THE PRESENTATION

The nature of the presentation also needs to be considered when determining the density of outlets. The precise configuration of a presentation will depend on the planning zone but will typically include two power points, one or two telephone sockets and one or two data sockets. A second telephone socket in a presentation provides extra flexibility and should add only about one-third to the cost of installing a presentation — perhaps an extra $25 for each additional socket.

It is more difficult to make a general case for a second data socket because one data socket can often be made to support more than one workstation (by using a two-tailed balun or a local area network protocol, for instance) and because they are often much more expensive to install than telephone sockets. In our view, two data sockets should be installed if the cost per socket is low or if a significant proportion of staff are likely to need two workstations. However, providing 'spare' presentations over and above the maximum number of staff that can be accommodated will reduce the need to provide a second data socket at each presentation.

Additional presentations will also be needed for shared equipment, such as printers, file servers, and facsimile transceivers, and we suggest that a general provision of at least 10 per cent of the number of work locations should be made for these purposes. Although these shared presentations need not be grouped in the same presentations as those provided for work locations, the power and data sockets should be adjacent. Again, installing 'spare' presentations will reduce the need to provide extra outlets for shared equipment.

At first sight, it may seem excessive to install outlets on this scale. However, even if just the direct costs of moves and changes are considered over the life of a wiring system, the additional costs of installing spare presentations can be justified.

BUTLER COX FOUNDATION

Butler Cox

Butler Cox is an independent management consultancy and research organisation, specialising in the application of information technology within commerce, government, and industry. The company offers a wide range of services both to suppliers and users of this technology. The Butler Cox Foundation is a service operated by Butler Cox on behalf of subscribing members.

Objectives of the Foundation

The Butler Cox Foundation sets out to study on behalf of subscribing members the opportunities and possible threats arising from developments in the field of information systems.

The Foundation not only provides access to an extensive and coherent programme of continuous research, it also provides an opportunity for widespread exchange of experience and views between its members.

Membership of the Foundation

The majority of organisations participating in the Butler Cox Foundation are large organisations seeking to exploit to the full the most recent developments in information systems technology. An important minority of the membership is formed by suppliers of the technology. The membership is international, with participants from Australia, Belgium, France, Germany, Italy, the Netherlands, Sweden, Switzerland, the United Kingdom, and elsewhere.

The Foundation research programme

The research programme is planned jointly by Butler Cox and by the member organisations. Half of the research topics are selected by Butler Cox and half by preferences expressed by the membership. Each year a shortlist of topics is circulated for consideration by the members. Member organisations rank the topics according to their own requirements and as a result of this process, members' preferences are determined.

Before each research project starts there is a further opportunity for members to influence the direction of the research. A detailed description of the project defining its scope and the issues to be addressed is sent to all members for comment.

The report series

The Foundation publishes six reports each year. The reports are intended to be read primarily by senior and middle managers who are concerned with the planning of information systems. They are, however, written in a style that makes them suitable to be read both by line managers and functional managers. The reports concentrate on defining key management issues and on offering advice and guidance on how and when to address those issues.

Selected reports

8 Project Management
20 The Interface Between People and Equipment
21 Corporate Communications Networks
22 Applications Packages
23 Communicating Terminals
24 Investment in Systems
25 System Development Methods
26 Trends in Voice Communication Systems
27 Developments in Videotex
28 User Experience with Data Networks
29 Implementing Office Systems
30 End-User Computing
31 A Director's Guide to Information Technology
32 Data Management
33 Managing Operational Computer Services
34 Strategic Systems Planning
35 Multifunction Equipment
36 Cost-effective Systems Development and Maintenance
37 Expert Systems
38 Selecting Local Network Facilities
39 Trends in Information Technology
40 Presenting Information to Managers
41 Managing the Human Aspects of Change
42 Value Added Network Services
43 Managing the Microcomputer in Business
44 Office Systems: Applications and Organisational Impact
45 Building Quality Systems
46 Network Architectures for Interconnecting Systems
47 The Effective Use of System Building Tools
48 Measuring the Performance of the Information Systems Function
49 Developing and Implementing a Systems Strategy
50 Unlocking the Corporate Data Resource
51 Threats to Computer Systems
52 Organising the Systems Department
53 Using Information Technology to Improve Decision Making
54 Integrated Networks
55 Planning the Corporate Data Centre
56 The Impact of Information Technology on Corporate Organisation Structure
57 Using System Development Methods
58 Senior Management IT Education
59 Electronic Data Interchange
60 Expert Systems in Business
61 Competitive-Edge Applications: Myths and Reality

Forthcoming reports

The Future of the Personal Workstation
Evolution of the Corporate Database
Network Management
The Marketing of Management Services
Computer Aided Systems Engineering (CASE)
Mobile Communications

Availability of reports

Members of the Butler Cox Foundation receive three copies of each report upon publication; additional copies and copies of earlier reports may be purchased by members from Butler Cox.

Butler Cox & Partners Limited
Butler Cox House, 12 Bloomsbury Square,
London WC1A 2LL, England
☎ (01) 831 0101, Telex 8813717 BUTCOX G
Fax (01) 831 6250

Belgium and the Netherlands
Butler Cox BV
Burg Hogguerstraat 791
1064 EB Amsterdam
☎ (020) 139955, Fax (020) 131157

France
Butler Cox SARL
Tour Akzo, 164 Rue Ambroise Croizat,
93204 St Denis-Cedex 1, France
☎ (1) 48.20.61.64, Télécopieur (1) 48.20.72.58

Germany (FR)
Butler Cox GmbH
Richard-Wagner-Str. 13
8000 München 2
☎ (089) 5 23 40 01, Fax (089) 5 23 35 15

United States of America
Butler Cox Inc.
150 East 58th Street, New York, NY 10155, USA
☎ (212) 486 1760

Australia/New Zealand
Mr J Cooper
Butler Cox Foundation
3rd Floor, 275 George Street, Sydney 2000, Australia
☎ (02) 236 6161, Fax (02) 236 6999

Ireland
SD Consulting
72 Merrion Square, Dublin 2, Ireland
☎ (01) 766088/762501, Telex 31077 EI,
Fax (01) 767945

Italy
SISDO
20123 Milano, Via Caradosso 7, Italy
☎ (02) 498 4651, Telex 350309, Fax (02) 481 8842

The Nordic Region
Statskonsult AB
Stora Varvsgatan 1, 21120 Malmo, Sweden
☎ (040) 1030 40, Telex 12754 SINTABS

Spain
Associated Management Consultants Spain SA
Rosalía de Castro, 84-2°D, 28035 Madrid, Spain
☎ (91) 723 0995