Report Series
No 21

Corporate Communications Networks

November 1980

The Butler Cox Foundation

Abstract

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by Tony Gunton

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Business communication has traditionally centred around the telephone system, and many organisations, both large and small, have installed private telephone systems of varying degrees of sophistication. The relatively stable market of private telephone systems was one of the first to feel the impact of the convergence of computing and telecommunications. IBM not only captured a large share of the private exchange market in those countries where it launched the 3750 exchange, but its success also signalled a permanent change in the traditional approach to private telecommunications. The PABX was no longer merely a telephone switching device, it had become part of the corporate information distribution system.

In comparison with voice communication, data communication still represents a minor part of the cost of corporate communications. However, as computers and terminals proliferate, its importance is increasingly being recognised. In addition, if and when office automation gains real momentum, there is the possibility of an explosive growth in the demand for text, image and possibly even video communication.

While corporate communications systems hover on the threshold of a revolution, public communications systems are already well into their own revolution, as traditional transmission and switching systems cede to the all-pervading digital technology. This development opens up the possibility of integrated digital networks, both public and private, conveying information in all its possible forms into every corner of the business world and society. Clearly this revolution will not take place overnight, but it will certainly be well advanced by the end of this decade.

Many organisations, irrespective of whether they are conscious of the changes that are taking place in communications technology, are now aware of the contribution that corporate communications can make to the future efficiency and competitiveness of their business. This awareness has led organisations to see the need for a clear strategy for corporate communications and to back that strategy with investment.

This report is intended to contribute to the formulation of corporate strategy for communications. It reviews the technological changes that are affecting both communications equipment and the communications services provided by national telecommunications authorities. It summarises experience with corporate networks for voice, data and message traffic. It concludes by discussing the main elements of a corporate strategy for communications.

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— Through *professional and technical seminars* where the members' own specialist managers and technicians meet with the Foundation research teams to review their findings in depth.

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CORPORATE COMMUNICATIONS NETWORKS

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November 1980

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CHAPTER 1

INTRODUCTION

Voice communication has traditionally accounted for the bulk of corporate communications costs, and many organisations already have a private telephone network. Organisations in particular business sectors (for example, airlines and banks) have been operating private data networks for some considerable time. Others, whose business does not so obviously demand a data network, are also constructing them, perhaps either to meet a fast-growing demand for timesharing services or to link distributed minicomputers to a centralised data processing system.

Over and above these well-established private communications needs, new requirements to communicate text and image information are now beginning to emerge. Some time in the future, new high-bandwidth transmission systems, such as satellites, might act as catalysts for video communications, and so add yet another dimension to corporate communications needs.

During the 1980s, the growth of non-voice communications will be explosive. The latest Eurodata report, commissioned by the European PTTs and published in the late summer of 1980, predicts that data transmission revenues will grow from 5 per cent of the PTTs' total revenues in 1979, to something like 20 per cent by 1987. The Eurodata report also predicts that the number of network termination points will grow from 390,000 to 1,620,000 during the same period, and that, by 1987, there will be 4,000,000 terminals in Europe connected to data transmission facilities. Public data networks are expected to take a larger share of the data communications market, accounting for 30 per cent of the market by 1987. These predictions may seem to be optimistic, but it is noteworthy that the forecasts in the previous Eurodata study proved to be pessimistic. The amount of data communications equipment installed today is actually twice that predicted in the first Eurodata study, which was carried out in 1972.

Against this background, communication systems are becoming a focus of interest for senior management in many organisations, and not merely because they are a major cost area. The many recent developments in both private and public communications technology have drawn attention to the potential benefits of corporate communications, which is an under-exploited resource in many businesses.

THE COMMUNICATIONS MARKET

The use of digital technology and microelectronics underlies much of the current activity in the field of telecommunications. On the face of it, the use of digital technology offers major opportunities both to suppliers and consumers of communications products and services. Suppliers have an opportunity to exploit the integration of previously separate communications media by offering new products and new services. Consumers should benefit from this widening of the market, and they should also be able to achieve economies by combining communications equipment or capability in new ways.

Digital technology has its origins in the computer industry, and that industry has been one that has experienced rapid technological change. In that industry the two most damaging effects of this rapid change have been price degradation (for the supplier) and technological obsolescence (for the consumer). However, the telecommunications industry is more closely regulated than is data processing, and this will help to shield the suppliers and the consumers of telecommunications products and services from the most damaging effects of rapid technological change. Even so, the way in which the communications industry and market will develop cannot be predicted with certainty and there are several questions that the communications planner needs to answer.

In particular, there are questions that arise from the different backgrounds and priorities of the many suppliers who are seeking to take advantage of the attractive new communications markets. The main contenders fall into the following four categories:

- The telecommunications authorities, most of whom are constrained in their efforts to introduce new services by the compelling need to protect their existing massive investment in plant and cabling. Sometimes, too, they are hampered by government interference.

- The computer system suppliers, who have traditionally included data communication equipment as well as data processing equipment in their product range.

- The established telecommunications suppliers, many of whom have gained much of their business in the public market for telephone exchanges, but who may be forced by increasing competition and changing manufacturing economies to seek more of their business in the private market for communication equipment.

- Certain major firms, such as Xerox, for whom communication systems are a natural extension to existing markets, and Exxon, for whom they are an attractive new business area, and specialist high-technology companies like Rolm and Tran, who have developed innovative communications products.

The battle for supremacy, and in some cases, even, for survival, between these diverse contenders, will be a feature of the next decade. For the interested observer, it should be a fascinating struggle. The communications planner may also find the struggle fascinating, but his fascination may well be over-shadowed by his awareness that the viability of some of his judgements may stand or fall according to the outcome.

PURPOSE OF THIS REPORT

The brief statement of the present status of the communications market in the previous section also serves to introduce the main concerns of this report. Faced with a promising but uncertain communications market, the communications planner, and through him the organisation, must find satisfactory answers to three key questions:

- What are the key technological changes that are taking place in communications, and what is the significance of them for corporate communications networks?

- What will be the future role and influence of the various suppliers who are currently offering communications products and services?

- What is the best way to prepare for the integrated digital communications systems promised for the near future?

Many of the developments that could have a crucial influence on future events are still at the experimental stage. Within this constraint, the report seeks to provide answers to these questions. The answers also depend on national policy for public communications, and this, at the present time, is in a state of flux as the developed world prepares itself for the heralded

Information Society. The report concludes by discussing the elements of a corporate communications network strategy that is designed both to make the most of the certainties of the communications world and to provide some protection against its uncertainties.

SCOPE AND STRUCTURE OF THE REPORT

The report focuses on corporate communications networks, whose purpose is to enable users within an organisation to communicate both with one another and with the outside world. The report considers public communications services as well as private networks, because public services will form a necesary part (with few present exceptions) of any corporate network that is not limited both to one site and to internal communications only. Chapter 2 elaborates on the role and the structure of the private network. It also provides some definitions both of the terminology used to describe the characteristics of communications, and of the major types of communications traffic.

We interviewed a number of major users of private communications networks, and we carried out a survey of Foundation members in the United Kingdom. Based on the interviews and the survey, Chapter 3 describes user experience both with voice and non-voice networks. Chapter 4 then reviews the recent developments in private network technology, some of which are in the telecommunications area and some of which are in the computing area, and some of which attempt to exploit the convergence of telecommunications and computing.

Many of the recent developments originate in the United States. Whether or not they eventually become available in Europe will depend not solely on their technical merit, but also, and perhaps equally, on whether they are acceptable in the European environment. The development of private voice network technology has always been closely regulated by the telecommunications authorities (the PTTs). Data networks have not been so closely regulated, but the plans the PTTs now have for introducing public data networks, and the awareness they have of the value of new markets for non-voice services are changing the situation. With this in mind, Chapter 5 concentrates on the communications environment the PTTs have created, and Chapter 6 concentrates on the impact technology will have on the nature and the cost of the services the PTTs provide.

Chapter 7 draws the several threads together and summarises the key findings and the implications they have for corporate communications networks. Chapter 8 then discusses those issues that influence the policy for data networks, since it is in this area that the greatest uncertainties exist at present. Finally, Chapter 9 puts forward the major elements of a strategy for corporate communications networks.

Corporate communications networks will influence, and will be influenced by, the procurement policy for communications terminals, as well as by the design of applications to support the terminals. However, the report ventures no further into discussing policy for communications terminals than is essential to present a coherent picture. The policy for communicating devices is a major topic in its own right, and it will be addressed in Foundation Report No. 23.

CHAPTER 2

ANALYSIS OF PRIVATE NETWORKS

The concept of the private network is not new, and during the 1970s many private voice and data networks were installed. Some were installed even earlier. Private message networks are also widespread, and new ones are being installed at a rapid rate, reflecting perhaps the growing awareness within organisations of the importance of good text communication between offices. In this chapter we analyse the structure of private networks and the reasons for installing them. The purpose of this analysis is to establish a common basis for discussing voice, data and message networks. At present, the three network types are usually treated as separate entities, but the use of digital technology opens up the possibility of their coming together in a single integrated network. If sensible decisions are to be made on the speed and the mode of integration, it is important to recognise both the similarities and the differences between the three types.

THE REASONS FOR INSTALLING PRIVATE NETWORKS

Voice Networks

Efficient and reliable desk-to-desk dialling within an organisation is a concept that can command considerable support from top management. It is possible for an organisation to effect some improvement of its in-house telephone facilities without installing a full-scale private voice network (for example, by installing computerised branch exchanges). But an extra dimension is added when an organisation introduces a dedicated inter-site switching system, which can provide a high and uniform level of service right across the organisation.

In the past, organisations have installed private voice networks for inter-site traffic either because the public switched telephone network was too congested or too noisy, or because the switching was too slow or too unreliable. Usually, an organisation constructed a sound cost justification, based on the cost of carrying internal traffic on private lines leased from the PTT, compared with the cost of using the public telephone system.

In some European countries (Sweden and West Germany, for example), leased-line tariffs completely discourage private networks. In others, and particularly in the United Kingdom, private networks are relatively easy to cost justify. However, British Telecom (and other PTTs) have recently signalled their intention of raising leased-line charges. In the future, therefore, the economic justification for private voice networks may become weaker, if it does not disappear altogether.

To enable an organisation to communicate with other organisations, the superior in-house facilities available with a private voice network will be combined with the use of the public telephone network. The reason for this is that the PTTs will rarely allow a private voice line to interconnect separate organisations, unless one of the organisations is a subsidiary of the other.

Message networks

Organisations have installed their own message networks for reasons similar to those that apply to private voice networks. Private message networks usually have links to the public telex system, and thus they also provide a mixture of private and public transmission facilities. However, private message networks differ from private voice networks in that a number of them interconnect independent (but similar) businesses. Two examples are SITA, the inter-airline network and SWIFT, the inter-bank network. There are more than 160 private message networks in the United Kingdom alone, and new ones are being installed at the rate of six per month.

Data networks

The public telephone system can be used to transmit data, but those organisations that need to use data transmission facilities have tended to install leased (un-switched) lines because:

- The error rates of leased lines are lower than those of the public telephone network (because switching in the public system generates significant amounts of line noise).
- The PTT will guarantee the quality of leased lines.
- The speeds at which data can be transmitted over leased lines are higher than the speeds that can be achieved with transmissions over the public telephone system. This is especially true if the latest modems are used, since PTT regulations often prohibit their use on the public telephone system.

However, a data network will nearly always need to be justified also in terms of transmission costs, in the same way as a private voice network is cost justified. How easy it is to do this varies from country to country, and it depends both on the times of the day when the lines are used, and on the intensity with which they are used. In the United Kingdom, where leased-line tariffs are among the cheapest in Europe, a leased line can be justified when it is used for as little as two hours a day. This amount of usage is common with transaction processing, and it is not unusual with timesharing and remote job entry applications.

To date, private data networks have served mainly to reduce communications costs and to improve service levels to network users. But more recently, a new aspect has been added to the use of data networks. Traditionally, a single leased line has been used to connect either one or a few terminals to a single mainframe computer. This has been appropriate because terminals have been justified and installed to serve one particular application. Now, however, organisations are installing different computers for different applications (often at several sites), and users are beginning to treat terminals as utilities, rather than as parts of dedicated systems. To cope with these developments, the corporate data transmission facility now needs to provide a higher degree of connectivity. This higher connectivity can be provided by a private network that has a switching capability or (and increasingly in the future) it can be provided either by public data networks or by a mixture of public and private networks. This more dynamic environment calls for a more adaptable structure than has been needed in data networks in the past, so that additional devices can be connected and new traffic patterns can be catered for without major disruption.

NETWORK STRUCTURES

Until recently, the differences between voice and data networks have been more apparent than have the similarities. (Message networks, such as the public telex network, stand somewhere between voice and data networks, but we leave these aside for the time being and concentrate on the structure of voice and data networks.) The main differences are derived from the nature of the communication processes that the networks serve. Voice communication is isochronous (that is, tied absolutely to a timescale) and multi-destinational, whereas data communication can tolerate delay, and it has tended to be predominantly point-to-point, because most terminals have needed to address only one or at most a very few computers.

These differences are reflected in the different techniques used to handle the traffic. Voice systems rely on circuit switching, in which a direct communication channel is established between the telephones. Once a circuit-switched connection has been set up, the network users have full and undisturbed use of the communication channel until they terminate the call.

On the other hand, data networks tend to use what, for want of a better term, we describe as item switching. (Packet switching is a special type of item switching, and describes the multiplexing techniques used on networks such as Tymnet and Telenet in the United States and Transpac in France.) Item-switching networks direct traffic, in the form of individual items of information, along logical channels (often known as virtual channels) between the sending and the receiving devices. Because the physical channel is shared by many sending and receiving devices and/or because the receiving device has a finite capacity to accept information, strict rules govern the use that both the sender and the receiver make of the logical channel.

In summary, switching functions dominate the functions in voice networks, because a voice network has largely completed its task when it establishes a connection between the network users. In data networks, however, transport control has tended to be the dominant function. (By transport control we mean the procedures necessary to control access to, and the use of, the communication path.)

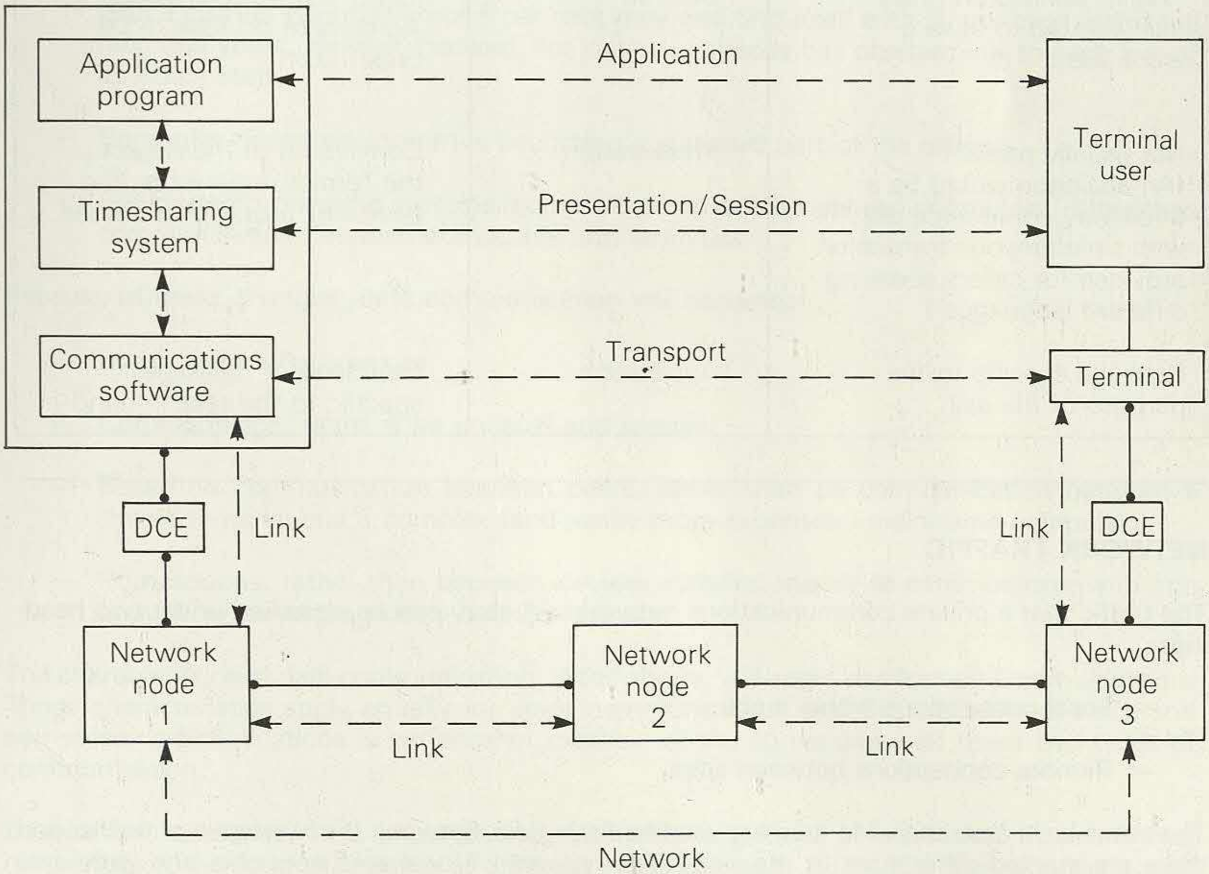
There is a further difference between voice and data communication and it is a significant one. Once a voice call has been established, the network functions are transparent to both the terminals (the telephones) and the network users (the calling parties). Any procedure that is necessary to establish identities, or to determine who speaks when, etc., is carried out directly between the network users with neither help nor hindrance from either the network or the terminal. In a data network, on the other hand, the interface between the user (who might be a terminal user or an applications program) and the network is indirect, in that communication is by means of coded messages. For this reason, the procedure (or signalling) that is necessary to control a dialogue must be structured, and it must be built into the logic of either the network or the communicating devices. This signalling is necessary to recognise and recover from errors, or to verify that the called party is ready to receive information, etc., and it is the counterpart of the complex but largely subconscious signalling that people use to control a telephone conversation. As the understanding of data communication has developed, so the signalling procedures have been progressively more rigorously and more methodically defined, leading to the multi-layer network structures that are common today. These signalling procedures, which are termed protocols, are illustrated in figure 1, and figure 2 on page 8 contrasts the protocols used on a data network with those used on a voice network.

Even though the traffic characteristics and the signalling procedures of voice and data networks will continue to be distinct, networks are, in other respects, converging. This convergence is most apparent in the topography of the networks. The importance of switching and routeing functions in data networks has grown as point-to-point traffic has given way to more cross-network traffic. As a consequence, data networks are evolving from their being an outgrowth of the mainframe computer into the autonomous, self-manging, near-transparent communication service that telephone networks have always been. This change has been apparent in the public sector for some time (in the packet-switched networks mentioned earlier), and it is also beginning to affect private data networks. It was discussed at length in Foundation Report No. 1.

So far, we have identified the two broad functions of a network as switching and transport control. The description of the network as self-managing introduces a third broad function. This function, for which we use the term network management, provides those who operate the network with the facilities necessary to manage both it and its resources, such as fault diagnosis, configuration control, etc.

To complete this brief description of the macro-structure of networks, we refer again to figures 1 and 2, which show the structure of data network protocols. The first three levels of protocol (physical, link and network) are now well defined. However, the remaining high-level protocols are not defined at the present time, and there is considerable debate about the precise scope each layer has, and also about the relationship that each layer has with its neighbouring layers. The highest levels of protocol cater for signalling between network users with a task to carry out. Examples are the engineer with a mathematical problem to solve, or the application programmer wishing to transfer a file to another network user elsewhere. High-level protocols are vital if meaningful communication is to take place, as opposed to merely transferring information from place to place. By analogy, a Frenchman and an Englishman can telephone each other, but they can communicate with each other only if they use a common language, or if they can use an effective translation function. A private language (that is, protocol) is quite adequate for a dedicated terminal that performs a particular application. It has been recognised, however, that some common tasks (such as file transfer or job transfer) and some applications (such as information retrieval from databases) require standard high-level protocols. The subject of high-level protocols is discussed in more detail in chapter 5 on pages 37 and 38.

Figure 1 Example of a protocol hierarchy



Key: DCE = Data circuit terminating equipment
•——• = Physical relationships
◄–► = Logical relationships at the six levels of link, network, transport, session, presentation and application.

Figure 2 Comparison of voice and data protocols

VOICE Typical activities	PROTOCOL	DATA Typical activities
Reception and generation of electrical signals	Physical	Reception and generation of electrical signals
Signalling to local exchange	Link	Control of data integrity
Signalling to remote exchange across the network	Network	Control of information flow; Routeing and addressing; Multiplexing
"Sorry didn't quite follow that. Could you please repeat it."	Transport	Control of message sequence
"Hello, John Smith here. Just wanted to have a word about . . ."	Session	Identity/privacy checks; Agreement on task to be undertaken
Not usually present (An analogue would be a three-way conference call with simultaneous translation provided for callers speaking different languages.)	Presentation	Conversion of message to the format required by the device or process addressed
Dialogue specific to the purpose of the call	Application	Exchange of messages specific to the task in hand

NETWORK TRAFFIC

The traffic that a private communications network will carry can be classified under two headings:

- Local connections within a site.

- Remote connections between sites.

The terms local-area and wide-area are used to distinguish between the two types of traffic, and there are marked differences in the respective natures of local-area networks and wide-area networks. One obvious difference is that PTT transmission services are generally mandatory for wide-area networks, whereas fewer restrictions are imposed on the methods that may be used for local-area services. However, there are other differences that are caused by the different characteristics of local and remote communications, as we next discuss.

In both public and private telephone systems, the cost of local-area distribution has always been greater than the cost of wide-area distribution. As we explain in chapter 6, wide-area switching and transmission costs will decline over the next decade, and this will emphasise the importance of local-area networks. Also, there is evidence that local traffic forms an increasingly dominant proportion of business communication. Studies carried out in the United States showed that 60 per cent of communication for business machines was within the same building, and a further 22 per cent was transmitted less than fifty miles. We therefore now look at the need for local-area facilities.

The existence of the private automatic branch exchange is, in part, a recognition of the fact that a large part of corporate voice communication is local. Non-voice communication systems, on the other hand, have failed to pay the same attention to the requirements for local distribution. Telex is typical in this respect. A telex message can spend such a long time on a large site making its way from the telex room to the addressee that the speed advantage of electronic transmission is lost.

The requirements for local distribution in data communication systems have also not received the attention they deserve. This is largely a result of the economics of terminal-based computer systems, where the terminals had to be heavily utilised to justify themselves. Thus, they were concentrated in a single department, and generally they communicated with a single mainframe computer system. This traditional pattern is now changing, and for the following reasons:

- The penetration of terminals is increasing rapidly and exponentially. An organisation with a current penetration of 5 per cent may well find itself with 50 per cent within the next few years. Hewlett-Packard, for instance, already has one terminal to each two of its office staff.

- Computer-based equipment is becoming a standard part of the office.

- Distributed processing systems require communication between computers, rather than communication between computers and terminals.

Because of these changes, data communication will become:

- Local, rather than remote.

- Commonplace, rather than unusual and special.

- Based on communication between peers, rather than on communication between a simple terminal and a complex (and vastly more expensive) mainframe computer.

- Promiscuous, rather than between devices installed merely to communicate with one another in serving a closely-defined function.

The characteristics of data communication, listed above, will apply also for text communication. Those characteristics apply equally for voice communication, and this similarity of voice and non-voice communications is yet another example of the convergence of these two types of communication.

Despite this similarity, it is important to appreciate and bear in mind that there are real differences in the form that traffic of different types will take. As well as the voice/non-voice division reflected in the signalling procedures, there are also major differences within the non-voice category. There are five major types of communications traffic that can be defined in terms of their timing constraints, their speed (or bandwidth) requirements and their tolerance of transmission errors, and they are:

1. Voice communication
   This is isochronous, and it needs little error correction. The PTT standard for the

transmission of speech in digital form will be 64k bit/s. (To economise on line utilisation however, an acceptable quality can be provided at speeds well below that figure). The main use of such a service is obviously for voice communication, although it could equally well be used for surveillance or for freeze-frame video communciation (that is, a picture that is refreshed periodically rather than moving continuously).

2. Bulk data communication
   Bulk data traffic is relatively indifferent to timing, but it needs full error correction. The volume of information involved permits high line speeds to be used efficiently. Applications that require bulk data transmission include file transfer, document distribution and remote job entry.

3. On-line data communication
   In terms of timing constraints, on-line data traffic falls between voice and bulk data. Network transit times of a few seconds will be needed, and error correction will need to be thorough. Transmission speeds will need to match the capabilities of the terminals, and they will range from about 300 bit/s up to 10k bit/s or thereabouts. Applications that require on-line data communication include information retrieval, data entry and timesharing.

4. Message communication
   Message traffic is similar to on-line data traffic, but it does not require fast network transit times.

5. Video communication
   Full video communication, which is used for conferencing, resembles voice in that it is isochronous and requires little error correction. However, it differs from voice in its demand for bandwidth. To transmit moving television-quality pictures in colour as a digital stream of information requires a transmission rate of at least 2M bit/s.

Some of the definitions given above overlap. We present them both to establish a terminology and to illustrate the considerable differences in requirements that an integrated communications network would need to take into account. These differences would affect the switching and the control mechanisms more than the transmission system, as is clear from current technology. A packet-switching exchange is as different from a PTT telephone exchange as a statistical multiplexor is from a private automatic branch exchange, yet all four use the analogue voice network as the transmission medium.

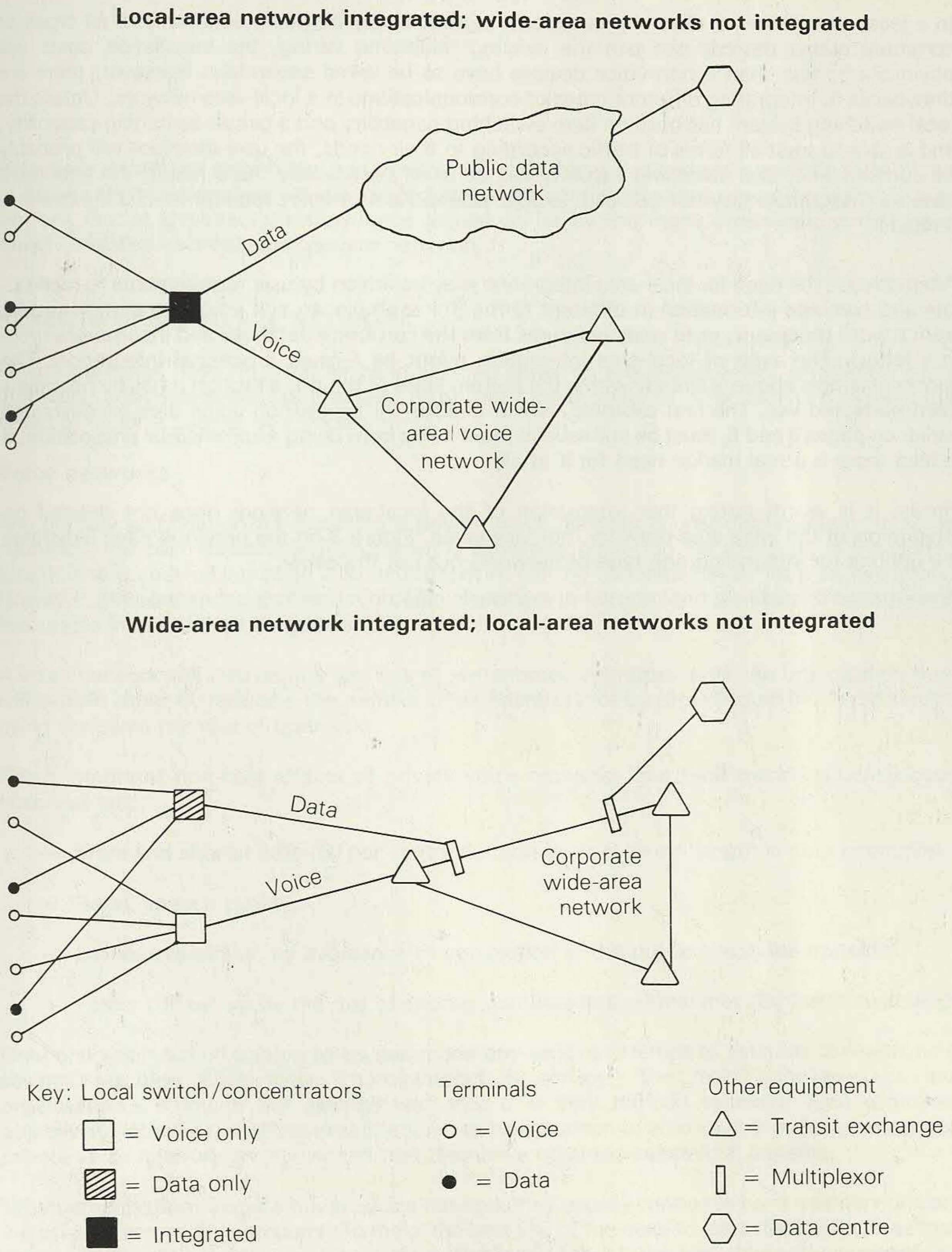
NETWORK INTEGRATION

We have already referred to integrated networks, and it is important that we should define what we mean by this term. Moreover, it is necessary to distinguish between wide-area integration and local-area integration.

In a wide-area network, the incentive to integrate different types of communications into a single network is primarily economic. Where the characteristics of different forms of traffic are complementary, it is possible to share transmission capacity and thus reduce costs. Clearly, the different types of traffic must follow compatible routes. The transmission capacity can then be shared either dynamically (for example, by inserting non-real-time data traffic into the gaps between real-time voice traffic), or statically (for example, by using lines for voice traffic by day and non-voice traffic by night).

It is also possible to achieve savings in wide-area network costs without any sharing of individual lines. This can be done simply by leasing groups of circuits (generally either 12 or 60), and using some for voice traffic and others for non-voice traffic. This form of integration

Figure 3 Options for integrated networks



generally affects only the transmission system, not the switching system, because, as we explained earlier, voice traffic uses circuit switching, and data traffic uses item switching over dedicated lines.

In a local-area network, also, the case for integration may be partly economic. If all types of communications devices can use the existing telephone wiring, the installation costs will obviously be less than if non-voice devices have to be wired separately. However, there are drawbacks to integrating different types of communications in a local-area network. Unless the local switching system has both an item-switching capability and a circuit-switching capability, and is able to treat all forms of traffic according to their needs, the user interface will probably be cumbersome, and switching capacity will be used inefficiently. As a result, the economic case for integration may not be valid, except where the non-voice requirements are extremely limited.

Alternatively, the need for local-area integration may be driven by user requirements to manipulate and combine information in different forms (for example, to add voice annotation to text from a word processor, or to retrieve figures from the corporate database and incorporate them in a letter). This type of local-area integration might be termed functional integration. The second example above is already within the current state of the art, although it has by no means been perfected yet. The first example, which crosses the voice/non-voice division described earlier on pages 5 and 6, must be still several years away from being a commercial proposition, if indeed there is a real market need for it at all.

Finally, it is worth noting that integration of the local-area network does not depend on integration of the wide-area network, nor vice versa. Figure 3 on the previous page illustrates the options for integrating one type of network, but not the other.

CHAPTER 3

USER EXPERIENCE

Before we review the technology and the environment that will shape and constrain the options of organisations when they are developing corporate communications networks in the future, we look first at the practical experience gained so far by the many organisations that have already installed and operated private networks.

BENEFITS OF A PRIVATE NETWORK

Private networks have, in general, been justified either on the displacement of existing costs (normally, public network call charges) or on the total inability of other facilities to meet the needs of either a project or a department.

Voice networks

The primary justification for installing a private voice network is cost displacement. In some countries, the cost displacement argument is extremely powerful. For example, in the United Kingdom the cost of installing a private network can be recovered in as little as two years. However, circumstances are less favourable elsewhere in Europe (and are likely to become less favourable in the United Kingdom also).

A voice network will also require less use of switchboard operators' time. An organisation then will benefit either by reducing the number of its operators, or by providing an improved service using the same number of operators.

Some important non-cost effects of private voice networks that have most frequently been observed are:

— More and shorter calls (50 per cent reduction in average call length is not uncommon).

— Better speech quality.

— Higher availability, by avoidance of congestion in the public telephone system.

— Faster call set-up by the use of shorter numbers and, sometimes, by faster switching.

Only one organisation known to us has made any serious attempt to estimate the staff time savings resulting from these improvements in service. The main conclusion of this organisation's study of the savings was that it is very difficult to make such estimates objectively. However, all those organisations we have spoken to who have experience of using a private voice network are convinced that they have obtained substantial benefits.

When organisations install a private voice network they usually choose to have a single numbering scheme across the company. To make the best use of the desk-to-desk dialling facilities that such a network provides, and to reduce the workload of the switchboard operators, an organisation needs to compile a corporate telephone directory. A corporate telephone directory often has a number of secondary benefits not directly associated with the private network.

Once an organisation accepts that some central management of voice communications is justified, it can add other facilities, of which the most important, probably, is call accounting. The introduction of call accounting has been found to give cost savings of between 15 per cent and 30 per cent. A further benefit of call accounting is that it draws attention to the actual costs of the telephone system. Consequently, it makes it easier to cost-justify the selective use of other communication systems (for example, electronic mail).

Data networks

When we use the term data network we are not referring merely to the use of telecommunications facilities for data transmission. Rather, we are referring to the establishing of an overall system to support data communications. Sometimes the transition from data transmission to a data network is not easy to pinpoint. Perhaps the distinguishing characteristic of a data network is that it is capable of performing a switching function, as well as of multiplexing point-to-point streams of data. Until recently that criterion would have excluded the data communications products of most computer suppliers, but most suppliers now provide, or at least promise to provide, some kind of switching function.

Organisations have tended to justify data networks on functional grounds, rather than on cost grounds, although elements of the network may well justify their existence on cost displacement criteria. Statistical multiplexors, for example, justify their cost by extracting additional utilisation out of leased lines, and switching nodes may permit traffic to follow fewer, faster routes, at an overall cost saving. This means that cost displacement can form a convincing justification for a data network, but functional gains are often the catalyst. At present, the functional gains are mainly in simple connectivity, which, for example, enables terminals to access more than one computer system, or permits minicomputers to be interconnected without cumbersome switching. Some organisations have already gone beyond this simple connectivity. They use their data network to interconnect incompatible devices, and, in this way, overcome the limitations of manufacturer-dependent protocols.

To be capable of interconnecting incompatible devices, data networks either need to be built specially (like British Steel's packet-switching network) or need to be acquired from specialist network supply companies, like Tran Telecommunications. Organisations that have installed proprietary networks of this type generally report that they have provided better performance and can perform additional functions at lower cost, compared with the standard communications products of computer manufacturers. The drawback of these proprietary networks is that they need to be interfaced with the computer supplier's systems software. To design and maintain a workable interface is not a particularly difficult undertaking, but it does demand specialised skills. The network supplier will of course contribute to the effort involved, but it is unwise to rely on their expertise. Communications software has for years been a trouble-spot both for large and small suppliers.

Proprietary data networks also offer an advantage in the area of network maintenance. Until IBM announced its intelligent modems, computer suppliers tended to regard network fault diagnosis as the province of the PTT. Fault diagnosis, on the other hand, has often been one of the selling points of the products of those suppliers that specialise in communications equipment. For example, companies such as Ferranti and Racal-Milgo offer network control devices for use with their proprietary modems and multiplexors. These devices enable faults in the network to be isolated and diagnosed from one central maintenance point.

Finally, organisations we have spoken to who have experience of using large-scale data networks have commented on three secondary effects:

- Systems designers are able to place data and intelligence at the best place in the system, rather than being constrained by a rigid communications scheme.

- An organisation's reliance on the PTT to provide additional leased lines for expansion is reduced. The cost of an organisation over-provisioning for the future is reduced, and it is easier for the organisation to extract the latent capacity out of existing lines.

- Data networks are normally designed for traffic between terminals and computers, or between computers and computers. However, staff find that they can use the network to transmit messages from terminal to terminal. This development is most noticeable in multinational companies, but it is also evident in organisations operating on a small scale.

Message Networks

Corporate message networks have been installed both to reduce costs and to improve service levels. Organisations have reduced their costs by displacing public network call charges or postal costs and also by reducing their staffing requirements. They have obtained service improvements in three ways. Firstly, the use of the store-and-forward facilities available with a private message network has meant that neither incoming nor outgoing messages need ever wait until the called party or device is available. Secondly, links to data processing systems or to other networks have permitted terminals other than telex terminals to send, and sometimes, to receive, telex messages. Thirdly, an internal addressing scheme that is more flexible than the one provided by the public telex system has been introduced.

FORECASTING TRAFFIC GROWTH

Users of private voice networks have found that the growth of voice traffic can be estimated reasonably reliably by extrapolating from past traffic levels, and by allowing for all known business changes (such as the closure of a factory). However, the growth in data traffic is more difficult to foresee, because of the so-called "motorway effect". The motorway effect is caused by a data network revealing an unsuspected latent demand. This can be particularly true in the growth of the discretionary use of a data network for activities such as timesharing.

In addition, the extent to which data network facilities are used depends on how valuable they are to the end-users, and users will often not be able to appreciate the value of a facility until they have made some use of it. Consequently, users have a poor record in forecasting their future needs and tend to include only those needs they are sure of. Staff may also buy equipment without sanction from the centre, and then ask for it to be connected to the data network. Because it is difficult to forecast the growth in the use of a data network it is dangerous to switch data traffic through a private automatic branch exchange, because a high volume of data may degrade the level of voice service.

At this stage in the development of corporate message systems it is even more difficult to forecast the growth of message traffic. In most organisations the volume of telex traffic has now stabilised. However, it is reasonable to expect that the use of communicating word processors and electronic mail systems will increase the demand for message communication systems. This is already happening in some organisations, but, in others, the initial fast growth of message traffic has declined. This decline is sometimes attributed to disillusionment by the users when the first flush of enthusiasm for the new service fades.

ATTITUDES TO INTEGRATION

Most organisations do not accept that they have a need to integrate the different types of communication into a single network. Those that do are reflecting a "technological imperative" rather than an identified business need. Alternatively, they are merely pursuing the cost savings that can be achieved by combining the complementary switching or, more usually, the transmission requirements of voice and non-voice communications.

Some organisations are, however, beginning to link data terminals and computers both with their corporate message switching systems and their telex systems. Products such as the Datashare Telex system (marketed by Ventek) permit telex messages to be generated by data processing systems.

The use of separate networks for transmitting messages and data has arisen as a kind of historical anomaly. In fact, almost all data may be regarded as a kind of highly-structured text, and conventional data processing systems have often had an element of simple word processing (for example, the printing of names and addresses). The spread of communicating word processors requires a reappraisal of the way in which message transmission is handled. In the future, higher speeds will be necessary for message transmission, and this development will lead to a greater need to integrate data and message communications.

The armed services tend to be most advanced in their attitude to network integration. They expect that integration will lead to manpower savings, lower line charges and improved performance.

Apart from the armed services, the main factors keeping integration at its present low level are:

- Cost.
- Fear of putting all the corporate eggs in one basket.
- Lack of integrated switching products.
- Lack of demand for integrated services from line departments.
- Suspicion of "state of the art" systems.

QUESTIONNAIRE SURVEY

Using a questionnaire, we carried out a survey of Foundation members in the United Kingdom, with a two-fold purpose. Firstly, it was designed to give us some broad indications both of the level of expenditure and the level of traffic on voice, data and message networks. Secondly, it was designed to allow us to identify the way in which the communications function is organised in large corporations. The findings of the survey are summarised below.

Expenditure on networks

For those members who reported expenditure for all three types of network traffic, the expenditure on voice networks dominates the total network costs. For most respondents, a voice network accounted for at least 60 per cent of costs.

Expenditure on data networks varied more widely. Higher expenditure (39 per cent or more of total costs) was strongly associated with high growth rates in traffic. It was also associated with higher proportionate expenditure on switching (as opposed to transmisison or staffing). For those organisations that spend fairly large sums on data networks, switching costs were uniformly between 40 per cent and 50 per cent of the total cost of the data network.

Message networks generally accounted for between 10 per cent and 15 per cent of total expenditure, and expenditure was highest for those organisations that operate on an international scale. The main variation was in the proportion of expenditure devoted to staff. A comparison of the message network figures with those for data (which do not allow for the cost of operators) leads us to surmise that where terminals run unattended, staff costs account for less than 10 per cent of total network costs. Where terminals are manned, staff costs account for 30 per cent or more of the total network costs.

The units organisations use to measure network traffic were too diverse for us to obtain any reliable measure of usage costs. We were able to establish, however, that the cost of one minute of voice traffic per day was about £30 per annum for those organisations that have a private voice network, and it was about £40 or more for those that do not. This cost advantage for a private network reflects the low leased-line tariffs in the United Kingdom.

Traffic growth

The growth of both voice and message traffic is low (less than 10 per cent per annum), and in some organisations there is no growth at all. Where voice and message traffic is growing, it seems to be associated with either a recent development or the promotion of the services. Data traffic, on the other hand, is generally growing at more than 10 per cent per annum. In several organisations it is growing at more than 20 per cent per annum, and in a few it is growing at more than 50 per cent per annum. We have already noted that the higher growth rates for data traffic were associated with higher expenditure. This apparently confirms the motorway effect that the introduction of improved services has on the demand for data transmission services.

Organisation of the communications function

In the majority of organisations, voice and message networks are under the central co-ordination and control of either the corporate telecommunications group, or the management services department. In some organisations, however, responsibility is dispersed to user sites. The responsibility for formulating the policy for data networks and for developing them subsequently is mostly centralised under the same authority. In a substantial minority of organisations, however, the data processing department controls data communications separately. Most of those organisations spend very little on data communications. There is, however, a general trend in all organisations towards centralising policy making and network development for all types of network.

CHAPTER 4

PRIVATE NETWORK TECHNOLOGY

The capability and the sophistication of communications equipment are growing steadily, as new developments in microelectronics make it practical to incorporate more and more intelligence into devices ranging from a modem to a 2000-extension private automatic branch exchange. In this chapter we review the recent and the possible future developments in the three key areas of private voice switching, data network architectures and local-area networks.

PRIVATE VOICE SWITCHING

Although the trend towards computerised private branch exchanges is now well established both in the United States and in Europe, these devices undoubtedly still have a long development path ahead of them. When compared with electro-mechanical designs, the computerised exchanges already available on the European market offer advantages principally for the telephone user, for the operator and for the staff who manage the system. These advantages were described in detail in Foundation Report No. 9 — The Selection of Computerised PABX. Further development of these first-generation computerised private branch exchanges is now beginning to centre around two key areas:

- The ability of the exchange to handle data traffic as well as voice traffic.
- The ability of the exchange to interwork in a corporate network.

Handling voice and data traffic

One of the conclusions of Report No. 9 was that the European market for computerised private branch exchanges would not see any major technological change before the mid-1980s, when second-generation devices would start to become available. Products foreshadowing those second-generation devices are now starting to come onto the market in the United States, and they are distinguished by their ability to handle non-voice traffic as well as voice traffic. To date, non-voice features on computerised private branch exchanges have developed in the following two stages:

1 Low-level data capture
Low-level data capture, from sensors, time clocks and other simple data collection devices, was available on the IBM 3750 when it was launched, although the emphasis was heavily on the improved voice features.

2 Off-line batch transfer
IBM also pioneered the ability to use a computerised exchange for the off-line batch transfer of information. IBM's teleprocessing line-handling (TPLH) software can be used to initiate the transfer of text between word processors, via a computerised branch exchange.

Logically, the next stage in the development of non-voice features must be to permit full interactive on-line working directly between terminals and a computer system. To enable interactive on-line working to be handled in parallel with voice traffic, a computerised branch exchange must ensure that the characteristic long hold times of some terminal applications (such as timesharing) do not degrade the service level for telephone users. Telephone traffic patterns are now well established, and private automatic branch exchanges are designed to handle about 10 per cent of extensions at peak times. If the exchange has to handle a significant amount of data in addition to its normal voice traffic, the design parameters both of a computerised branch exchange and of a corporate voice network will alter radically. To minimise the load on a computerised branch exchange (and on the network), the exchange must do more than just provide a circuit for non-voice calls. It must also accommodate the non-voice protocols both for connection and for flow control, so that the switching and the transmission capacity is not used wastefully.

The designer of non-voice facilities on a computerised branch exchange needs, therefore, to take account of the fundamental differences between voice traffic and non-voice traffic. The peak-to-average transmission ratio for a telephone conversation is 1 since telephone users need to use the circuit continuously. On the other hand, the peak-to-average ratio for almost all man-computer dialogues is greater than 10, and for buffered terminals it will usually be greater than 100 and sometimes greater than 1,000. At best, pure circuit switching for on-line data traffic will therefore achieve a line efficiency of 10 per cent, and at worst it will achieve 0.1 per cent or less.

The problem of switching capacity is partially or completely solved in advanced computerised branch exchange designs, such as those of Intecom (an Exxon affiliate) and Rolm. The two designs are illustrated in figures 4 and 5 on pages 20 and 21 respectively. Rolm estimates that, initially, data traffic will account for about 7 per cent of the total traffic handled by their switches. Rolm also estimates that, by 1985, this will have risen to 35 per cent, and Rolm envisages that its CBX will still be adequate to handle this high volume of data traffic. Other modern switches, including the Intecom IBX, have a fully non-blocking architecture, which means that all extensions can be busy at once. The extra cost of providing a non-blocking architecture is, apparently, not prohibitively high.

A non-blocking architecture solves the switching capacity problem, but, if anything, it increases the transmission capacity problem. To cope with high peak-to-average data transmission ratios effectively, a computerised branch exchange must additionally concentrate the traffic, and this will probably be achieved by using store-and-forward techniques. The best way of achieving this would seem to be by providing support for the X.25 interface to packet-switching networks or for a well-established protocol such as IBM's BSC. Although Intecom have not yet released full details, they appear to have chosen this strategy.

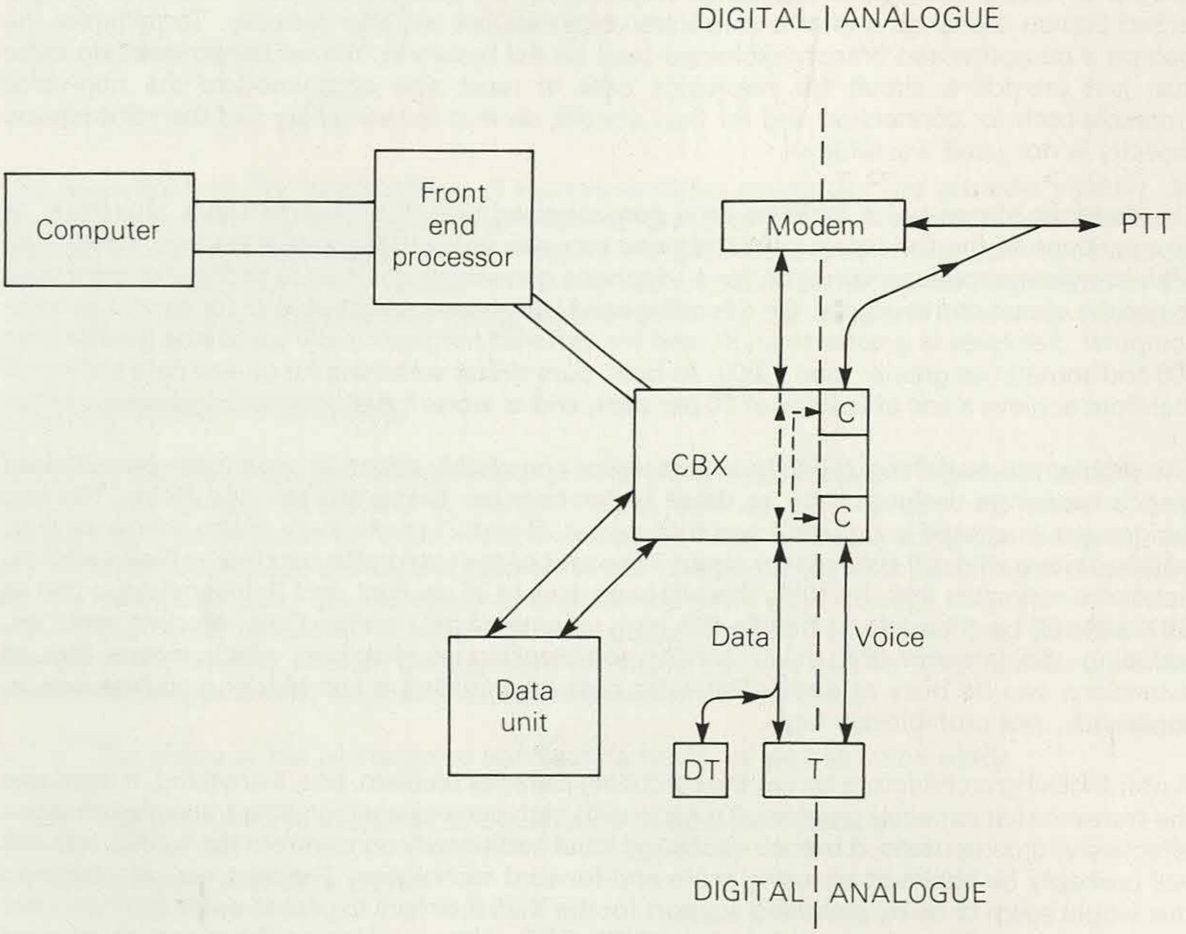
As well as taking account of the fundamental differences between voice traffic and data traffic, a computerised branch exchange must also provide a friendly user interface with the data terminals. Again, to achieve this, the exchange should provide full support for an item-switching protocol (such as BSC). The protocol should extend out to the terminal, and it should be integrated with the signalling procedures of the exchange. Without integration, the data terminal user is compelled to obtain a connection with telephone-like signalling procedures, and he then has to go through a different procedure to connect with, and to sign on to, the called computer. Such a procedure is likely to be unwieldy, and, if it involves using the telephone to set up the connection initially, it may also be inconvenient.

Both the Rolm and the Intecom switches permit telephone and data calls to take place simultaneously over one connection (6-wire for the Rolm, 2-wire for Intecom), but neither can yet demonstrate a fully integrated voice/data capability, such as that just outlined. The hardware capability is there, but the software problem remains unsolved so far. This position is, of course, not an unfamiliar one for advanced computer-based equipment to be in.

Interworking in a corporate network

PTT regulations and the nature of the market compel all suppliers of private automatic branch

Figure 4 Rolm CBX architecture

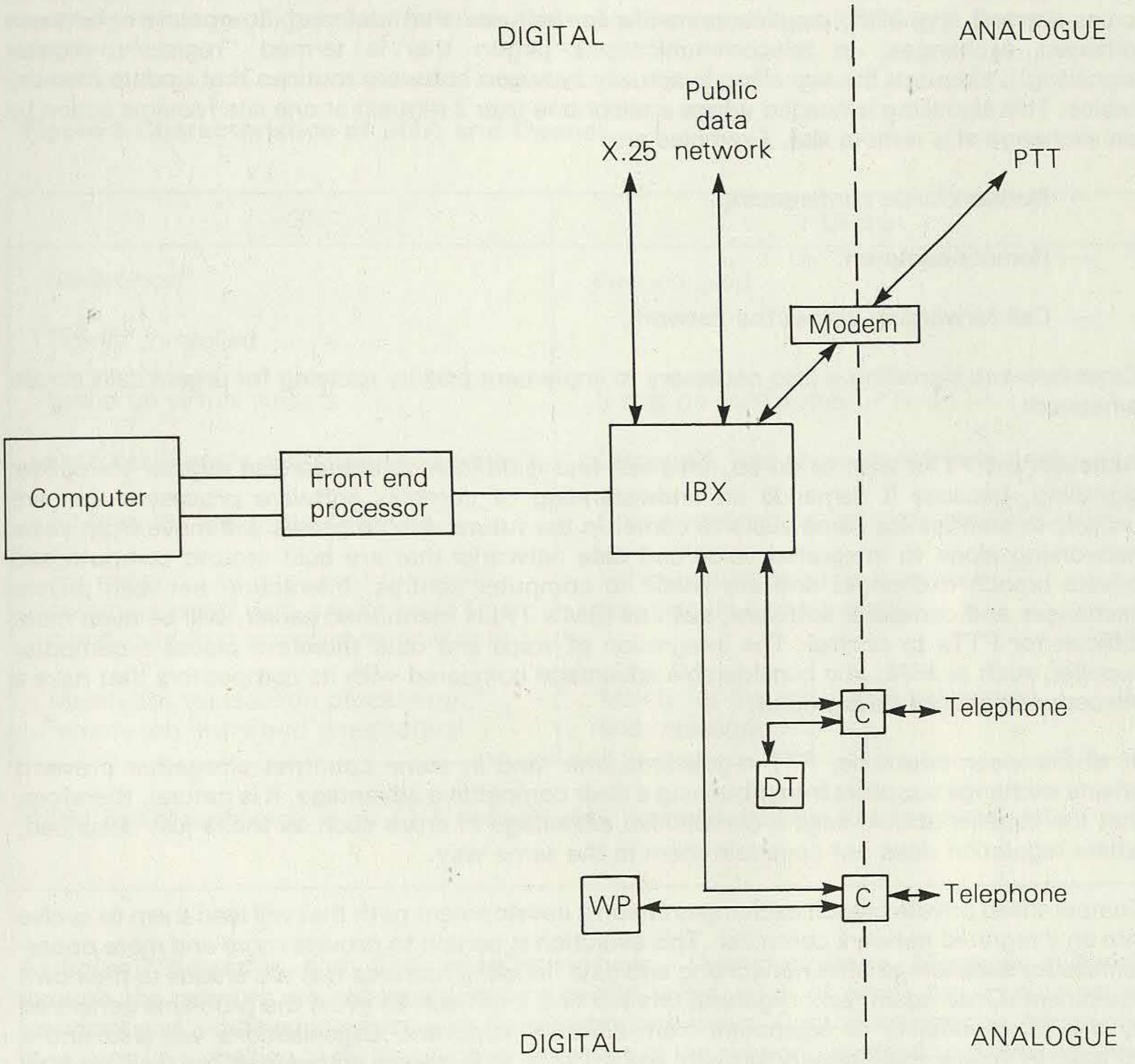


Key: DT = Data terminal
T = Telephone
C = Codec (coder/decoder)

CBX features:

- Time-division electronic circuit switch.
- Voice calls are digitised at the switch (coded) and are reconverted (decoded) before being sent on.
- Each extension line can handle voice and data calls simultaneously.
- The data unit provides store-and-forward message facilities.
- Local terminals do not require modems.
- Computers with the appropriate interface may establish a circuit through the CBX (one physical circuit being required for each logical call).
- CBX coding conventions are not directly compatible with those of European PTTs.

Figure 5 Intecom IBX architecture



Key: DT = Data terminal
C = Codec (coder/decoder)
WP = Word processor
IBX = Integrated Business Switch

IBX features:

- Digital transmission is used right up to the telephone (a codec is built into each telephone).
- Each line can provide 64k bit/s for voice and 56k bit/s for data on a single twisted copper pair.
- First deliveries will take place in the United States in January 1981 (there are no plans to offer it in Europe).

exchanges to offer equipment that will interwork across a corporate network with other suppliers' exchanges. However, although some of the features that are (or will be) available on computerised branch exchanges are not directly incompatible with other suppliers' equipment, in a corporate network they work better with like equipment than with unlike. This need for cross-network signalling applies primarily to features that demand co-operation between different exchanges. In telecommunications jargon this is termed "register-to-register signalling", although the signalling is actually between software routines that update memory tables. This signalling is needed where a telephone user's request at one site requires action by an exchange at a remote site. Examples are:

— Network-wide conferencing.

— Remote camp-on.

— Call forwarding across the network.

Cross-network signalling is also necessary to implement priority routeing for urgent calls across a network.

Although the PTTs wish to do so, they will find it difficult to standardise register-to-register signalling, because it demands an understanding of complex software processes that are unlikely to stabilise for some years to come. In the future, the emphasis will move from voice networking alone to integrated voice and data networks that are built around computerised private branch exchanges and are linked to computer centres. Interaction between private exchanges and computer software, such as IBM's TPLH mentioned earlier, will be even more difficult for PTTs to control. The integration of voice and data therefore places a computer supplier, such as IBM, at a considerable advantage compared with its competitors that have a telecommunications background.

In all European countries, PTT regulations limit (and in some countries altogether prevent) private exchange suppliers from obtaining a clear competitive advantage. It is natural, therefore, that the supplier should seek a competitive advantage in areas such as those just described, where regulation does not constrain them in the same way.

Computerised private branch exchanges are on a development path that will lead them to evolve into an integrated network controller. This evolution is certain to provide more and more opportunities for suppliers to offer networking and data handling features that are unique to their own equipment. Once again, user organisations will find it difficult to avoid the problems generated by the incompatibility of equipment from different suppliers. Organisations will also find it difficult to follow evolutionary growth paths other than those determined by their existing supplier. For large organisations, it may soon be just as important to have a supplier policy for computerised private branch exchanges as it is now for computer equipment.

DATA NETWORK ARCHITECTURES

In the past, data communication developed haphazardly, and communications products were too application-dependent. Thus, different and incompatible procedures grew up for transaction processing, for timesharing and for remote job entry. Data network architectures brought order into this disorder, and promised a growth path that would lead from the rigid and inflexible structures associated with centralised mainframe processing, into distributed processing and office automation.

The two most well-developed data network architectures available are IBM's Systems Network Architecture (SNA) and Digital Equipment Corporation's Decnet. SNA is a hierarchical data network structure, and Decnet is a peer-coupled structure. These two architectures, therefore, typify the two major variants of data network structures. However, Decnet has its origins directly in distributed processing systems, rather than in centralised mainframe systems. This means that it is designed specifically for groups of semi-autonomous minicomputers co-operating with one another, rather than for a network of terminal devices surrounding one or more large systems. Figure 6 summarises the main characteristics of SNA and Decnet.

Figure 6 Characteristics of SNA and Decnet

SNA	Decnet
Hierarchical*	Peer-coupled
Tightly controlled	
Based on virtual circuits	Based on datagrams
Complex, largely centralised software	Dispersed, less complex software modules
Bit-oriented link protocol (SDLC)	Character-oriented link protocol (DDCMP)
For networks of intelligent terminals communicating with one or more host computers (but assigned to only one)	For networks of computers each handling its own terminals
Mainly for transaction processing, remote job entry and timesharing	Mainly for file and peripheral sharing and message switching

*IBM 8100s connected to an SNA network will, however, be able to converse directly.

As figure 7 illustrates, both SNA and Decnet have a layered structure. Messages in transit through the network are processed in turn by the layers, each of which has a given set of functions and a defined interface with its neighbouring layers. Control information, which one layer uses for signalling to its counterpart elsewhere in the network, is added to the message by each layer. Both SNA and Decnet provide transport control, network management and (limited) switching facilities. In other words, they are complete networking products.

The rules that SNA and Decnet use for record size, flow control, internal multiplexing of flows and recovery from lost or duplicated message conditions may overlap, or even conflict with, the rules that a PTT imposes for the use of the public data network. This overlap, and the fact that most computer suppliers' networking products show a natural preference for the supplier's own terminals and computers, raises the familiar problem of compatibility. Market pressure will ensure that users of products such as SNA and Decnet will be able to access public data networks, but the arrangement may not be as economical as it is for users of communications products designed specifically to interface with public data networks. Both IBM and Digital Equipment Corporation have indicated their intention to support public data networks. They have also declared their approval of the concept of open system interconnection, which we discuss in chapter 5 on pages 37 and 38. Nevertheless, if the conflict between a computer supplier and a PTT is inherent in product philosophy or in market strategy, rather than in mere technical detail — as it probably is — it will not be easily resolved.

Figure 7 Network and message structures

	Protocol layer	Message structure
SNA	Application	Request/response unit (RU)
	Presentation services	RU
	Data flow control	RU
	Transmission control	RH | RU
	Path control	TH | RH | RU
	Data link control	LH | TH | RH | RU | LT

Key: RH = Routeing header
TH = Transmission header
LH = Link header
LT = Link trailer

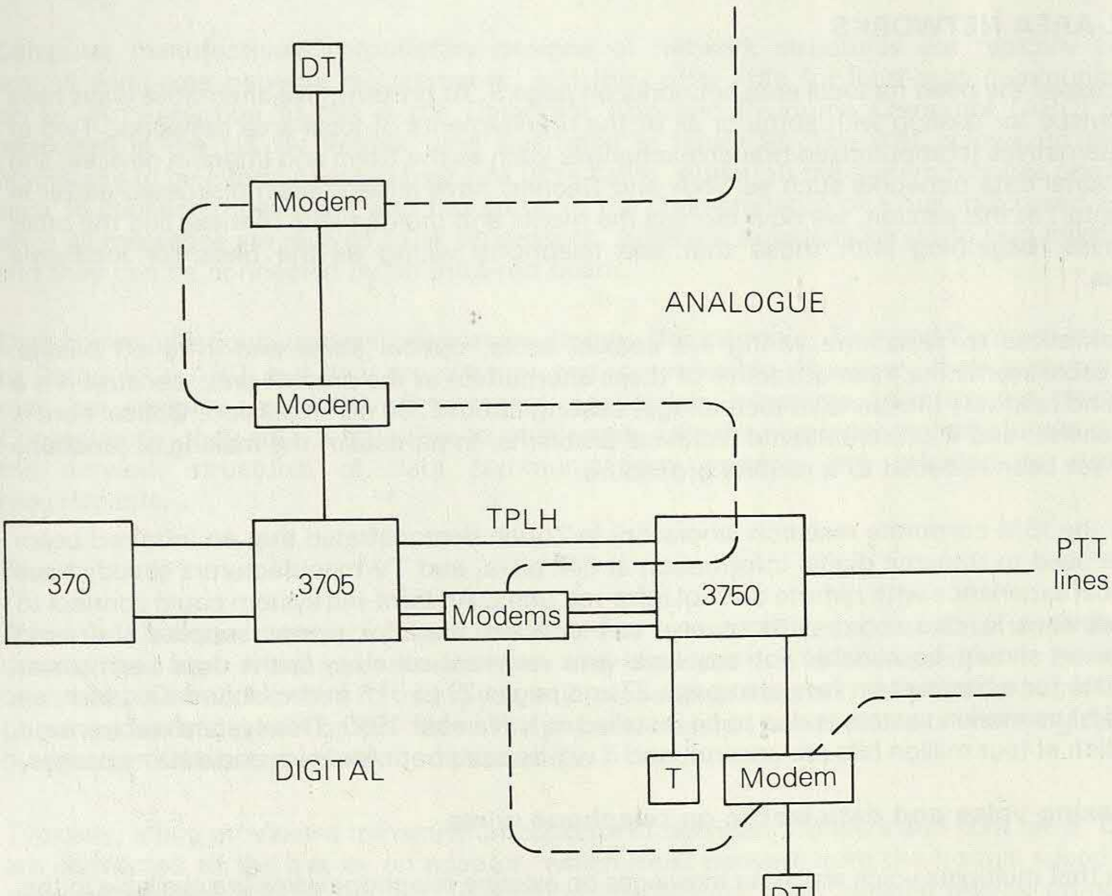
	Protocol layer	Message structure
Decnet	User-supplied program/ data access services	DAPH | User data
	Network services	NSPH | DAPH |
	Transport	TPH | NSPH | DAPH |
	DDCMP	LH | TPH | NSPH | DAPH | | LT

Key: DAPH = Data access protocol header
NSPH = Network services protocol header
TPH = Transport protocol header
LH = Link header
LT = Link trailer
DDCMP = Digital data communication message protocol

Another problem with layered network architectures is that they are much less efficient than were the more limited communication procedures that they replaced. This inefficiency can make it difficult for the supplier to deliver in practice the flexibility and the long-term growth capability that his architecture promises in theory. His difficulty arises because his designers and his programmers may be forced to compromise the structure in order to achieve reasonable performance, and this compromise leads inexorably to the vicious circle of unco-ordinated software amendment that has plagued operating software since the beginning of computing.

The risk that networking software will become difficult to manage is in proportion to the ambition of its objectives. Digital Equipment Corporation has already shown signs of moderating its initial plans for Decnet, and the effort that IBM had to put into the development and launch of SNA shows that it was a major undertaking, even with the vast resources that company has at its disposal. Also, the development of SNA is still not complete. Senior IBM technical staff make no secret of their view that SNA is a blueprint for all corporate communications, not just for data and text. Already, the beginnings of the process of integration are apparent, as IBM's 3750 private automatic branch exchange (marketed in France, Italy, the United Kingdom and West Germany only) is linked into the architecture, as shown in figure 8. (The components of this integrated architecture are discussed overleaf.)

Figure 8 IBM's integrated network architecture



DT = Data terminal
T = Telephone

The components of IBM's integrated network architecture are as follows:

— A 370/303X (or compatible) computer. This runs the VTAM software which supervises the data network. The computer also provides all application processing and any message handling that may be needed.

— A 3705 communications controller. This runs the Network Control Program, which provides item switching in conjunction with VTAM. A network may include several 3705s, each of which is attached to up to four 370 computers by high-speed channels.

— Data terminals. These terminals are served directly over lines with modems, or access to them may be via cluster controllers.

— A 3750 or 1750 private automatic branch exchange. Calls are usually made by telephone dialling, but they may also be established on instructions from a 370 computer running the TPLH software. Data calls may be established to local extensions or to remote sites (for example, for batch transfer of text between word processors).

In order to provide fully integrated services IBM must bring voice traffic into SNA. However, regulatory problems may defer, or prevent, it from achieving this in Europe.

LOCAL-AREA NETWORKS

We discussed the need for local area networks on page 9. At present, five alternative ways have been devised for dealing with some or all of the requirements of local-area networks. Two of these alternatives (computerised branch exchanges such as the Rolm and Intecom devices, and conventional data networks such as SNA and Decnet) have already been discussed earlier in this chapter. In this section, we now discuss the merits and the demerits of these and the other alternatives, beginning with those that use telephone wiring as the basis for local-area networks.

The alternatives to telephone wiring are coaxial cable, optical fibres and infra-red beams. Coaxial cable seems the most attractive of these alternatives at the present time, because it is a proven and relatively inexpensive technology, costing about £300 per extension. Optical fibre is still expensive, and it presents some technical problems. In particular, the making of junctions has not yet been reduced to a routine procedure.

In 1979, the IBM corporate research laboratory in Zurich demonstrated that an infra-red beam could be used to transmit digital information at 64k bit/s, and TV manufacturers already have substantial experience with remote control infra-red units. An infra-red system could connect to all the devices in one room without any wiring other than for power supplies. Infra-red transmission should be suitable for any local-area network scheme, but it does seem most appropriate for a bus system (see also page 27 and pages 29 to 31). In the United Kingdom, an infra-red transmission system is due to be installed in November 1980. This system can transmit information at four million bits per second, and it will be used both for voice and data messages.

Multiplexing voice and data traffic on telephone wires

Systems that multiplex voice and data messages on existing telephone wires are available in the United States, but, for regulatory reasons, they are not available in Europe. Their advantage is that they avoid the need to install new wiring for data terminals. Even so, they cost more to install than does re-wiring over short distances, and they are likely to be attractive only for large sites where the installation of new wiring is physically difficult.

The computerised branch exchange

We explained on page 19 how modern computerised branch exchanges, such as the Rolm and Intecom devices, permit a telephone and a data terminal to share a standard telephone connection. The three principal difficulties with the use of an integrated computerised branch exchange are:

- The suppliers' abilities to combine voice and data switching functions above the transport level have yet to be demonstrated. The software to achieve this will be complex.

- The PTTs may hinder the introduction of innovative products. In the process of re-engineering the Rolm exchange for the European market, Plessey have been obliged to connect the telephone by twisted pairs, rather than by the 6-wire circuits used in the United States. As a consequence, the European version of the exchange may have lost the ability to integrate data and voice. Datapoint has also abandoned attempts to get its Infoswitch device approved in the United Kingdom.

- If the exchange becomes inoperable because of a major fault, or flood, or fire or an industrial dispute, all corporate communications facilities will be lost.

Conventional data networks

Computer manufacturers' proprietary designs of network structures are typically centred around wide-area network requirements, and they offer little for local-area communications per se. An exception to this is the Datapoint Attached Resource Computer (ARC) system (marketed in the UK by Ventek, and illustrated in figure 9). The ARC allows up to 1,300 processors to be interconnected by 2½M bit/s cable. Although the system requires one hub to each 16 connected devices it also has some of the characteristics of a bus (discussed below), since all messages are relayed to all processors. Adjacent hubs can be up to two miles apart, and they can be connected by an infra-red beam.

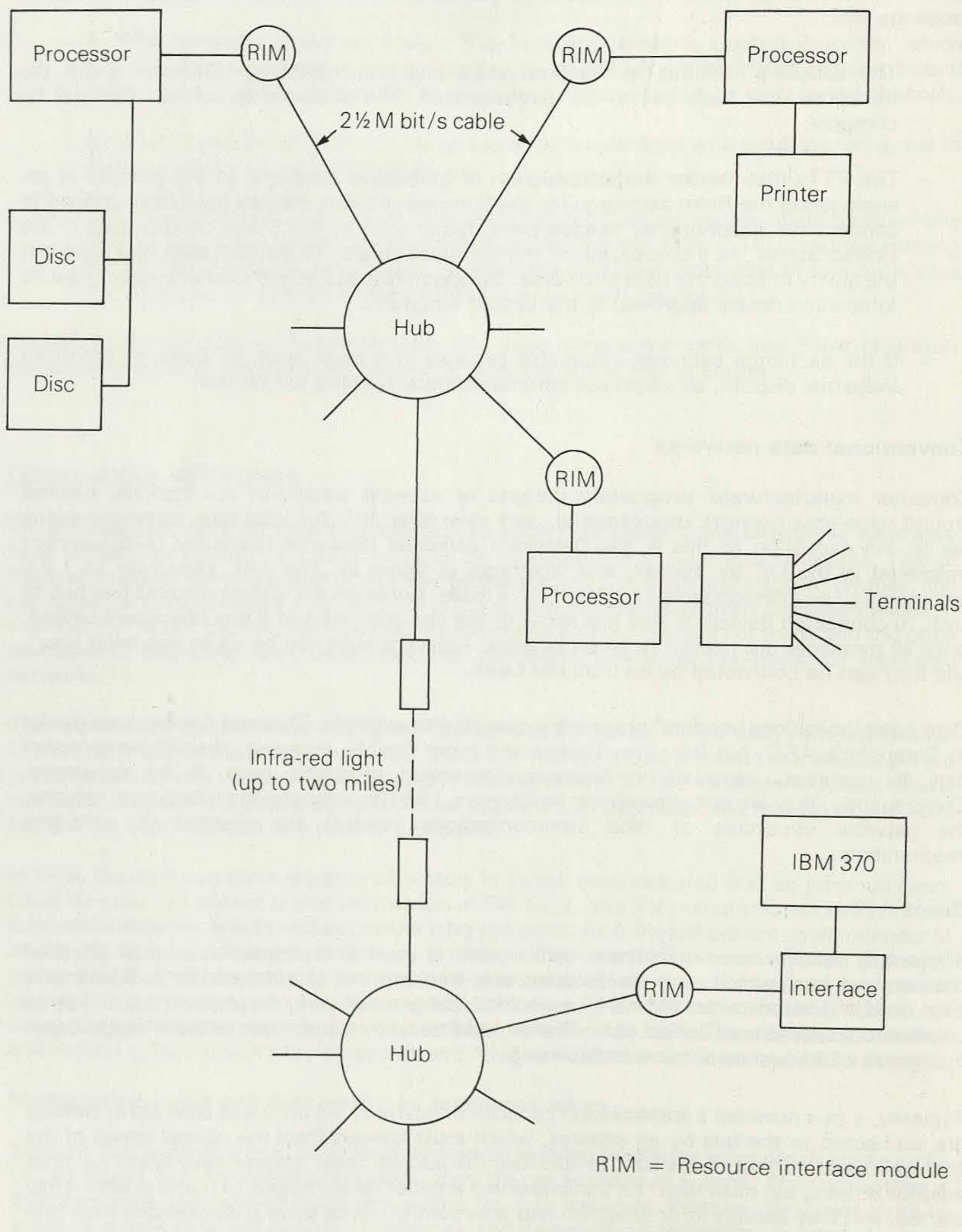
Data communications vendors' proprietary designs (for example, Tran and Comten) are similar to Datapoint's ARC, but they are cheaper and more flexible. However, their implementation may be complex, especially if protocol conversion programs have to be developed. Consequently, they are not attractive to small users. Like the computer manufacturers' designs, the network structures of data communications vendors are oriented to wide-area requirements.

Buses

A bus is a passive communications medium that is used to broadcast data to all attached devices, and from which each device takes only the data that is addressed to it. Buses have been used in minicomputers for many years. In a local-area network, the physical bus is likely to be either coaxial cable or optical fibre. The physical bus may support one or more logical buses by the use of frequency division multiplexing.

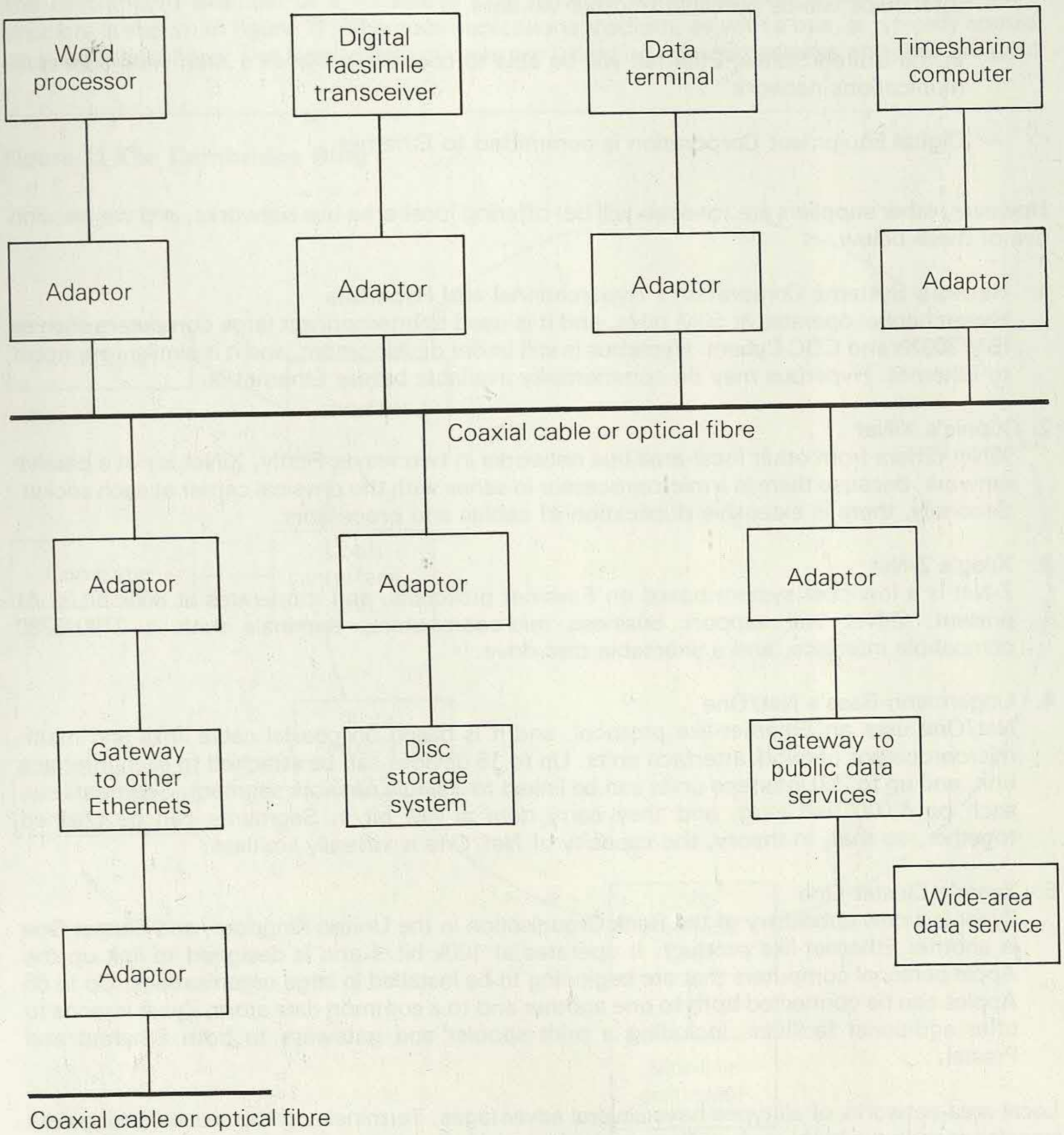
Typically, a bus provides a transmission capacity of between 1M bit/s and 50M bit/s. Devices are connected to the bus by an adaptor, which must convert from the normal speed of the terminal device to that of the bus. In addition, the adaptor must transmit only when no other adaptor is doing so, must abort its transmission if another device begins to transmit after it has started, and may provide error detection and flow control. Since there is no central switch (the functions being distributed amongst all the adaptors), a single failure disconnects only one device.

Figure 9 Datapoint's Attached Resource Computer (ARC) system



The best known example of a local-area network based on a bus is Xerox's Ethernet, which is illustrated in figure 10. Ethernet uses a coaxial cable, but it has also been implemented, experimentally, on a 50M bit/s optical fibre system under the name Fibrenet. Xerox expects that Ethernet will be used to interconnect devices such as word processors, printers, storage devices and digital facsimile transceivers, and that it will provide gateways to other Ethernets. In the longer term, a voice message system may also be incorporated.

Figure 10 Xerox's Ethernet



Xerox has concluded an agreement with Digital Equipment Corporation and Intel for the joint development of Ethernet standards. The parties have now agreed on their first two layers of protocol, and detailed specifications have recently been published for a standard based on 10M bit/s. By late 1981, Intel should be ready to supply bulk quantities of chips suitable for use in the adaptors, which will reduce the price substantially compared with the development networks that have been constructed so far. Digital Equipment Corporation will adopt Ethernet as their standard local-area network. It will, in fact, be incorporated into their overall hardware architecture, and take over some of the functions carried out at present by their Unibus (for example, the connection of slow peripherals to processors).

Ethernet is likely to become the de facto standard for local-area bus networks for three reasons:

- Intel chips will be available to other vendors.

- In the United States, Ethernet will be able to connect to Xerox's Xten wide-area communications network.

- Digital Equipment Corporation is committed to Ethernet.

However, other suppliers are (or soon will be) offering local-area bus networks, and we mention five of these below.

1. Network Systems Corporation's Hyperchannel and Hyperbus
   Hyperchannel operates at 50M bit/s, and it is used to interconnect large computers such as IBM 303Xs and CDC Cybers. Hyperbus is still under development, and it is similar in concept to Ethernet. Hyperbus may be commercially available before Ethernet is.

2. Xionic's XiNet
   XiNet differs from other local-area bus networks in two ways. Firstly, XiNet is not a passive network, because there is a microprocessor in series with the physical carrier at each socket. Secondly, there is extensive duplication of cables and processors.

3. Xilog's Z-Net
   Z-Net is a low-cost system based on Ethernet protocols, and it operates at 800k bit/s. At present, Z-Net will support business microcomputers, terminals with a 2780/3780 compatible interface, and a shareable disc drive.

4. Ungermann-Bass's Net/One
   Net/One uses an Ethernet-like protocol, and it is based on coaxial cable links and multi-microprocessor network interface units. Up to 15 devices can be attached to each interface unit, and up to 250 interface units can be linked to a single network segment. Segments can each be 4,000 feet long, and they carry data at 4M bit/s. Segments can be chained together, so that, in theory, the capacity of Net/One is virtually limitless.

5. Zynar's Cluster One
   Zynar is a new subsidiary of the Rank Organisation in the United Kingdom, and Cluster One is another Ethernet-like product. It operates at 120k bit/s and is designed to link up the Apple personal computers that are beginning to be installed in large organisations. Up to 65 Apples can be connected both to one another and to a common data store. Zynar intends to offer additional facilities, including a print spooler and gateways to both Ethernet and Prestel.

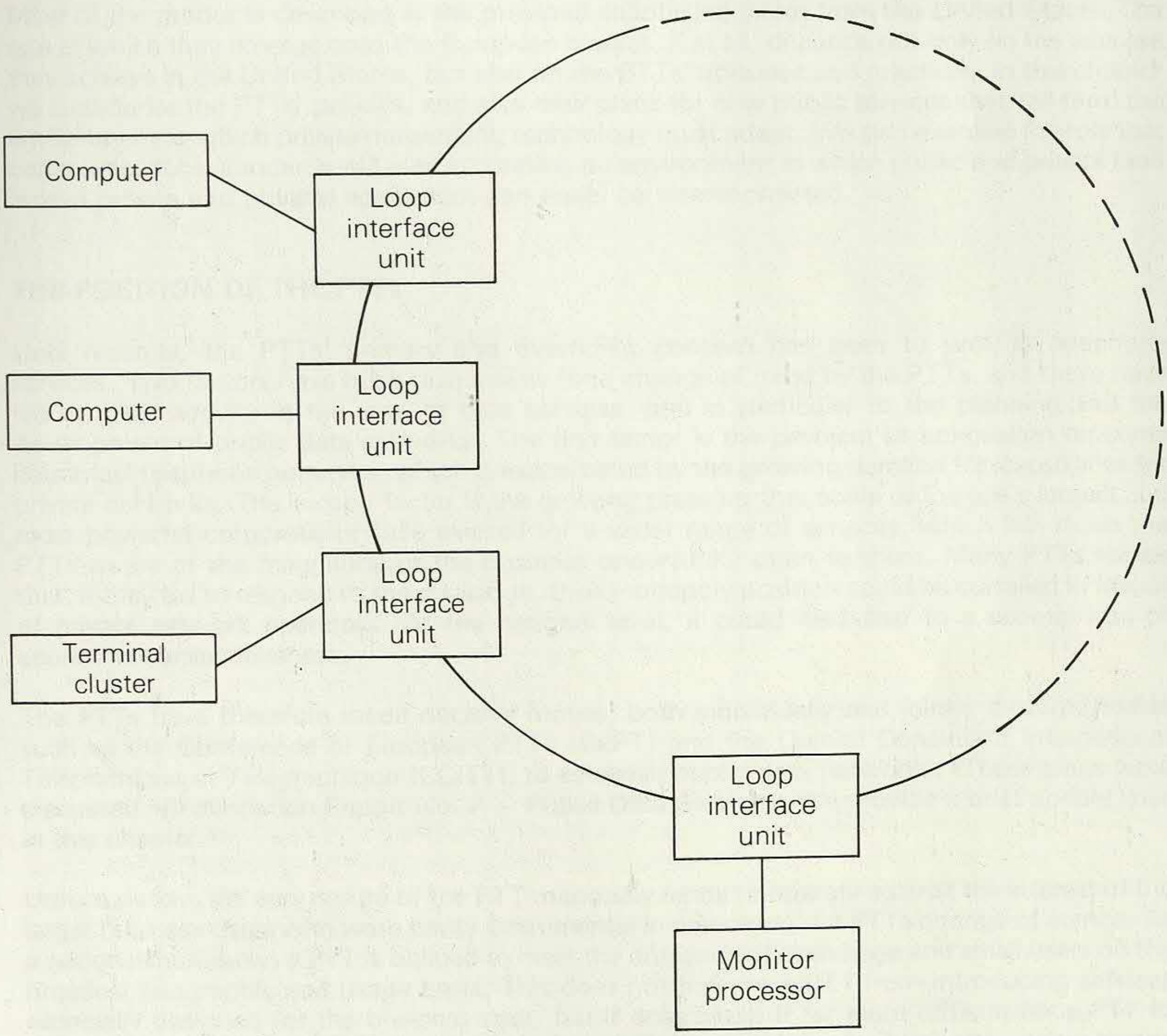
Local-area networks of all types have several advantages. Terminals can be moved easily, data transfer speeds are high, and cabling can be laid and extended easily. However, bus networks have one distinctive advantage over other types of networks. A bus network has no central switch that can break down or that needs to be maintained. The reliability of computerised private branch exchanges is very high, but the reliability of a cable is higher.

Experience of local-area buses is now substantial, and that experience is not restricted to suppliers alone. They are easy to install and they are reliable. At 10M bit/s, the new Ethernet standard provides plenty of capacity (for example, a facsimile image of an A4 page can be transmitted in 0.1 seconds or less). But, local-area buses have a characteristic disadvantage. The evolution of integrated voice and data services is inhibited, because telephones are not served by bus networks.

Rings

The best known example of a local-area ring network is the Cambridge Ring, whose basic structure is shown in figure 11. The communications medium, as with a bus, is typically coaxial cable or optical fibre. The loop interface units are based on microprocessors and they are used

Figure 11 The Cambridge Ring



to connect processors and other devices to the ring. In a ring network, a fixed number of packets circulate continuously, and any relay station may write data into any packet that is free. When that packet next passes the relay station, after circling the ring once, the orginator is required to reset its status to "free". A disadvantage of ring networks is that every relay station needs to function without error if the integrity of the system is not to be lost. A Cambridge Ring requires a special monitor processor, as well as processors with applications functions.

CHAPTER 5

THE PTTs AND THE COMMUNICATIONS ENVIRONMENT

In the United States, the regulation of the communications industry is vested in a federal agency, the Federal Communications Commission (FCC). Since the celebrated Carterfone decision in 1968, the FCC has been pursuing a liberal policy on communications. This has led to the growth of the so-called interconnect industry, where firms supply devices to connect to the Bell telephone system. In Europe, on the other hand, the regulation and the operation of communications services are generally not separate, but instead are vested in state bodies — the PTTs. The European PTTs have monopoly and/or regulatory powers that extend well beyond the "plug-in-the-wall" at which Bell's influence nominally terminates.

Most of the products described in the previous chapter originate from the United States. The rate at which they emerge onto the European market, if at all, depends not only on the success they achieve in the United States, but also on the PTTs' attitudes and practices. In this chapter we summarise the PTTs' policies, and also their plans for new public services that will form the environment to which private networking technology must adapt. We also examine the role that communications standards will play in creating an environment in which public and private (and indeed private and private) equipment can easily be interconnected.

THE POSITION OF THE PTTs

Until recently, the PTTs' primary and overriding concern has been to provide telephone services. Two factors have been responsible for a change of mind by the PTTs, and these have led to great activity in the area of data services, and in particular to the planning and the development of public data networks. The first factor is the problem of congestion on some countries' telephone networks, which is exacerbated by the growing demand for leased lines for private networks. The second factor is the growing pressure that some of Europe's largest and most powerful corporations have exerted for a wider range of services, which has made the PTTs aware of the magnitude of the business opportunity open to them. Many PTTs realise that, if they fail to respond to the challenge, their monopoly position could be curtailed in favour of private network operators. At the national level, it could lead also to a serious loss of economic competitiveness.

The PTTs have therefore made decisive moves, both individually and jointly through bodies such as the Conference of European PTTs (CEPT) and the Comité Consultatif International Téléphonique et Télégraphique (CCITT), to establish public data networks. (These plans were discussed in Foundation Report No. 7 — Public Data Services. We provide a brief update later in this chapter.)

Unfortunately, the very nature of the PTT monopoly tends to operate against the interest of the larger business users who were partly instrumental in provoking the PTTs change of stance. As a national monopoly, a PTT is obliged to meet the demands of both large and small users on the broadest geographic and usage basis. This does not prevent a PTT from introducing services especially designed for the business user, but it does make if far more difficult for a PTT to direct the sort of attention and investment specifically towards the business market that is evident in the United States. Most PTTs are also too preoccupied with return on investment to underprice new services and thus stimulate demand. Many PTTs' charters, in fact, prohibit them from taking commercial risks.

There are, however, some signs that the PTTs' attitudes are changing. For example, the French public packet-switched network, Transpac, is jointly owned by the French PTT and private investors. It is also aggressively priced, because the tariffs have been designed to provide a clear cost justification for organisations to move from private networks onto the public service. So far, the tactic appears to have been reasonably successful, although, as we suggested on page 23, the barriers to moving onto packet-switched networks such as Transpac may not be based purely on cost. Another example of PTT enterprise is in the development and launching of videotex, where British Telecom and the French PTT have led the world in what must still be regarded as a high-risk venture.

Despite these two examples, the PTTs still tend strongly to adopt protectionist practices to ensure the commercial success of their new public data services. The most effective weapon they have is tariff policy. By raising leased-line tariffs, the PTTs would hope to force traffic off private networks and onto public services. This approach is already being used in West Germany, where the Bundespost applies a surcharge to certain categories of leased-line user, based on the volume of data transmitted. For historical reasons, leased-line tariffs in the United Kingdom are now too low, and British Telecom officials have advised organisations to base their plans on the assumption that leased-line tariffs will increase by 50 per cent per annum for several years. Yet, as we indicate on pages 44 to 46, the digitisation of the PTT transmission network ought to lead to a steady decline in the cost of providing transmission services. United Kingdom tariffs are supposedly cost-based, but it is difficult to see increases of this magnitude as being based on anything other than an intention to discourage private networks.

There is one other key element of PTT policy that is relevant to private network plans. The PTTs are opposed to third-party traffic on private networks. This means that it will be difficult, if not impossible, for an organisation to link outsiders (such as customers or suppliers) into its private network other than via public services. Nor will it always be possible to use a private network to save long-distance public service call charges. For example, a customer wishing to call a distant office may have to dial it directly, because he may not be permitted to dial into the nearest node of the private network and then be carried the rest of the way over the private network.

To summarise the position, the PTTs will encourage private traffic to use public data networks to guarantee the success of the latter. The timescale in which this change will happen will depend on the plans of particular PTTs (which we summarise on pages 39 to 40), but the next five years will certainly be crucial in most countries. The PTTs will also continue to oppose the use of private networks for third-party traffic, and this opposition will limit the value of private networks principally to internal communications.

TYPE APPROVAL AND THE TRANSFER OF TECHNOLOGY TO EUROPE

Apart from tariff setting, the other major policy instrument available to the PTTs is type approval. Any private supplier of telephone or data equipment needs attachment approval before he can connect his products to PTT equipment, irrespective of whether his products are connected to leased lines or public networks. In many countries, the PTTs themselves act as sole suppliers of transmission and terminating equipment, and in particular of modems, private automatic branch exchanges and telex terminals. Where private competition is permitted, delays, whether deliberate or otherwise, in the PTTs' granting of licences for attachment can deter new suppliers. Some United States suppliers have indicated that the cost and the time involved in obtaining type approval in Europe (which has to be done country by country) could cause them to decide to stay out of the market altogether. This effect, presumably, would not be entirely disagreeable to some of the governments to whom the PTTs are responsible.

The impact of the PTTs on technological development varies from one communications area to another. We now review the general position in the areas of voice, data and message communications.

Voice communication

In the previous chapter we discussed the rapid development in the United States of computerised private branch exchanges. This rapid development is due, in part, to the existence of a larger market than there is in Europe, and (following the Carterfone decision) to more liberal interconnection policies. It should be emphasised that interconnection policy is a political, rather than a technical, issue. The experience in the United States shows that equipment from many suppliers can be connected to the public telephone network without damaging the network or without interfering with other users.

The transfer of new voice communication technology from the United States to Europe is slow not only because of type approval procedures. It is also due to the difference there is between European and United States standards (the standard for pulse code modulation in the United States is 56k bit/s, whereas the European standard is 64k bit/s), and to variations in the technical standards of the various European PTTs.

Message communication

Message-switching technology in the United States is also somewhat in advance of that available in Europe. Several sophisticated electronic mail systems are in use in the United States (as described in Foundation Report No. 17 — Electronic Mail), but the transfer of these systems to large private networks in Europe poses no regulatory problems. In one respect, Europe is actually ahead of the United States. In Europe, there is a single telex system, in contrast to the separate and incompatible telex and TWX systems in use in the United States. Also, the penetration of telex in Europe is higher than either telex or TWX in the United States. The introduction of teletex could lead to both a greater penetration and an improved quality of public message services. (Teletex is the name given to an international standardised text message service. CCITT is expected to ratify the protocols for teletex at its 1980 plenary conference.)

Data communication

In general, data communication in the United States also is more advanced than in Europe. Again, the technology seems to be transferable in a fairly direct manner, as the marketing in Europe of systems by companies such as Tran and Telenet demonstrates. However, there are sometimes delays in introducing new equipment in Europe because of the engineering differences and also the restrictive attitudes of some PTTs.

COMMUNICATIONS STANDARDS

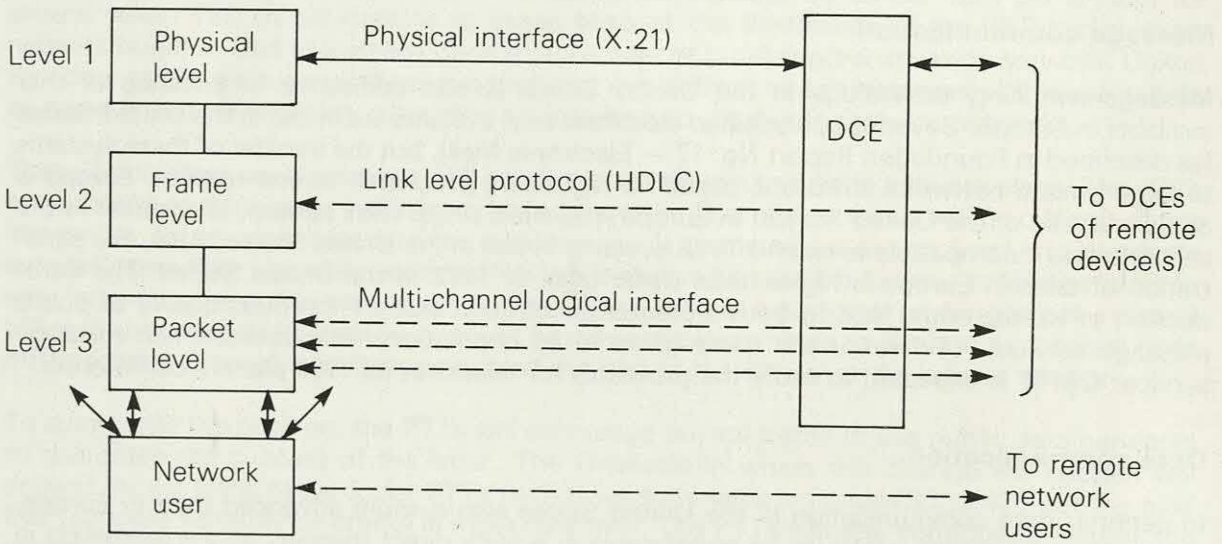
To prepare for the advent of public data networks, CCITT has been formulating a new series of standards prefixed with the letter X. Of these, the X.21 interface for circuit-switched networks and the X.25 interface for packet-switched networks are the best known.

X.21 specifies the physical interface between a terminal and a digital data network, as V.24 does between a terminal and a modem attached to the analogue voice network. It exists in two versions, known respectively as X.21 bis and X.21. X.21 bis extends the V.24 interface to allow access to a digital circuit-switched network from an analogue circuit, as will often be necessary in the early stages of network development. X.21 provides for digital working right up to the terminal device.

X.21 does not significantly extend the scope of the PTT-supplied data transmission service beyond the point where it has stood for some time. The signalling used is more sophisticated than in V.24, making it easier for devices to operate unattended. However, the mode of operation of the network is much as it would be on the public telephone network or on an analogue leased line, except that error rates will be lower and call set-up times will be much shorter.

X.25, however, does extend the span of influence of the transmission service. It consists of three independent levels of protocol, illustrated in figure 12. The lowest of these (level 1) is the X.21 (or X.21 bis) protocol, which means that a terminal can access the packet-switching service either via the public telephone network or via the circuit-switched network (if the two co-exist). The terminal can also choose the transmission service according to the nature of the information to be transmitted. Broadly speaking, bulk data would be appropriate for a circuit-switched connection, on-line data for a virtual call packet-switching service and messages for a datagram packet-switching service. (Virtual call and datagram are defined below.)

Figure 12 X.25 interface protocol



DCE = Data circuit terminating equipment (supplied by the PTT)

Level 2 of X.25 is a link level procedure borrowed from the International Standards Organisation's High-Level Data Link Control standard (HDLC), which is similar to IBM's Synchronous Data Link Control used within SNA. HDLC specifies a content-independent frame (or record) structure and a set of procedures for transporting frames reliably across a network.

The highest level of X.25, level 3, is the packet level. It is this that defines the characteristics of a packet-switching service, rather than the levels below it (which have only local significance and could be replaced by any others that had the same function). Level 3 provides for a number of logical channels within each physical connection to the network over which a network user can set up a number of simultaneous virtual calls to other network users. A virtual call is set up and cleared down in a manner analogous to dialling a call on a telephone network. Once a call is set up, information can be exchanged using only the logical channel number as the address information. Permanent virtual circuits can also be obtained, thus avoiding the need to set up and clear down calls. The PTTs are also discussing a datagram service, whereby single addressed packets will be passed to the network without the prior need to either set up a call or obtain (at some expense) a permanent virtual circuit.

X.25 represents an advance on earlier data communications procedures. This is because it incorporates a content-independent message format and a multiplexing capability, in addition to providing a standard mode of access to a switched digital network. The switching and the multiplexing capability of an X.25 network can reduce the need for interface equipment within a computer system that supports a number of terminals. This interface equipment can be a significant cost factor where low-activity terminals are involved. For example, a timesharing system will need at least one port for each 600 bit/s dial-up terminal that is to be serviced concurrently, whereas 30 terminals could be serviced via two or three 9,600 bit/s packet-switched network ports. An X.25 network can also make it easier to handle either a mix of terminals or a mix of applications, because all information is presented in the same frame format at a common speed, this being the speed of the access port, not the speed of the individual terminal.

The main difficulty with X.25 arises because the PTTs and some computer manufacturers do not see eye-to-eye over what is properly the function of the network and what is properly the function of the computer software. Foremost among those unhappy about X.25 is IBM, whose first SNA products were designed before X.25 was devised. IBM is now facing the problem of amending the SNA software to support an X.25 interface. Normally, SNA terminals are polled from the 3705 communications processor. It would be grossly inefficient (as well as unnecessary) to poll across a packet-switched network, and so IBM proposes to move the polling out to the controller nearest to the terminals. This arrangement will undoubtedly work, but it does not exploit fully the capabilities of the packet-switched network. The user may therefore find himself paying both for the features of the packet-switched network, which he is not using, and for equivalent features in SNA, which he is using. The software to provide an interface between SNA and X.25 has been released too recently for there to be any indication of how efficient it will prove to be in practice.

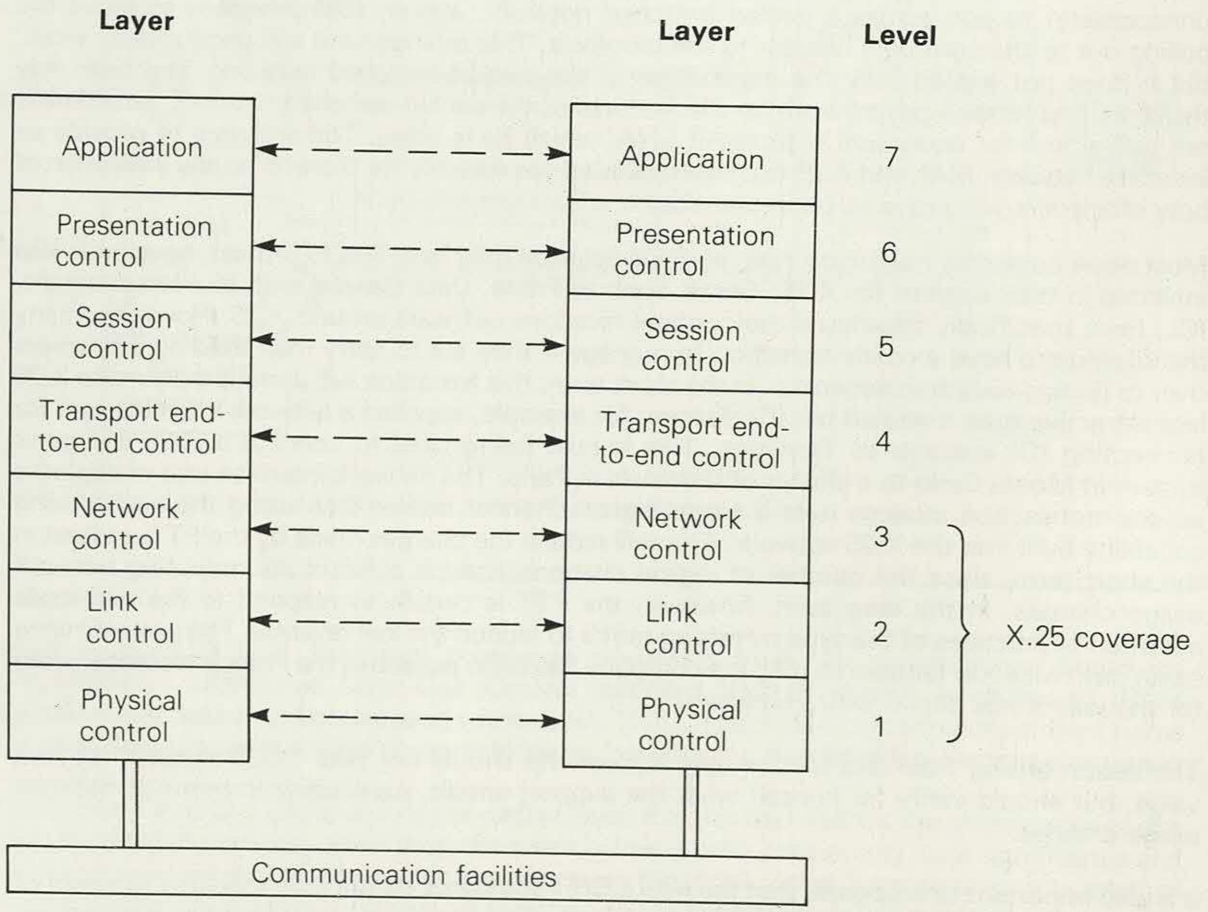
Most other computer manufacturers, perhaps because they have less to protect, have been less inhibited in their support for X.25. Some, such as Prime, Data General and, to a lesser extent, ICL, have specifically structured their communications software around X.25. However, many manufacturers have a costly transition to manage if they are to carry their existing customers over to packet-switched networks. In the short term, this transition will undoubtedly make X.25 less attractive than it should be. ICL France, for example, supplies a network interface unit for connecting ICL systems to Transpac. This is now being used to connect a 2905 computer system in Monte Carlo to a cluster of terminals in Paris. The network interface unit multiplexes several transaction streams over a single logical channel, rather than using the multiplexing capability built into the X.25 network. This will reduce the charges made by the PTT, at least in the short term, since the number of logical channels used is a factor in computing network usage charges. In the long term, however, the PTT is certain to respond to the wholesale adoption of practices of this type by raising tariffs to recoup the lost revenue. The user will once again pay twice. (In fairness to ICL, the company has been praised in the French technical press for the way it has coped with Transpac.)

The lesson arising from this for the user is clear. He should not take "X.25 support" at face value, but should verify for himself what the support entails, particularly in terms of network usage charges.

It is also important to recognise that the new CCITT standards do not fully solve the problem of terminal compatibility. They will certainly enhance connectivity, but compatibility depends on agreement about end-to-end control and also about high-level protocols. In other words, compatibility depends on agreement about the format and the presentation of information, as well as about the method of transporting it. This aspect of standardisation is currently under study within the International Standards Organisation, which has coined the term "open systems interconnection" to describe the objective of free and uninhibited worldwide communication between terminals and computer systems. The International Standards Organisation has established a reference model, shown in figure 13, which effectively extends the X.25 structure, just described, up to the applications level. The name "reference model" has been chosen advisedly, since experience indicates that it is unrealistic to regard this as the basis for a universal architecture that is capable of dissolving away the myriad differences between applications as well as between networking technologies. It is realistic, however, to expect it to lead eventually to a family of standards with a common base, tailored to particular applications. Even so, progress is certain to be slow, bearing in mind the conflicting commercial interests of the suppliers who will be responsible for implementing the standards. Open systems interconnection is an attractive concept, but it is unlikely to have any direct practical relevance for some years.

Elsewhere, though, work on specific high-level protocols is in progress. File transfer protocols and virtual terminal protocols are of particular relevance for many users. Since, however, they take us beyond the scope of this report, we can only mention here that they are most important.

Figure 13 The International Standards Organisation's reference model for open systems interconnection



PTT SERVICE PLANS

Apart from the digitisation of the public telephone network, which will have a profound impact and which we discuss separately in chapter 6, the PTTs' plans relevant to private networks may be divided into the two areas of circuit-switching services and packet-switching services respectively.

Circuit-switching services

X.21 defines a digital interface suitable for a fast-select, circuit-switching service. The Nordic PTTs (Sweden, Norway, Denmark, and Finland) are introducing such a service under the name Nordic Data Network, which is actually four interconnected national services. It is probable that additional facilities such as packet-switching and high-level protocols will also be added.

The Bundespost will also implement an X.21 network under the name Datex-L. It will be linked to the Nordic Data Network.

Packet-switching services

Different PTTs have varying attitudes to their new packet-switched networks, and we briefly describe four of the networks below:

1. West Germany
   The Bundespost's Datex-P services are intended to attract traffic from existing leased-line systems, though the pricing of Datex-P is said to be equitable. The Bundespost intends to raise leased-line charges to provide a financial incentive to move to Datex-P.

2. France
   Transpac is regarded as a key part of the new "Informatique" infrastructure, which is designed to lead France towards the future Information Society. Transpac is intended to displace traffic from leased lines and it is subsidised to achieve this.

3. The Netherlands
   The Dutch PTT's DN1 service is planned to begin operation early in 1981. To start with, DN1 will provide only X.25 connections, and will be used by a selected group of seven organisations, who are all large data communication users. In 1982, the PTT plans to add packet assembly/dis-assembly facilities to DN1, and to make it available to other users. The tariffs for using DN1 are similar to those for using packet-switched networks in other countries. At the present time, however, the tariffs appear to be unfavourable when they are compared with those for a leased line used for a high volume of traffic. This unfavourable comparison is due to the small distances in Holland, and also to the low leased-line tariffs. Nevertheless, DN1 is attractive to several organisations, firstly because the tariffs are fixed for five years, and secondly because the PTT intends to link DN1 to other national packet-switched networks.

4. The United Kingdom
   British Telecom's PSS network is intended not to displace existing traffic, but to support new, mainly inter-business, applications. Pricing is equitable, though it is based on conservative traffic estimates. Leased-line charges will be raised to make them "fair" and to compensate for inadequate investment during the last decade.

The figures overleaf, supplied by a Transpac spokesman, show, for a "typical" application, the costs of packet switching relative to leased lines:

— France	1
— West Germany	0.7
— United Kingdom	3
— United States	2

We expect that the United Kingdom ratio will tend to fall as leased-line charges increase.

Over the next five years, the geographic coverage of packet-switched networks will increase rapidly, and national networks will be interconnected. Figure 14 shows the networks that should be accessible through British Telecom's PSS network by 1983. The usefulness of the packet-switching services will also increase as:

- Data banks are made available.
- Connections are provided to other services such as teletex and videotex.
- X.25 interfaces are provided by more manufacturers on their terminals and computers.

Many devices on packet-switched networks use the asynchronous, teletype interface, but experience of Transpac shows a higher proportion of X.25 connections than had been expected. Computers account for one-third of all connections, and 68 per cent of the computers use an X.25 link. The remainder of the connections are terminals, 79 per cent of which use an X.25 link (51 per cent use adaptors and 28 per cent use internal implementations). The proportion of X.25 connections may continue to increase as adaptors become readily available.

The major users of Transpac are:

— Banks	27.8%
— Industry	15.2%
— Administration	13.5%
— Computer services	11.7%

TARIFF POLICY

As we mentioned earlier, PTT tariff policy is likely to be influenced by political and marketing considerations, as well as by the cost and the profitability of the services provided. One possible effect will be that tariffs for private leased lines will increase at a faster rate than will other PTT tariffs, and it is even possible that the availability of leased lines will be restricted. Without doubt, some PTTs would like to see the demise of private leased lines, and they will use tariffs to promote this aim. It is possible, therefore, to predict with certainty that some PTTs will attempt to discourage the use of private leased lines, but it is not possible to predict how far they will be permitted to succeed. The cost ratio between leased lines and public networks must therefore be viewed as an unpredictable variable.

As far as public services are concerned, the major choice lies between circuit-switching and packet-switching services. The former caters both for voice traffic (on the public telephone network) and non-voice traffic (Datel services on the public telephone network and X.21 services on digital networks). The latter caters for non-voice traffic only. The cost relationship

Figure 14 Networks expected to be available through British Telecom's PSS service by 1983

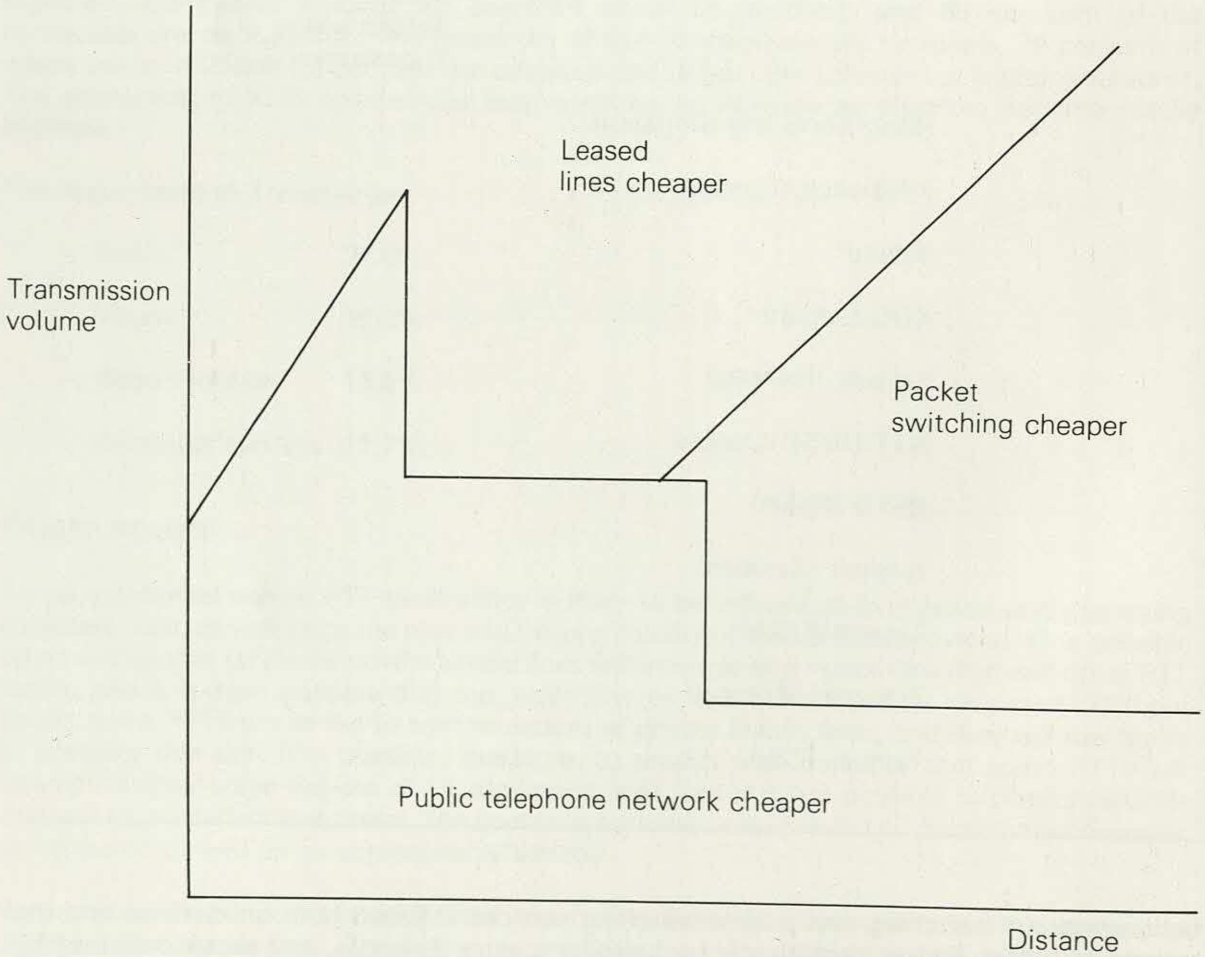
Australia		
Datapac (Canada)		
Datex-P (West Germany)	linked to	Datapac Telenet Transpac Switzerland
Euronet	linked to	Austria Belgium Denmark France Ireland Italy Luxembourg Netherlands Spain Switzerland Yugoslavia
Hong Kong and Singapore		
Infoswitch (Canada)		
Ireland		
KDD (Japan)		
Norpak (Norway)		
NTT DSSO (Japan)		
RETD (Spain)		
Swenet (Sweden)		
Telenet (USA)		
Transpac (France)		
Tymnet (USA)		

between circuit-switching and packet-switching services is based both on distance and the volume of traffic. Packet switching is favoured by greater distances, and circuit switching by higher utilisation. In practice, the equation is considerably more complex, and it may also involve the factors listed overleaf:

- The cost of the connection to the nearest public service access point.
- The cost of interfacing terminals and computers to the service (see also page 37).
- The different tariffs for peak and off-peak working.
- The public service facilities that are used (for example, packet assembly/dis-assembly for asynchronous terminals, the number of logical channels, reverse charging, etc.).

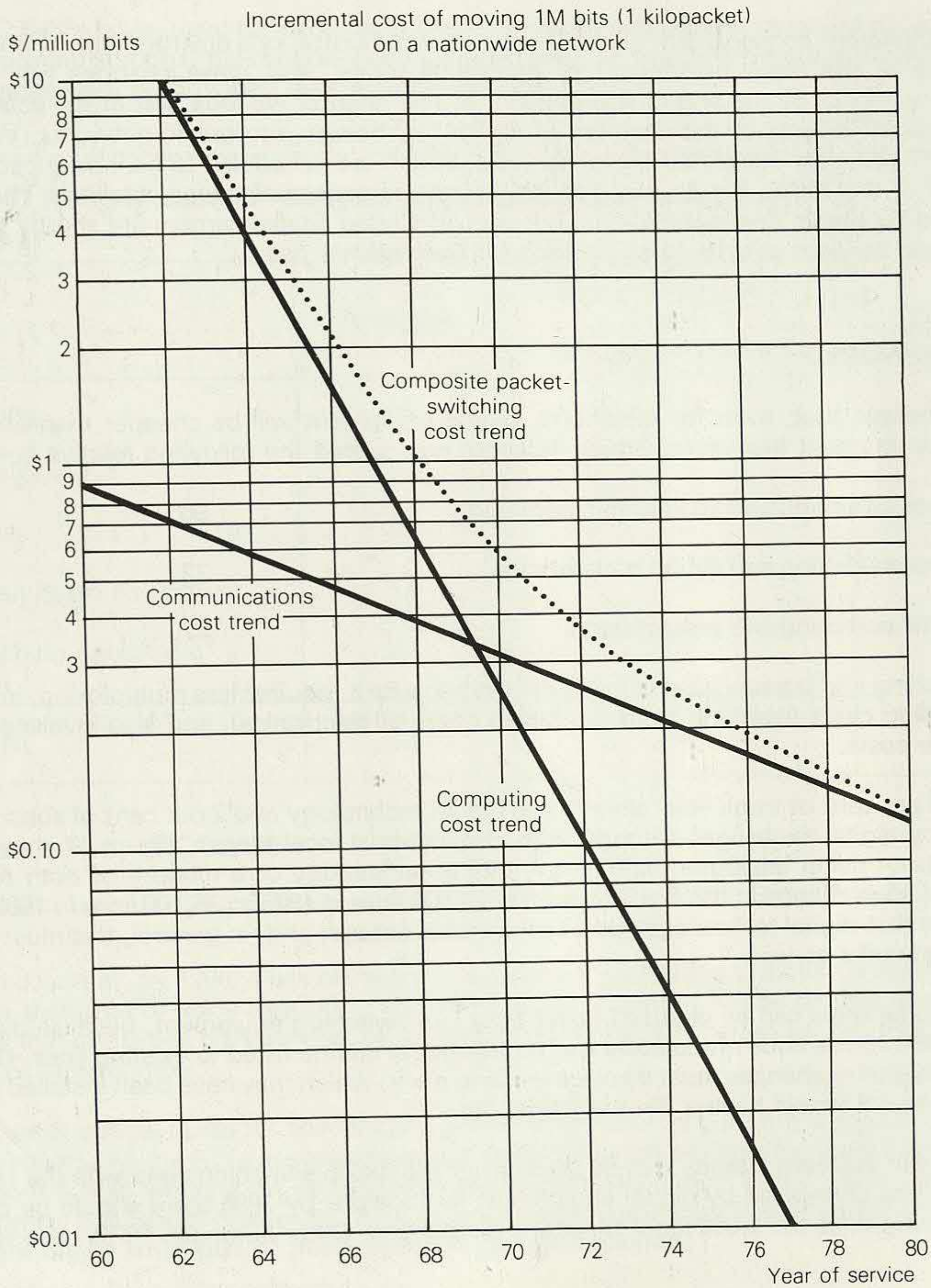
We illustrate, in figure 15, the service cost relationships that exist at present. The figure shows clearly the value of packet switching for low activity devices, particularly over long distances. (These cost relationships do not reflect the savings in interfacing costs that can also be achieved.) Because the effectiveness of packet switching depends very heavily on the processing power of the packet-switching nodes, it benefits both from the reducing cost of processing and the decline in transmission costs. Figure 16 illustrates the trend in packet-switching costs in the United States, and it shows how the cost of packet switching is converging with the cost of raw transmission capacity, such as private leased lines. This figure shows the incremental cost of moving a certain amount of data. For the PTTs, the problem is to

Figure 15 Cost relationships of existing transmission services



attract enough traffic to justify the initial investment. Telenet's experience in this respect is something of a warning. After several years of operation the Telenet network has yet to return a profit. However, it is now suffering from an excess of demand, and a profitable operation must now be very close.

Figure 16 Packet-switching cost performance trends



(Source: L. Roberts; GTE-Telenet)

CHAPTER 6

TECHNOLOGICAL CHANGE AND ITS IMPACT ON COMMUNICATIONS

Despite the inherent conservatism of the European communications environment, changes are taking place in the basic technology of communications, and these changes will have a revolutionary impact by the end of this decade. In this chapter we look first at the economics and the probable effects of the irruption of digital technology into public networks. We next describe PTT plans for integrated digital services, which are scheduled to be introduced in the second half of the 1980s. Finally, we discuss the role of communications satellites. These are already used for public communications, but several United States carriers are shortly to offer satellite-based services directly to businesses for their private use.

A DIGITAL WORLD

The PTTs believe that, even for telephony, digital equipment will be cheaper than analogue equipment in the next few years. British Telecom has quoted the following relative costs:

— Space switching and analogue transmission	90
— Space switching and digital transmission	72
— Digital switching and transmission	47

Digital switching and transmission is lower in cost because it requires less multiplexing, involves lower signalling costs (resulting from the falling costs of electronics), and also involves lower maintenance costs.

In France, 4 per cent of trunk lines already use digital technology and 2 per cent of subscribers are served by digital exchanges (though with conventional local loops). Figure 17 shows the relative costs of using analogue technology, digital technology or a mixture of both for the expansion of an exchange in the Brest area from 13,500 lines in 1975 to 35,100 lines in 1985. The figure shows that digital technology has a real cost advantage, and, in general, this must apply to private networks as well.

Transmission facilities can be digitised faster than can switching equipment, because digitisation equipment (pulse code modulators and multiplexors) can be fitted to existing lines. On the other hand, digital exchanges must displace existing plant, which may have been installed in the expectation that it would have a 35-year useful life.

By 1984, British Telecom intends that 90 per cent of the group switching centres in the United Kingdom will be connected by digital equipment. In addition, by 1986 there should be digital access to nearly all of the 6,000 local telephone exchanges. Other European PTTs have similar plans.

The digitisation of the public telephone network will permit a range of integrated digital services to be made available to subscribers. As the integrated public services become available, a new range of transmission speeds will become standard, somewhat as follows:

— 300 bit/s, used for teletype transmission (although this will be a declining market).

— 8k bit/s, used for personal computers, terminal clusters, electronic mail and facsimile. This speed will be provided on telephone lines in parallel with voice transmission.

— 64k bit/s, used for voice, facsimile, file transfer, utility computers, freeze-frame video conferencing, word processors, etc. This speed will be provided over a single telephone line.

— 2.048M bit/s, used for large computerised branch exchanges, large computers, satellite ground stations, full-motion video conferencing, and various other special services. This speed will be provided over a 32-circuit digital group.

Figure 17 Relative costs of using analogue and digital technology

	Analogue	Digital transmission and analogue switching	Digital
Buildings	24	25	14
Cable laying	19	0	0
Cables	12	0	0
Transmission equipment	6	18	6
Switching equipment	41	43	45
TOTAL	102	86	65

(Source: Luhan, CIT Alcatel)

We expect that, by 1990, a 64k bit/s digital service will be tariffed at a charge about 50 per cent higher than that of voice telephony. An 8k bit/s digital service will be tariffed at a charge well below that of the 64k bit/s service, but there will be additional charges for value added services, such as error control.

The use of optical fibres for transmitting digital information is currently a matter of large-scale experiments. All the PTTs are experimenting with using optical fibres for trunk links, and British Telecom is also working on an undersea cable that uses optical fibres. Optical fibres offer a theoretical bandwidth greater by some orders of magnitude than that of existing cables, but at present only a small part of this bandwidth can be exploited.

Moreover, optical fibres are difficult to join under field engineering conditions. They do, however, have two distinctive advantages. Firstly, they are very difficult to tap (which is valuable in secure installations), and, secondly, they are unaffected by electrical noise (which is valuable in electrically noisy environments).

The introduction of digital technology will transform both the economics of telecommunications and the services that the PTTs offer. We summarise below the main consequence of the new digital technologies under the five headings of:

- Circuit and switching costs.
- New services.
- Packet-switching costs.
- Size of equipment.
- Transmission techniques.

1. Circuit and switching costs
The costs of circuits and switching will fall over the next decade, and these savings will be passed on to customers. The users of digital lines will benefit especially because, by about 1990, the standard voice circuit on a new exchange will be a 64k bit/s link, with parallel 8k bit/s links for signalling and data respectively. The interface between the user and the PTT will include an indication of the type of service being used, and so PTTs may charge more for data services than for voice transmission.

2. New services
New services with high-bandwidth requirements will be introduced. These may include bulk data transfer, high quality facsimile and video communications (such as video telephones and video conferencing). Current freeze-frame video-conferencing systems operate succcessfully at 56k bit/s, and British Telecom is experimenting with a system that provides half of the picture quality of a 625-line television picture. The experiment uses a refresh period of five seconds, and 48k bit/s links. Although British Telecom believes that this is acceptable only for surveillance purposes, experience in the United States with refresh periods of between ten and fourteen seconds shows that even marketing presentations can be given effectively over such a service. Developments in data compression technology will permit better picture quality and faster refresh rates to be obtained over a 64k bit/s circuit.

3. Packet-switching costs
Digital technology will cause the costs of packet switching to fall. At present, 50 per cent of PSS costs are associated with access to the system, and a significant part of this element is the modems used. Digital trunk lines will allow the modems to be eliminated, and so produce a reduction in costs.

4. Size of equipment
Switching units will become physically smaller and will require less specialised accommodation.

5. Transmission techniques
Multiplexing will become less important. Already, British Telecom has decided that for speeds above 2400 bit/s it is inappropriate to try to multiplex several logical circuits onto a single 64k bit/s physical circuit. Instead, the full capacity of the circuit will be filled by reiterating bits at the lower speed.

INTEGRATED NETWORK SERVICES

In this section, we now describe the plans that the PTTs in the United Kingdom, France and Italy have for integrated digital services.

1. The United Kingdom
British Telecom has coined the (rather inelegant) term Integrated Services Digital Network (ISDN) to describe the service it hopes to offer to telephone subscribers in central London during 1986. The service will be based on a System X exchange, and there will be two basic kinds of interface. The first kind of interface will be to one or several 80k bit/s circuits, each provided from the exchange over a single twisted pair (or its equivalent). The capacity of each circuit will be rigidly partitioned into three channels:

 - 64k bit/s for voice transmission using standard pulse code modulation techniques, but available also for data transmission.

 - 8k bit/s for signalling and synchronisation.

 - 8k bit/s for data transmission. This channel will be fully multiplexed with the main 64k bit/s channel, so that voice and data may be transmitted simultaneously.

 Small private branch exchanges would be linked to one, or a few, of these 80k bit/s circuits. A circuit might also terminate at either a facsimile machine, a computer communications processor, or a cluster controller, etc.

 The second kind of interface will be to a 2.048M bit/s circuit provided on a polyquad cable, which supplies up to 30 channels each of 64k bit/s, with a separate 64k bit/s channel for signalling. This 2.048M bit/s circuit would be linked to larger private branch exchanges.

 The ISDN protocols are not yet fully defined, but will be similar to X.21 and X.25 in order to preserve customers' exisiting investments.

 The ISDN interface will provide direct access to circuit switching at the local exchange. In addition, there will be through access to other services such as packet switching and videotex.

 British Telecom is not the only PTT that is committed to ISDN. The Norwegian PTT plans to provide ISDN to all major business areas by the mid-1980s.

2. France
Supported, as it is, by a government willing to invest large sums in developing a national communications infrastructure, the French PTT is able to be more speculative in its thinking. A recent article published in *L'Echo des Recherches* presents two scenarios that show how the telecommunications services of today might develop up to the year 2000. One scenario (audiomatique) assumes a continuation of present trends, with services centering round voice and data. The other (vidéomatique) assumes an explosive growth in demand for video communication services, needing high-bandwidth transmission via optical fibres and satellites. With both scenarios, the network is developed by progressively overlaying new facilities over the old. The audiomatique scenario is characterised by a high degree of integration at the local-level switching system, and relative diversity in the transit network. The vidéomatique scenario results in a much more homogeneous network, using satellites for the transit network.

3. Italy
As far as its telecommunications infrastructure is concerned, Italy starts from a point some way behind other European countries. Because it has less investment to protect, it has an opportunity to make a major stride forward, provided of course that it can mobilise the necessary resources. Italy's plans, approved in 1979, are in fact very ambitious, and the timescale is particularly ambitious.

 Italy intends to implement, by 1982, an integrated voice/data network that will provide both circuit-switching and packet-switching services. The network structure is a two-level hierarchy. The higher level, provided by the telecommunications ministry, will handle transit data traffic via circuit-switching exchanges and packet-switching nodes. The lower level, provided by the telephone company, SIP, will consist of digital exchanges, and it will switch local voice and data traffic. This lower level will route transit traffic through to either the higher level or the public telephone network. Packet-switching nodes may be accessed directly by packet-mode (X.25) terminals. Access by non-packet terminals will be via a packet assembly/dis-assembly facility, which will be available either via the public telephone network or via the voice/data local network.

COMMUNICATIONS SATELLITES

Satellites are already used by the PTTs for transatlantic circuits. The Intelsat system currently uses analogue transmission methods. It will, however, switch to digital techniques in the early 1980s, and all future satellites are likely to use digital techniques. From the mid-1980s, inter-satellite links will be added to the Intelsat system to provide global coverage from space.

Satellite costs will fall as the operators gain more experience, as the space shuttle becomes available, and as the technology matures. Costs have already fallen dramatically. The original Telstar ground station cost $50m. One American firm will now install a 15ft backyard dish for less than $17,000, and receive-only dishes at a few hundred dollars each are expected to be available soon. The annual investment for one satellite voice channel has fallen from $23,000 in 1965 to $400 today, and within two years it is expected to fall to $200.

In the United States, the number of satellite ground stations is increasing very rapidly, rising from 800 in 1978 to 2,000 in 1979. By December 1980 the number is expected to reach 4,000. Satellite communications have already given some United States corporations large benefits. Martin Marietta Corporation estimates that it has reduced its expenditure on trunk circuits by 33 per cent in the first year, with increased savings in subsequent years as Bell rates rise. The Harris Corporation estimates that its projected satellite system will save between 10 and 20 per cent of its $5m annual wide-area communications bill. (The mean distance between the three ground stations is 1,230 miles.)

The current attitude of British Telecom is that cable is cheaper than satellites within the United Kingdom. Across Europe, however, satellites will certainly be cheaper. Moreover, they offer one advantage that all affected must recognise — a circuit from France to Sweden will concern only those two PTTs. Negotiations with those PTTs in between will not be necessary.

Some European PTTs are experimenting with satellites. In 1979, for example, France and West Germany agreed to launch Telecom-1 by 1983. This satellite will provide:

- Voice, data and video communications between the French government, and its overseas territories, using very high bandwidth links of between four and six gigahertz.

- Intra-company links, using technology from Satellite Business Systems Inc. This provides transponders with a total capacity of 25M bit/s.

The most likely outcome of the Telecom-1 launch is that European PTTs will begin to make some use of satellites both for national public telephone networks and for national leased lines (perhaps based on PTT-maintained ground stations, and with tariffs similar to those of other PTT leased-line services). The launch of Telecom-1 could also lead to PTT co-operation within CEPT to offer international leased lines based on satellite technology.

Satellite communications technology may not be used first in the more developed European countries. It could be particularly attractive to countries such as Greece, where there is relatively little investment in existing plant.

Experience in the United States has shown that satellites can offer the following benefits:

- Very low error rates that are two or three orders of magnitude lower than with terrestrial services.

- Rapid installation (a ground station can be installed within two months).

- Wideband circuits (typically 56k bit/s) are available at affordable prices. This bandwidth can be used for video conferencing, high-speed facsimile, etc.

It seems clear that those European multinational companies that have substantial traffic between sites separated by hundreds of miles could obtain similar benefits.

Almost certainly, an independently-funded European satellite carrier that was free from the obligations of existing investments in trunk links could offer cheaper services than the PTTs will wish to. It is equally clear, though, that the PTTs will resist any such developments. This resistance is likely to be successful for some years for three reasons:

- The PTTs have great monopoly powers.

- The PTTs would have to consent to each international circuit. (International communications would be the essence of a European satellite system.)

- Many countries are increasingly concerned about issues of transborder data flow.

In the longer term, changes in technology, changes in political attitudes to the PTTs, and the sheer difficulty of enforcement seem likely to undermine this position.

CHAPTER 7

SUMMARY OF THE KEY FINDINGS

Before we present our recommendations for a policy for data networks and a corporate network strategy, we first review the key findings of this report and their implications for corporate communications.

THE COMMUNICATIONS INDUSTRY

In the introduction to this report we listed the four main categories into which the suppliers of communications equipment and services could be divided. These four categories are the PTTs, the computer system suppliers, the established telecommunications suppliers and the outsiders such as Xerox, Rolm and Tran. We have made frequent references to suppliers, or to groups of individual suppliers, throughout this report. Any attempt to summarise the strengths and weaknesses of suppliers in categories as wide as these four is bound to be unfair to individual suppliers. Nonetheless, we do attempt such a summary below. Our purpose in doing so is to give a general indication of the capabilities and the probable intentions of the various elements comprising the supply industry.

The PTTs

Digital technology is important for the PTTs since it permits them to add value to their existing, often obsolescent, plant. By adding new functions to existing services, they can both increase their revenue and preserve their existing investment. Packet-switched networks and videotex services are prime examples of new services they are overlaying on the existing telephone network.

Some PTTs (for example, British Telecom and the French and the Italian PTTs) are faced with an urgent need to upgrade an out-dated telephone network. This will require massive new investment, and the extra revenue that new functions can generate from existing plant may be not only commercially attractive, but also the only way of funding the enormous investment needed. Consequently, many PTTs will be under heavy pressure to exploit the enhanced revenue opportunities that more sophisticated services present. This will apply particularly in the non-voice area, where the PTTs will not be content with their traditional role as suppliers of raw transmission capacity.

That is not to say that the PTTs will suddenly, or even eventually, displace all the private data communications equipment that larger organisations have now. However, they will certainly attempt to displace some of it. The PTTs will, perhaps, before long provide smaller organisations with public data services that are good enough for them merely to plug in their geographically dispersed terminals and computers. For the larger organisation, the new public data services will provide improved reliability and improved connectivity (aided by progress in manufacturer-independent communications standards).

However, public data networks will not solve many of the vital network management and information management tasks with which today's private networks are charged. Nor will they solve completely the problems of compatibility between terminals and computers, although they may ease them by providing a common transport mechanism (X.25-based) that all can adopt. Whilst some PTTs may believe that a generalised solution based on public services is the best approach, there are risks inherent in attempting such a solution. AT&T in the United States has indefinitely postponed the introduction of its Advanced Communications Service, which was intended to provide a total solution to data communications problems.

The computer manufacturers

The computer manufacturers have supplied much of the data communications equipment that may eventually be displaced by public data services. Their equipment was designed primarily to link dedicated data terminals with centralised data processing systems. As we indicated on page 9, data (and message) traffic is becoming more volatile, and the somewhat rigid structures of the computer manufacturers' network products are quickly becoming outmoded. In response to this increased volatility, the computer manufacturers, led by IBM, are beginning to introduce more flexible and more adaptable networking structures. But it is no easier for them to escape from the data communications structures of the past than it has been for them to adapt, to today's on-line and timesharing needs, operating systems that were designed originally for batch working. Consequently, the data network architectures that they have recently introduced are cumbersome, complex and, sometimes, inefficient. The ability to communicate easily and freely promised by the new architectures is still largely an expectation rather than a present reality.

The telecommunications suppliers

The European telecommunications suppliers were jolted out of a rather cosy relationship with the PTTs when they realised that digital technology would not only influence the telecommunications market, but was about to revolutionise it. Digital technology not only affects product design, it also affects the marketing of the product. In particular, digital technology takes telephone exchanges, both public and private, into entirely new application areas. This, rather than the use of digital technology itself, is the challenge telecommunications companies such as ITT, Siemens and Plessey face. Producing and marketing an integrated voice/data exchange is not primarily an engineering problem (although engineering problems do exist). The significant difficulties are the same as those that the major computer manufacturers have faced for some time, namely:

- Determining system requirements.
- Selling a systems solution.
- Producing and maintaining general-purpose software.

The speed with which the communications market develops will be determined by the speed with which the established European telecommunications suppliers develop the necessary skills to overcome these difficulties. It will depend also on the regulatory practices of the PTTs. The rate of innovation is greater in the United States, but PTT regulation, which tends to fragment the market opportunity, will slow the transfer of United States technology to Europe.

The outsiders

All three categories of supplier just described are constrained because they have an established market to protect and established skills with which to work. Much of the advantage of the outsiders in the communications market is that they are not encumbered in that way. Because of the dramatic impact that microelectronics and digital technology have had, the communications market is, in effect, a new market. The outsiders are the specialists in this new market, and as such they have much to offer. Most of the organisations concerned have a very limited understanding of data processing, but it is questionable whether they really need this. It is largely an historical accident that data processing systems have involved themselves in data communications, which demands radically different hardware and software structures. It is noteworthy that most of the developments in local-area networks, which we regard as a significant area, have been initiated by this category of supplier.

ADVANCES IN TECHNOLOGY

We now turn from communication suppliers to technology, and we review below the developments in six key areas.

Private voice switching

Computerised telephone exchanges already show the beginnings of a non-voice capability, although typically this capability has been grafted onto what is essentially a voice switch, rather than having been integrated into the architecture. Computerised branch exchanges can already handle a low level of data traffic, although they cannot yet handle on-line data. We expect that the second generation of computerised exchanges, which will be available in Europe from about 1985 onwards, will be fully equipped to handle a significant amount of data traffic. They will probably have a fully non-blocking architecture, and they will offer features such as an X.25 or an SNA network interface, and message store-and-forward facilities that link with the telex network.

Data network architectures

A structured architecture is essential to support the more diverse and less orderly traffic patterns of both data and other non-voice communications of the near future. What form that structure should take, and, in particular, how far it should seek to integrate corporate communications into a single unified network, is still an open question. The arguments for and against network integration are similar to those we put forward in Foundation Report No. 18 for and against centralised and decentralised computer systems. The essential conflict is between the need to preserve local autonomy and adaptability, and the need for central control.

The network architectures discussed on pages 22 to 26 typify the alternative approaches. SNA is a tightly-controlled hierarchy, which retains most of the control at the centre. Decnet, on the other hand, disperses the control and simply provides a mechanism that enables systems to co-operate as and when it suits them. As a generalisation, the SNA approach will be best for heavy on-line data traffic, the integrated organisation and the very large user. Decnet and similar products are best for a loosely-coupled or diverse organisation, particularly if it is geographically dispersed.

Local-area networks

In this report, we have paid special attention to local-area networks for three reasons. Firstly, a number of attractive products are coming onto the market. Secondly, distributed processing and office systems are drawing attention to the importance of local distribution for non-voice traffic. Thirdly, advances in transmission technology will reduce long-haul transmission costs, thus emphasising the importance of local distribution costs.

Cable-based systems approach local-area networking mainly from the non-voice end, whereas computerised branch exchanges approach it from the voice end. Neither type of product is likely to be fully developed before the mid-1980s. Nevertheless, some products that handle non-voice traffic already offer enough to interest those organisations that have particular sites that are heavily populated with communicating devices.

Public data services

Public data services are an additional factor influencing non-voice network architectures, and organisations will find it more and more difficult to ignore these services in the future. Public data services will initially have a limited impact on existing applications. However, packet-switching services (if they are attractively tariffed) will promote new applications that involve relatively low communications activity but need a high degree of connectivity or network flexibility. The attractiveness of packet switching will, at first, be masked by a high conversion overhead. It will rapidly become more attractive in those countries where the PTT invests enough effort to build up traffic to a critical mass. Circuit switching, either as a leased line or a public data service, will remain attractive for heavy point-to-point traffic, such as the traffic between large sites.

Digital transmission and switching

Digital transmission technology is already beginning to influence costs, and as a result the cost of raw bandwidth will decline steadily. The premium on acquiring bandwidth in bulk will increase, with a 64k bit/s digital link eventually costing little more than a voice-grade circuit costs now. The first impact of digital technology will be on the trunk network. Full digital working at the local level is ten years or more away.

Satellites

Satellites offer the prospect of substantial reductions in the cost of long-haul and high-bandwidth (video) services. Satellites are therefore of most interest to very large organisations (and particularly multinationals), as well as, of course, to the PTTs and the broadcasting authorities. It seems unlikely, for two reasons, that satellite-based services will be available to private organisations in Europe in the foreseeable future in the way that they are already available in the United States. Firstly, many PTTs favour terrestrial technologies such as optical fibres. Secondly, there are several sensitive political and regulatory issues that need to be resolved both nationally and internationally before the use of satellites can be widespread in Europe.

THE ROLE OF THE CORPORATE NETWORK

At the simplest level, a private corporate network may be justified by savings in communications costs. These savings result from transferring intra-company traffic from public services onto private lines, or from concentrating traffic onto fewer, high-speed connections between sites. The extent of the savings available will depend on the PTT's tariff policy. In those countries where significant savings are available, the cost justification is unlikely to disappear suddenly. Probably, however, it will decline over the long term, and eventually (perhaps by the mid 1990s) it may disappear altogether.

An increasingly significant reason for establishing a corporate network, which is less subject to the vagaries of PTT policy, is to improve the level of service within the organisation. Service improvements may be necessary either to overcome the deficiencies of the PTT's services or else to reduce reliance on them. In addition, a data network may be desirable to enhance internal service levels above the levels that the PTT is able to, or attempts to, provide on a national basis. In voice communication, the use of private facilities to enhance internal service levels, is a long-established principle. It is embodied in the use of private automatic branch exchanges for local distribution, and it is also embodied in the use of tandem switches for inter-site traffic.

Private data communication networks, on the other hand, have generally been essential to perform the basic job of communicating data between a terminal and a computer, because public services for data transmission have simply not been adequate to this task. Thus, most data networks have needed to provide little more than fairly straightforward transport control facilities. However, this aspect of private data networks will become less important as the PTTs introduce improved public data services. At the same time as this happens, users' needs will change, and the emphasis will shift towards service improvements. Data networks will, therefore, need to be more flexible (including having a switching capability) and more adaptable. Also, to help the network operator cope with this more complex environment, data networks will need to provide adequate facilities for network management.

This changing role of the data network indicates that there is a case for separating (from a functional point of view) the communications system from the devices that it serves. Additionally, as communicating devices become more numerous and more varied, it will be essential to provide a central core of stability by decoupling the communications network from the devices that use it.

Cost considerations will probably constrain the way in which this decoupling (or functional separation) is achieved. Ideally, the communications network should be completely autonomous. This means that it would consist of hardware separate from (for example) data processing systems, and it would have its own power supply, operating software, etc. In the near term, this autonomy is likely to be cost justifiable only in large organisations and on large sites. Even then, for an organisation to construct a sound case for a fully autonomous network it might need to quantify the gains it would obtain in improved flexibility, greater reliability, etc.

In less favourable circumstances (for example, where the traffic level is low), it will be necessary to compromise and use some of the capacity of a data processing system to perform the networking functions. In such an arrangement, the functional separation will be logical rather than physical. ICL's Information Processing Architecture incorporates just such an arrangement, decoupling between the network and the session levels of the International Standards Organisation's open systems interconnection model.

Eventually, it will become easier for an organisation to justify full functional separation. This will occur as an organisation's traffic levels build up and as public data services increase in sophistication, thus leaving less work for the private interfacing equipment to do.

Clearly, some constraints will be placed on an organisation's choice of communicating devices, no matter how flexible and how adaptable the organisation's communications network is. Infinite flexibility can be bought only at infinite cost. Even so, these constraints need not be onerous, particularly if an organisation addresses its local-area needs and wide-area needs separately.

The role of the local-area network is to reduce the diversity of requirements on each site and to present a standard interface to the corporate wide-area network and, where necessary, to public networks also. In many aspects this role is precisely the same as that of the private automatic branch exchange at present, although generally a private exchange does not have to cope with a diversity of terminal devices.

This brief analysis of the changing role of the corporate network for voice and data traffic is used as the basis for the network blueprint that we discuss on page 62 and pages 64 to 66.

CHAPTER 8

POLICY FOR DATA NETWORKS

Before we turn to the broader issues of corporate network strategy, we first summarise the major policy issues affecting data networks. Data network policy calls for separate treatment because it is subject to the greatest uncertainties. This uncertainty arises because data transmission is not regulated as closely as is voice transmission, and because technology, both for public and private networks, is undergoing radical change. In addition, user needs can be expected to apply the greatest pressure in this area, as the moves to distributed processing and its close relative, office automation, gain momentum.

CHOOSING AN ARCHITECTURE

The minimum requirement for a data network is that it should support existing and/or planned applications in a cost-effective way. Over and above this, the organisation may be looking for the flexibility to handle future needs and for better levels of service. When an organisation is deciding how to structure its data network, it has three broad choices:

— To base it on its main computer supplier's architecture.

— To base it on a proprietary networking product.

— To adopt international and/or its own standards and require the supplier to conform to these.

Some organisations with the resources to do so may choose to build a data network themselves from scratch, but this will occur only exceptionally, and we do not discuss this possibility further.

Computer suppliers' architecture

Rather than talking about computer suppliers' architectures in general, it is more useful if we talk specifically about the most widely used product, IBM's SNA, and then review the different considerations applying to other suppliers' products.

As well as being the most widely used network architecture, by virtue of IBM's dominating market presence, SNA is also the most ambitious one available. IBM sees it as a framework for all corporate communications, not just for data, and IBM is one of the few suppliers in the world that could make such a claim with any degree of credibility. Because of these high ambitions that IBM has for the product, SNA betrays, in a more acute form than competitive products do, the difficulties that are inherent in a computer manufacturer's attempt to build a universal network architecture. These difficulties can be summarised under three headings:

1. Compatibility with PTT plans
   In defining its architecture, a computer supplier is seeking to serve a set of user requirements and a set of marketing priorities that are very different from those that a PTT will be addressing in planning for new public services. As soon as the PTT offers anything more than a basic transmission service, which most already do for voice and increasingly will do

for data, conflict between the PTT and computer suppliers becomes difficult, if not impossible, to avoid.

The demarcation between the responsibilities of the network supplier and those of the carrier is unclear. While the PTTs drive their responsibilities upward (into message handling in packet-switched networks), IBM is pushing downwards. For example, IBM's intelligent modems enable full diagnostics to be provided at the host system. This type of product has previously been an opening that the communication specialists like Codex have exploited to obtain a small, but significant, presence in SNA networks.

2. Complexity
Network architectures are complex. Complexity is relative, of course, and its cost, if measured in the use of computer resources, may be of declining significance. The cost may equally be experienced in terms of poor service for the network user. Also, complexity may make it progressively more difficult for the architecture to deliver in practice the flexibility and the long-term growth capability it offers in theory.

3. Inefficiency
Many SNA users have commented on the product's large requirement for machine resources. Again, this factor is of declining significance as hardware costs fall. Even so, as IBM pursues its goal of a fully integrated network, the level of inefficiency must rise still further. The result will be that the benefits may be worthwhile only if the inefficiency is shared widely across many network users.

In summary, SNA may really be worthwhile only for those large organisations that are prepared to commit themselves heavily to IBM.

The objections discussed above arise, to a lesser degree, with other computer suppliers' network products. Those suppliers that do not have IBM's influence on the market will look more favourably on CCITT standards, which enable them to compete on more equal terms with IBM's de facto standards. Nonetheless, those suppliers will still defend what they regard as their rightful territory as jealously as IBM defends its position. The complexity and the inefficiency of their network architectures, compared with SNA, will also be scaled down broadly in proportion to their level of ambition for the architectures.

Those suppliers with less of an investment to protect in obsolescent data communications software will be at a further advantage. This accounts for the success of companies such as Hewlett Packard and Datapoint in constructing sophisticated and also very effective networking software.

Undoubtedly, network architectures are of enormous potential value as a long-term base for corporate non-voice communications, just as database management systems are for corporate information. Like database management systems, though, network architectures can be expensive to realise in practice, and they may not show real gains for some considerable time.

Large or heavily committed users will find it easier to justify the investment in a network architecture. However, to ensure that the investment does provide a pay-off, an organistion may need to promote non-voice communications. By encouraging enough traffic and enough applications to use the network architecture, users will more quickly see the benefits from its range of features and flexibility. There are, however, risks in such a course of action. It could lead to a painful dilemma in the future if the PTTs introduce public services whose features either overlap or conflict with those of the network architecture, or whose tariffs are structured according to conflicting assumptions about methods of working. The result either way will be transmission cost penalties, and these could be high.

Proprietary products

An organisation need not necessarily commit itself to its computer supplier's own architecture. It can instead turn to specialist and independent suppliers whose products may match its needs more closely.

Proponents of this approach believe that dedicated communications processors give a better performance and provide more functions at a lower cost. The main disadvantage lies in the difficulty of interfacing proprietary communications products with mainframe computer protocols. To achieve a satisfactory interface demands perserverence and some technical involvement, but the problem is not insoluble. Even so, it is a problem that those without the appropriate skills in-house may well wish to avoid. But, once an organisation has implemented a network based on products supplied by independent suppliers, it is easier for it to cope with traffic growth and to add more functions to the network than it is for it to optimise mainframe-based software.

Specialist suppliers also tend to be more open-minded about competitors' equipment than are, say, IBM or ICL, because their main concern is to sell communications equipment, not computer systems.

International or own standards

A third alternative for an organisation when it chooses a data network architecture is for it to adopt a set of standards that all suppliers are required to comply with. This option will not be viable for all users, because, ideally, it requires a limited existing investment in equipment that does not conform to the standard, and which may first need to be converted. However, any conversion problems can be overcome by careful planning and progressive upgrading. This option also requires the ability to apply a great deal of pressure on suppliers.

CCITT standards are the obvious base for this approach, although at present they help only as far as the transport level. This may be sufficient for bulk data and message traffic, but it is unlikely to cope satisfactorily with on-line working for the time being.

PUBLIC OR PRIVATE DATA SERVICES

In most European countries, public data networks are already, or soon will be, in operation. Packet-switched networks will be available almost everywhere, and fast-select circuit-switched networks will be available in the Nordic area and also in West Germany. The packet-switched networks will soon permit interworking throughout the developed world. Despite this development, their initial impact on the existing everyday private communications traffic will be limited. They are more relevant to the emerging applications such as information retrieval, and to potential new applications such as electronic funds transfer. The tariff policies of the PTTs will determine when, if ever, packet-switched networks will be able to compete for a large part of the data traffic that is now carried over leased lines.

Circuit-switched networks are more closely equivalent in characteristics to leased lines (apart from their switching function, which is an advance in capability). An organisation's evaluation of public circuit-switched networks as an alternative to leased lines will depend largely on transmission economics, although their reliability should also be higher than that of leased lines.

Public data networks will make feasible some applications that have not previously been so. However, they will not make a major short-term impact on the economics of private networks, except where PTTs mount a campaign to transfer traffic from leased lines onto them. So far, only the Bundespost in West Germany has shown any real determination to apply pressure on its customers, while the French PTT and some others are likely to adopt favourable tariffs to overcome their customers' inertia.

In summary, public data networks will influence the economics of data transmission, but they will not make a radical impact on either network engineering or network structure in the near term. Interface standards, such as CCITT's X.25, will aid terminal connectivity, but they will not solve the compatibility problem. Nor will X.25 (packet-switched) networks provide a ready-made solution to non-voice networking problems for the foreseeable future. They will provide a backbone network broadly equivalent to the public switched telephone network, but they will leave user organisations with the task of assembling the equipment and software necessary to meet the requirements of each site, and also of controlling the flow of traffic between sites.

The integrated public networks will make a much more radical impact, because they will deliver digital bandwidth for both voice and non-voice applications over the existing telephone wiring. Exciting though this possibility is, it is unlikely to materialise before the late 1980s, except on a limited scale. Consequently, it cannot yet influence user organisations' plans.

There is a general movement towards introducing international standards for non-voice networks. This movement is not restricted to PTT-supplied networks, but it extends also to some proprietary products and networks that are being developed for special purposes. Even developers who are not committed to X.25 are often using it as a base, so that they can, if necessary, make their products compatible with CCITT standards at a later stage.

Below we review four other factors that influence the choice between public and private data services.

1. Response time
   Response times on private networks should be more predictable than those on public services, because the load can be foreseen. (In the United States, Telenet is currently experiencing an overload caused by excess demand.) A public system will be able to use faster trunk lines, and more of them, and this will lead to shorter trunk transit times. On the other hand, a public system may have greater queue lengths during busy periods.

2. Facilities
   From the time they are first installed, public packet-switched networks will have facilities that are not available in conventional data networks (although these facilities, and others, can be built into private networks using the more advanced proprietary software). Notably, public packet-switched networks will offer:

   — Alternate routeing.

   — Auto-dial and receive.

   — Speed conversion.

   Initially, the kinds of devices that can access public networks will be limited, but this limitation will become less stringent as time passes.

3. Reliability
   Because of its greater number of trunk lines, switches and alternate routes, a public network should be more reliable than is a private network. However, particularly in its early stages of development, the reliability of a public network may be less certain because it:

   — Will require frequent enhancements.

   — May be under-configured because of traffic load uncertainties.

   — May be crippled by industrial action within the PTT.

The operators of Transpac claim that it has an availability of 99.9 per cent. It seems unlikely that private networks will be able to improve on this figure. In one case, quoted at a public conference in the United States, the higher reliability of a public network produced a financial saving as great as the whole cost of the equivalent private network.

4. Staffing
A private network will require a network supervision function. Some support will be necessary on a 24-hour basis, though it may be possible to restrict this to emergency call-out. Appropriate staff agreement will be needed to whatever arrangements are made, and achieving this agreement may prove troublesome. If public networks are used, then some network management tasks can be left to the PTTs to perform on a national basis.

CHAPTER 9

CORPORATE NETWORK STRATEGY

The convergence of voice and data communications systems has been the focus of much of the discussion in this report. In this chapter, therefore, we first look at the case for an integrated corporate network before discussing those key issues that affect network development in the hitherto separate areas of voice, data and message communication. In some respects, the detailed shape of corporate networks in the future remains confused, but it is already possible to discern the overall shape that they are likely to take under the twin pressures of changing user needs and a changing communications environment. We then put forward a blueprint for the corporate network of the 1980s and finally, we suggest the way in which the communications function should be managed.

DECIDING ON ONE NETWORK OR MORE

In the long term, all information will be transmitted in a digital form, and this development forms a powerful argument for corporate networks to be fully integrated. An integrated network would make it possible for an organisation to gain maximum economies from common switching and transmission requirements, and, where appropriate, to take advantage of functional gains be they multifunction workstations, the voice annotation of documents, or any other attractive option.

In the short term, however, technology and regulation place severe limits on the degree of integration that an organisation can attempt at reasonable cost and reasonable risk. Consequently, most organisations will find it attractive at the present time either to develop separate voice and non-voice networks, or to postpone any major development in either area until the mid-1980s.

A separate non-voice network may be the most sensible approach for any organisation that expects to have a major demand for non-voice communications. And even when integrated voice/data computerised branch exchanges become available, separate non-voice and voice networks at the local level may still be the most sensible approach for such an organisation. Separate voice and non-voice switching systems will be more effective than an integrated switch, because they are more specialised. On the other hand, judged purely in financial terms, separate switches will probably not represent the best solution.

Those organisations that see a need for the functional integration of voice and non-voice services should either wait until the mid-1980s — when integrated local-area networks will be feasible — or else adopt new protocols that they can easily interface with a future integrated network. In practice, this means that they should adopt international standards such as CCITT's X.21 and X.25, or possibly IBM's de facto standards. Eventually, the International Standards Organisation's open systems interconnection model may also provide a base for standard protocols.

It should be re-emphasised, however, that integration at the local-area level is not a prerequisite for an integrated digital wide-area network, nor is the reverse.

PLANNING NETWORK DEVELOPMENT

Before putting forward a blueprint for corporate communications in the 1980s, we review the strategic issues as they affect each type of separate network (voice, data and message).

Voice networks

The motivation for developing a private voice network might be to:

— Reduce costs.

— Provide a better and more uniform service within the organisation.

— Give the network operator greater flexibility to meet communication needs.

As our comments about the capabilities of computerised branch exchanges on pages 18 to 22 implied, voice networks will generally stand or fall by their ability to handle telephone traffic. The impact of other forms of traffic on the cost justification equation will probably be marginal.

There will sometimes be scope, however, for sharing the trunk bandwidth with non-voice traffic, and this possibility should be reviewed when the voice network is configured. The sharing may be passive, by allocating a fixed proportion of the bandwidth to different services. The benefit with this sharing derives solely from the favourable tariffs the PTTs offer for groups of circuits (normally 12 or 60), although this benefit is partly offset by the cost of multiplexing traffic within the group.

Alternatively, the sharing may be dynamic, either on a demand basis or by time period. The dynamic sharing of bandwidth makes it possible for an organisation to exploit the spare bandwidth available at off-peak periods or, by using more sophisticated equipment, to interleave real-time voice traffic with non-real-time traffic. Assuming that the non-voice traffic does not reduce the level of telephone service, the cost justification for the dynamic sharing of bandwidth will be based on straightforward economics. An obvious prerequisite is that the traffic patterns of the information that shares the bandwidth should be compatible in both time and space, and this compatibility will need to be verified by measurement. To support trunk bandwidth sharing of any kind but the simplest, the switching equipment should be capable of making intelligent decisions (for example, to optimise routes) about the use of the available bandwidth.

Private branch exchanges, and, consequently, the private voice network also, may be used to carry either messages or low-volume data traffic from devices such as sensors, time recorders, etc. Where the volume of this traffic is low, or where it takes place only overnight, when there is ample spare capacity, carrying this traffic presents no problems. Where these conditions do not apply, care needs to be taken to ensure that the volume does not rise to such a level as to either interfere with voice service levels or precipitate expensive upgrades. There have been many examples of the motorway effect of a good communications service, particularly for discretionary activities such as timesharing.

Data networks

The point at which a switched data network becomes worthwhile will depend on the type, the volume and the geographic distribution of data traffic. It is not possible to give firm guidelines for recognising when that point is being approached. It is necessary to assess each situation on an individual basis. Those organisations that do not possess the information on which to base a cost justification exercise should certainly take steps to assemble it. An organisation also needs to be aware of the rapid rate at which both the usage and the numbers of terminal devices tend to increase once communications-based services are made available. A data network can very quickly become essential, in order either to control costs, or to maintain service levels or to cope with new demands for connection.

The network should have a coherent (and probably, layered) structure. Two aspects of this structure are of paramount importance:

- The wide-area distribution network should be designed in such a way as to make cost-effective use of the PTT services that will be available within the lifetime of the equipment. For many organisations this will imply an interface to a public data network to which traffic should migrate as tariffs dictate. The transport sub-network in some organisations may eventually be displaced totally by PTT services.

- The local-area network should provide a constant interface for whatever devices require communications services, and it should have the flexibility to cope with changing terminal technology and changing user needs. Any additional investment that is made in order to obtain this flexibility will (within limits, of course) undoubtedly be justified in the future.

Those organisations that cannot justify a network to handle either all, or a large proportion of, their non-voice traffic will need to make a separate decision for each different form of traffic. In Figure 18 we reproduce the matrix published in Foundation Report No. 7 — Public Data Services, which shows the best choice of service in the United Kingdom for various data communications applications. This matrix remains valid, for the United Kingdom, even though there has been some slippage in the availability of PSS, and it is within the power of British Telecom to make leased lines uneconomic for all but the most heavy usage.

The matrix takes no account of distance or of the special tariff and service options many PTTs offer. In this respect, the figure over-simplifies the position. In addition, the time at which one type of service will supersede another may vary in other countries. It will vary particularly in those countries where a circuit-switching service is due soon to come into operation, where it will displace bulk data applications from leased lines sooner than is shown in the matrix.

Any readers who are interested in the detailed reasoning behind the matrix may refer to pages 38 and 39 of Report No. 7.

Message networks

Once a switched data network has been established and terminals have become widespread within an organisation, the internal distribution function of a message network (which is more often than not a telex store-and-forward switch) can be transferred onto the data network. This transfer can be achieved with limited cost and probably with an improved level of service. Also, where private automatic branch exchanges carry non-voice traffic, the same function could be performed by the voice network. In addition, a telex gateway will be needed to provide access to the outside world. (Where the PTT provides a bridge between telex and teletex services, a teletex interface may be required as well.) For some special applications, a videotex interface may also be appropriate.

A BLUEPRINT FOR CORPORATE COMMUNICATIONS

On pages 53 and 54 we analysed briefly the changing role of the corporate network for voice and data traffic. From this analysis, we derive the network blueprint shown in Figure 19 on page 65. This shows the corporate network as consisting of three main parts:

— Transport services between sites, which are provided by the PTT either as private lines or as public services.

— A corporate wide-area distribution network, using PTT transport services as necessary and as tariffs dictate. Eventually, this wide-area network would become a fully

Figure 18 Service choice matrix

Data communications application					Service choice			
Category	Time of day	Hours per day	Turn-around time	Multi-destinations?	1980	1982	1984	1986
Transaction processing / On-line data entry	P	8	3 to 8 secs	No	LL	LL	LL	LL
Information retrieval	P	0.5 to 2	5 to 10 secs	Yes	VN (PS)	PS	PS	PS
Information transmission: — high volume	O	0.5 to 4	Overnight	Few	LL	LL	LL	CS/LL
— low volume	O	0.5 to 4	Overnight	Yes	VN/TX (PS)	VN/TX (PS)	PS/TX	PS
Timesharing	P	0.5 to 4	3 to 10 secs	Few	VN/LL (PS)	VN/LL (PS)	PS/LL	PS/LL
Remote job entry	P	4 to 8	Greater than 1 hr	No	LL	LL	LL	CS/LL
Message switching	P	More than 8	5 to 10 secs	Yes	LL	PS/LL	PS	PS

Key: Time of day: P = Peak (0800 hours to 1800 hours)
O = Off-peak

Service choices: LL = Private leased line
VN = Switched voice network
PS = Packet-switching service
CS = Circuit-switching service

Service choices shown in brackets will be attractive on cost grounds, but they may be disqualified by temporary limitations, such as inadequate coverage.

integrated digital network, but in the interim period it might consist of separate voice, data and even message networks.

— Local facilities on each site, interfacing with the corporate wide-area network and, where necessary, with public services.

The local facilities would consist of three types of equipment:

1. Local-area switching systems
   Local-area switching systems for voice, data or message distribution would be available, either independently, or combined in one piece of equipment. The needs of each site and the economics of different levels of integration at the time of installation would determine the particular combination.

2. Corporate services
   Corporate services (such as mainframe computers, electronic mail systems or gateways to public telex or videotex services, etc.), would be accessible via the distribution network, to all sites that needed them.

3. Administrative routines
   Special administrative routines for accounting or for protocol conversion would be available. These routines should ideally be separated from the distribution network to keep the latter as clean and uncomplicated as possible.

The structure shown in Figure 19 would offer the following advantages:

— It eases migration to the most cost-effective PTT services.

— It partitions the problem of corporate communications, enabling wide-area and local-area requirements to be dealt with separately on their differing merits, and also to be accounted for separately.

— It caters for the diversity of local facilities that are certain to develop in practice.

— It permits the integration of facilities at the local level to proceed at its own pace.

A vital aspect of any network strategy is that it should provide the freedom for local-area facilities to develop as and when they are needed, subject only to the constraints that must be placed on them to enable them to interface with the corporate network as a whole. There are two reasons why this is a vital aspect. Firstly, as computer systems become dispersed throughout the organisation, costs will increasingly be centred in local, rather than remote, communications. Secondly, to meet network users' changing needs, integration and flexibility will be needed most at the local level.

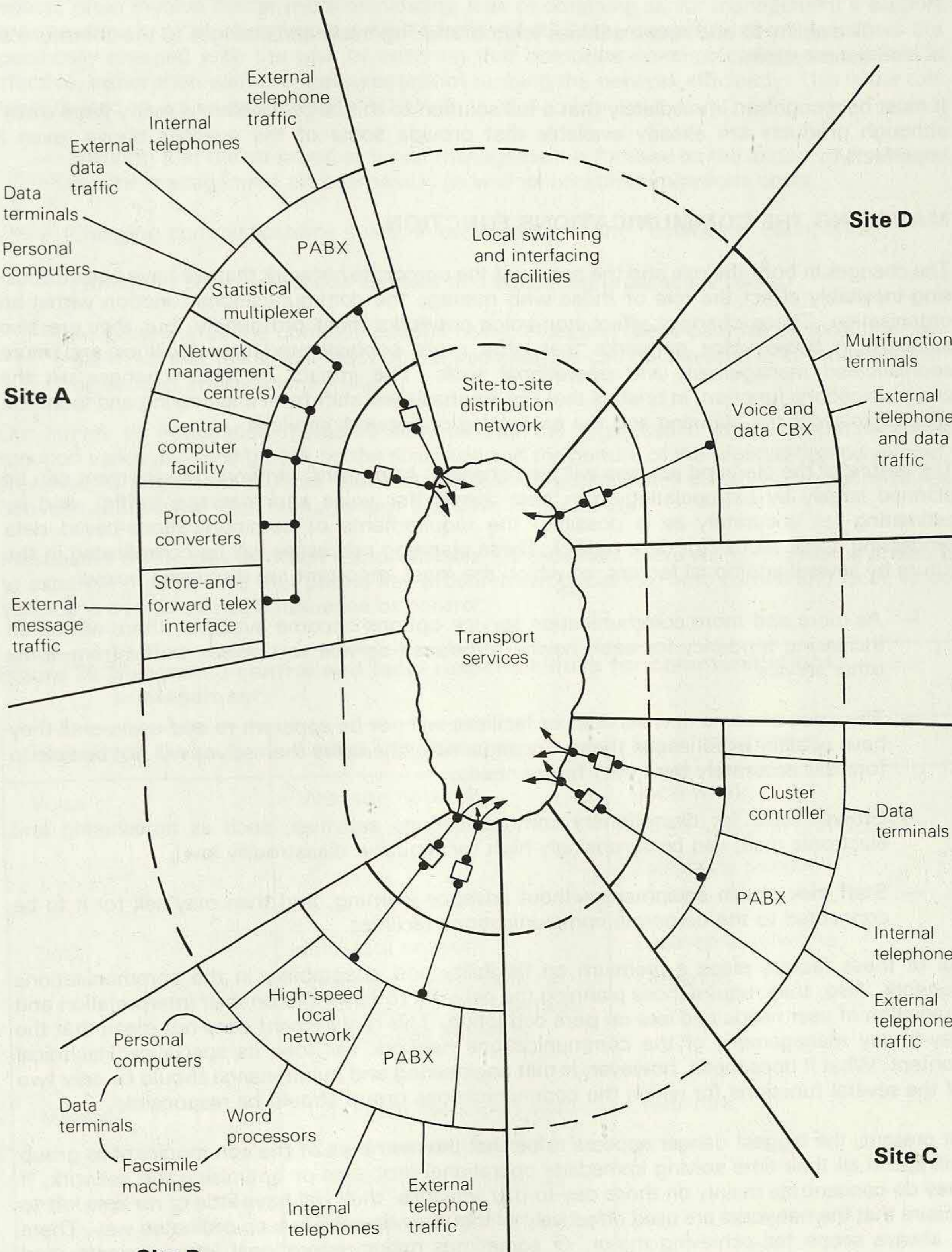
We list below the five qualities that will be demanded of the local-area network if it is to cope with the communications needs of the ubiquitous computing power of the near future:

— The ability both to establish and to answer calls without the need for manual intervention.

— Ease of use, such that a typist, a clerk, or a storeman can make use of the facilities without the need for expensive support staff to maintain the system, or to repair faults, etc.

— The ability to communicate between dissimilar devices, in different places, supplied by different vendors, without incurring excessive costs, delays and restrictions.

Figure 19 Blueprint for a corporate network



- The ability to move machines from one place to another without lengthy delays and without substantial charges for rewiring.

- The ability to add new machines without making traumatic changes to the communications system.

It must be recognised immediately that a full solution to this large problem is many years away, although products are already available that provide some of the qualities above, even if imperfectly.

MANAGING THE COMMUNICATIONS FUNCTION

The changes in both the role and the nature of the corporate network that we have been discussing inevitably affect the role of those who manage the communications function within an organisation. Those changes affect non-voice networks most profoundly, but they are also apparent in those voice networks that offer more sophisticated user facilities and more sophisticated management and operational tools. The impact of these changes on the communications function, in brief, is that the emphasis will shift from engineering and technical support towards the planning and the promoting of network services.

The nature of the planning process will also change. At present, network development can be planned largely by extrapolating from past trends (for voice and message traffic), and by estimating (as accurately as is possible) the requirements of communications-based data processing applications (for data traffic). These planning processes will be complicated in the future by several additional factors, of which the most important are discussed below:

- As more and more communication service options become available, there will be an increasing tendency for each newly introduced service to displace traffic from some other service.

- The value of some new services or facilities will not be apparent to end-users until they have actually experienced them. Consequently, the users themselves will not be able to forecast accurately their own future needs.

- Growth rates for discretionary communications activities, such as timesharing and electronic mail, can be surprisingly high (or, equally, disastrously low).

- Staff may obtain equipment without advance warning, and then may ask for it to be connected to the corporate communications facilities.

All of these factors place a premium on flexibility and adaptability in the communications network. Also, they require those planning the network to rely more on their interpretation and prediction of user needs and less on pure deduction. This requirement does not mean that the day-to-day management of the communications network will lose its specialised technical content. What it does mean, however, is that engineering and maintenance should be only two of the several functions for which the communications group should be responsible.

At present, the biggest danger appears to be that the members of the communications group will spend all their time solving immediate operational problems or optimising the network. If they do concentrate mainly on those day-to-day activities, they will have little or no time left to ensure that the networks are used effectively or that they develop in a co-ordinated way. There is always scope for achieving minor, or sometimes major, operational improvements, and certainly this aspect of communications management should not be neglected. (Indeed, the short-term gratification that work of this kind brings may be essential to the job satisfaction of skilled engineers, who will always be difficult both to recruit and to retain.)

Unfortunately, urgent low-level technical tasks can easily become a convincing excuse for the communications manager not to tackle the longer-term aspects of his job. These longer-term aspects often involve the far more demanding task of obtaining senior management's support for innovations, or of changing the way people work. Some communications managers are specifically charged with the task of ensuring that corporate communications as a whole is effective, rather than with the narrower task of running the network efficiently. This wider role tends to lead to activities such as:

- Ensuring that the attention of senior management is focused on the impact of communications management on overheads, as well as on communications costs.

- Charging communications costs, in order to avoid any "overhead" connotation.

- Promoting communications services and educating prospective users.

- Ascertaining all the communications costs, including those paid for by local management, so that the total impact of planned changes can be assessed in advance and can be verified after implementation.

Our survey of Foundation members showed that the organisation of the communications function varies depending both on the structure and the culture of the organisation concerned. However, a suggested rational (but not necessarily appropriate) division of responsibilities between central and local management is shown in Figure 20.

Irrespective of the way in which responsibilities are allocated, there will be increasing pressure to establish mechanisms that permit key procurement decisions, both central and local, to be subject to overall strategic influence or control.

Figure 20 Suggested central and local responsibilities for communications management

Traffic type	Central management	Local management
Voice	Inter-site network Inter-PABX signalling	Local wiring PABX selection and operation Telephone selection
Data	Inter-site network Standard protocols to be supported by the interface to local-area networks	Local-area networks Terminals
Message	Corporate message switch Corporate telex interface Corporate electronic mail Addressing and interface standards	Terminals

CHAPTER 10

CONCLUSION

At this time, the benefits of a co-ordinated strategy for private voice, data and message communications may not be readily apparent. Costs can obviously be reduced by sharing transmission facilities, but apart from this there is no pressing need for private communications to be co-ordinated. There is no real evidence of any user demand for new integrated communications services, and, at the present time, no major cost savings or functional gains can be had from a co-ordinated strategy.

There is, however, a powerful, but negative, reason for a co-ordinated approach to private communications. During the 1970s, many organisations became aware that a fragmented approach to data communication is an excessively costly one. Those organisations that do not soon attempt to co-ordinate all types of communications developments will incur similar excessive costs in the 1980s, as the public networks of Europe become digital, and as many new communications products come onto the market.

Organisations should, therefore, plan to move to more closely integrated (or co-operating) networks, and the implementation of this move will depend on the co-ordination of developments in different areas. Amortisation periods should be decided on for each of the different types of switching equipment (for example, private automatic branch exchanges and data switches) so that all the equipment can be replaced at the same time. Where possible, the replacement of equipment should be synchronised with the expected major developments in products or services. For voice transmission, this replacement might ideally coincide either with the release of second-generation computerised branch exchanges in the mid-1980s, or, alternatively, with the implementation of the PTTs' digitisation programmes from 1990 onwards. For data transmission, the time when public data services become available or, again, the implementation of the PTTs' digitisation programmes could be the major checkpoints.

In this report, we have reviewed the potentially revolutionary changes that will take place both in the communications environment and in the market place during the 1980s and beyond. Those organisations that do not adopt a co-ordinated approach to corporate communications will lack the management structures and the skills necessary to take advantage of the opportunities that these changes will present. In our view, both the opportunities and the penalties for failing to exploit them will be substantial.

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Printed in England