Report Series
No 26

Trends in Voice Communication Systems

January 1982

The Butler Cox Foundation

Abstract

Report Series No 26 — Trends in Voice Communication Systems

by David Butler

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Because of the maturity of the basic technology of the telephone, it is tempting to assume that the voice communication industry is static. Such an assumption could not be further from the truth. But it has always been easy to underestimate the potential of the telephone, and those who do so are in good company. Mr Culley, who was Engineer-in-Chief of the British Post Office, said in 1877, "My department is in possession of full knowledge of the details of the invention, and the possible use of the telephone is very limited".

Today, telephony is a growth industry, and its expansion will continue for as far ahead as anyone can see. The changes in voice telephony — in how it is provided and how it is used — form the basis of this report. Until recent times, the telephone administrations of the world were fully occupied in providing a basic telephony service throughout their individual territories. In some countries (notably in the United States, and soon also in Europe), the remit to provide basic telephony services has been fulfilled. Telephone administrations will therefore be seeking to provide new enhanced services based on their existing telephone networks. The attitude of the telephone administrations towards the changes that are now taking place is epitomised by Mr Charlie Brown, Chairman of AT&T, who in 1980 said, "With each passing year we are transforming the network, endowing it with 'intelligence'. Not so long ago it provided a more-or-less uniform service to all its customers. Before long it will serve no two of them alike".

The Butler Cox Foundation is a research group that examines major developments in the fields of computers, telecommunications and office automation on behalf of its subscribing members. The Foundation provides a set of 'eyes and ears' on the world for the systems departments of some of Europe's largest organisations.

The Foundation collects its information through its office in London and also through its associated offices in Europe and the US. It transmits its findings to its members in three main ways:

— Through regular *written reports* that give detailed findings and substantiating evidence.

— Through *management conferences* for management services directors and their senior colleagues, where the emphasis is on the policy implications of the subjects studied.

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

The Foundation is controlled by a Management Board whose members include representatives from the Foundation member organisations. The responsibilities of the Management Board include selecting topics for research and approving the Foundation's annual report and accounts, which show how the subscribed research funds have been employed.

Report Series No 26

TRENDS IN VOICE COMMUNICATION SYSTEMS

by David Butler

January 1982

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CONTENTS

CHAPTER 1

INTRODUCTION

The basic technology of the telephone is more than a century old, and today the telephone is one of the most common pieces of office equipment. The worldwide voice communication network is by far the largest system ever devised by man. In just one country (the United Kingdom) it serves 27 million stations from which 20,000 million calls are made each year. Yet the role of the telephone in business is full of contradictions. It is one of the most useful pieces of office equipment, but it can also be one of the most infuriating. It is one of the most productive pieces of office equipment, yet it can be the most wasteful. Everyone takes the telephone for granted, and yet its future is both exciting and uncertain. It is incredibly reliable, but it can be utterly unpredictable. Subscribers may dial with ease from a major European city to a small town in the Australian outback, for example, but it may be almost impossible to obtain a connection between two cities in Japan.

Despite the maturity of the basic technology, telephony is today a growth industry, and its expansion will continue for as far ahead as anyone can see. The changes in voice telephony — how it is provided and how it is used — form the basis of this report.

STRUCTURE OF THE REPORT

Much of the content of this report is technical, and requires a basic understanding of both the technology of switching and the structure of a national telephone network. For those readers who are not familiar with these two subjects we begin the report with a brief description of them.

The report then continues in chapter 3 with an overview of the substantial changes that are taking place in the voice communication industry — changes in telecommunication capacity and in the use and cost of facilities. These changes also include a changing range of voice communication products.

In chapter 4 we review the significance of the continuing trend towards digital voice telephony, and in chapter 5 we consider the changes that can be expected in the technology and use of the telephone handset. Next, in chapter 6, we examine the likely developments in transmission technology, including cables (coaxial and optical fibre), satellites, radio transmission and local-area networks. Chapter 7 considers the services that telephone administrations will offer in the future, as the market for basic telephony gradually becomes saturated. The report concludes with a review of the responsibilities of the telephone manager in the 1980s.

INTENDED READERSHIP

The report is intended primarily for telephone managers, for the management services director (if telephony is included in his portfolio) and for those responsible for designing and implementing voice communication systems. Everybody is a telephone user, however, and every business manager has a valid concern with the development of speech services, and so the report will be of value to a wider readership. The report therefore avoids wherever possible the most technical language, and defines such technical terms as are unavoidably employed.

One of the lessons that emerges from the Foundation's research is that the very considerable costs of voice communication are often less tightly controlled than they should be. These costs are easily dispersed over dozens of departmental budgets, and the abuse of telephone usage is often difficult to detect or deter. We hope that departmental managers with high telephone bills will also read this report, so that they may better understand both the scale of the problem and the opportunity that voice telephony represents.

A CAVEAT

One of the central themes of the Foundation's work is that computer systems, telecommunications and office automation are but three aspects of a single, emergent discipline. There is (at least in English) no globally accepted name for this discipline, although the French word 'télématique' has been anglicised into 'telematics'. But, named or nameless, the phenomenon is real. It may therefore seem unwise, or even downright perverse, to consider voice communication in apparent isolation from data, text and image communication. And yet, as technological developments come crowding in upon managers in an ostensibly endless and unordered stream, it is useful to group those developments sometimes in one way, and sometimes in another. The unifying factor in this report is the ubiquity of the spoken word, which, as well as being mankind's oldest form of intelligent communication, is also unrivalled in its immediacy. In the context of the past century, what we consider in this report is the continuing effort towards the fulfilment of the great dream that is the heritage of Alexander Graham Bell.

CHAPTER 2

BASIC TELEPHONE TECHNOLOGY

Much of the content of this report assumes that the reader has a basic understanding of the structure and the technology of telephone systems. Many readers will already possess a deep level of knowledge in this field; we suggest that these readers omit this chapter and move on to chapter 3. For the benefit of readers who are not fully familiar with the workings of a telephone system, we set out in this chapter a brief history of the technology of switching systems, starting with the original Strowger exchange and finishing with a brief description of modern stored program electronic exchanges. We also examine the structure of a typical national telephone network.

SWITCHING TECHNOLOGY

When a subscriber initiates a telephone call, a signal is sent to the local exchange where routeing switches and control equipment are installed. The control equipment must receive the messages from the caller, translate them and perhaps re-transmit them. The most important control message is, of course, the called number. The control equipment must then use the routeing switches to set up, supervise and terminate the required connection. The exchange must also record call information for charging purposes, and it must be designed so that any faulty equipment can be by-passed. For economic reasons, it is not possible to provide non-blocking exchanges that permit every subscriber to be simultaneously connected to the exchange.

Switching equipment is therefore shared, and this sharing is achieved by 'partitioning' the switching equipment into several stages that provide concentrating functions as well as routeing functions. These several stages share common control equipment, and the whole exchange is designed to handle a predetermined number of simultaneous calls.

Originally, the switching functions were performed by human operators who routed calls by manually plugging the appropriate connections on the switchboard. Automatic exchanges became an economic necessity, and the first commercially viable automatic exchanges used the technique invented by Strowger. This technique splits the switching function into several discrete stages, and uses two-motion switches that step vertically in accordance with a dialled digit and then hunt in a rotary fashion for a free outlet to the next stage.

Early Strowger equipment could not provide all the flexibility of manual operations, however. Translation of dialled information was not possible, for example, and this meant that in a large network the caller would have to dial numbers containing codes that would vary depending upon the location of the caller. The answer to this problem was to supply register-translator equipment at the exchange, and before such equipment was developed, subscriber trunk calls had to be connected by a human operator.

As telephones became more widespread, reliability and quality of service became more important. The switch-contact noise problem in early switching systems was overcome by using precious metal contacts. This development, because it increased the cost per switch, provided the incentive to reduce the number of switches required in an exchange. As a result (but also for other reasons), switches incorporating arrays of individual contact sets, such as crossbar switches, came into favour. Thomas Edison himself had conceived the first crossbar exchange. In his model there was an array of vertical and horizontal metal bars. Where the bars crossed there was a small hole, into which a metal peg could be inserted to make the connection. Later, in Sweden in 1912, Betulander developed a switching system that used a matrix arrangement like Edison's, but with relay circuits instead of metal plugs at the intersections.

In 1936 Bell Telephone Laboratories produced a new type of relay known as a reed. The contact springs of such a relay consist of two reeds made from an alloy that is easily magnetised. The reeds are surrounded by a wire coil, and the whole arrangement is then sealed in a glass tube filled with non-corrosive gas. When a current is passed through the coil the reeds are magnetised in such a way that they are attracted towards each other, and the relay closes.

The technology of electromechanical telephone switching reached maturity with the invention of the reed relay, but several other inventions also had to follow before modern switching systems could be designed. In particular, more efficient ways of using switching matrices were found. The greater efficiency comes from replacing a single large matrix with several small matrices, thereby reducing the total number of crosspoints. We illustrate this phenomenon by means of the following example.

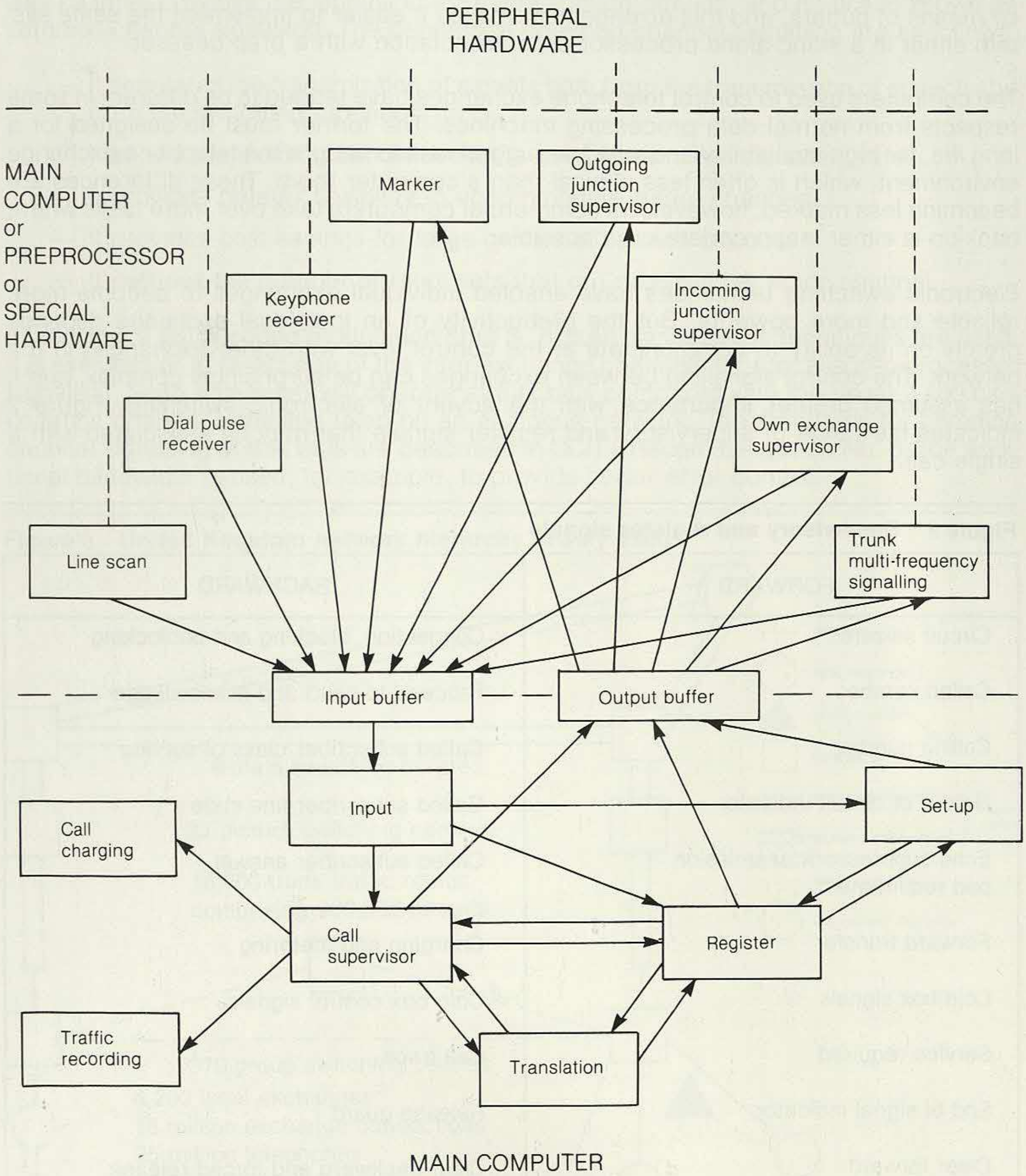
If a switching system is required to permit any one of sixteen extensions to be connected to any one of sixteen lines, then a 16x16 matrix (with 256 crosspoints) will perform this function. However, the same function can be performed by a three-stage switch that consists of twelve 4x4 matrices, but at a lower cost because it will have only 192 crosspoints. In real-world exchanges the scale is much larger, and so is the potential reduction in the number of crosspoints.

The cost savings from reducing the number of crosspoints can only be gained, however, if all of the matrices operate under a common control system. The common control systems used in telephone exchanges perform a function that, in many respects, is similar to that of a computer system. Common control crossbar exchanges began to be installed in reasonable quantities from about 1950, and even now they represent a large proportion of working exchanges. The period during which common control crossbar exchanges were being introduced overlapped with the rise of the electronics industry, but it was some time before electronic switches began to have an impact on the crossbar market. The combination of Edison's idea both with Betulander's practical genius and with Bell Laboratories' inventiveness kept the electronic switch at bay for a surprisingly long time.

But today it is clear that electronic stored program control exchanges will bring about the demise of the traditional wired-logic electromechanical exchanges. Compared with modern stored program control exchanges, wired-logic systems have several shortcomings. The first shortcoming is concerned both with the volume of traffic that traditional exchanges can handle and with their reliability. It is a simple matter to establish an individual call, but the need to handle millions of calls from thousands of subscribers in a sequence that is controlled entirely by the subscribers results in great complexity. This complexity is compounded by the very nature of wired-logic systems, because the designer of the system has to build-in facilities to by-pass, isolate and correct faulty components.

Another shortcoming of wired-logic systems is their inherent inflexibility. For suppliers with an eye on export markets, it is difficult to design wired-logic systems that will not need to be redesigned before they can be sold in other national markets. The habits of subscribers and the patterns of telephone usage vary in different countries, as do the existing network facilities into which a new exchange may have to be installed. In addition, public telephone exchanges are installed on the assumption that they will have a long life. They must therefore be able to cope both with a growth in demand for telephone services, and with technical changes such as new signalling systems. Wired-logic systems lack this flexibility.

Figure 1 Typical program schema for an electronic exchange



(Source: GEC Telecommunications Limited)

The future therefore belongs to stored program control exchanges, with a minimum program size of about 20,000 bytes. The need to provide comprehensive maintenance and diagnostic aids, however, increases the size of the software needed to run an electronic exchange to perhaps as much as 0.5 million bytes.

If the electronic exchange is truly to be more maintainable than the wired-logic exchange, then the programs must be arranged in a modular form. Figure 1 on the previous page shows a typical program schema. Control programs for electronic exchanges need to handle two kinds of processes — those dealing with external devices and those concerned with actual call processing. The two kinds of processes are linked by means of buffers, and this arrangement makes it easier to implement the same system either in a stand-alone processor or in association with a preprocessor.

The computers used to control telephone exchanges have tended to be different in some respects from normal data processing machines. The former must be designed for a long life, for high availability and with the ruggedness to endure the telephone exchange environment, which is often less clinical than a computer room. These differences are becoming less marked, however, as commercial computers take over more tasks where back-up is either inappropriate or impossible.

Electronic switching techniques have enabled individual exchanges to become more reliable and more powerful. But the productivity of an individual exchange depends greatly on its ability to communicate at the control level with other exchanges in the network. The control signalling between exchanges can be surprisingly complex, and it has assumed greater importance with the advent of electronic switching. Figure 2 indicates the range of supervisory and register signals that may be associated with a single call.

Figure 2 Supervisory and register signals

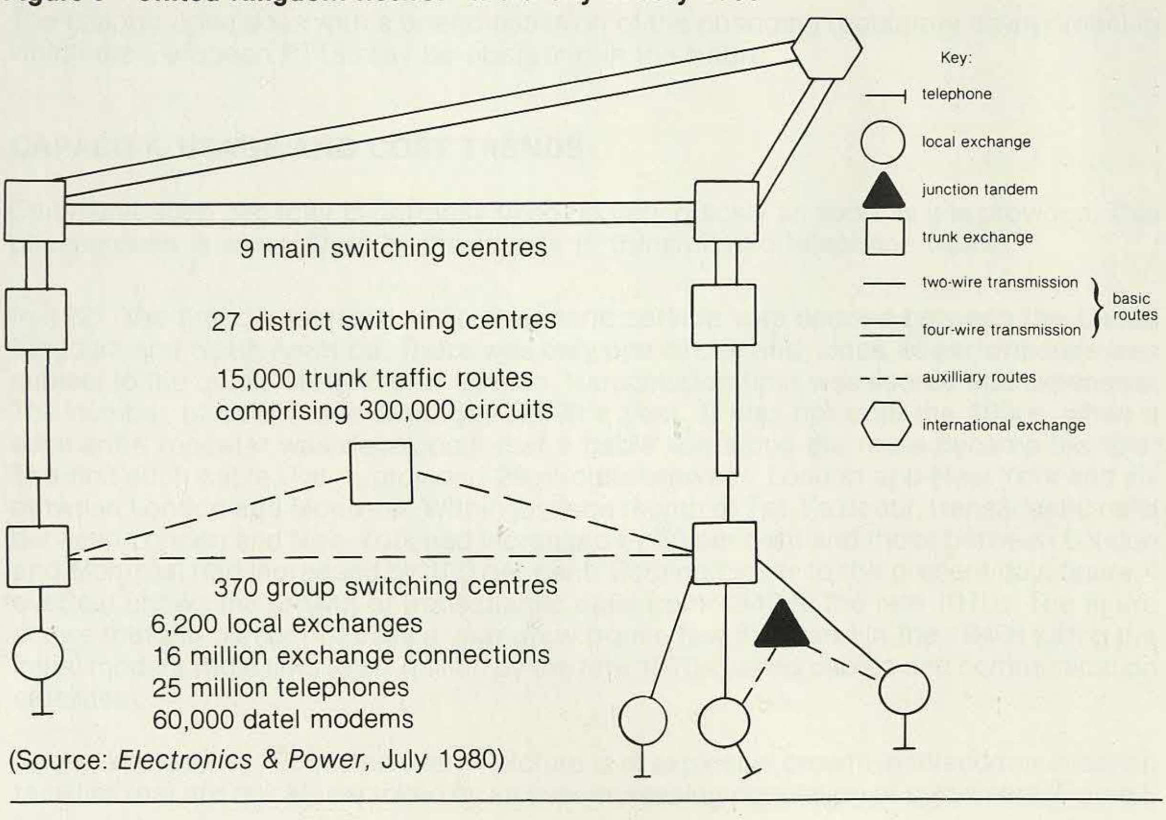
FORWARD	BACKWARD
Circuit seizure	Congestion, blocking and unblocking
Called number	Proceed to send and acknowledge
Calling number	Called subscriber class of service
Nature of circuit indicator	Called subscriber line state
Echo suppressor/transmission pad requirement	Called subscriber answer
Forward transfer	Charging and metering
Coin box signals	Coin box control signals
Service required	Call trace
End of signal indicator	Release guard
Clear forward	Clear backward and forced release

In manual systems, supervisory signalling was carried out mainly by keys and flashing lamps, and register signalling was carried out by the spoken word. The same circuits were used both for speech and for signalling. Later designs incorporated a by-pass signalling route known as order wires and, with the advent of automatic exchanges, signalling was then carried out over the speech circuit by means of controlled breaks in the D.C. pulses and by polarity reversals. Common control exchanges provided even more facilities, and D.C. pulse signalling became too slow for register signalling and was replaced by multi-frequency tones. Modern electronic exchanges control the switching by using a high-speed processor, and it is much more efficient to provide a common data channel between the controlling processors of adjacent exchanges. This common two-way channel provides the signalling for many speech circuits, and its use is known as common channel signalling. The benefits of common channel signalling are as follows:

- It separates the transmission of signals both from the transmission of speech and from the switching functions.
- It allows the existing bandwidth to be used for a faster signalling rate.
- It provides greater flexibility to accommodate future changes.
- It provides cost savings for large groups of speech circuits.
- It reduces the number of relay sets that are required per voice channel.

In addition, if pulse-coded modulation (that is, digital) transmission techniques are used, it is even easier to select one of the inter-exchange channels for processor-to-processor signalling. Such a channel will operate at 64k bit/s compared with the usual 2,400 bit/s common channel signalling used on an analogue network. The standards for common channel signalling at 64k bit/s are described in CCITT Recommendation No. 6. The additional bandwidth is used, for example, to provide better error control.

Figure 3 United Kingdom network hierarchy in July 1980



(Source: *Electronics & Power*, July 1980)

THE STRUCTURE OF A NATIONAL TELEPHONE NETWORK

To understand the full significance of the many changes that are occurring in the technology of telephony, it is necessary first to examine the structure of a typical national telephone network. Figure 3 (on page 7) shows such a network hierarchy.

The figure shows that telephone subscribers' apparatus is connected (directly or through a private exchange) to a local exchange. The local exchanges are connected in turn to trunk exchanges (known as group switching centres). In this national network, each trunk exchange serves about 150 local exchanges. Depending upon the volumes of traffic, these trunk exchanges may be interconnected by direct routes. The hierarchy above the group switching centres consists of a transit network of district switching centres and interconnected main switching centres.

The economics of the whole network is complicated by the fact that the transit network often provides a high proportion of the total routeings within the network, including those rarely used, but it carries only a small proportion of the actual trunk calls.

CHAPTER 3

THE CHANGING VOICE COMMUNICATION INDUSTRY

In this chapter we give an overview of the substantial changes that the voice communication industry is experiencing or will experience in the foreseeable future. We begin with a review of trends in communication capacity, in the usage of communication facilities and in the cost of using those facilities. Next, we emphasise that reliability of service is of paramount importance, and we outline ways in which reliability will be improved during the 1980s. We then review the types of facilities and features that the emerging digital networks will make possible.

Telecommunication is, by its nature, a worldwide industry, and the telephone system that an individual country can afford will to some extent depend on the success of its suppliers in world markets. We therefore next discuss the changes that are likely to occur in the world market for telecommunication products during the next decade.

The longest section of this chapter (which begins on page 16) is concerned both with the expanding range of voice communication products and with the suppliers of those products. The products mentioned have been chosen to give an indication both of the range of choices open to customers now and in the near future, and of the range of decisions likely to be faced by telephone managers. The management responsibilities associated with these decisions are examined in chapter 8 of this report.

The chapter concludes with a brief discussion of the changing regulatory environment in which the European PTTs may be operating in the future.

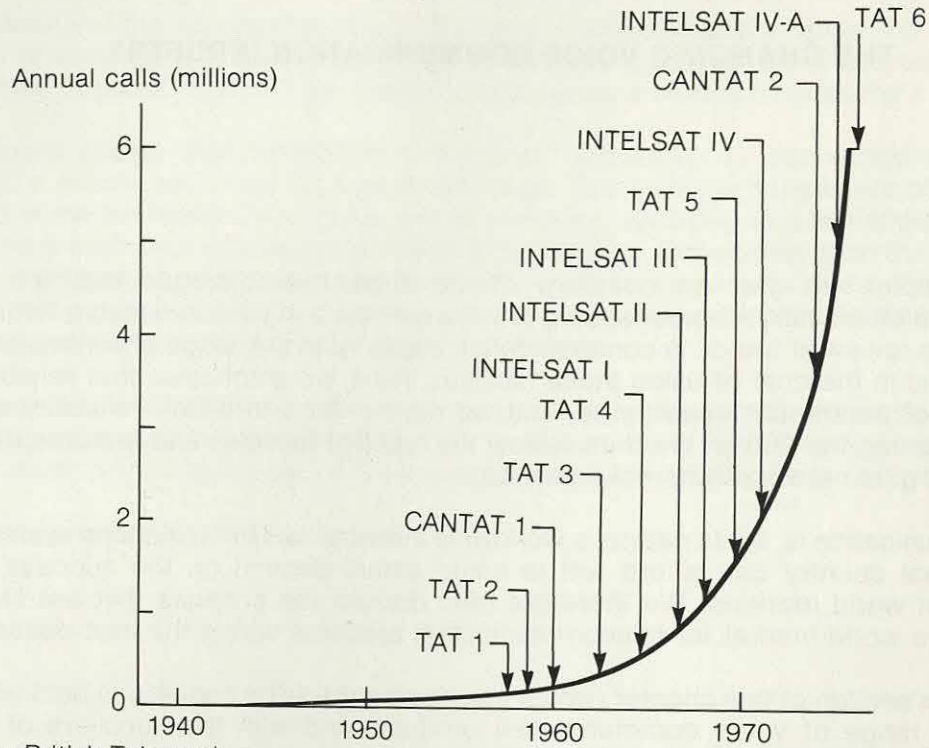
CAPACITY, USAGE AND COST TRENDS

Communication capacity is normally used up very quickly as soon as it is provided. This phenomenon is exemplified by the growth in transatlantic telephone traffic.

In 1927, the first commercial radio telephone service was opened between the United Kingdom and North America. There was only one circuit and, since its performance was subject to the quirks of radio propagation, transmission time was scarce and expensive. The number of calls made averaged 2,000 a year. It was not until the 1950s, when a submarine repeater was developed, that a cable line along the route became feasible. The first such cable, Tat 1, provided 29 circuits between London and New York and six between London and Montreal. Within just one month of Tat 1's debut, transatlantic calls between London and New York had increased by 50 per cent and those between London and Montreal had increased by 100 per cent. Coming closer to the present day, figure 4 overleaf shows the growth of transatlantic calls from 1940 to the late 1970s. The figure shows that the number of calls a year grew from a few thousand in the 1940s (using the initial modest radio link) to six million by the late 1970s (using cables and communication satellites).

Today, in the early 1980s, the overall picture is of explosive growth in telecommunication facilities that are quickly exploited by an ever-increasing population of customers. Figure 5

Figure 4 Growth of transatlantic telephone calls from 1940 to the late 1970s



(Source: British Telecom)

shows for selected countries in Continental Europe the growth from 1970 to 1979 both in their population of telephones and in the resulting number of domestic calls.

To any telephone administration or communication equipment supplier this explosive growth is a comforting picture. It ill accords, however, with the reality of a business customer kept waiting inconveniently long for leased circuits or of a domestic customer on the waiting list for a telephone. In the context of the rapid expansion of facilities across Europe, acute shortages of some facilities show how difficult it is to balance supply with demand. But these shortages also reflect the enormous capital investment that administrations must make if they are to keep pace with the forward march of the voice communication industry. One European PTT recently calculated that, although labour costs accounted for over 75 per cent of total costs in its postal business, the equivalent figure was only 41 per cent in its telecommunication business. For its postal business, capital investment accounted for only 3 per cent of total costs. In one year of account (1979), the net capital assets added to the telecommunication balance sheet were nearly 30 times those added to the postal business.

Many telephone users have a distinct and understandable impression that telephone costs are always rising. In cash terms they may be right, but the relative cost of telephony is declining quite sharply. Figure 6 (on page 12) shows the cost of transmission (as a percentage of annual communication charges) since the end of the Second World War, forecast to 1985. Although the decline in the relative costs of the components of voice telephony has been impressive, there remain opportunities for further cost reduction. Some of these opportunities will flow from the further technological advances described later in this report. Others will result from the better use of telephones within the users' own installations — from the use of automatic call distribution systems, for example, or from better private exchanges, or (in some cases) from the use of professional telephone services.

Figure 5 Telephone populations and the number of domestic telephone calls

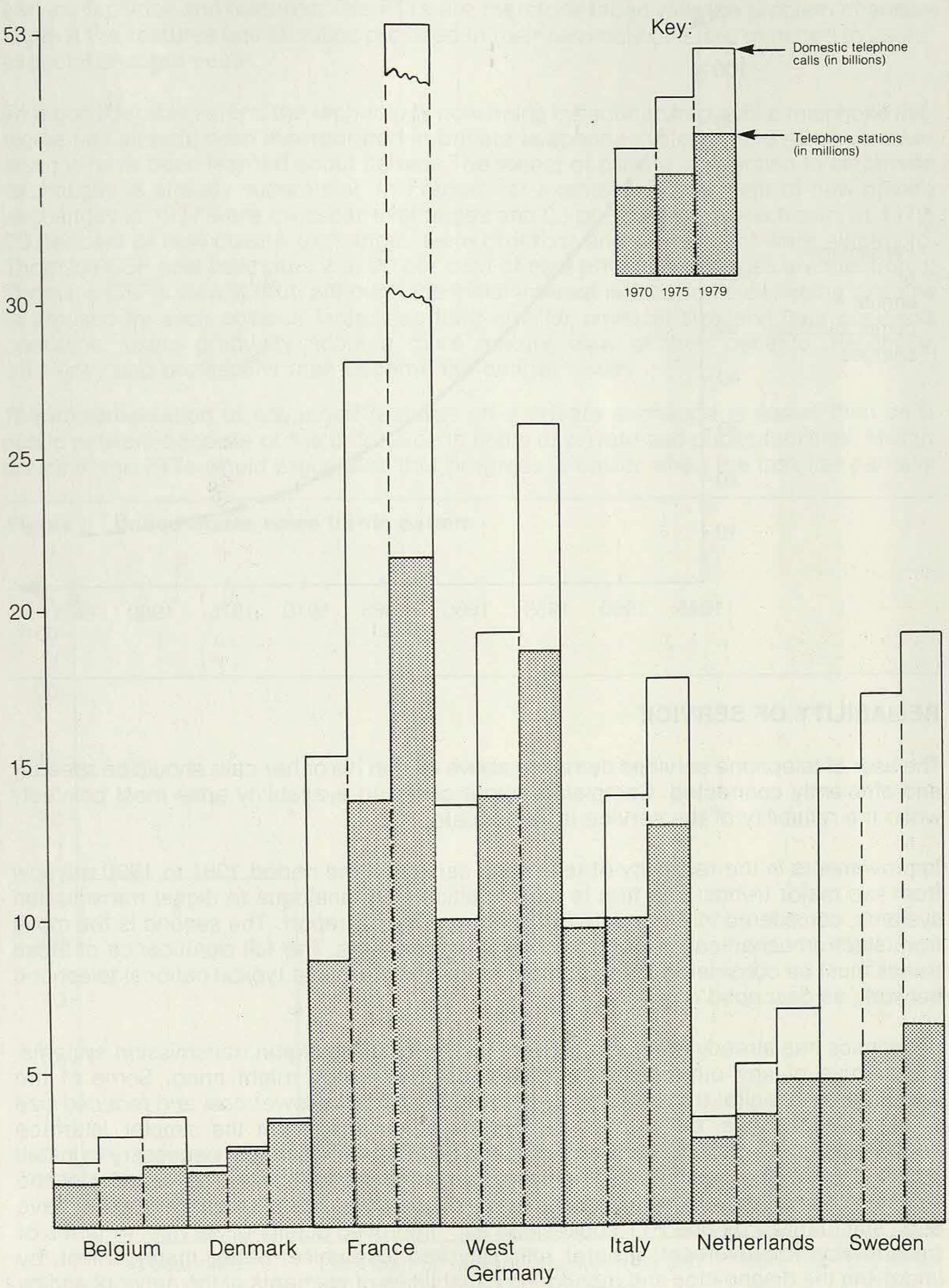
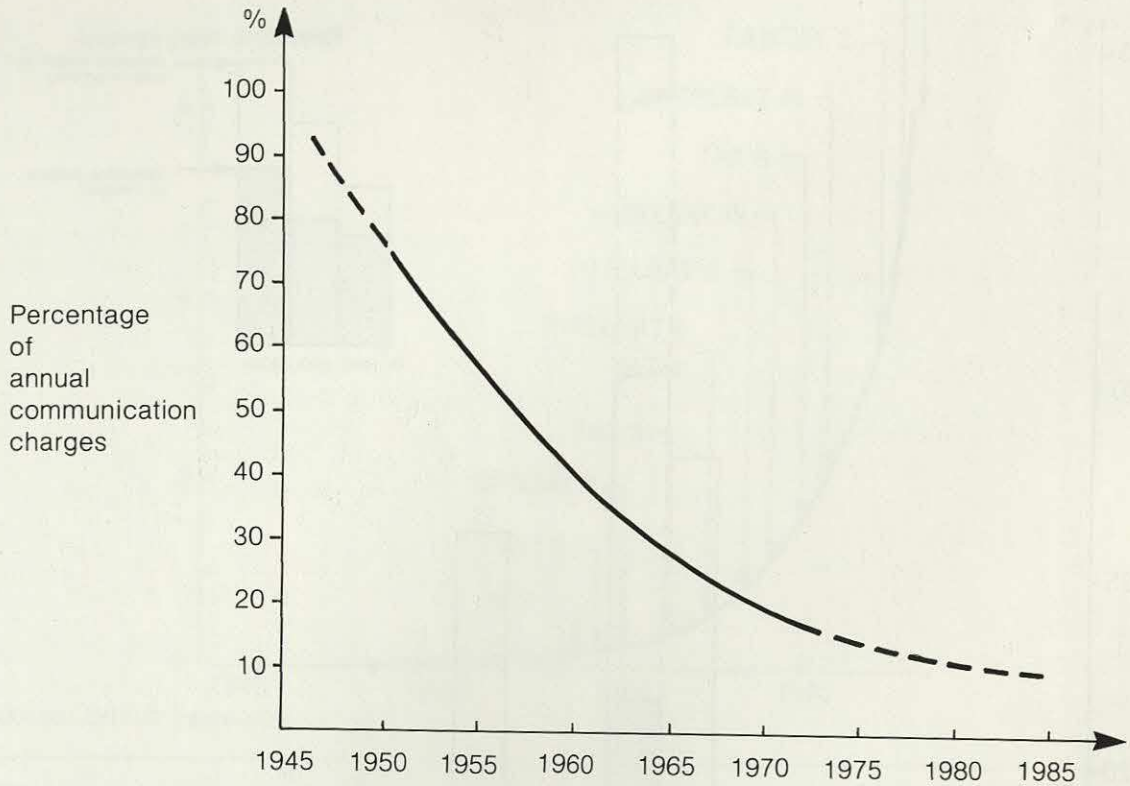


Figure 6 Relative cost of transmission since the end of the Second World War



RELIABILITY OF SERVICE

The user of telephone services demands above all that his or her calls should be speedily and efficiently connected. Complaints about cost and availability arise most pointedly when the reliability of the service is inadequate.

Improvements in the reliability of telephone service in the period 1981 to 1990 will flow from two major trends. The first is the transition from analogue to digital transmission systems, considered in more detail in chapter 4 of this report. The second is the move from electromechanical to electronic switching systems. The full significance of these trends must be considered in the context of the structure of a typical national telephone network, as described on page 8.

Economics has already created a powerful case for using digital transmission systems, irrespective of any other benefits that digital technology might bring. Some of the advantage of a digital transmission system comes from the lower cost and reduced size of digital exchanges, but part of the benefit stems also from the simpler interface between pairs of switching units and from the fact that it is no longer necessary to install separate signalling equipment or channel-termination equipment. The benefits of the digital networks and electronic exchanges now being planned around the world have been summarised by one PTT spokesman as: "Improved quality of service, in terms of transmission improvement; greater reliability and less noise; better management, by improving the diagnostics and monitoring capabilities of elements of the network and by enabling changes to be made from a keyboard instead of with a soldering iron; and new supplementary services".

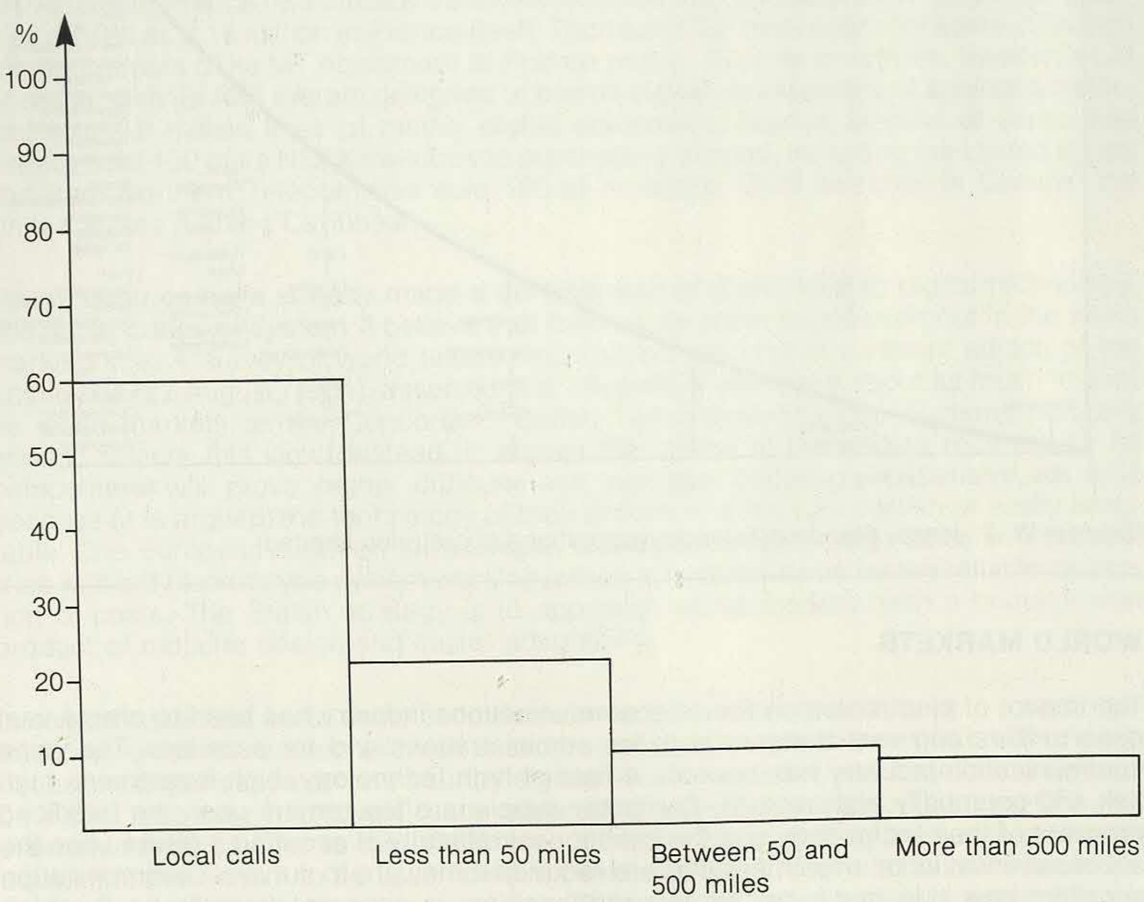
SERVICE FACILITIES AND FEATURES

The digital networks that most countries are now installing can provide a wide range of service facilities and features. The PTTs are therefore faced with the problem of ensuring that the features and facilities provided in their new networks are matched to users' expectations and needs.

To a considerable extent, the technology now being introduced into public telephone networks has already been incorporated in private telephone systems, and some valuable lessons have been learned about its use. The extent of private conversion to electronic exchanges is already substantial. In France, for example, 77 per cent of new private exchanges in 1977 were crossbar exchanges and 23 per cent were electronic. In 1979, 20 per cent of new private exchanges were crossbar and 80 per cent were electronic. Thomson-CSF now estimates that 90 per cent of new private exchanges are electronic. Thomson-CSF's view is that, although the initial interest in electronic switching systems is aroused by such obvious factors as their smaller physical size and their noiseless operation, users gradually adopt a more mature view of their benefits. Reliability, efficiency and profitability then become the central issues.

The implementation of advanced features on a private exchange is easier than on a public network because of the difference in scale of private and public facilities. Malign critics of the PTTs would argue also that progress is easier when the task lies partially

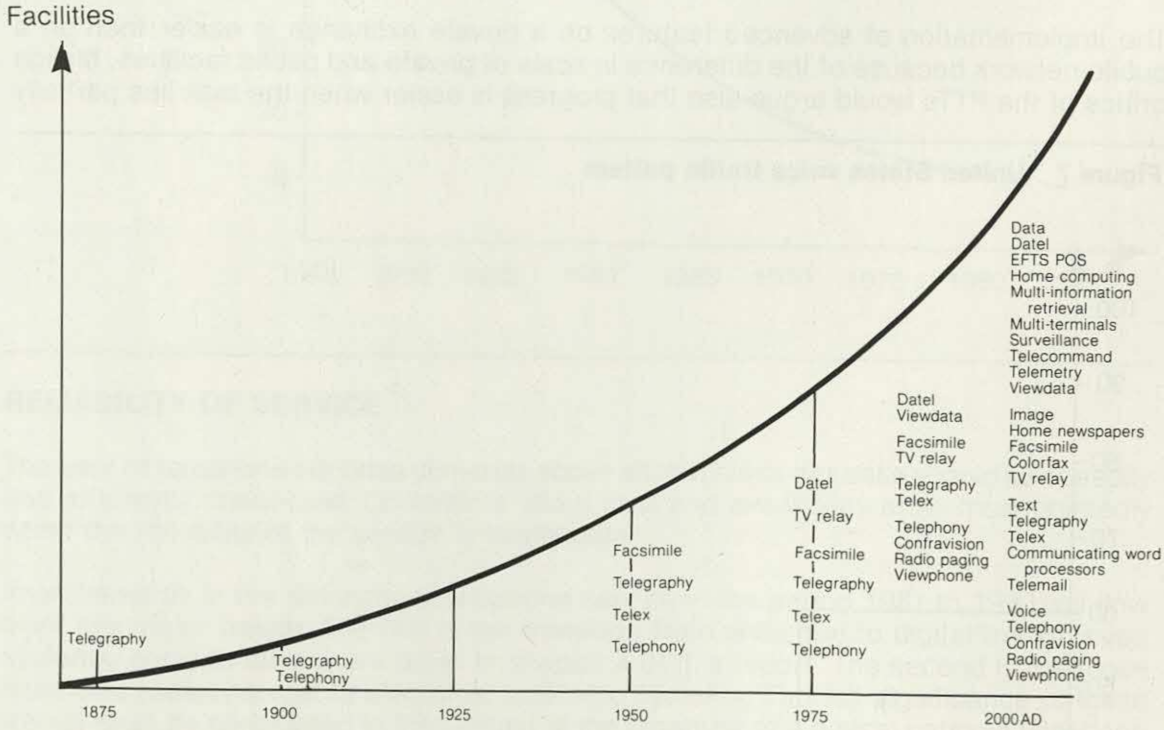
Figure 7 United States voice traffic pattern



outside the domain of the administration. But the main reason is the pattern of voice traffic in business. Even in the United States, where a single continental economy exists, the pattern for voice traffic shows a surprising parochialism, as figure 7 (on the previous page) illustrates. This traffic pattern means that many large organisations can provide for themselves at a single site the well-known features of the stored program control exchange in advance of such facilities becoming available on the public network. These features (which are described in some detail in Foundation Report No. 9) include call transfer, conference calls, call barring, follow-me, camp-on and abbreviated dialling.

Looking to the future, one view of the next range of facilities likely to be offered to telephone users is that these facilities will be inextricably linked with the evolution of local-area computer networks. The fundamentally parochial pattern of business traffic, it is argued, means that the dominant suppliers of private exchanges will be those who can offer computer hardware and communications as part of a coherent system. We discuss the role of local-area networks in more detail on pages 48 to 50 of this report.

Figure 8 The accelerating demand for telecommunication facilities



(Source: W. T. Jones, Standard Telecommunication Laboratories Limited)

WORLD MARKETS

The impact of electronics on the telecommunications industry has been to create vast opportunities and vast dangers both for administrations and for suppliers. The voice communication industry has become a field of high technology, high investment, high risk and potentially high reward. Computer suppliers often remark upon the headlong progress of their technology and the consequent difficulty of securing a return upon the successive waves of investment that are required if they are to survive. Communication suppliers now ride much the same switchback, as is apparent from figure 8, which shows the growth in facilities from 1875 to 2000.

Because the necessary investment in a modern telephone system is, on a national scale, so vast, much of the progress that an individual nation can achieve depends upon its ability to create export markets for its technology. In this way the huge investment is spread over a greater run of products. In 1980 the world market for telecommunications products totalled $40 billion, and the telephone service that each major country will be able to afford will depend to some extent on its success in this huge market over the next decade or more. Sales teams from the United States, Canada, Europe and Japan will be competing fiercely for multi-million-dollar contracts, and they will receive active support from their national governments and from their telephone administrations.

In Britain, for example, a sales and marketing organisation called British Telecommunications Systems has been jointly established by British Telecom, GEC, Plessey and STC to seek overseas sales for System X. The aim is to designate one of the three suppliers as the lead contractor for each possible sales zone and to co-ordinate these efforts through a small but highly qualified central staff. British Telecommunications Systems hopes that its market entry is well timed, because its technology is planned to leapfrog that of rivals already in the field with first-generation systems. They hope, in other words, that substantial rewards will be gained by bringing a better product to markets that have already been activated by the pioneers. In this way it is planned to remedy the drop in world sales that Britain's telecommunication export companies suffered between 1963 and 1975, when their share dropped from 25 per cent to 13 per cent.

The task of British Telecommunications Systems is a formidable one, because of the progress that suppliers from other countries have already made. For example, by 1980 CIT-Alcatel in France had already sold over 600,000 line equivalents in 18 foreign countries as well as 2.16 million in France itself. Thomson-CSF had orders for some 22 million line equivalents of its MT equipment in France and in 15 other countries. Sweden's LM Ericsson, with its AXE system designed to permit digital replacement of analogue traffic, had sold 1.6 million lines of mainly digital equipment. Nippon Electric of Japan had already sold 150 of its NEAX switches to purchasers abroad, including the United States and Iraq. Northern Telecom had sold 160 of its digital DMS switches in Canada, the United States and the Caribbean.

Many countries have already made a commitment of some kind to digital technology, and some critics of System X believe that there is no room for newcomers in the world marketplace. A survey of world telecommunication markets in a recent edition of the *Economist* (22 August, 1981), asserted that "System X will make about as much impact on world markets as the Concorde". British Telecommunications Systems naturally enough rejects this view. Instead, it argues that some of the orders received by its competitors will prove highly difficult, and perhaps cripplingly expensive, to fulfil because (it is argued) the technology of their products is not fully proven or easily adaptable. One European supplier, for example, is alleged to have made sales in five countries with only a prototype system working, which is hardly a basis for the reliable estimation of costs. The British strategy is to approach world markets with a home-proven product of modular design and easier adaptability.

In a volatile political world some countries with an ostensible commitment to a particular telecommunication system will wish to secure second or more sources, in order to avoid excessive dependence on one country's goodwill. Commercial and negotiating flair will be called into play to subvert many apparently settled situations. Thomson-CSF, for example, made its offer to the USSR more attractive by arranging for 1 million lines of equipment per annum to be assembled in Soviet factories. There is bound to be scope for similar agreements in other countries. Time and the order book will determine the national winners and losers in this global sales war.

In the ever-changing world market for telecommunication products only two things are certain. First, the explosive growth of world markets in telephony over the next decade or more will mean that surprises are in store, and the markets will develop in unpredictable ways. Who, for instance, will make the best showing in the Chinese market? A country with 900 million people and only 5 million telephones is far from trivial. The second indisputable fact is that those countries whose suppliers fail in the world market will have domestic telephone systems that are worse and/or more expensive than the systems of other countries.

PRODUCTS AND SUPPLIERS

In this section of the report we illustrate the changes that are taking place in the voice communication industry by examining the strategies and the products of several suppliers. Many of the products indicate that computerised branch exchanges are developing rapidly into products that perform far more than their traditional telephone switching role. New functions are being added and users are being encouraged to exploit the growing power of the exchange.

One of the most powerful arguments put forward by the advocates of greater competition in the European telecommunication market is the more advanced state of communication technology in the United States, which, they believe, has developed as a direct result of the greater openness of the United States market. Others argue that it is the sheer size and homogeneity of the United States market that has created America's strength in this area. Whatever the cause, United States homogeneity in telecommunication technology is a fact of life, and this is reflected in the products cited in this section of the report.

We emphasise that reference to a specific product within these pages is in no sense an endorsement or recommendation of that product. The products have been chosen because they suggest interesting lines of future development, and, more often than not, the choice of a suitable example is arbitrary.

A North American telecommunications company

Many suppliers — and the European administrations — believe that organisations will not make substantial investments in advanced communication systems until top management is involved in communication planning. A North American telecommunications company (designated here as NATC), has a highly distinctive approach to the problem of involving top management. In its market development and product strategy work, NATC has consciously relegated technology to a subordinate level in favour of economic arguments and (most particularly) in favour of human factors. (In many respects, NATC's approach is similar to that taken by IBM when marketing the 3750 PABX.)

NATC has calculated that the capital value of transforming one hour per day of office worker's time from unproductive work to productive work is between $18,000 and $20,000 (based on a five-year depreciation plus accrued interest). Yet NATC believes that potential customers will be prepared to invest perhaps only a quarter of that sum. If NATC is right, the range of office workstations that are now emerging with prices around the $20,000 mark will prove to be an irrelevance in the marketplace.

NATC has developed a prototype voice-messaging system that is designed to appeal to top management by alleviating the manager's problem of disruption by the telephone.

The system, known as Voice Integrated Message System (VIMS), has three elements — an executive terminal, a secretarial terminal and a VIMS operator terminal.

The executive terminal consists of a small CRT, which is used for message reading, and a 20-button extension to the standard electronic telephone. Each of the buttons is a command for handling screen information, and screen prompts are used to help select the appropriate commands. A small thermal printer is also available so that messages can be received without disturbing the executive. The printer can also be used by the executive to obtain a hard-copy of a particular message.

The secretarial terminal consists of a standard CRT display, a typewriter keyboard and a conventional audio cassette recorder that is linked to the telephone. The secretary uses VIMS to take messages, to enter them into the system and to handle responses.

The VIMS operator has two CRT terminals — one similar to the secretarial station and one for use as a standard telephone answering service terminal. Calls are diverted to the VIMS operator either by user commands or as a result of standard PABX transfer or call-barring conditions. When a call is diverted, the exchange passes the called number to VIMS so that the user's answering instructions are displayed on the CRT screen. For most calls, control is passed to an audio recorder, and priority calls can be recorded on a fresh cassette that is then ejected for priority treatment.

Between handling calls, the VIMS operator transcribes the messages that were previously recorded. Each transcribed message is then routed to the appropriate executive terminal, where either it is displayed (with a non-disruptive beep and a flashing light indicating its arrival), or it is printed to await attention.

VIMS is in trial operation in a department of some 40 users. NATC claims that VIMS has resulted in fewer meetings, better communications, the virtual disappearance of the office memorandum, more working at home with portable terminals and improvements in productivity. Well within the time frame of this report, NATC will introduce integrated messaging systems into its product line, and these systems will be based on the VIMS experience that it is currently gaining.

The IBM Corporation

IBM is pursuing two parallel policies in the area of voice telephony, although its most highly-publicised venture in the United States (Satellite Business Systems Inc.) was not intended originally for voice communication. In Europe, IBM has focused its attention on terrestrial switching in the form of the 3750 and 1750 PABXs. These devices provide the usual PABX facilities such as conferencing, abbreviated dialling, call hold and call transfer, camp-on, follow-me and traffic analysis.

For the future, the most interesting addition to the initial repertoire of these PABXs is the Integrated Network System (INS), which permits advanced user functions to be extended throughout a whole network of such switching systems. INS permits register signalling between PABXs over a variety of 2-wire and 4-wire tie lines. This signalling provides faster call set-up times, tandem switching and alternative tie-line routeings.

IBM also intends to market products that are designed to improve the productivity of the telephone user. The inadequacies of conventional methods of handling telephone calls have been well documented and need not be repeated here. An IBM survey of one of its customer sites found that, as a result of these inadequacies, top managers spent 14 per cent of their time on the telephone. IBM recently announced details of its Audio Distribution System (ADS), which is designed to alleviate this problem.

The ADS is based on a Series 1 computer, and, compared with voice message systems from other suppliers, it has several unique features. IBM has placed particular emphasis on the user interface, and this emphasis reflects the extensive experience within IBM of using the experimental Speechfile voice message system. The features of the ADS include the following:

— Message recipients are addressed alphabetically by name. The system confirms the addressee as soon as sufficient key depressions have been made to identify the name uniquely.

— Pauses in recorded messages may be reduced significantly when they are played back.

— The ADS guides the user in the use of the system by playing back appropriate messages from the hundreds of pre-recorded prompt messages. Many of these messages are context-sensitive, and the messages are played back slowly for inexperienced users, but may be speeded up for users who are more familiar with the system.

— The system provides positive confirmation of user commands.

— The command codes are mnemonic.

— The listener may control the rate at which a message is played back.

The initial version of the ADS has 500 million bytes of storage and it is limited to ten line interfaces and to about 1,000 users. IBM describes the ADS as a "principal support system". In other words, it is designed to provide a communication system for managerial or professional peer groups. IBM appears to have selected these specific groups for its first venture into the voice message market, and the ADS has been designed to both address and test that market. The ADS should therefore be seen as an in-depth market venture by IBM rather than as the more typical broad-brush approach that addresses a wide range of messaging needs.

Products that increase the capacity of private circuits

Most large organisations now use private telephone circuits, and the problems of extracting full value from those circuits without impeding the flow of business are substantial. However, products based on the TASI (time assignment speech interpolation) principle are now available that permit customers to extract added capacity from their private circuits. TASI (which was introduced on the public transatlantic routes in the early 1960s) connects the speaker to the circuit only while he or she is actually speaking.

During a normal telephone connection, one party speaks while the other listens, and thus, at most, only 50 per cent of the channel capacity is employed. The TASI system enables the capacity of a group of circuits to be doubled by allowing one channel to be shared by several connections.

TASI relies on a channel being available for use very soon after the resumption of speech. On public networks, where the number of channels is very high, there is little danger of a channel not being available. On private networks, where the number of channels is more limited, TASI has only recently become feasible as advancing technology has made it both cheaper and more refined. One TASI system (the COM 2 from Storage Technology Corporation) has been developed for use on groups of trunk circuits ranging from five to sixteen circuits. Products such as this and the recently announced PLC-1 from Northern Telecom now bring speech interpolation technology within the reach of private organisations. According to reports from users of such systems, speech quality is not affected. For example, one large insurance company in the United States reports that there is no noticeable difference between interpolated lines and other private circuits.

Products that increase the level of telephone service

For many organisations the telephone represents the first contact with customers or potential customers. The level of telephone service is therefore of paramount importance to such organisations. Telecommunications suppliers are well aware of this market opportunity and they have responded with products designed to improve the level of telephone service without a proportionate increase in costs.

One example of products of this type are the automatic call distribution systems that use computer-based methods for connecting incoming calls with sales agents or inquiry staff. Automatic call distribution systems guarantee an even distribution of work among the agents while also providing managers with useful information about the effectiveness of the telephone service. We now examine briefly two examples of such systems — the Rolm ACD (which operates as an adjunct to the Rolm CBX switching system) and the Datapoint Infoswitch.

1. Rolm ACD system
   The Rolm ACD system offers three types of telephones for use at agents' desks. The first is a standard handset with an optional call-waiting light. The second is a keyset with six or ten function buttons. The third is a full agents' terminal with an LED message and display unit, LED status lamps and a digital keypad. This full agents' terminal is recommended for high-value sales operations. All three telephones, however, enjoy the full range of PABX facilities provided with the CBX. Data concerning the overall performance of the telephone service can either be displayed on a screen or printed as a permanent record. This data can be used in deciding whether to increase or decrease the number of agents and/or the number of telephone lines.

2. Datapoint Infoswitch system
   The Datapoint Infoswitch system (which is functionally similar to the Rolm ACD) has the following features:

   — A short recorded message (which is not heard by the caller) tells the agent the city of origin of the call.

   — A console light tells the agent when a call is in the queue, and the light flashes when a call has been waiting for longer than a prescribed time.

   — A function button, which the agent uses to call the supervisor for assistance. The supervisor can then monitor the call or intervene in the conversation.

   — A panic button that the agent uses to alert the supervisor to an awkward or a threatening call, and that (optionally) records the call.

   — The automatic transfer of long-waiting calls to a standby group.

   — A wealth of information is provided that can be used by the supervisor for minute-by-minute management of the telephone answering service.

Datapoint claims that, compared with other systems, Infoswitch provides management with better network planning data, better staff control and better knowledge of the level of service that is actually being provided.

Telephone answering services

Many organisations will in the future have to choose between using better technology to improve their own in-house telephone performance, or subcontracting their telephone interface with the outside world to a professional answering agency. Many companies are instinctively hostile towards answering agencies, because they feel that only their own employees can provide customers with the desired reception. However, there is mounting evidence in the United States that suggests that technology can now overcome this objection, and in Europe the first attempts to exploit that same technology are now being planned. A second objection often heard in Europe is that the high-technology answer to providing a telephone answering service is not applicable to small groups of users, whether they be small companies or small offices in a large company. We believe that these objections are not valid, as the experience of the United States shows.

In the United States there is a highly successful Telephone Answering Service (TAS) industry, with services being provided by between 4,000 and 5,000 companies. TAS subscribers in the United States in 1980 totalled some 1.25 million users, of which about 80 per cent were commercial and business customers, about 20 per cent were medical services and less than 1 per cent were private or domestic users. Nearly 10 per cent of TAS subscribers have their own trunk lines terminating at the TAS centre, and secretarial lines account for some 90 per cent of the TAS users.

The American TAS industry is in the process of rationalisation, with the larger bureaux buying the smaller ones and replacing their operations with a concentrator. The industry believes that automation (in the form of automatic call distribution systems) is profitable in a bureau with four or more positions, of which there are more than 1,000 in the United States. But it is sceptical of the value of advanced features such as online storage of customer data and the use of keyboards to replace paper messages.

The United States evidence suggests that advanced call handling equipment, whether of the conventional automatic call distribution type or the more ambitious Delphi Delta type, can equip operators to deal with incoming calls in a manner that lacks nothing in precision and relevance of information. In fact, to have built the industry that now exists in the United States the professional answering bureaux must perform better than in-house operations. The evidence also suggests that professional telephone answering services can appeal to large and small customers alike.

In Europe, the incentive for the development of telephone answering services lies not only with firms who might provide such services profitably, or with customers who might obtain better telephone service at equal or lower cost and with less management effort, but also with the PTTs. On page 21 we identify the PTTs' major problem as the need for high capital investment in new plant. As a consequence, whilst the PTTs struggle to convert from the old technology to the new technology, they need to obtain the maximum utilisation from their existing investments. Unanswered calls are a plague to the PTTs since they consume plant and line capacity but produce no revenue. (In Britain alone in 1979 there were nearly 500 million non-effective calls.)

We believe that there is a market for telephone answering services in Europe, and that the PTTs must face the short-term need to encourage its growth. TAS bureaux need facilities that only the PTTs can supply, such as incoming lines, key-and-lamp units, and manual extensions.

There is, however, a critical difference between the communication environments in the United States and in Europe. The viability of the United States TAS industry depends on the availability of remote concentrators. Any bureau, even the small ones, can thus seek customers whose local exchanges are spread over a wide geographic area. Incoming calls to a large number of subscribers are intercepted and diverted to the bureau via a small number of leased lines. Remote concentrators thus provide a cheap link between the bureau and its customers who may be served by different local exchanges. On average, each TAS bureau is connected to three remote concentrators, and in this way the commercial catchment area of the bureau is widened. It is not yet clear what short-term answer the European PTTs will proffer to meet this need, though a major announcement by at least one PTT is known to be imminent.

THE CHANGING REGULATORY ENVIRONMENT

In the preceding section of this chapter we have shown that the supply industry is not short of innovatory products, and that users have a healthy interest in these products provided they can see how to save or make money from them. Before these innovatory products can come into widespread use in Europe, however, several changes will need to take place. Most of these changes are concerned with the policies of the European PTTs, and in particular with the need for the PTTs to provide services that are commensurate with the growth of the voice communication industry.

The telephone answering service industry provides a clear example of the way in which the European PTTs are unable to meet the needs of potential bureau operators. TAS bureau operators in Europe told us that the average lead time to provide a new customer with a full secretarial answering service is between six and nine months. This lead time is based on estimates for the installation of operator-controlled call-transfer facilities or private external extensions. East Coast American TAS bureau operators can provide the same service within 24 hours.

Such a comparison is totally unfavourable to the PTTs in Europe, and it is unacceptably glib unless it also takes into account the severe investment difficulties faced by many of the European PTTs. They provide services more slowly not because they wish to, but because their capital funds do not permit them to do otherwise. The dilemma of the PTTs has been precisely summarised by one PTT spokesman as follows:

"Telecommunications development will advance further in the next decade that it has in the whole of the previous 100 years. The current pace of change of technology and service opportunities in telecommunications is unprecedented. The period of exploration and slow advancement, which follows the birth of most new fields of endeavour, is over and we have entered into an era of ever-accelerating change. It will be a period of great excitement for those wrestling with the problems of bringing new technology to bear. It will also be a period of great challenge for those reconciling the need to use the latest technologies as soon as they become cost-effective, with the 20 billion dollars that this PTT has invested in existing telecommunications plant — investment that simply cannot be discarded overnight.

"Advancing technology will open the door to a new world in which the telecommunications networks of many countries will provide the basis for a host of new services and facilities for both customers and controlling administrations."

Many people believe that the way out of this dilemma is to deregulate the environment in which the PTTs operate but, at the present time, the United Kingdom is the only European country that has embarked on a deregulation programme. The basic philosophy of this move is that the inadequacies of telephone service in the United Kingdom stem from the monopoly position of the PTT, and that the dynamic which is evident in the United States telecommunications industry can be generated in a European country by encouraging competition.

The deregulation programme in the United Kingdom has three main elements, which we now describe briefly:

1. Licensing of alternative common carriers
   The Government will license a limited number of alternative common carriers, who will provide completely independent network services. At the time of writing it is not officially known which organisations will receive such licences. Initially perhaps only one licence will be issued, and the most likely candidate is the Mercury Service consortium of Cable & Wireless, Barclays Merchant Bank and British Petroleum.

2. Attaching devices to the public network
   The regulations governing the attachment of devices to the public network will be made less stringent. By making it easier to attach devices to the public network, the government believes that the flow of new terminal devices into the market will increase.

3. Encouraging the development of value-added services
   Value-added network services (such as private packet-switching systems operating on the public network) will be encouraged.

Clearly risks are involved in the pursuit of deregulation. If the rules governing the attachment of devices to the public network are eased, then inadequate or even dangerous products might find their way into the market. Also, suppliers who lack sufficient resources to build a long-term future, might be drawn into the United Kingdom market. In addition, the indigenous communications industry may find its domestic market being penetrated by overseas suppliers, while other countries maintain the same degree of protectionism as has been normal in the past. There are genuine fears that, in a deregulated environment, the technological edge and global reach of American and Japanese companies might be used to saturate the United Kingdom market with cheap products, which will remain cheap only as long as their British competitors survive.

Despite these risks, the British government has judged that the benefits that deregulation will bring are worth pursuing. It remains to be seen whether this British experiment will succeed in securing a wider choice and better value for money for telecommunications' users and, if so, whether the example will be followed or ignored by other European governments. These are large questions which may take a decade or more to answer.

CHAPTER 4

THE TREND TOWARDS DIGITAL TELEPHONY

Until the mid-1960s, all the apparatus connected to telephone networks was electromechanical, and the transmission of calls across the network was based on analogue signalling. Since that time telephone switching systems have been developed that are, to all intents and purposes, indistinguishable from special-purpose computers. In such systems the switching from one circuit to another is controlled by a digital computer. In addition, digital transmission techniques are increasingly being used to transmit 'information' across the network. With digital transmission techniques, there is in effect no difference between a voice call, the transmission of data, the transmission of a facsimile document, or whatever. All these types of information are presented to the network as a stream of bits to be transported across the network.

The first production model of a computer-controlled switching centre (known as No. 1 ESS) was developed by Bell Laboratories and entered public service in the United States in 1965. It was designed to handle a maximum of 65,000 lines and up to about 25,000 calls in the busy hour. Since the advent of the No. 1 ESS, the capacity of computer-controlled switching systems has increased substantially: the systems that entered service in the late 1970s had a capacity of 130,000 lines and could handle up to 240,000 calls in the busy hour. But the entry of digital technology into the public telephone network has had a much wider impact than that of simply increasing the capacity of switching systems. It has also led AT&T, and the rest of the telecommunications world, to define the concept of the Integrated Services Digital Network (ISDN). In this chapter we first review the requirements of ISDNs and the progress that telephone administrations are making in implementing them, and we then discuss the kind of services that might be provided over the digital networks of the future.

INTEGRATED SERVICES DIGITAL NETWORKS (ISDNs)

AT&T defines the ISDN as "a public, end-to-end digital telecommunication network providing for a wide range of user applications". Although such networks are already partially in existence, the overall concept of the ISDN is still sufficiently new and sufficiently flexible to accommodate a myriad of ideas. The shape of the world's future ISDNs will be determined by the decisions that are now being taken about standards, about investments and about regulation.

The main motivating force for the drive towards the ISDN is the search for economies and flexibility. The economies result from the fact that many emerging new services are digital in nature and can be integrated with existing services. It is not possible to predict all the services an ISDN would carry, but the arrangement shown overleaf in figure 9 for connecting a subscriber's premises to the ISDN indicates the way in which the ISDN will provide access to specialist information services and to specialist networks. The key concept is that a digital pipe provides the user with a transport capacity that is measured in terms of a maximum bit rate at a standardised interface. The customer will aggregate the different bit-rate capacities of different types of equipment at a control device that interfaces with the digital pipe. Packet switching or circuit switching will be provided within the same pipe, and control information or signalling information will also be multiplexed in the digital access pipe to instruct the serving centre how to unpack and distribute the total bit stream.

AT&T and other telecommunication administrations are in broad agreement about the general nature of an ISDN, and the functional requirements of the ISDNs now being planned around the world include:

— A variety of data speeds or bit rates.

— A wide range of holding times.

— A wide range of calling rates.

— Economic transport of bursts of data as well as continucus data.

— Customer ability to control costs and services.

— Fast call set-up and clear-down time.

— Low impairment and error rate.

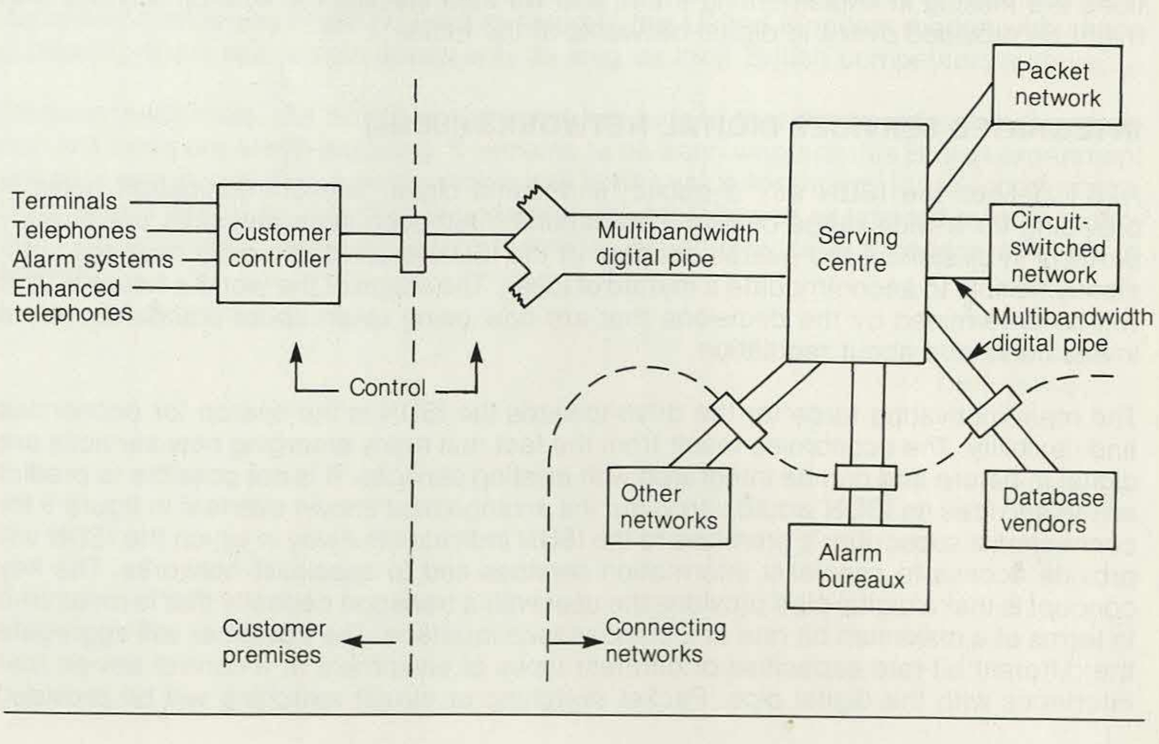
— Low data transfer delay times.

— Various levels of secure transmission.

— A variety of service grades.

When a telephone administration is designing an ISDN, it needs to ensure that the customer/network interfaces are both simple and few. Many and complex interfaces would

Figure 9 ISDN local access arrangements



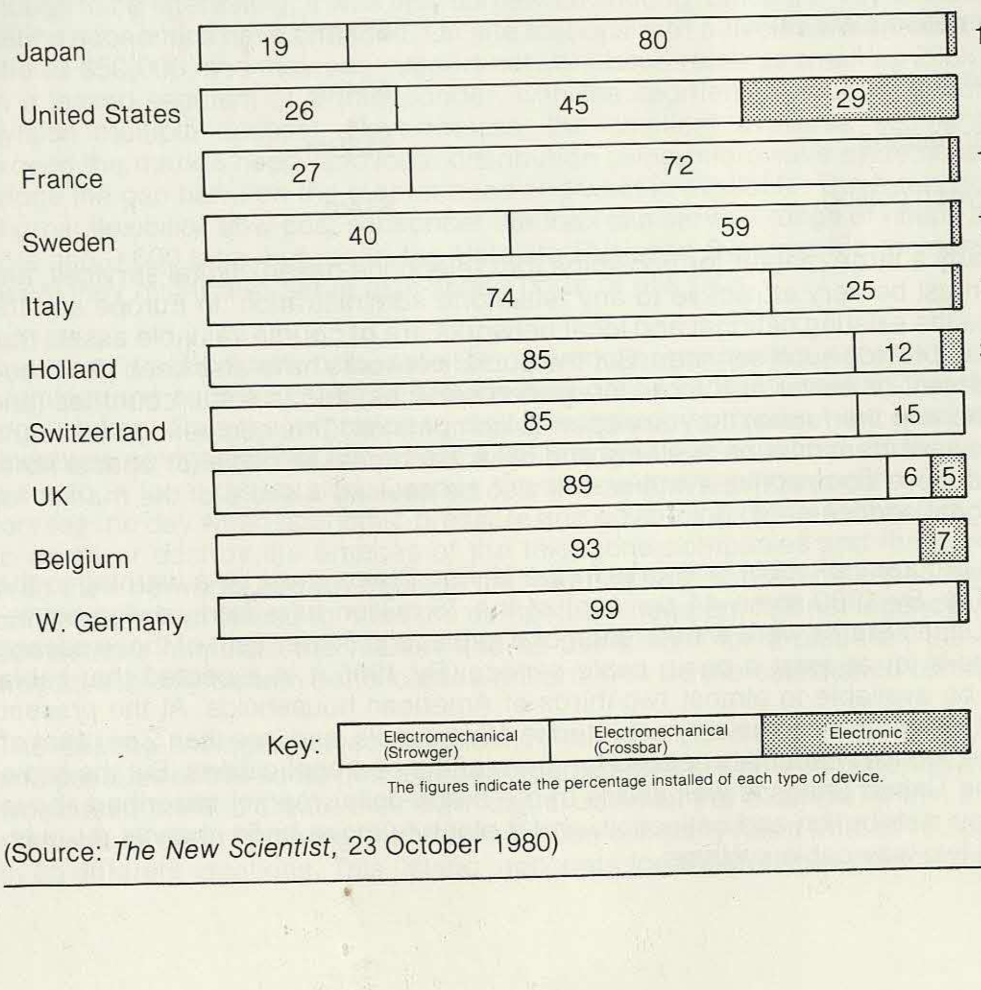
mean higher costs and a loss of flexibility. In the ISDN layout shown in figure 9 the customer controller converts the customer's signals into a standard interface protocol. The customer signals the type of service required, the network itself converts the protocol for transport efficiency and then reconverts it to the original protocol for delivery to the distant interface.

Different administrations may differ about the detailed arrangements for an ISDN, about how an ISDN should be implemented, about the interface definitions, about the speed of network evolution and about the prime services required. Progress towards the building of ISDNs can, nevertheless, be measured by the progress made in digitising voice telephony, because AT&T is confident that voice traffic will, for the foreseeable future, remain the dominant form of communication traffic.

In the United States, substantial progress has been made in digitising the public network. (For example, there are now about 250,000 local loops employing digital technology.) Transmission using lightwave techniques is also a fast-developing digital medium, and by 1984 AT&T expects to have a 1,000-kilometre lightwave system in service on the Boston-Washington corridor. A year earlier a 140M bit/s digital system on the coaxial cable route between Oakland and Chicago is to be introduced, and digital switching to permit alternative transmission of voice and data (at 56k bit/s) over the public network may be available within a few years.

In Europe, progress towards digitising the various national networks is naturally far from uniform. The first European administration to commit itself to digitising its network was the French PTT. A lightwave transmission system is already being used in Paris, and

Figure 10 National progress with introducing electronic switching



(Source: *The New Scientist*, 23 October 1980) after 1983 only digital switches will be ordered throughout France. In addition, an electronic telephone directory experiment (based on the French Antiope standard for videotex) involving some 250,000 terminals is proposed for Ille de Vilaine. In the United Kingdom an ISDN based on the System X family of products is planned, and the PTTs in West Germany, Italy and Sweden are all committed to plans that will involve a greater reliance on digital switching and digital transmission. Introducing a national digital network is a time-consuming and capital-intensive activity. Figure 10 (on the previous page) shows just how much (or how little) has been achieved in several countries.

SERVICES PROVIDED OVER DIGITAL NETWORKS

Most telecommunications engineers are reluctant to commit themselves to hard and fast predictions about the kinds of services that might be provided over the digital networks of the future. One American source, however, forecast the following annual revenues in the United States from extended services based on the telephone:

— Remote controls	\$27m
— Home security	\$202m
— Home shopping	\$39m
— Business security	\$79m
— Home banking	\$66m
— Continuing education	\$135m
— Information retrieval	\$54m
— Cable games	\$54m
— Meter reading	\$139m
— Research polling	\$14m

There is clearly a large market for non-voice (but telephone-based) digital services, and this market must be very attractive to any telephone administration. In Europe and the United States the existing national and local networks are of course valuable assets that can be used to provide such services. But the public networks have also been described as an impediment to newer and more integrated services, and in some countries (and perhaps in more in the future) they are open to competition. This competition takes the form of radiowave transmission systems and broadband coaxial cable (or optical fibre) systems, and these competitive systems will also be seeking a share of the market for non-voice digital services.

The startling progress of cable networks in the United States must be a warning to the European PTTs. By 1980 some 44 per cent of the 76 million television-viewing households in the United States were within reach of a cable, and 50 per cent of those passed were customers for at least a basic cable service. By 1985 it is expected that cable systems will be available to almost two-thirds of American households. At the present time, most of the cable systems are restricted to 12 channels, and less than 2 per cent of them have the two-way capability needed for many of the new applications. But the cable industry in the United States is well aware of the billion-dollar market described above for information distribution and collection, and it plans to move to 54-channel (or even 108-channel) two-way cable systems.

Cellular mobile communication services are also a potential contender for carrying the new non-voice digital traffic. Cellular systems re-use the limited radio frequency bandwidth that is available by transmitting only within a small geographical area. By their nature, such systems are well adapted for providing communications services to mobile receivers (such as those in cars), and statistics suggest that there exists a large potential market for such services. One of the telephone companies in the United States reports that, although 87 per cent of its mobile subscribers are business users, less than 2 per cent of the total market is currently served. Given adequate business justification (and one in four of its customers describe their car-phones as a necessity) the market for mobile services is likely to expand rapidly. (We describe radio transmission techniques in more detail in chapter 6.)

Digital services will also be provided over satellite communication links, and the volume of digital traffic using satellite links will grow dramatically in the next five years. Satellite Business Systems Inc. is the forerunner in providing this type of service, but in 1980 alone authorisations were filed or approved for 24 new satellite services in the United States. Most of these new services were aimed at satellite links between cities 800 kilometres or more apart. Significantly, however, the new satellite-based carriers are being drawn inexorably into competition with the established telephone companies not only for long-haul communications, but for local communications also.

For example, Satellite Business Systems Inc. will use coaxial cable systems or microwave cellular systems to transmit signals between user terminals and a central node (that is, an earth station). The significance of adding local communication facilities such as these to long-haul satellite communication lies in the extra markets that they open up. At the satellite prices of the 1970s the only market open to the satellite carriers was to provide direct delivery services to very large customers. Although this market was large enough to be interesting, it was also somewhat limiting. Since the 1970s, however, earth-station economics have changed. On-site stations with a five-metre antenna now cost as little as $50,000, and they can support network baud-rates as small as 256k bit/s (based on a leased segment of a transponder, with the segmentation being effected by time-division multiple access). Nevertheless, the smallest available segments may still exceed the market need, and local distribution using microwave systems is intended to bridge the gap between the market need and what is available. The total package is one of great flexibility. Low-cost subscriber stations can serve a range of needs between 300 bit/s and 9,600 bit/s, but (as in the Satellite Business Systems Inc. demonstration services) they might also serve high-speed ports of 56k bit/s.

In addition to cable networks, satellite networks or microwave networks, local network architectures such as Ethernet provide new options for information transfer within an organisation. Thus the migration to digital technology provides new competition for the telephone companies not just where it has always been expected, on the trunk network, but also in local distribution. Despite these new forms of competition it is not easy to foresee the day when economic pressure and advancing digital technology will combine to erode or destroy the empires of the telephone companies and the European PTTs. With their networks already in place and offering vast unused potential, the established carriers are well placed to meet the competition head-on. It is not inconceivable that, as competitors stimulate the market and as users fight for a place on the digital bandwagon, the only certain beneficiaries will prove to be the established common carriers.

The existing analogue telecommunication infrastructure cannot be swiftly dismantled, and because of this some of the larger organisations are now considering a strategy that would lead them to create their own 'digital' islands. For example, within a 50-kilometre diameter circle in Pittsburg, the Westinghouse company has a total of 15,000 telephones in 65 different locations. This 'island' accounts for about 15 per cent of the company's employees, and for a much higher percentage of its communications traffic. Westinghouse has placed a $26 million contract with GTE Telenet Systems to convert this zone into a private digital island. The system, to be called Wesdin, will incorporate 20 digital PBXs, 4 tandem/local switches and 16 end-office switches. The main operating features of the Wesdin system include the concentration of operators, least-cost routeing, data transmission facilities up to 56k bit/s and an external link provided by a Satellite Business Systems digital connection. The progress of the Wesdin project will be watched with keen interest both in America and in Europe.

CHAPTER 5

DEVELOPMENTS IN SUBSCRIBER APPARATUS

In chapter 3, we illustrated the overall trends that are occurring in the voice communication industry by describing some of the new products that are emerging into the market. In this chapter we consider in more detail the changes that can be expected in the technology and the use of the most familiar component of a telephone system — the apparently simple telephone handset. For convenience, we have divided the material in this chapter into discussions of European developments and American developments. This division does not mean that the two markets are mutually isolated — indeed, the reverse is the truth.

EUROPEAN DEVELOPMENTS

We begin this section of the report with a review of the progress that is being made in Europe in introducing electronics into telephone handsets (that is, with the progress of the so-called electronic telephone). We then offer a glimpse into the future by describing British Telecom's experimental Pathfinder system. Finally, we provide some pointers to the way in which subscriber telephone apparatus in Europe is likely to develop in the future.

Electronic telephones

The telephone handset is a mass-produced piece of equipment, and it would therefore seem logical to displace its conventional electromechanical parts with standard electronic components. It is rather surprising, therefore, to see how slowly electronic components have been introduced into the handset. The only significant change that has been made to telephone handsets in the last few decades is that the rotary dial has been replaced by push-button signalling circuits (although the rotary dial is still commonly used in Europe). Other components, such as the carbon microphone, the inductive speech circuit, and even the bell, have remained virtually unchanged since the beginning of telephony.

There are two reasons that explain why electronics has not been more widely used in telephone handsets. The first reason is that conventional technology has proved to be highly durable and highly improvable. The second reason is that, until the advent of large-scale integrated technology, electronic telephones were technically feasible but economically unattractive. The declining cost of LSI chips has loosened the economic constraints, and telephone users are now increasingly aware of the benefits that electronic telephones can provide. This awareness has been stimulated by the growing knowledge of the services that can be provided by digital exchanges (both private and public). However, conventional Strowger and crossbar exchanges will continue in use for many years yet, and some of the services that will one day be provided by digital exchanges can be provided today by building 'electronic intelligence' into the telephone handset.

In Europe, a joint team from Plessey, GEC and Philips has studied the design philosophy, technology, features and operation of an electronic telephone. The team determined that the economic key to an electronic telephone is to reduce to a minimum the number of custom chips required to provide the necessary functions. A modular approach is therefore preferred, with the rotary dial and the carbon microphone being the first candidates for electronic replacement.

The rotary dial will be replaced by an electronic keypad that can be used to generate one of two types of signals. The first type replicates the function of the rotary dial by storing the keyed digits in an electronic buffer and then generating the familiar loop-disconnect pulses as if they had originated from a rotary dial. Alternatively, an electronic keypad can be used to generate multi-frequency tone signals, where each digit is represented by a pair of frequencies within the audio band. Unlike loop-disconnect pulses, multi-frequency tone signals can be transmitted across the network and received at the called party's telephone. Such signals can therefore be used (for example) for direct communication of data to a computer.

The carbon microphone can be replaced by an electronic microphone, known as a linear transducer microphone. The advantage of a linear transducer microphone is that it minimises the interference caused by external (and transient) electromagnetic fields, thereby minimising the clicks and bangs associated with the conventional microphones used in telephones today. In addition, with an electronic microphone, a telephone user can accidentally knock the handset against a desk or table without producing a deafening clank in his own ear.

Electronic telephones enable a wide range of facilities to be provided at realistic price levels. As a result, the main problem confronting the telephone suppliers and the PTTs is that of selecting the facilities that telephone users can and will use. We now describe briefly three facilities that electronic telephones are likely to provide.

1. Repertory dialling
   With a repertory dialling feature, an electronic telephone stores a pre-selected set of telephone numbers that can be automatically recalled and dialled. The required number is identified by pressing the appropriate buttons on the existing keypad, and additional buttons are used to initiate the recall sequence and to enter numbers into the memory. A 'try-again' feature can also be incorporated, where, at the push of a button, the telephone automatically re-dials the last number manually attempted.

2. On-hook dialling
   The on-hook dialling feature enables the user to make a call without lifting the handset off of its hook. The dial tone, the ringing tone and the voice of the called party are played back through a loudspeaker.

3. Subscriber unit meter
   The subscriber unit meter is a feature of the electronic telephone that is designed to increase cost-consciousness. A small single-line display is used to show any one of five continuously monitored parameters:

   — The number of charge units logged so far for the current call.

   — The cost of the current call.

   — The number of charge units logged since the meter was last reset to zero.

   — The cost per charge unit for the current call.

— The total cost logged since the meter was last reset to zero.

The telephone user does not have to enter the charge rate because the subscriber unit meter operates in response to meter pulses received from the exchange.

Electronic telephones can also be used to provide enhanced features for the class of systems known as Plan telephone systems (or house exchanges). This class of system lies between the normal residential arrangement (a direct exchange line with one or more extensions around the home), and the sophisticated PABXs of the large business users. Plan telephone systems are used in smaller businesses or in the local offices of large firms, and they vary in size from one exchange line with two telephones to about five exchange lines and ten telephones.

With conventional Plan systems, the most common means of using the facilities provided has been by mechanical key-and-lamp units. Modern telephony now offers a better solution in the shape of the Electronic Plan System, one important feature of which is that each telephone is connected to the central unit by two pairs of cables. (Conventional Plan systems use multi-wire cable, which causes considerable disruption when the layout of the system has to be changed.) One pair of cables carries the speech and signalling information, and the other pair is available for transmitting data between the telephone and the central unit. The data link permits the user to access the central unit's features (such as repertory dialling and on-hook dialling). The link also permits the central unit to signal information about the status of lines and telephones for display on the users' telephones.

British Telecom's Pathfinder system

In the East Anglian region of Britain, about one hundred telephone users are today trying out the telephone of the future. They are a sceptical sample of users, because they are all experts in voice telephony. They work at the British PTT's research centre at Martlesham and their telephone system is known, appropriately enough, as Pathfinder. The Pathfinder system provides a variety of supplementary services, which are accessed by special codes that have been standardised by the CEPT (conference of European PTTs). The codes use the normal 0 to 9 plus two control codes, ★ and #. A service is activated by keying ★ followed by the service's two-digit code, and is concluded by keying #. Literals, such as times or telephone numbers, are marked by keying a further ★.

At present, the Pathfinder system is not very different from a standard PABX. A main objective of the experimental use of the system is, however, to determine the characteristics of the optimum interface between the telephone user and the features that electronics and digital technology can provide. For example, it is known that the use of codes to activate services is notoriously prone to errors. To overcome this problem the user needs to be guided through the control procedure, and the Martlesham experiment has been designed to test the kind of guidance that users prefer. The main danger is that the system may provide detailed guidance where none is needed. To overcome this, there are three possible approaches. The first is to delay the guidance until the user hesitates. The second is to provide the guidance only when it is specifically requested, and the third is to permit the user to override the guidance by simply dialling over it.

The experience gained at Martlesham has shown that users also need to know how the exchange has responded to a service request. This need, together with the need to provide guidance to the user, means that much more information has to be fed back to the user than can be supplied by the normal audible tones. The Pathfinder system uses voice feedback to meet these needs. Because of the speed and the range of responses needed for a telephone system, conventional tape recorded messages are not suitable, and an automatic announcement sub-system has therefore been developed for use with the Pathfinder system. This sub-system uses a large number of identical speech storage segments, which are cycled in synchronism, and individual announcements are assembled from these segments. In this way the telephone system can produce feedback that is very precisely tailored to the user's needs. If, for example, the user dials a wake-up call, the system will read back the exact time requested. There is, however, some evidence that users react poorly to the incurable artificiality of synthetic speech.

As a result of their use of the Pathfinder system, the experts at Martlesham have been able to forecast the range of telephone services that, in the current decade, will need some form of message feedback system. Their forecast is shown in figure 11.

Figure 11 Services forecast to need a message feedback system

Service type	Service description
Short code dialling	Allows the customer to associate a long telephone number with a short code thereby saving him the necessity of entering the full telephone number each time he wishes to make a call to that particular number.
Repeat last call	Sets up a repeat attempt to the last telephone number that was dialled. This service is of particular benefit when a number is found to be engaged upon the first attempt.
Repeat last stored call	Enables the number last dialled to be stored for later use, thereby enabling the user to dial other telephone numbers before making a repeat attempt at the stored call.
Alarm call	Enables the customer to book a call to his own telephone at a specified time. The maturing call can then be used as a reminder or an alarm call.
Incoming calls barred	Enables the customer to bar incoming calls to his telephone.
Outgoing calls barred	Enables the customer to bar outgoing calls from his telephone.
Basic diversion service	Diverts all incoming calls to another telephone.
No-reply diversion	Diverts incoming calls to another telephone if the call remains unanswered for a specifed period of time.
Engaged diversion	Diverts incoming calls to another telephone if the called telephone is engaged.
Call waiting	Provides a means of answering an incoming call when already engaged upon a call.
Three party service	Enables the customer to set up a 3-way conversation on his telephone.
Remote control service	Enables the customer to set up services on his telephone from any other telephone.

(Source: *British Telecom Journal,* Spring 1980)

FUTURE DIRECTIONS IN EUROPE

The foregoing discussion of European developments in the technology and use of telephone subscriber apparatus provides some pointers to the kind of telephone systems that will develop in Europe. We believe that the principal features of the telephone system of the future will be as follows:

- — Telephone instruments will incorporate larger displays than the single-line displays used in some of the experimental systems. These large displays will be used, for example, to show more detailed charge information.
- — The use of microelectronics in the telephone handset has made the cordless telephone possible.
- — The continuing move to digital exchanges (public and private) will make it more attractive to convert from analogue signalling to digital signalling in the telephone instrument itself.
- — Two-way digital transmission over local subscriber cables makes it possible over existing cables either to offer the equivalent of today's four-wire telephone service, or to enhance the voice channel with a simultaneous data channel.
- — Public telephones in the future may be equipped with a powerful separate channel which will be used both for signalling (thereby making many types of enhanced services possible), and for simultaneous data services such as videotex and facsimile.

We have focused our discussion on the appeal of the electronic telephone in the marketplace. However, it must never be forgotten that the telephone of the future must also appeal to the telephone administrations of the world. From their point of view, the most attractive telephone instrument is one that is cheap and has certain functions that make it more usable. The telephone of the future may therefore also incorporate the following features:

- — The ability to detect the type of exchange it is connected to, so that it can generate loop-disconnect signals or multi-frequency tone signals as appropriate.
- — The ability to access the facilities of public digital exchanges by keying a single button on the telephone instrument.
- — The ability to test itself on command from the exchange.

AMERICAN DEVELOPMENTS

In the United States the development of advanced telephone instruments is part of a larger battle in the market for private exchanges. We therefore begin our discussion of American developments in subscriber apparatus by reviewing the development of the market for stored program control PABXs. We then review the classes of telephone instruments designed for use with those modern PABXs, concentrating in particular on the new generation of integrated voice and data telephones.

Stored program control PABXs

In the United States the traditional suppliers of PABXs are finding it hard to keep pace with the developments of some of the newer entrants into the computerised PABX market. Customers are demanding exchanges that support additional functions such as electronic mail, teleconferencing and electronic filing, and that also provide convenient links to data processing files and videotex files. International Resource Development, a market research company, recently stated that conventional suppliers such as Western Electric, GTE and Northern Telecom were losing their market share to the new vendors of enhanced exchanges such as Rolm, Wescom/Rockwell, InteCom (an associate of Exxon) and Mitel. IRD argued that the market for private exchanges is not infinite, but is linked to the replacement of obsolete equipment and the construction of new offices. The PABX market of the middle 1980s is therefore expected to be intensely competitive. The key factor governing choice is likely to be the range of enhanced features and functions provided. IRD also expects that IBM will find this market too attractive to ignore.

Stored program control PABXs began to dominate the market for new PABXs in 1975 following the introduction of Northern Telecom's revolutionary SL-1 switch. AT&T's Dimension and Rolm's CBX and a score of other products quickly followed. The SL-1 and the CBX are both digital devices. Yet the market leader (Dimension) is an analogue device. Many telecommunications experts in the United States find it hard to reconcile Dimension's success with their belief in the inherent superiority of digital systems. Perhaps AT&T's unique position both in the market and in manufacturing volume explains the paradox.

Nevertheless, it is generally agreed that digital PABXs capable of switching both voice and data traffic will be the standard for the future — for AT&T and the rest of the supply industry. Digital systems that combine voice and data are already in the field from those suppliers (such as InteCom, Datapoint, Mitel and Lexar), who are less heavily weighed down with installed-base responsibilities. (We review the Intecom and Datapoint products below.) Meanwhile, Rolm and Northern Telecom have contrived to match their newly arrived competitors with ingenious upgrades. The United States market for PABXs is, without doubt, moving rapidly towards a concept that might be termed 'super-connectivity', in which voice and data terminals are mingled in a plan conforming only to the user's needs, and where the makeshift wirepulling now required for moves and changes is consigned to the past. We illustrate this trend by examining two products — InteCom's IBX and Datapoint's ISX.

1. InteCom's IBX
   Intecom is an affiliate of Exxon, and its IBX was the first of a new generation of private switches. Intecom says that the aim of the IBX is "to allow for the proliferation of devices and systems in today's multivendor environment and to eliminate constraints in traffic, memory and real-time processing". No one can regard these aims as less than ambitious. Each IBX extension line consists of two pairs of wires capable of transmitting at 128k bit/s. This capacity is partitioned into 64k bit/s for digitised voice traffic, 8k bit/s for control signals, and the remaining capacity is used to transmit data from synchronous or asynchronous terminals at speeds ranging from 110 bit/s to 56k bit/s.

   The IBX is designed as a non-blocking switch with substantial computer power. It has a maximum capacity of 4,000 ports, with one telephone and one data device per port. At its heart the IBX has a master control unit, with up to 16 interface multiplexors spread around the office. Each microprocessor-controlled interface multiplexor can handle up to 256 ports. It is interesting to note that all traffic is transmitted in packets, with priority given to voice packets (although a packet in this context is different from the packet concept used in X.25 networks). InteCom is contractually committed to develop protocol conversion routines for the IBX for a wide range of dissimilar terminals.

The IBX provides telephone users with the following facilities:

— The name of an internal caller can be displayed on an (optional) alphanumeric display that can be incorporated into the standard electronic handset.

— Each user has access to a 15,000-name telephone directory.

— Call progress assistance can be provided both by messages displayed on the handset, and by verbal prompting from a speech synthesiser.

— For larger organisations, twin IBXs can be linked, although not all of the terminal features are yet available on a processor-to-processor basis.

2. Datapoint's ISX
Computer suppliers in the United States have notoriously and perilously neglected the market for voice communication. They have thus handicapped themselves in the race towards integrated voice and information systems. (This neglect stems partly from the regulatory environment in the United States. During a current court case, executives of IBM — the only major data processing company with a substantial interest in the voice communication business — were reportedly obliged both to distance themselves from their company's European efforts in voice communication and to describe the IBM 1750 and 3750 products in very belittling terms.) Datapoint has been an exception to the prevailing myopia and timidity of computer suppliers in the United States. It introduced a family of products under the general name of Infoswitch, including a long-distance control system and an automatic call-distribution system. By April 1981, Datapoint had quietly acquired a base of 1,000 sites. It then announced the ISX — a voice/information switch with a capacity ranging from 100 to 20,000 terminals.

The terminals are linked to a microprocessor-controlled remote switching unit, with each unit supporting up to 352 ports. A total of 60 remote switching units can be linked to one central switching unit. The links from central to remote units may be implemented at present by coaxial cable, and in the future by a range of technologies including microwave links, infra-red links and satellite links. Data is transmitted on these links at 4M bit/s in full duplex mode, and between one and four links may be used. The ISX may also be attached to Datapoint's local area network architecture, ARC.

At first sight, the ISX resembles the IBX in its functions, but there are important differences in both function and market appeal, and these differences can help to illuminate the evolution of voice systems generally. In addition to standard handsets the ISX also supports single-line electronic telephones. It also provides 20 programmable function keys (otherwise known as line keys) and a 24-character display. Electronic telephones can also be connected to a device called a data service unit, which also contains a socket for any data terminal with a standard RS 232 connector.

The IBX and the ISX systems illustrate the trend towards 'super-connectivity' in the United States, encompassing both voice and data communications. The differences between the two systems, however, indicate the emerging choices for American telephone users. Both systems provide electronic telephones with optional features such as displaying the caller's name. Both permit the sharing of lines by electronic telephones and data terminals, although this sharing is effected via a separate unit in the ISX. Both offer links to electronic message systems, data capabilities up to 56k bit/s, tandem switching, and well-conceived diagnostic and maintenance facilities (including the substitution of redundant or malfunctioning equipment).

There are, however, significant differences between the two systems. In the IBX, the analogue to digital conversion is carried out in the telephone handset, whereas in the ISX it is carried out in the line card at the remote-switching unit. The ISX can accommodate up to 20,000 ports, whereas the IBX can accommodate 4,000 port units with two terminals per port. The IBX is a non-blocking switch, with the fibre-optic links between the remote and central elements of the system able to transmit at a rate far in excess of a full simultaneous load on every terminal. For these reasons, the IBX does not need to concern itself with traffic balancing. In contrast, the ISX links its central and remote units with 4M bit/s channels, each of which can handle 62 transmissions at 64k bit/s. With up to four such links possible, traffic analysis is required to determine the economic level of linkage. It is in fact possible to achieve fully non-blocking status with the ISX, but the use of four links reduces the port capacity of each remote switching unit to 232.

The most significant difference between the two systems lies in their approach to protocol conversion and the market perception that this implies. InteCom emphasises the ability of the IBX to provide communication between dissimilar terminals. Datapoint states only that the ISX will permit connection of foreign, but mutually compatible, terminals. Time will tell whether InteCom has over-estimated the user's demand for mixed terminal populations, or whether Datapoint has unduly restricted the user's freedom to mix-and-match terminals. We believe that, in the future, Datapoint will also provide protocol conversion capabilities in the ISX.

Telephone equipment

In the United States, three classes of telephones are associated with the stored program control exchange. The first is a basic telephone with the standard 12-button keypad, or even a rotary dial for use where only the basic voice service is required. However, the 12-button keypad is a poor medium for accessing the features available on a modern PABX. The second class of telephone is the so-called executive telephone, for which the following more-or-less standard profile now exists:

— It has local memory, which is used for access aids such as speed dialling.

— It has between 10 and 30 programmable function keys.

— It has a single-line alphanumeric display of between 12 and 24 positions. This display is used for messages, identification of the calling party, account codes, call duration, feature status, etc.

— It has a loudspeaker, and either a connector for a data terminal or a link to a separate unit with such a connector.

One anticipated extension to the executive telephone is the ability to initiate features and functions by voice command. Voice recognition technology has recently declined sharply in cost, and makes it feasible to incorporate limited-vocabulary, isolated-word, speaker-trained response systems into the executive telephone.

The third class of telephone is a subset of the executive telephone with fewer keys and no display.

There is also a new generation of voice/data telephones emerging in the United States. Many suppliers are developing such telephones, and the Displayphone currently on offer from Northern Telecom in a limited market trial is typical of these instruments. In addition to normal voice telephony, the Displayphone provides facilities for message functions and information retrieval. Its features include a voice telephone, a typewriter keyboard in a pull-out drawer, modems (which are 300 bit/s versions in the trial) and a CRT display with either 40 or 80 characters per line. It also has five 'soft' keys whose functions can be changed as needed. Up to 81 names and numbers can be stored in the Displayphone's telephone directory, and these numbers can be retrieved for automatic dialling. The Displayphone can issue reminders, and can also store and retrieve messages at designated times. It notifies the user of an incoming message (or a reminder) by means of an audible tone or a flashing light. For concurrent voice and data usage, the Displayphone is connected to the exchange by two telephone lines.

An expected niche for this type of telephone is, however, in conjunction with a PABX such as the SL-1, where simultaneous voice and data operation is provided over two pairs of wires, and where the PABX's intelligence will enhance the utility of the terminal.

SUMMARY

In this chapter, we have quoted several examples of developments, both in Europe and the United States, which illustrate the ways in which telephone subscriber apparatus will evolve. From these examples it is clear that telephone users will face in the future a wide and almost baffling array of choice. Higher reliability and more functions are both available — but at a price. The task both of suppliers and telecommunication administrations is to ensure that the range of choice is well balanced between the cheap, basic products and the expensive, fully-featured offerings.

CHAPTER 6

DEVELOPMENTS IN TRANSMISSION TECHNOLOGY

From an investment point of view, and from the viewpoint of the larger user, the economics of transmission is a critical consideration. From 1950 to 1980 the falling cost of analogue trunk transmission reflected improvements in semiconductor performance, and this reduction (in relative capital cost per circuit-kilometre of coaxial cable systems) is shown in figure 12. In addition to the advances in technology that increased the effective bandwidth of the transmission medium, savings in materials also arose from the move from 9.5mm to 4.4mm diameter coaxial cable. The figure shows that a sevenfold reduction in the cost per circuit was achieved in these three decades.

During the last ten years of the period the merits of digital transmission for trunk routes was keenly debated. Digital transmission uses more bandwidth than analogue transmission, and at first sight the trend to digital technology may appear counter-productive. Digital transmission is attractive, however, because of the overall increase in system performance that it produces when it is used in conjunction with digital switches. In particular, digital transmission allows for the easy and rapid insertion of signalling channels into the digital bit-stream. Digital transmission makes economic sense only when it is used in conjunction with digital switching systems.

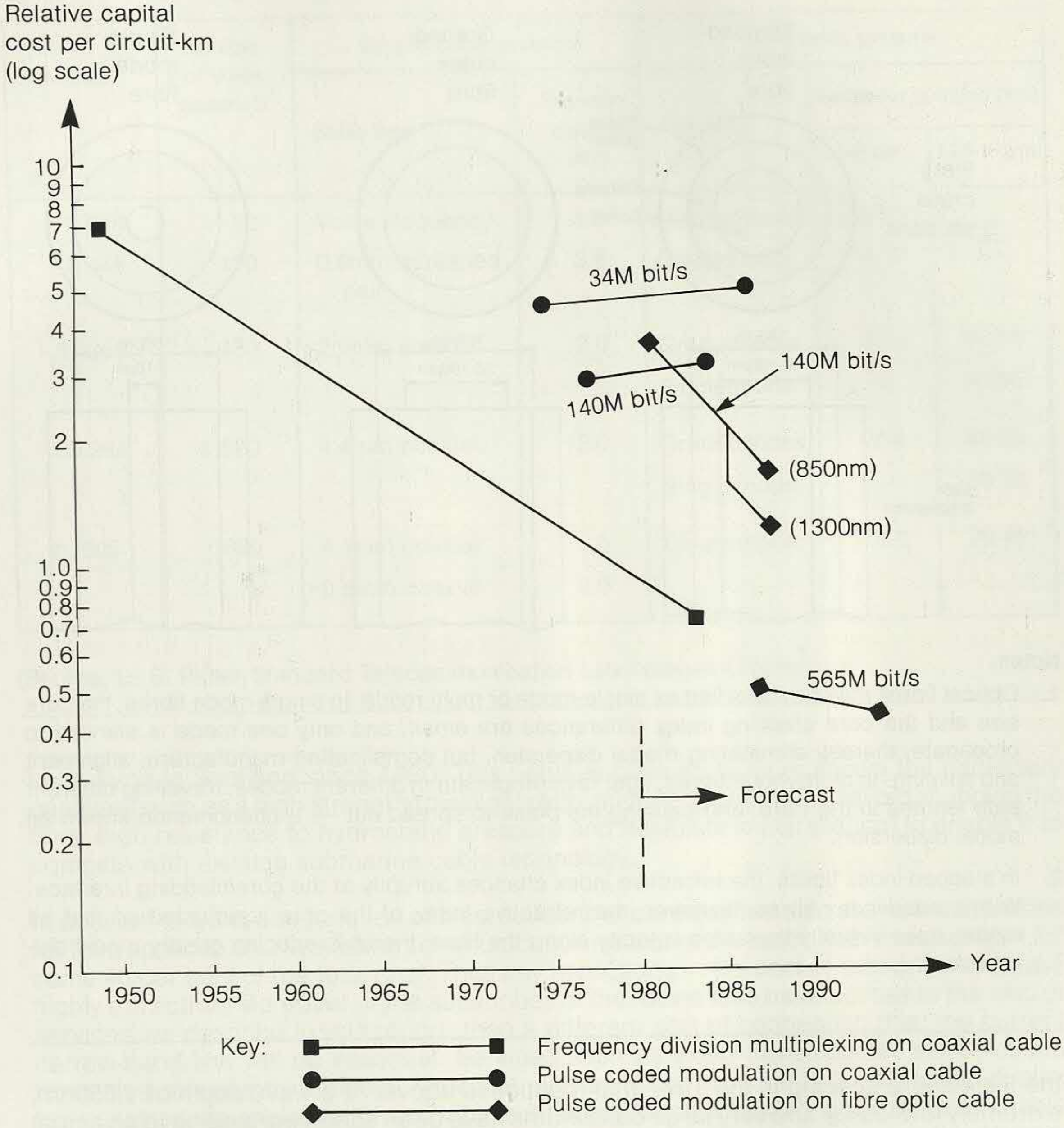
In this chapter, we examine four developments that will affect the way in which voice communication traffic will be transmitted in the future. First, we review the state-of-the-art of optical technology. We next assess the impact that the continuing developments in satellite technology will have on transmission systems, and we then discuss the types of voice services that radio transmission makes possible. Finally, we discuss the relevance of the emerging local area network technologies to voice transmission systems.

OPTICAL TECHNOLOGY

Optical technology includes not only optical fibres but also the electro-optic and integrated-optic technologies that are needed to produce the devices used in association with fibres. Early experiments with optical fibres were both successful and revealing. Early in 1977, two ITT affiliates in Britain installed an experimental optical fibre system that operated at 140M bit/s over a 9-kilometre span, with repeaters at 3-kilometre intervals. This experimental link was used until November 1980 both for voice telephony and for digital television experiments. The experiments were successful, but were abruptly (and ironically) curtailed when one of the fibres was accidentally severed as a new copper cable was being inserted into the same duct.

Since the early experiments, steady progress has been made in the technology of fibres. Most of the research effort has been focused on the two fundamental variables — the wavelength of the light that is transmitted, and the geometry of the fibres themselves. The aim of the research is to minimise the absorption and dispersion of light pulses so that fewer repeaters are needed in the cable. The early experiments used an optical wavelength in the region of 850nm, because the only lasers and detectors then available operated at that wavelength. However, it is now known that the absorption characteristics

Figure 12 Relative capital cost per circuit-kilometre

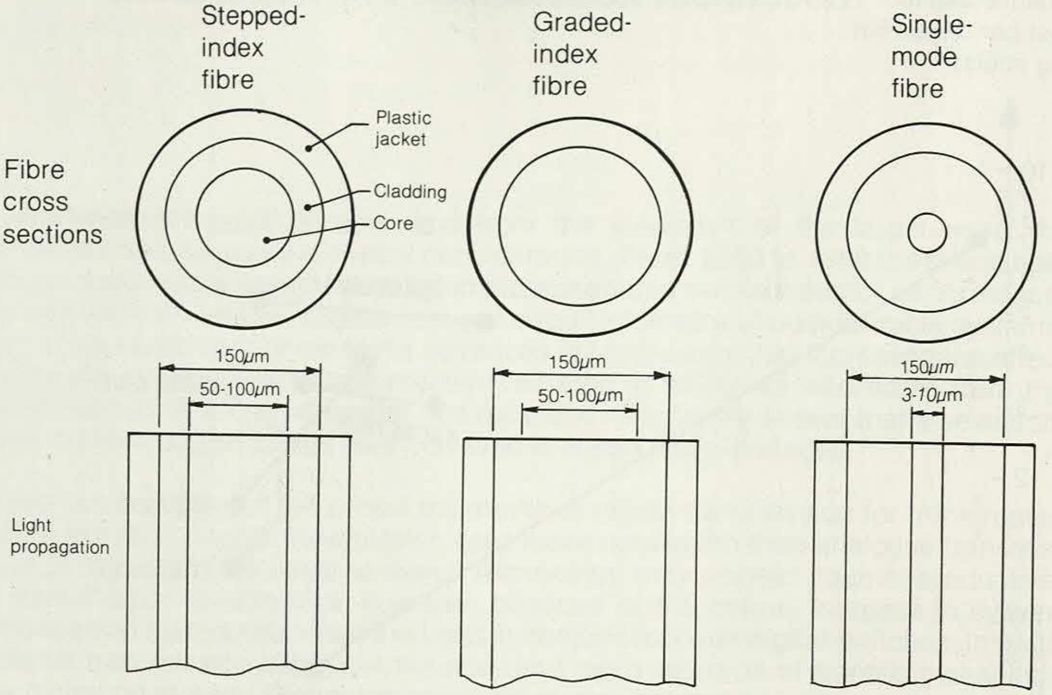


(Source: D. S. Ridler, Standard Telecommunication Laboratories Limited)

at a wavelength of 1,300nm (or 1,500nm) are an order of magnitude better than at 850nm, and these higher wavelengths are now likely to be used for trunk landlines. There are three competing types of geometry for the fibres themselves (single-mode fibres, stepped-index fibres and graded-index fibres); their relative merits are explained overleaf in figure 13.

Figure 14 (on page 41) shows the typical potential improvement (in terms of repeater spacings) of optical fibre systems compared with copper cable systems. The figure shows that, using a wavelength of between 1,260nm and 1,600nm and transmitting at 34.368M bit/s, the repeater spacing is as much as 80 kilometres. This is a dramatic improvement on

Figure 13 Optical fibre geometries and their relative merits



Notes:

1. Optical fibres may be classified as single-mode or multi-mode. In single-mode fibres, the core size and the core cladding index differences are small, and only one mode is allowed to propagate, thereby eliminating modal dispersion, but complicating manufacture, alignment and splicing. In multi-mode fibres, light rays propagate in different modes, travelling different path lengths in the fibre, and causing the pulse to spread out — a phenomenon known as modal dispersion.
2. In stepped-index fibres, the refractive index changes abruptly at the core/cladding interface. With graded-index fibres, however, the refractive index of the core is adjusted so that all modes have virtually the same velocity along the fibre, thereby reducing greatly modal dispersion.

the 3-kilometre spacing in the 1977 trial mentioned above. At a wavelength of 1,550nm, extremely low losses and very large bandwidths have been achieved, leading to an actual repeater spacing of 100 kilometres.

With repeater spacings as large as these, optical underwater systems begin to be feasible, and interest has recently been shown in submarine fibre links as an alternative to cables or satellites. For example, Bell Laboratories has recently completed a design study of a submarine fibre system that could combine the advantages of cheapness and ruggedness with digital transmission. The system, designed to operate across the Atlantic Ocean, would be 6,500 kilometres in length and would operate at depths down to 6.5 kilometres. It would employ a single-mode gallium-arsenide laser operating at a wavelength of 1,300*u*m over a monomode fibre with a 10*u*m core. The expected repeater spacing would be 35 kilometres and the expected system life would be 24 years, with a mean time between repair dives of 8 years. The practicality of such a cable has also been demonstrated by Standard Telephones and Cables, who has been operating an underwater fibre system at

Figure 14 Repeater spacings for copper cable and fibre optic transmission systems

M bit/s	Number of voice channels	Copper cable systems		Fibre optic systems		
		Cable type	Repeater spacing (km)	Fibre type	Repeater spacing (km) 0.85μm	1.26-1.6μm
2.048	30	Voice frequency	1.8	Stepped-index	10-15	Less interest initially
8.448	120	0.9mm screened pair	3.6	Graded-index	10-12	
34.368	480	2.9mm coaxial	2.0	Graded-index	8-10	40-70
				Single-mode	—	40-80
139.264	1,920	4.4mm coaxial	2.0	Graded-index	7-9	20-25
				Single-mode	—	30-70
c. 565	7,680	4.4mm coaxial	1.0	Single-mode	4-5	20-45
		9.5mm coaxial	2.0			

(Source: D. S. Ridler, Standard Telecommunication Laboratories Limited)

Loch Fyne in Scotland since 1980. This cable is claimed to have shown the necessary qualities (such as a high strength-to-weight ratio, minimal elongation to avoid snapping the fibre, high resistance to hydrostatic pressure and flexibility in installation) to enable it to compete with existing submarine cable technology.

In addition to trunk and junction cables, subscriber connections also are now candidates for fibre applications. In existing communication networks the subscriber lines account for some 40 per cent of the total cost. Thus any reductions in the cost of subscriber links are highly attractive. Moreover, if the subscriber of the future is to have access to the kind of services we describe in this report, then a different sort of connection than the current narrow-band link will be essential. Services such as video transmission, stereo sound transmission, videotex, teletex, facsimile, and so forth, could be provided by full duplex transmission via one fibre (or perhaps two fibres). Such a system would provide usable bandwidth up to 100MHz, which could be partitioned into several narrow-band and broad-band services.

Optical fibres with an analogue bandwidth of 100MHz, and with very low harmonic distortion and a signal-to-noise ratio of more than 50dB, have been demonstrated over distances of 5 kilometres. In urban areas the average length of a subscriber line is less than 5 kilometres, and a line length of 8 kilometres includes more than 97 per cent of all subscribers. If optical fibres such as those just mentioned are used for subscribers' lines, then the need for repeaters simply disappears. AEG-Telefunken has specified an optical subscriber line that allows for telephone traffic to be transmitted together with two television and two stereo channels over a pair of fibres. The second fibre can also be used for narrow-band reverse transmission and can thus be used (among other purposes) as a signalling channel to choose from a menu of services.

When bi-directional transmission is required, it has so far been necessary to employ two fibres. Attempts are being made, however, to permit a single fibre to be used for two-way communication by means of wavelength multiplexing, with the two sources injecting signals into the fibre at different wavelengths.

Optical technology has many advantages, and to conclude this section we list the most important ones:

— Optical fibres are immune from electromagnetic interference and from cross talk.

— Optical systems are free from the problems of earthing.

— Optical fibres are small both in size and weight.

— Optical systems are safe in a combustible environment, and they are immune to lightning, to electrical discharges and to electrical hazards if they are accidentally cut.

— Optical fibres are flexible and strong, and they are resistant to high temperatures and to nuclear radiation.

With these advantages, there is clearly an important place for optical transmission technology in communications in the years ahead.

SATELLITE TECHNOLOGY

In chapter 3 (on page 9), we referred to the inauguration in 1956 of the first transatlantic cable telephone link, Tat 1. By 1965, a total of 57 cable routes had been built across the beds of the world's seas and oceans. They provided a total of 4,200 international and inter-continental circuits, which is small enough by today's standards but was a huge leap forward from the days of high-frequency radio links. Yet in that same year of 1965, two years before submarine technology was to turn to the transistor repeater, a threat to the dominance of cable technology came (quite literally) over the horizon when the Early Bird satellite was launched. The advance of satellite technology was so rapid that full global coverage by the Intelsat system was achieved only three years later.

The global satellite network enabled many countries, particularly in the Third World, to secure good-quality international circuits for the first time. The relatively sparse and diverse traffic streams of such nations meant that they could rely entirely upon satellite links. But nations with heavier traffic volumes — especially those already using the submarine cables — recognised in satellites a potent medium for route diversification. Public awareness of the potential for satellite transmission was also stimulated by a feature that cables could not provide — simultaneous worldwide television coverage.

In the United States, the clash between submarine and satellite technologies was bitter, and it was seriously questioned whether submarine technology would survive at all. A protracted investigation by the FCC into disputes between the established carriers and Comsat (Communications Satellite Corporation) resulted in an apparent victory for Comsat. But in 1970 submarine technology responded with the first transistorised broadband transatlantic cable (Tat 5), built between the United States and Spain, and this development marked the beginning of a technological race between satellite and submarine technologies.

Between 1965 and 1970 three generations of satellite, each more powerful than the last, were placed in orbit by Intelsat. The cable industry responded by increasing the circuit capacity of submarine systems by a factor of ten in the decade from 1967. The wideband cable designs that brought about this increase provided reductions both in the capital cost per circuit and in operating costs. For cable systems, the average investment per added circuit has fallen from $150,000 in 1960 to one-tenth of that figure in 1978. During the same period, the number of cable systems installed has grown by a factor of 36 (in terms of circuits) from 60 in 1960 to 2,200 by 1978. Those who believed that the FCC ruling signalled the demise of submarine cable technology had rapidly to revise their ideas. In fact, the progress of submarine technology since 1965 makes an excellent case history of the way the advent of a competing technology can stimulate developments in another.

At the end of 1980 the world's submarine cable network comprised nearly 200 systems, totalling some 140,000 nautical miles and providing over 136,000 circuits. The forcing ground for the submarine cable industry was the medium-haul routes of Europe and the Mediterranean basin, where nearly three-quarters of the world's submarine capacity is concentrated. The success of this technology has been a vital element in the growth of international subscriber dialling facilities, which are much better in Europe than in most other parts of the world.

The growth of the satellite industry has not dissuaded either the FCC or the European PTTs to renounce submarine cable transmission systems. Tat 7, with a capacity of 4,000 circuits, is planned for implementation by 1983. Of the $2.8 billion invested in the world's submarine cable systems, nearly half has been invested in the last five years. Published plans account for a further investment of $500 million, with $200 million of this allocated to Tat 7 alone. We have already indicated that there may be further benefits to be derived from submarine optical technology. All in all, satellite technology has signally failed to eliminate the undersea cable, as some so confidently predicted it would.

The satellite designers meanwhile concentrated their major thrust towards providing large circuit capacity over long-haul routes (for example, from the United States to Europe), whilst also offering the ability to handle low-volume diverse traffic elsewhere. In the mid-1960s, the Intelsat I satellite provided only a few hundred telephone circuits. By the mid-1980s, Intelsat V will provide 12,000 circuits, and by the late-1980s Intelsat VI will provide about 35,000 circuits. Perhaps the growth of the Intelsat network would have been even faster if satellite costs had fallen as quickly as some of the early optimists predicted. Nevertheless, by the end of 1980 the Intelsat network was carrying some 60 per cent of the world's intercontinental traffic. In the 17 years it has existed, Intelsat has extended its services to over 140 countries and territories, the number of satellite circuits carrying international traffic has grown from 75 to more than 17,000 and the cost to the customer of a circuit has fallen to one-sixth of its 1965 level.

So far the satellite industry has found an ever-growing demand for its services. This demand has been met by increasing the capacity of individual satellites or by introducing multiple satellites. Most satellites have operated at frequencies in the 4 to 6GHz range, but there is now a distinct shortage of orbital slots for satellites operating at these frequencies. Another problem with this frequency range is that it may interfere with terrestrial microwave systems, and satellite antennae must therefore be positioned away from the centres of microwave activity — but these are the business and industry centres where satellite operators are most likely to find their potential customers. Intelsat's satellite for the 1980s (Intelsat V) will therefore supplement the 4 to 6GHz frequency band with a band operating at 11 to 14GHz. It will also employ new transmission techniques, such as dual polarisation to permit two sets of signals to be transmitted simultaneously on the same frequency. Using these techniques, Intelsat V has about twice the capacity of its immediate predecessor (Intelsat IV-A).

To some extent, however, Intelsat's plans have been overtaken by events. Market forecasts suggest that some Intelsat V satellites (for example, the primary vehicles in the Indian and Pacific regions) may be overloaded well before the end of their seven-year life. Thus, there is an incentive also to increase capacity through improvements in earth station procedures as well as by upgrading the satellite. The answer to this problem, Intelsat hopes, is the use of time-division multiple access and digital speech interpolation. Intelsat plans to triple the capacity of an 80MHz transponder by means of these two techniques.

Another development that will increase the transmission capacity of satellite systems is the use of scanning (or spot) beams. This development will allow the same frequency to be 're-used' several times for different applications. Conventional satellites disperse their signals over a relatively wide area (known as the footprint). To prevent the antennae beam of a satellite overlapping with other beams using the same frequency, earth stations need to be about 1,600 kilometres apart. A scanning beam has a much smaller footprint, and several beams all using the same frequency can therefore be focused into adjacent, but non-overlapping areas. Bell Laboratories estimates that 10 beams of the same frequency could operate in the United States without interfering with each other.

Because a scanning beam is accurately focused onto a particular antenna, the beam can be transmitted at relatively low power compared with conventional satellites. This lower power requirement produces additional benefits in that it can reduce the weight of the satellite and the launch vehicle. Alternatively, the present level of transmission power could be used for scanning beams, and this would mean that the diameter of earth-station antennae could be reduced from 30 feet to 10 feet. Bell Laboratories sees the availability of less costly and less bulky antennae as the key to a mass market for satellite transmission services.

In the United States, the growth in satellite transmission capacity continues unabated. At the end of 1980, the FCC sanctioned a doubling of the nine domestic satellites then in orbit. The competition for orbital slots is acute, however; figure 15 shows the present and planned positions of the American and Canadian domestic satellites in the 4 to 6 and 12 to 14GHz bands. The slot positions are shown in degrees West longitude. The minimum spacing for the new satellites is 4 degrees, or 5 degrees for the Canadian Anik series. Thus, the current round of FCC approvals entirely fills the orbital slots for the 4 to 6GHz band, although the FCC is considering a reduction in spacing to 3 degrees. Whilst it is true that the 12 to 14GHz slots are less fully assigned, no one knows for how long this will continue.

In the rush to occupy these slots in space, AT&T is planning to spend $230 million to launch and operate three Telstar satellites in 1983, 1984 and 1986. These will replace three existing Comstar satellites leased from Comsat. In its own satellites, AT&T plans to introduce some improvements in technology, including better batteries, which are expected to lead to a 10-year life for the satellites. Also, transponder capacity will be increased from 1,500 analogue circuits to 1,800. Alternatively, transponders may be used for 30 data channels each operating at 1.544M bit/s, compared with 24 data channels with existing transponders. It is interesting, and perhaps of the utmost commercial significance, that this new generation of AT&T satellites does not exploit the scanning-beam technology tested by Bell Laboratories. AT&T may feel that it has enough features to compete in the present market, and can afford to keep scanning-beam technology in its arsenal for the next round of approvals. Whatever the outcome, there is little doubt that the battle now about to take place 23,000 miles above the cities and towns of America will have resounding implications in Europe and throughout the world. (A review of European satellite developments, given by Larry Blonstein at the 8th Foundation Management Conference held in January, 1980, is contained in the transcript of that conference.)

Figure 15 Present and planned positions for American and Canadian domestic satellites

Slot	Satellite	Launch date
4 to 6GHz		
143	Satcom 2R	September 1983
139	Satcom 1R	March 1983
136	Satcom 1	In orbit
135	Hughes	1982
131	Satcom 3R	In orbit
128*	Comstar D1	In orbit
127	Comstar D4	In orbit
123.5	Westar 2	In orbit
123	Westar 5 (2R)	August 1982
119	Satcom 2	In orbit
119**	SPCC	1983
104-114	Anik (Canada)	Various
99	Westar 1	In orbit
99	Westar 4	March 1982
95	Comstar D2	In orbit
95	Telstar 301	1983
91	Westar 3	In orbit
91	Adv. Westar	1983
87	Comstar D3	In orbit
87	Telstar 302	1984
83	Satcom 4	In orbit
79	Adv. Westar	1983
74	Hughes	1982
70	SPCC	1983
12 to 14GHz		
106	SBS-1	In orbit
128	SBS-2	Not known
103 or 106	GSAT-1	Not known
100 or 103	GSAT-2	Not known
119	SPCC	1983
70	SPCC	1983

* = Will move to 95° West longitude as a backup satellite.
** = Also to be used at 12 to 14GHz.
R = Replacement satellite.

RADIO TRANSMISSION TECHNOLOGY

No discussion of voice communications technology would be complete without an assessment of radio transmission technology. The market for radio communication is huge, and it includes some applications that are beyond the scope of this report, such as maritime communications and military systems. In this section of the report we restrict our discussion to the use of radio transmission technology for providing terrestrial services to mobile subscribers, such as users of car telephones.

Many enterprises (including emergency services, and commercial and industrial firms) use mobile radio voice services to support their operations, and the equipment market for such applications is expanding worldwide by about 10 per cent per annum. As with satellites, the main constraint on the growth of radio services is the shortage of bandwidth. Mobile radio applications compete for every part of the frequency spectrum with broadcasters, fixed-service providers, satellite services, radio astronomers, and a growing army of radio amateurs. At the World Administrative Radio Conference (WARC) held in Geneva in 1979, the mobile radio contingent won some modest gains. But there simply is not enough spectrum capacity to meet all the needs of mobile radio services, and the operators of such services are forced to find ways of making better use of the available spectrum.

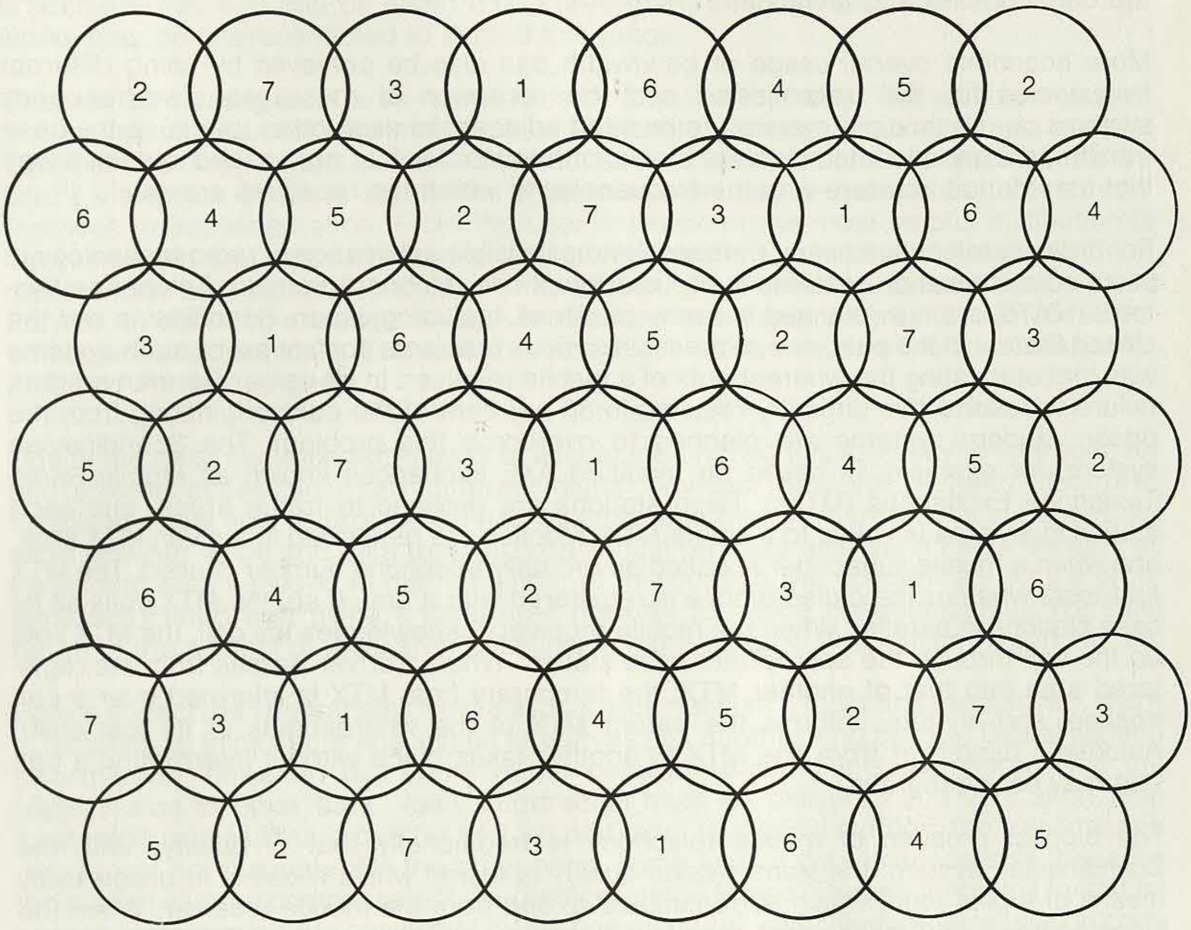
One option that has been suggested is to ration the available frequencies by price. The argument is that if public and private organisations rented frequencies from their governments, efficient usage would be encouraged. Another option is to minimise the on-air time of bandwidth users by encouraging them to use standard numerical codes for routine messages. The use of such codes is almost as old as radio itself, but a more modern method is to use tone signals for routine messages. Even more recent methods of making more efficient use of bandwidth are selective calling systems and digital systems. Selective calling uses a unique multi-frequency code to actuate tuned reed relays at the mobile station, so that only the desired recipient is called. Digital systems employ coded messages, and each mobile unit has a set of numbered buttons to correspond with a range of responses. With digital systems, messages can be pre-assembled and then transmitted in less than one second.

The so-called 'ultimate digital solution' to the radio bandwidth problem is to equip all mobiles and base stations with keyboards and screens so that every message can be assembled and edited before it is transmitted. Messages could then be transmitted and received in times that are much shorter than the times taken to transmit the corresponding voice messages. However, the disadvantages of such a solution, in terms of cost and the skill required to operate the system, and the loss of immediacy, seem to detract from the basic advantages of radio communication.

The bandwidth constraint means that the available bandwidth needs to be shared by different classes of users, and this can be achieved in several ways. For example, in some large countries the international marine frequencies are used in inland areas remote from the sea. The most realistic way of sharing bandwidth, however, involves the trunking of calls. In such a scheme, several users share a limited number of circuits, on the basis that only a few of the subscribers will wish to make a call at any given time. Circuits are, in effect, loaned to a user whilst he or she is busy, and they are then returned to the circuit pool. Several research projects have shown that trunked systems can accommodate up to six times as many users as non-trunked systems.

An alternative way of sharing bandwidth is to use several channels that all operate on the same frequency but are geographically separated. (The principle of this technique is very similar to the scanning satellite beams we have already mentioned.) A technique

Figure 16 Cellular structure for a 7-channel mobile telephone system



(Source: *Communications Engineering International,* December 1980)

known as the cellular (or honeycomb) structure is becoming popular in urban mobile telephone systems that use the higher UHF band. Figure 16 shows such a structure for use with seven separate channels. If each circle in the figure has a radius of 15 kilometres, any single channel can be re-used without significant interference after a separation of 70 kilometres.

Developments in radio technology itself are also leading to a more efficient use of bandwidth by reducing the bandwidth required to transmit a signal. In the 1950s, channels with a bandwidth of 100kHz were common, but this has been reduced progressively to 12.5kHz in the VHF band and to 25kHz in the UHF band. A further halving in the UHF band is already on the horizon; in France, for example, it has been decided that all national frequencies will be spaced at 12.5kHz intervals. A move to 6.25kHz in the VHF band is also a possibility, and the British company Marconi demonstrated 6.25kHz channel spacing as long ago as the mid-1970s.

The bandwidth requirement can also be reduced by a technique known as single sideband transmission, where part of the signal is suppressed at the transmitter, and is then reinstated by the receiver. In addition, this technique offers a gain in effective transmitter output power and improved signal-to-noise ratio. The only major disadvantage is that it requires more complex equipment. So far, the impact of the single sideband technique in the marketplace has been muted. The arguments for and against the technique are both complex and technical.

More economic overall usage of bandwidth can also be achieved by using different frequencies for the transmission and the reception of messages. Two-frequency systems permit multiple systems to be sited adjacent to each other, because the base transmitters are allocated discrete blocks of frequencies that are spaced in such a way that they do not interfere with the frequencies at which the receivers are set.

For ordinary telephone users, perhaps the most visible application of radio technology in voice communication systems is the car telephone. Mobile Automatic Telephone Systems (MATS) are now planned in many countries, including Japan, Scandinavia and the United States. In the past, one of the most serious problems confronted by such systems was that of locating the whereabouts of a mobile receiver. In an earlier German system, failure to resolve this difficulty resulted in 80 per cent of the calls originating from the driver. Modern systems are planned to overcome this problem. The Scandinavian system, for example, is based on modified AXE exchanges known as Mobile Radio Telephone Exchanges (MTXs). Base stations are grouped in traffic areas, and each station in an area is linked to a single MTX. Mobiles are registered in a given MTX area, and when a mobile subscriber is called an ordinary telephone number is used. The MTX first tests whether the called mobile is registered with it and, if so, the MTX calls all its base stations in parallel. When the mobile receiver acknowledges the call, the MTX sets up the call through the appropriate base station. When a driver passes from his registered area into that of another MTX, the temporary host MTX is informed over a call channel and, in turn, informs the parent MTX of the whereabouts of its lost child. Automatic hand-over from one MTX to another takes place without interrupting a call that may be in progress.

The biggest problem of mobile telephony is traditionally that of quality. With the Scandinavian system, the transmission quality is tested whilst a call is in progress by means of a pilot tone, which is transmitted to and from the mobile receiver. When the signal-to-noise ratio of the pilot tone falls below a certain level, the MTX commissions other nearby base stations to conduct signal strength tests. The MTX can thus determine if another station can provide a better-quality signal.

The problems caused by the spectrum famine are assuming ever-more serious magnitude for the radio engineers, and for this reason the future for mobile voice communication systems is far from clear. In the view of Professor Gosling, one of the leading experts in the field of mobile systems, the key to overcoming the spectrum famine is the availability of a low-cost vocoder that could digitise speech for transmission at low data rates. If speech could be adequately transmitted at 2,400 bit/s (or less), then the future for mobile voice systems would be more promising.

LOCAL AREA NETWORK TECHNOLOGY

In the same way that the ISDN promises to deliver a range of digital services to the communications user on the national scale, so at the local level advances in technology promise new services and new economies. The problems of implementing a digital network at the corporate level are great enough, yet they are dwarfed by those that arise at the national level. Thus the benefits of certain digital services are more readily available to companies than to whole nations. The chosen vehicle for the delivery of such services is known as the local area network, and competing products and philosophies are now becoming available for the user to evaluate.

All of these local area network products and philosophies have certain common characteristics. They use digital transmission techniques, and their internal operating speeds range from about 1M to 10M bit/s. The topological range of a local area network embraces devices that can be about 2,000 feet apart, although separate local area networks may be interconnected to extend this range.

One way to classify local area networks is by physical topology. The resultant classes include broadband cable systems such as Videodata, baseband cable systems such as Ethernet and ring systems such as XiNet. But such a classification is misleading from the user's viewpoint, because similarities of specification may be more important than differences in implementation. From the user's viewpoint the most helpful distinction is between open and closed networks. An open network is one to which many kinds of devices can be attached. Examples of open local area networks include Net/One and Polynet. In contrast, a closed network is intended to be used only by the vendor's own computers and terminals. Examples of closed local area networks include Datapoint's ARC and Prime's Ringnet.

One of the most common attractions of a local area network is its ability to interconnect and provide access to many different digital devices. However, modern electronic PABXs are now able to provide similar facilities, and many organisations are uncertain as to whether voice and data transmission should be integrated via a PABX network or via a local area network. In the remainder of this section, we concentrate on the problems associated with using a local area network for voice communication. We shall return to the subject of local area networks in more detail in Foundation Report No. 28.

Before speech can be transmitted via a local area network it must first be digitised, and it is tempting to think of the ensuing bit stream as just another kind of data. Digital speech transmission, however, has some rather peculiar requirements, compared with the transmission of other data. Voice information must be delivered in a very short time (preferably in less than a quarter of a second) and, to avoid distortion, the transmission delay must not fluctuate. On the other hand, some loss of data is acceptable, because the human ear can compensate for surprisingly large losses. The requirements for digital speech transmission are easily met by the type of circuit-switching systems used in computerised PABXs, and the bit stream representing the digitised voice communication is decoded and played out through the telephone as it is received.

Some local area network architectures also have a basic transmission system that comes close to meeting the requirements of voice communication. For example, the minipackets used in the Cambridge Ring could be used to carry one speech sample. These minipackets are subject to only small variations in transmission times, and these variations can be compensated for by using quite small buffers in the telephones. Other ring network architectures operate in a similar way, and the Hasler Silk product does in fact offer PABX facilities — but at a very high price.

Most local area network architectures, however, constrain the network to transmit speech samples in packets, each of which contains several hundreds of samples. The transmission time is therefore increased and, because the packet length is variable, the variations in transmission times are also much greater than with ring architectures. Although voice transmission has been demonstrated with Ethernet, it is much more complex to achieve than it is with a suitable ring architecture. It is also much more prone to interference from transmissions by other devices attached to the network. These problems can probably be overcome but, despite this, the economics of using an Ethernet-type of architecture for pure telephony is unfavourable. We believe that, for at least the next five years, voice services on most local area networks will be restricted to store-and-forward messaging, and perhaps to some form of limited intercom functions.

Ring architectures, however, are an attractive basis for telephony and for voice/data integrated systems. We therefore expect that advanced computerised PABXs based on local rings will find a significant place in the market.

Many organisations have important existing investments both in local wiring of sites and in trunk communications. These investments will be important factors when the relative merits of local area networks and enhanced PABXs are considered. Some of the investment might be preserved in a network of interconnected local area networks. But unless a local area network is restricted in scope to new systems — an approach that jettisons the inherent advantage of interworking and universal access — then a major part of that existing investment may have to be written off. Moreover, for many of the typical configurations that we have studied, the price of local area network technology still exceeds that of a conventional PABX that has been enhanced to provide data transmission facilities. We expect this price disincentive to the installation of local area networks to weaken, but it will persist throughout the 1980s.

Local area networks also suffer in comparison with PABXs in that much of the technology is novel and has been implemented initially on sites that are manned by academic staff or by other specially qualified staff. The problems of transferring such technology to industrial and commercial sites with less sophisticated manpower are not as yet fully understood. The suppliers of local area network technology are also relatively untried in the hurly-burly of the world's communications markets. In particular, some of them lack experience or expertise in the extension of their local technology to embrace trunk lines, a feature that will be essential to many of their potential customers.

CHAPTER 7

FUTURE VOICE COMMUNICATION SERVICES

We began this report by emphasising that the voice communication industry is experiencing substantial changes, and we illustrated the trends by describing the strategies and products of several telecommunications suppliers. In this chapter we now draw together all that we have said about technology, suppliers and products, and we examine the type of services that will be available to the telephone user in the future. From what we have already said in this report, we believe that even the most sceptical reader will be convinced of the great changes ahead.

The telephone administrations of the world will, of course, have a dominant role to play in introducing the new services, and many administrations are beginning to plan their strategies. The motivation for introducing new services stems from the fact that, as the market for basic telephony service reaches saturation, telephone administrations need to find new ways of generating additional revenues. A clear indication of the type of services that could be introduced was given at the tenth Foundation Management Conference by Mike Aysan from the Manitoba Telephone System.

A few (but not all) European countries are nearing the time when their PTTs will have fulfilled their remit of providing a basic telephone service to all who require it. In the United States, this position has certainly been reached, and we first examine the changes taking place in the United States regulatory environment and in the services provided by AT&T. We do this because we believe that these changes provide a pointer to the future directions that will be taken in Europe once the need for basic telephony has been fulfilled. We next examine both the need for and the characteristics of voice store-and-forward message systems, and we then review the current state of the art of voice recognition and voice response technology. We conclude the chapter by examining the way in which voice communications will in the future be combined with other forms of communications to provide teleconferencing services and integrated voice and data services.

DEVELOPMENTS IN THE UNITED STATES

In 1981, the FCC explicitly recognised that the basic remit of the United States common carriers had been fulfilled when it decided that installation expenses should be treated as revenue expenditure rather than as capital expenditure. In the United States, nearly all businesses and 98 per cent of homes are equipped for basic telephony, and 80 per cent of the 180 million telephones installed have been provided by AT&T. Although the number of telephones installed has grown by an impressive 60 million since 1971, this represents an annual compound growth of only 4.1 per cent. Nevertheless, in the period 1970 to 1979, AT&T's annual revenue grew from $17.3 billion to $45.4 billion — an annual growth of more than 11 per cent. The key to this growth is a strategy known as new service stimulation.

The FCC has directed that, after 1 March 1982, the services provided by the telephone companies shall be separated into basic and 'enhanced' categories, and that all new provision of terminal equipment shall be deregulated. Basic services will continue to be regulated and provided under a controlled tariff, but enhanced services will be provided by separate subsidiaries. Petitions have, however, been filed for judicial review of both of the major points in the FCC decision. In particular, AT&T has asked the FCC to permit all terminal equipment, including that already installed, to be freed from tariff restrictions by 1 March 1982, on the grounds of the administrative cost and difficulty that the 'bifurcated' treatment would otherwise create. Freeing existing terminal equipment from tariff restrictions would, at a stroke, create massive assets and cash flow for the unregulated subsidiaries, and this petition by AT&T is itself being vigorously contested. AT&T believes that its Custom Calling II services (which provide voice answering and advanced calling facilities, and which we discuss on page 54) should be classified as basic services rather than as enhanced services. AT&T argues that such facilities form a basic and integrated part of the network facilities as a whole, and that the provision of a network interface that is available equally to all communication-service providers will generate unnecessary delay and cost. The FCC takes the opposite view, however, but if AT&T is successful in having the Custom Calling II service classified as basic services, it will be of considerable significance to the longer term evolution of the voice communication industry.

The current regulatory turmoil in the United States is indicative of the fundamental (and worldwide) debate that is now taking place about the extent to which telephone administrations' charters should be extended to encompass new services. AT&T is seeking to bolster attempts in the Senate and (less successfully) in the House of Representatives to have the 1934 Communications Act revised or rewritten. In addition, the legislative committees of both houses are under pressure both from the American Newspaper Publishers' Association and from AT&T over the 'electronic yellow pages' ambitions of the telephone companies. The key issue is whether telephone companies may move into current and classified advertising media. Despite the pressure of the commercial lobbies, informed sources doubt that these exceedingly complex issues can be addressed by Congress competently or in time.

As this report went to press, it was announced that the anti-trust case between AT&T and the Justice Department had been settled out of court. As a result, AT&T will divest itself of all its operating telephone companies by 1983, but these companies will continue to provide (state) regulated local exchange services. AT&T will supply long distance services under FCC tariffs, but competitive service suppliers will have equal access to the local exchanges. In addition, terminal equipment will be deregulated and will be supplied by AT&T, not by the operating companies. AT&T will retain all of Western Electric and Bell Laboratories. This settlement will probably reduce, but not stop, the legislative momentum. Although it forestalls some of the issues before the FCC, it is expected to create at least as many new ones.

A plausible interpretation of this settlement is that AT&T foresaw that the outcome of the anti-trust trial would mean that it would be broken up. AT&T therefore settled out of court in order to retain those elements of its empire (Western Electric and Bell Laboratories) that best positioned the company in the future marketplace.

AT&T has clearly stated that no limit to its ambitions will be voluntarily introduced. In his 1980 report, the Chairman of AT&T wrote "No longer do we perceive that our business will be limited to telephony or, for that matter, to telecommunications. Ours is the business of information handling, the knowledge business. And the market we seek to serve is global. More and more, the Bell System's services for business will take the form of comprehensive systems integrating virtually all aspects of information flow, encompassing voice, video, data storage, retrieval, processing and distribution, word processing and electronic mail. We expect to equip the home of the future with facilities that meet a wide variety of need: information, education, entertainment and — as in business — the control of energy consumption."

AT&T has already begun to install the infrastructure that will make new services possible. In May 1976 it launched a service known as Common Channel Inter-office Signalling (CCIS). This service is based on a packet-switched data network consisting of 20 signal transfer points spread throughout the regions of the United States. It is used to communicate signalling information between the processors that control switching offices. By the end of 1980, some 160 switching offices were interconnected by means of more than 250,000 CCIS trunk links. CCIS is not only more reliable and cheaper to maintain than conventional signalling systems, but it is also faster. For example, a coast-to-coast call can be set up in about two seconds, which is up to ten times as fast as with conventional signalling systems.

Because CCIS allows any point in the network to send a message to any other, many direct-dial services can be made available to customers from virtually every telephone. Two such services include automated credit-card calling and improved 800 calling. (800 is the code used in America for toll-free calls, which are often paid for by advertisers.) With credit-card calling, the subscriber dials a number sequence plus the desired telephone number. The network then asks him or her to dial a credit-card number plus a personal identification number. The system checks that these numbers are valid before connecting the call. A version of this facility became operational in Buffalo, New York, in July 1980. CCIS permits 800 calls to be managed, so that even after a national advertisement (for example) the network is not overloaded. The calls can be intercepted and routed to the 800 service line groups where they can receive the speediest attention.

CCIS is therefore a system that not only knows a call's point of origin, but can also communicate more-or-less instantaneously with any point on the national network. These facilities open up a variety of service opportunities for AT&T. For example, a chain of shops or hotels, or even a car rescue operation, could have a common number. A subscriber dialling that number would be connected automatically to the nearest branch or hotel or patrol man. A similar facility could also be provided for individuals so that calls made to their own numbers would be diverted to wherever they are (provided, of course, that the individual has remembered to tell the network where he or she is).

Because of the current momentum in the United States towards deregulation, it would be vastly imprudent to expect anything but a massive invasion of world markets by AT&T in the next decade over a wide range of services. Non-American suppliers facing this onslaught can hardly complain that no advance warning was given. In the remainder of this chapter we examine some of the service opportunities that AT&T are likely to pursue. With or without the impetus of AT&T, such services are certain to arrive in Europe as the market for basic telephony becomes saturated.

VOICE MESSAGE SYSTEMS

Many attempted telephone calls are unsuccessful because the person called is unavailable, or is already engaged in another telephone conversation. In Europe it is accepted that between 25 per cent and 30 per cent of all calls do not reach the required person, but in the United States a miss rate of 70 per cent is often quoted. The simplest way of minimising the problem of unsuccessful calls is to install a telephone answering machine that answers a subscriber's telephone after a pre-determined number of rings. The machine plays back a pre-recorded announcement inviting the caller to leave a message. Many callers (especially non-business callers) will hang up without leaving a message when their call is answered by such a machine and, in an attempt to provide a human interface, many United States organisations now use telephone answering services. (We have already reviewed the United States' telephone answering service industry in chapter 3.)

Telephone administrations are aware of the revenue potential of services that enable voice messages to be stored in equipment located at their exchanges, for subsequent retrieval by the called party. In the United States, the Bell System has recently announced a package of new voice message systems called Custom Calling Services II (CCS-II). The three components included in these services are call answering, advance calling and remote access. Call answering permits incoming calls to be answered automatically when the subscriber's line is busy or when, after a specified number of rings, no answer is forthcoming. (Several incoming calls can be answered simultaneously.) Calls are answered either with a message recorded by the subscriber or with a standard message provided by the Bell System, and callers can leave recorded messages for later retrieval. While the incoming calls are being handled automatically, the subscriber can use the telephone to make outgoing calls. When the subscriber hangs up, he is informed of the arrival of any incoming messages by a short ringback. When the recorded messages are retrieved, the system tells the subscriber how many other messages are waiting, and every message is annotated with a voice message giving the time and date at which it was received. The call answering facilities of CCS-II can be rented on a daily basis (for the casual user) or on a monthly basis. Monthly users have access to certain facilities (such as saving messages for later playback) that are not available to daily users.

The CCS-II call-answering facility is turned on either by dialling 1151 or by keying ★51. The subscriber then dials 1152 (or ★52) to retrieve messages, and 1153 (or ★53) to turn the service off. A particularly useful feature of call answering is that subscribers can record their own announcements. For example, if a wife is due to meet her husband at an airport at a particular time but she is delayed, she is then faced with the dilemma either of arriving late at the airport or waiting for her husband to telephone. With call answering she could leave a message saying that she is en route. This facility could also act as a security device, because it will be more difficult for intending intruders to know if a telephone is really unattended.

The advance-calling component of CCS-II enables subscribers to record messages for later transmission to designated telephone numbers, and the time at which a message is to be delivered may (optionally) be specified. Subscribers use the facility by dialling 1141 (or ★41), and they are charged on a per-message basis. The called party is told before the playback begins that a message is to be delivered, and a message sender can check with the system to find out if the message has been delivered.

The third element in CCS-II is remote access, which permits a subscriber to access call answering and advance calling from any touch-tone telephone. Wherever the subscriber may be, he or she can start or stop the call-answering facility, record new announcements, playback messages, record advance calls and check the status of earlier advance calls. Each subscriber also has a privacy code to check that no one else is accessing his telephone.

Bell's attempt to persuade the FCC to recognise CCS-II as a basic service has been unsuccessful. As a result, several versions of such services will be available to subscribers.

CCS-II is an example of a voice store-and-forward system, and such systems can alleviate the problems caused by unsuccessful calls in three main ways. First, a call that requires an answer in real time can at least be delivered, even though it is not answered at once. Second, many calls do not require an immediate answer, and some calls require no answer at all. For example, if a salesman wishes to inform a client that he will be half an hour late for an appointment an end-to-end connection is not required to deliver this message. Third, by removing the non-critical traffic from peak periods, voice store-and-forward systems can reduce congestion in the network.

In addition, voice store-and-forward message systems have several advantages when compared with text messages. Voice messages are often held to be more human, more recognisable, less dependent upon the originator's possession of special equipment and less dependent upon his or her skill as a keyboard operator. The corresponding disadvantages are that text is more permanent, easier to search through, and better for complex documents that may need to be scanned and re-read. Text messages are also faster to absorb than voice messages (surprisingly, most people read more rapidly than they talk) and, at present, they are much cheaper to store. By 1986, however, it is possible that the cost of storing voice messages will decline to the point where it may be cheaper to send and store a message in voice form than as text, provided that it is not stored for more than a few days.

In addition to voice store-and-forward message systems provided by the telephone administration, products are also becoming available that enable organisations to provide similar in-house facilities. One such system already in use in the United States is

Figure 17 VMS commands

Command	VMS action
Recording	
1	Start/stop record
2	Start/stop play
3	Back-up ten seconds
33	Back-up to beginning
4	Skip forward ten seconds
44	Skip forward to the end
5	End of message
55	Non-delivery notification
Retrieval	
2	Start/stop playback
3	Back-up ten seconds
33	Back-up to beginning
4	Skip forward ten seconds
44	Skip to the end
5	Acknowledge message receipt
7	Save this message

Electronic Communications System's Voice Message System (VMS). This system (which costs $500,000) links to an existing PABX via 64 lines, which can be a mixture of local lines and remote lines. VMS provides more than a billion bytes of storage for digitised speech which, with appropriate compression, represents 50 hours of speech.

As well as providing the VMS for use as a dedicated system, Electronic Communications Systems also provides voice-mail services at centres in Richardson Texas and in New York City. Service-centre users pay $160 per mailbox per month, but half of the payments can be credited towards the purchase of a dedicated system. The three basic functions of the service are to enable a voice message to be deposited, to deliver a voice message, and to service inquiries for any deposited voice messages. The average message lasts for 49 seconds, and 90 per cent of the service users opt to inquire for messages so as to avoid being interrupted. While recording a message, or playing one back, the user can use the keypad to trigger certain commands, such as skip forward ten seconds. (The full range of commands is shown in figure 17 on the previous page.)

The VMS appears to have broad appeal within the user environment, and Electronic Communications Systems states that 4 per cent of users are top managers, 36 per cent are middle managers, 17 per cent are supervisors, 20 per cent are professional staff, 14 per cent are secretaries and 9 per cent are other employees. The most promising application areas so far identified include the distribution of sales information from the head office to the field, support for technical sales, and support for travelling executives. Other application areas include international communication across time zones, and the co-ordination of major projects. The 3M Corporation has installed a dedicated system, and has calculated that the VMS may have saved it as much as $1.7 million in the first year. (More than $1 million of this saving is due to the virtual abolition of inter-office memoranda.)

Electronic Communications Systems plans to enhance the VMS by providing networking facilities that will enable multiple systems to pass messages to each other's mailboxes. The biggest obstacle to this development is the Bell System's ambition in the voice store-and-forward field.

VOICE RECOGNITION AND RESPONSE

The potential for using the telephone as a device for gathering and retrieving information is enormous, but to unlock this potential requires that speech can be recognised automatically and constructed automatically to provide recognisable responses. Most PTTs in Europe have for many years provided pre-recorded information services (such as the speaking clock), but to provide bespoke services requires sophisticated voice recognition and voice response technology. Figure 18 (on page 58) summarises the state of the art of these two technologies.

The companies who manufacture speech-recognition and speech-response circuits have recently changed their views about the market for such circuits. In 1980, for example, Texas Instruments stated that its total sales of speech circuits by the end of the decade would be $3 billion per annum, of which almost half would come from consumer products such as automobiles and toys. In May 1981, the same company reduced its forecast of the consumer market to only $600 million per annum. But its forecast for sales of speech circuits for industrial, data processing and telecommunications products has been revised from $1.5 billion per annum to $2.2 billion. Speech recognition and response systems are thus an area of great current interest.

Products are now beginning to emerge at a rapid rate into the marketplace, and system designers must learn how to use them effectively. Voice response is now a mature tech-

Figure 18 State of the art of voice recognition and response technology

Application	Capability	
	Recognition	Response
Office automation		
General purpose terminals	D, L	V, H
Interactive graphics	D, S	
Word processing	C, L	V, L
Voice store and forward	—	V, H
Warehouse/distribution		
Order entry	D/I, S	F, H
Inventory control	D, S	F, L
Shipping/receiving	D, S	F, L
Package sorting	D, S	F, L
Consumer		
Toys	D/I, S	F, L
Automotive	D/I, S	F, H
Environmental controls	D/I, S	F, L
Entertainment systems	D/I, S	F, H
Dial-less telephones	D, S	—
Reservation systems	C/I, S	V, H
Medical		
Aids to the handicapped	D, S	F, L
Laboratory specimen identification	D, S	F, L
Pathology/cytology	D, L	F, L
Record retrieval and maintenance	D, S	V, L
Manufacturing		
Quality control	D, S	F, L
Numerical control machine tools	D, S	F, L
Process control	D, S	F, L
Factory data collection	D, S	V, L
Banking		
Funds transfer	V, S	F, H
Pay-by-phone	V, S	F, H
Credit authorisation	I, S	F, H
Military		
Intelligence	C/I, L	—
Aircraft cockpit	D, S	F, H
Security	V, S	F, L

Key:

Recognition Capability
D = Speaker dependent
I = Speaker independent
C = Continuous
V = Verification
L = Large vocabulary
S = Small vocabulary

Response Capability
F = Fixed vocabulary
V = Variable vocabulary
H = High quality
L = Low quality

(Source: Carl L. Berney, Centigram Corporation) nology with a well understood theoretical base, and the effect of recent developments such as LSI-based devices has been simply to provide better quality at a lower cost. Voice recognition technology, however, is not so mature. Although a theoretical base does now exist (as do practical models) for systems that can recognise isolated words, there are still many unsolved problems in the areas of speaker independence, continuous speech recognition and speech comprehension.

Most researchers in the field of voice recognition technology agree that systems must be at least 96 per cent accurate before they can become usable products. Despite the uniformly high levels of accuracy that suppliers set for themselves, the prices of the least expensive and the most expensive voice recognition devices available today differ by a factor of 50. This price difference stems largely from the sensitivity of the device to the environment in which it is designed to operate. For example, the price will be higher if a device has to operate successfully against a lot of background noise from typewriting, from printers, from doors banging, and so forth.

Another major problem that has yet to be solved is that of making voice recognition devices easy to use. Most systems available today work best if the operator speaks in a somewhat flat and monotonous manner. Although operators can be trained to speak in such a fashion, it hardly enhances the working environment. The chosen vocabularly for a voice recognition system also affects the overall system performance. If the vocabulary is too large, then the accuracy will decrease. System performance will also be impaired if the vocabulary contains similar-sounding words.

Figure 19 Cost of voice recognition systems

System capability	Cost	
	Current	1983
	\$	\$
Speaker-dependent isolated-word small-vocabulary	1,500 to 3,000	350
Speaker-dependent isolated-word large-vocabulary	10,000 to 20,000	5,000
Speaker-independent isolated-word small-vocabulary multi-channel	60,000 to 100,000	20,000
Speaker-dependent connected-word moderate-vocabulary	80,000	10,000

(Source: Carl L. Berney, Centigram Corporation)

Voice recognition systems can be designed either to recognise isolated words (where the speaker is required to pause for about one-tenth of a second after each word) or to recognise continuous speech. Devices of the latter type have to determine the word boundaries from a stream of continuous speech. Another distinction between voice recognition systems concerns their sensitivity to individual voices. The simpler systems have to be speaker trained, which means that each user has to go through a laborious process of teaching the system to recognise the way in which he or she pronounces all the words in the vocabulary. The more complex speaker-independent systems can accept a variety of pronunciation by storing a wide range of dialect samples for each word in the vocabulary. At present, the only systems that are truly speaker-independent are those that have a very small vocabulary (up to 20 words). Figure 19 shows the costs (current and projected) for four typical levels of sophistication in voice recognition systems.

The problems associated with continuous speech recognition are complex enough, but the problem of trying to comprehend automatically the speech that has been captured introduces a still higher level of complexity. Speech comprehension poses problems in the fields of syntax, semantics and linguistics that are still at the stage of theoretical research. (The transcript of the eighth Foundation management conference includes a paper by Dr. Jelinek of IBM that contains a comprehensive review of progress in the field of speech recognition.)

Voice response systems also have varying capabilities, in that some have fixed vocabularies whereas others can produce unlimited variations in speech. Some variable-output devices record information in a digital form and play it back, some reconstruct words from stored elements of speech, and others directly synthesise speech. The quality of a voice response system is measured in terms of intelligibility and naturalness. Synthetic systems, which often sound quite intelligible but rather unnatural, require lower bit rates than reconstruction systems.

Voice recognition technology is used mainly for information entry applications where the information takes the form of commands, data or queries. The commands are usually single words, such as start, stop, left, right, scroll, next, etc. Data is usually numeric, but may also include information related to the application, such as colour or size. Queries may sometimes trigger off very complex recognition processes that require complex searches and analyses to determine the true significance of the question asked. Voice response technology is currently used to confirm to users that data or commands have been correctly received, or to ask the user either for data or for the next command. It is also used to convey answers to users' queries. To date, information entry applications form the vast bulk of the successful voice recognition and response applications. Other applications, such as security checks, where the user's claimed identity is checked against a voiceprint, are as yet too expensive and too unreliable.

TELECONFERENCING SERVICES

Many people have thought for many years that the most logical enhancement of basic telephony would be to provide visual communication as well as voice communication. The attractions of interactive audio-visual communication (or teleconferencing) remain as seductive as ever but, as yet, the promise of remote conferencing services remains unfulfilled. Nevertheless, the optimism and the confidence of the teleconference vendors has never been higher than it is today, and there are signs that their optimism may at last be justified by an impending boom in such services. Once again, we turn to the more highly developed market in the United States to provide pointers to subsequent developments in Europe.

AT&T estimates that about $290 billion a year is spent in the United States on business meetings, of which about $200 billion is spent on meetings that require travel. Approximately 40 per cent of this $200 billion is spent on meetings that require audio and graphic facilities, and a further 10 per cent is spent on meetings that require audio and full video facilities. The potential market for teleconferencing systems is therefore vast, but it is segmented into sub-markets with different requirements. Accordingly, a range of teleconferencing facilities such as audio, graphics and video is required (rather than one fully-featured teleconferencing system) to tap these various markets.

In time, the Bell System will provide such a range of facilities, but at present it offers its Universal Conferencing System. This system provides voice communication, a remote blackboard facility, slow-scan television and facsimile transmission. AT&T is also implementing a more advanced system that is designed to appeal to the top end of the teleconferencing market. This service is an all-digital wideband network service called Picturephone Meeting Service (PMS), which AT&T plans to extend to 41 cities by 1983. The company proposes to add a $2 million network of 1.544M bit/s circuits (terrestrial and satellite) to the existing facilities to provide an end-to-end PMS network. In fact, PMS will be AT&T's first nationwide, end-to-end, digital (but unswitched) network. The scheme is a bold attempt by AT&T to bury once and for all the failure of its Picturephone fiasco of the 1960s, and also to lift Picturephone revenue from its depressingly low level of $125,000 in 1979.

AT&T's market growth projections for PMS are staggering. Revenue from PMS is planned to reach $65.5 million by 1982 and $232.5 million by 1986. Cost projections indicate that by 1983 the system should be profitable, and that it should provide a yield of $91.4 million in 1986. The revenue and profit forecasts are even more fantastic when viewed in the light of past market indifference to teleconferencing services. The first obstacle to be overcome is that of price, and figure 20 shows the proposed digital broadband charges compared with the charges for the existing PMS service. The charges are based on the use of an AT&T studio, and at present studios are available in twelve cities. Alternatively, users may prefer to set up their own studios, and it would pay them to do so if they plan to use the new system for more than two hours per day. Figure 20 indicates that the PMS charges are about five times as high as the previous Picturephone charges, but it is by no means clear how AT&T intends to increase its Picturephone revenue to the planned levels.

In March 1980, one of AT&T's teleconferencing rivals, Satellite Business Systems Inc., complained that the old Picturephone service was grossly underpriced. The FCC decided to ignore the complaint, since the tariff for AT&T's service was in any case due to expire in June 1981. But SBS's posture towards teleconferencing services is ambivalent. SBS provides wideband switched digital private circuits to customers with their own earth station (or who are prepared to share an earth station). It does not provide equipment for use on customers' premises nor does it offer teleconferencing studios to rent. If an SBS customer is interested in teleconferencing, then SBS provides a contracting service to help that customer find equipment from other vendors, and its circuits are then used for teleconferencing or for any other purpose. SBS is therefore adopting a low-key approach to teleconferencing. There is, perhaps, a lesson here for other teleconferencing vendors. One of the reasons that led to the formation of SBS was the belief that a huge market existed for teleconferencing services. The response of the market to SBS has forced it to draw back from its teleconferencing ambitions (and also from its bulk data transmission ambitions). SBS is now concentrating most of its effort on telephony services.

The capital costs involved in establishing a wideband network such as the new PMS system may not be justified without a huge potential market. Narrower bands can be used for picture transmission, however, provided that some degradation of the television picture is acceptable. One European PTT has set out to produce and test a range of equipment that is designed to reduce the bandwidth requirements for picture transmission. The equipment operates at 1MHz for normal television transmissions, and it includes slow-scan television converters, video conferencing terminals and real-time picture compression converters. During a three-year period, this equipment will be tested for acceptability at operational sites.

The slow-scan system is designed to work over the public network, and the options available to the system designer are to send less-clear pictures, send less-frequent pictures, or reduce the redundancy inherent in the pictures. For many applications, such as surveillance, a transmission rate of 25 frames per second is quite unnecessary. For such applications, a transmission rate of one frame every four seconds can be accepted. Clarity can be reduced by transmitting only one field instead of the two interlaced fields that comprise a normal television picture. Also, the horizontal resolution can be reduced to 200 visible points, compared with the normal 600 points. Of course, the degraded images provided by such a system would not be acceptable for every purpose. In the trial, a range of possible applications is being tested, including teleconferencing and some specialist tasks such as underwater surveillance. Some of the test applications, the distances over which they are to operate and their speeds of transmission are shown overleaf in figure 21.

The future of teleconferencing in all its forms is, to say the least, problematic. No one doubts the logic of the arguments about the cost and difficulty of travel. These arguments were reinforced by the world events of 1973 but, even so, business people have not been motivated to make greater use of teleconferences. The manager of a European teleconferencing service once vouchsafed to the author of this report a telling comment on the users of his service. "They come and use our system," he said, "they say it is wonderful — but they never come back." Perhaps there is some instinct in mankind that urges us, whatever the costs and difficulties, to congregate physically. If so, the Picturephone fiasco may well be repeated, and AT&T's investors will be faced with a nasty shock.

Figure 20 PMS charges

Call length	New York/ Washington	New York/ Chicago	New York/ Los Angeles
	$	$	$
45 mins (existing PMS)	138	246	302
45 mins (proposed PMS)	970	1,170	1,570
90 mins (existing PMS)	275	494	604
90 mins (proposed PMS)	1,415	1,780	2,180

Figure 21 Slow-scan television applications

Application	Distance	Transmission medium
Protection of radio station following bomb threats	5km	4.8k bit/s dial up on PSTN
Detection of illegal dumping; rapid installation, temporary use	2 to 3km	4.8k bit/s dial-up on PSTN
Protection of bullion vault	5km	48k bit/s on metallic pair
Security of premises at night monitored from other company location — two cameras on one system	120km	4.8k bit/s dial-up on PABX
Traffic monitoring for control of signals	25km	48k bit/s on repeatered pair
Extension of radar systems to port control position	10km	48k bit/s on metallic pair
Underwater surveillance from submersible (via ultrasonic transmission link)	—	Data via acoustic transmission
Security of premises at night monitored from other company location	400km	4.8k bit/s dial-up on PSTN
Occasional access to remote camera for traffic control	20km	4.8k bit/s dial-up on PSTN
Transmission of X-rays between remote hospital and specialist	100km	4.8k bit/s dial-up on PSTN
Editorial submission to upper management	80km	9.6k bit/s on private voice circuit
Liaison between processing plants	300km	4.8k bit/s dial-up on PSTN
Aid to collaboration between principal and contractors	150km	4.8k bit/s dial-up on PSTN
Audio conferencing	250km	4.8k bit/s dial-up on PSTN
Audio conferencing	40km	48k bit/s on private groupband circuit
Audio conferencing	200km	4.8k bit/s on private telephone system
Editorial conferencing between newspaper offices	150km	4.8k bit/s on private circuit

(Source: *British Telecom Journal,* Winter 1980/81)

INTEGRATED VOICE AND DATA SERVICES

A recurring theme throughout this report has been the trend for voice communication services to be integrated with data communication services in the future. The ISDNs now being planned are designed with this in mind, and much of the equipment that we described in earlier chapters of this report illustrate the trend. The enhanced telephone, the operator stations designed for use with advanced telephone answering services, and communicating word processors are all examples of equipment that can combine two (or more) types of communication that have hitherto been separate. Such equipment comes under the generic term of multifunction workstations (described as long ago as 1977 in Foundation Report No. 4).

The likely profile of future products that will integrate voice and data communication can be assessed from the profiles of existing products and from the known plans of various suppliers. Such products will be organised in a highly modular fashion that will enable the customer to select the desired features from a gradually revealed menu of items. They will be intended for use by a wide range of office personnel, including clerical, secretarial, administrative, supervisory, professional and managerial users. They will integrate all forms of office information (voice, text, data, graphics and image); and they will provide for input, output, processing, storage and retrieval of information as well as for the distribution of information inside and outside the office. The appeal of such terminals will be based equally on their ease of use (human factors will be an important consideration) and on their contribution to increased productivity. To illustrate the type of multifunction product that is now becoming available, we describe a typical terminal system available from Office Technology Limited.

At the heart of the system is a shared controller that supports up to 32 clustered workstations. Each controller supports up to 64M bytes of local disc storage, and provides a communication capability for user-to-user mailing. Each workstation has a full alphanumeric keyboard and a full range of function buttons, and incorporates a telephone handset. The display on the workstation is a 3,000-character CRT, and each workstation will also support a letter-quality printer. In addition, each controller will support up to four letter-quality printers, and a lower quality (but faster) printer that can be used for printing draft documents. The operating software provides menus, prompts and guidance for the operator, and includes a text editor with facilities to merge text and voice streams. The system can be used for conventional applications such as word processing, electronic filing, electronic mail and data processing (including desk-top computing).

A key feature of this system is its ability to integrate voice messages with text, data and graphics. The voice-handling features of the system are initiated by the user through controls that resemble those of a conventional tape recorder. Documents stored in the system may contain voice marginalia or commentary and, when a document is retrieved, a screen symbol indicates that it includes (or perhaps consists entirely of) a voice message. Thus the system can be used as a voice store-and-forward message system. Alternatively, the system permits documentation associated with a telephone conversation to be stored in an integrated fashion. It can also be used between a principal and a secretary for dictation.

Office Technology Limited has paid great attention to human-factors aspects of the system. The terminal is light in weight, small and unobtrusive. The screen tilts and rotates, and the separate movable keyboard can also be tilted. The keyboard has separate zones for the alphanumeric keys, numeric keys and function keys, and the function keys are grouped in related clusters. The keys have non-reflective tops and they are clearly labelled. Menu selection and responses to prompts are built into the system, but can be by-passed by the experienced user. The CRT display is black-on-white and is flicker-free. The display can be scrolled in three directions (horizontal, vertical and diagonal) in such a way that the text can be read whilst it is being scrolled.

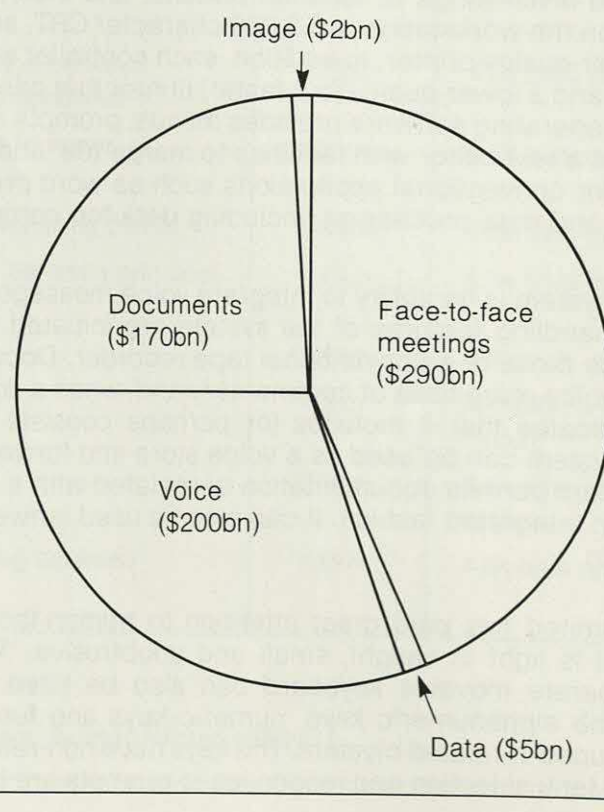
Such are the facilities and features soon to be offered in just one implementation of a multifunction product that can integrate voice and non-voice information and communication. We believe that in the next decade a bewildering variety of such devices is likely to emerge.

SUMMARY

The telephone administrations of the world face massive investments over the next decade. They also face the fact that their markets for basic telephone service will become saturated. For these reasons they must encourage their existing customers to make greater use of the networks they have so expensively installed. The European PTTs do not yet face market saturation, but they have already begun to plan and implement the new services they must offer. Hence their interest, for example, in videotex.

AT&T (which faces the problem of saturation right now) has made an estimate of the way American businesses spend money on communications in the broadest sense, as shown in figure 22. On the basis of this estimate, the appropriate targets for any communication company seeking new business are presumably voice, face-to-face meetings and documents. So far, most attention has probably been paid to communications that require documents and data to be transmitted. However, the analysis shown in figure 22 clearly explains why AT&T has now sharpened its interest in new services such as voice store-and-forward message systems and teleconferencing systems.

Figure 22 United States business expenditure on communications



(Source: AT&T)

The range of business applications for advanced telephony is very wide, but the range of home applications is potentially wider still. It includes (according to AT&T) shopping at home, banking, household accounts, library access, all manner of reservation systems, language lessons, electronic mail, and selection of television material. AT&T states that the market window for these services will open in 1984. At that point there will be (according to AT&T) a significant percentage of customers willing to purchase electronic information services.

CHAPTER 8

MANAGEMENT RESPONSIBILITIES

In this report we have shown clearly that the voice communication industry is experiencing great changes, and that these changes will continue for the foreseeable future. The telephone manager of today is likely to find that, increasingly, his remit will encompass telecommunications in its widest sense. Increasingly, also, he will be confronted with the need to provide facilities that can integrate the different forms of communication. It is surprising, therefore, that to date very little has been written about overall management problems in telecommunications — far less, for example, than has been written about the tasks of the data processing manager. This comparative dearth of literature perhaps stems from the fact that, in Europe, the bulk of the exchange and transmission equipment is owned by the PTTs.

The monopolistic position of the European PTTs is, however, being seriously questioned in several countries. The United Kingdom is already set on a path that will lead to a less regulated telecommunications environment, and we believe that, in time, other countries will follow the British lead. As this deregulation occurs, more telecommunications equipment will be owned and operated by individual organisations, and the associated management problems will become more visible. Even in those countries that preserve a monopolistic telecommunications structure the same trend will occur, although to a lesser extent. We conclude this report by identifying five important new tasks that the telephone manager of the 1980s will have to face as a result of the changes that are occurring in the voice communication industry.

1. Self education

   Telephone managers today may believe that they already know all that is to be known about voice communications. We believe, however, that their position is similar to that of a certain young man who, late in the nineteenth century, was seeking advice about which subject to study at university. He was advised not to select physics because everything that could be known about that subject was already known.

   The traditionally slow-moving world of voice telephony has become a maelstrom of competing technology, which is changing even faster than the world of computing. The first task of the telephone manager is therefore to keep himself briefed on the changes taking place in the technology, in the market and in the regulation of telecommunications. He needs to be aware of products developed in distant countries, of the new ambitions nurtured by the giant communications companies and of the unpredictable decisions taken by regulatory bodies, because all of these influence the choices and decisions that eventually will confront the telephone manager. A working knowledge of these changes and an understanding of their potential strategic significance is therefore essential.

2. User education

   The second new task for the telephone manager of the 1980s is to communicate at least some of his knowledge to his colleagues who are substantial telephone users. They too must come to appreciate the size of the expenses that they are incurring — often without their knowledge. They must also understand the scale of the opportunity open to them. A first-class voice communication system is like a highly developed nervous system; without it, the organisation cannot function properly. There is plenty of evidence to suggest that user managers can grasp the significance of the impending changes in voice telephony, provided that the changes are presented in a clear and dramatic fashion.

3. Investment policy
Many telephone managers will face the need in the 1980s for a substantial review of their investment policy, because the useful life of equipment will change. Historically, electro-mechanical exchanges have been installed on the assumption that their life will be between 20 and 30 years. Such a timescale is quite inappropriate for the stored program control exchanges of today and tomorrow; something nearer to the 5 or 7 year life common in the data processing world might be more appropriate. Nothing impedes progress more than past investments that have been made on the basis of unrealistic timescales. Although it is difficult to change such policies, it becomes progressively more difficult the longer the change is deferred. Another major investment question concerns the extent to which voice telephony should be expected to pay its way. The telephone manager needs to decide whether each investment must be justified in terms of cash savings, or whether communications should be considered as part of the necessary infrastructure of the organisation.

4. Integration
In the future, office systems will handle voice, data, text and image traffic in an integrated fashion — as foreshadowed by the plans of some of the suppliers that we have mentioned in this report. The action that telephone managers need to take to promote such developments will vary according to the size and scope of the existing communication facilities. Large international companies with highly developed and separate networks for voice, data and message traffic will require most of the remainder of this decade to unravel their problems. Smaller organisations with less ambitious existing facilities, however, will find it much easier to integrate the different forms of communication traffic. In Foundation Report No. 21 we provided strategic advice to organisations about the planning of corporate communication networks, and planning tools to assist such studies are now becoming available. (See, for example, the article by McWalters and Brill of Chase Manhattan Bank in the December 1980 edition of *Telecommunications*.)

5. Organisation
In many companies the existing organisation of the computer, telecommunications and office systems departments militates against the efficient use of processing, switching and transmission facilities. Although each department may be fulfilling in an admirable fashion its own specific assignment, opportunities to benefit from the combination of all three skills may be missed. The telephone manager is in a strong position to act as the glue to bind these forces together, because everyone in the organisation is likely to be a customer of his service. The evidence suggests that major organisational upheavals are not really necessary, provided that the various departments concerned with the different aspects of information technology are determined to work together.

We began this report with a caveat, which gave our reasons for considering the trends in voice communication systems in isolation from data, text and image communication. From reading the report it will be clear that, at times, we have found it impossible to maintain this isolation. Nevertheless, the emphasis of this report has been on voice communication. The Foundation will not, however, neglect developments in other forms of communication systems, and Report No. 28 will specifically address the issues concerned with the use of data networks.

Photoset and printed in England by Flexiprint Ltd, Worthing, Sussex

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