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No. 9

The Selection of a Computerised PABX

by Roger Camrass
July 1978

The Butler Cox Foundation

Abstract

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With the introduction of computer-based technology the nature of the private automatic branch exchange (PABX) has changed. These devices offer a new set of opportunities for information systems of the future and for this reason are of particular significance for the management services manager. At the same time, new questions are posed for the telecommunications manager, or any other individual concerned with the selection of such equipment.

Computerised PABXs provide some additional facilities for voice communication — at a cost — but they also offer completely new facilities which may be of strategic importance. Above all, they offer the opportunity to mix and control voice, data, text and graphics traffic on a single network.

This report describes the evolution of these exchanges, explaining the technology involved and the essential differences between it and that of the preceding generations of electro-mechanical equipment. The report describes the features and facilities which computerised PABXs offer and explains the additional opportunities which these facilities can provide. The justification for installing such equipment is examined and guidance given on the selection process and its management.

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I. INTRODUCTION

A The Case for Considering a Computerised PABX

The changes which have come about within the last decade, both in the design of private automatic branch exchanges (PABXs), and other office services (such as data processing) demand a close look at the private telephone network, of which the PABX forms a significant element.

In continental Europe, the telecommunications administrations (PTTs) have overall responsibility for providing a public telephone service, but large organisations have a limited opportunity for selecting and managing their own private telephone networks. These networks comprise manual switchboards, private automatic branch exchanges (PABXs) and, in many networks, private telephone lines. In the UK, the Post Office supplies and maintains all PABXs that have fewer than one hundred extensions and outgoing trunk lines. The Post Office allows organisations that have one hundred or more lines to select their own PABX, but it retains the responsibility for maintaining those PABXs.

Currently-available PABXs comprise a wide range of different products, all of which include features from several generations of technology. The computerised PABX is the most recent and most advanced of the available products, and the PTTs have announced that they intend to replace public telephone switching equipment with this technology.

An organisation may decide to examine the case for installing a new PABX for two different reasons. Firstly, and obviously, an organisation may need to replace the existing PABX because the equipment has already, or nearly, outlived its useful working life. Secondly, an organisation may believe that the advanced features and facilities that the new technologies have introduced into currently-available PABXs may make it worthwhile overall to replace the existing PABX by a new one, even though the former still has several years' useful life left in it. The unique features and facilities that are embodied in a computerised PABX clearly make it a strong candidate for any organisation that decides to replace its PABX.

B Background

The PABX is located between the individual extension user's telephone and the public switched telephone network (PSTN). As a result its development has been influenced by technical changes in the PSTN, and by technical changes at the telephone.

The public telephone networks in both the UK and continental Europe are almost entirely based on electromechanical switching technology. The public telephone exchanges employ three generations of switching technologies (Strowger, crossbar, and reed relay), and these are described in Section III. In the last five years, the European PTTs have announced that they intend to upgrade the public telephone exchanges to make them fully electronic, and the new electronic exchanges will employ computers to control the switching of voice traffic. Although some countries have already started to replace electromechanical telephone exchanges, the majority (including the UK) will not do so until the mid-1980s.

Compared with the computer industry, the introduction of electronics to telephone exchanges has been slow, primarily because the electromechanical devices have been remarkably cost effective. Recently, however, the advent of medium- and large-scale silicon technology has led to the development of electronic telephone exchanges at price levels which are justifiable in terms of the extra facilities they can provide.

Electronic telephone exchanges are also more compact, and they can provide, at marginal cost, many features which are either impossible, or else very expensive, to achieve on electromechanical telephone exchanges. These features derive primarily from the use of digital computers to control the operation of the exchange.

In both the UK and continental Europe, the PTTs have to approve all new PABXs before they can be attached to the PSTN. This approval procedure ensures that the various equipments throughout the telephone network in any one country are compatible one with another. On the other hand, the long cycle time of the PTTs approval procedure has meant that the process of introducing new technologies (including computerised PABXs) into the PABX has been a slow one. For example, IBM announced the first computerised solid-state PABX in the UK in 1972, but the Post Office did not approve the first installation until 1975. In the meantime, however, IBM have been very successful with the 3750, and now have over one hundred installations — and four other manufacturers currently have products awaiting Post Office approval. The Post Office is developing a microprocessor-controlled telephone exchange to sell to organisations that have installations with fewer than one hundred extensions — the market that the Post Office monopolises.

Despite the delaying effect of the PTTs approval procedure, the PABX has undergone similar changes in technology to the public telephone exchange, and at a more rapid pace. The original PABXs employed electromechanical Strowger technology, as described in Section III. In the 1950s, a new electromechanical PABX technology — crossbar — entered the European markets. Crossbar PABXs were able to operate at push button telephone speeds, and offered a new range of facilities both for the extension user and the operator. In the late 1960s, attempts were made to add computer control to crossbar PABXs, but these were largely unsuccessful. In the 1970s, however, when fully-electronic PABXs became an economical possibility, the computer became an integral part of the modern PABX.

The development of the computerised PABX has been paralleled over the last few years by the development of electronic equipment in the office that generates information (other than voice information) which can then be transmitted through the telephone network. Report 4, Trends in Office Automation Technologies, reviewed the devices which are in use today, and those which can be expected to appear on the market in the next few years. These include equipment for the transmission and receipt of information in the forms of text, image and data.

Because the PABX was, until recently, based on electromechanical technology, it has demanded specialist skills that are quite different from those required elsewhere in large organisations (for example, amongst the data processing staff). The telecommunications staff in large organisations have these skills, but they have not been closely associated with developments in other areas, such as data processing and electronic mail. The reason for this is that the telephone network in an organisation has always been quite separate from the data and text communications functions.

II. PURPOSE AND STRUCTURE OF THIS REPORT

A Purpose

The decision to install a new PABX carries with it a commitment that extends over ten or more years. It will affect not only the quality and cost effectiveness of today's voice communications, but also the possible evolution of a single business information system in which voice, data, text and image communications are brought together in the same private communications network within an organisation.

Deciding whether to install a computerised PABX and, if so, which one to install, is a new and uniquely different task. It requires both a knowledge of computer technology and an understanding of how the computer can integrate non-voice traffic into an organisation's private telephone network.

With these considerations in mind, this report discusses trends and developments in PABX technology and public voice services. Its purpose is to give those members of management who are responsible for selecting a PABX a solid background on which to base their decisions for the future.

The telecommunications manager, together with his staff, will be chiefly responsible for the task of selecting a computerised PABX. His advice will be acted upon either by the director of management services, or by the board itself. The report, therefore, emphasises those aspects of computer technology which will be useful to him and his staff when selecting a computerised PABX. In so doing, it also examines the increasing overlap there is between telephony and data processing, which has been discussed in detail in Report 5, on The Convergence of Technologies. The convergence of technologies into the private voice network will encourage the addition of non-voice traffic, such as data and text. The report, therefore, also discusses the ways in which this addition could take place, and how the telecommunications manager should plan for such an eventuality.

Many organisations now have an information services manager who has the overall responsibility for managing the private telephone network, the data processing division, and office services. It is his responsibility to approve the recommendation of the telecommunications manager as to which new PABX will be purchased. The report will assist him to evaluate the impact that a computerised PABX has on all non-voice services. It will also help him to decide whether the improvements in voice communications that a computerised PABX can introduce can, taken alone, justify the additional costs involved.

B Structure

The report first examines, in Section III, the evolution of the PABX from electromechanical to electronic technology (including computer control) over the past fifty years and, more particularly, over the past ten years. A knowledge of this evolution makes it easier to understand the additional capabilities which a computerised PABX brings to the private telephone network.

Section IV discusses the new features that computerised PABXs offer, so that the significance of incorporating a computer into a PABX can be seen. It discusses, in separate sub-sections, the features that are of relevance to the extension user, the operator, the system, and the network. It also gives examples of applications of computerised PABXs.

Section V highlights those future developments in telephony which are likely to affect the selection of a PABX today. It discusses the possible enhancements to the public telephone network, such as data communication services, trends in PABX design, and developments in the office (such as the electronic telephone). It also discusses the relevance of those developments to today's planning of telephone network facilities.

Section VI examines the case for selecting a computerised PABX in preference to an electromechanical PABX. Section VII compares the similarities and the differences of commercially-available products in the UK.

In an environment of rapidly changing technology in and around the telecommunications industry, perhaps the most difficult management decision is when to invest in new technology. The report concludes by offering, in Section VIII, some practical advice on how to balance today's needs against the demands of the future. In so doing, it attempts to answer what is probably the most difficult of all questions – when to buy a computerised PABX.

III. THE EVOLUTION OF PABX TECHNOLOGY

As already mentioned in Section II, a knowledge of the way technology has developed makes it easier to understand the benefits that computerised PABXs can provide.

A The Function of the Private Telephone System

The individual members of an organisation who work in a large building need to be able to communicate with one another when desired. Some of them, at least, also need to be able to communicate with members of the organisation who are located elsewhere, and also with individuals (such as customers, suppliers, clients, etc.) who are not members of the organisation. A private telephone system such as a manual switchboard or a PABX (which is the automated replacement of the manual switchboard) handles all internal telephone communications and provides connections to outgoing lines.

Because the internal extensions are used on a random and infrequent basis, the number of connecting circuits in the telephone exchange, or switchboard, need only be a small fraction of the total number of attached telephones and outgoing lines. In the case of outgoing traffic, the number of outgoing lines will also be only a small fraction of the total extensions. In effect, therefore, the PABX acts as a 'concentrator' for a large number of telephones, most of which have a low rate of activity.

This is particularly true of the outgoing lines. In a private network of, say, 1,000 extensions, it may be necessary to install only, say, 50 outgoing lines to handle all the external traffic. At any moment in time, the PABX takes on the task of allocating one of these 50 lines to any extension user who requires an external number. Occasionally, all the lines will be occupied, and other extension users, temporarily, will not be able to have access to the public network. However, on average, an outgoing line will always be available to any extension user who requires one.

B The Replacement of the Manual Switchboard

The first private telephone systems were manually operated. The manual switchboard was inexpensive to purchase, and because human beings operated it, and so supervised all the voice traffic, the telephone system was flexible in operation and well controlled. However, as buildings grew in size and labour costs of the operators escalated, the manual switchboard became less and less cost effective, and the level of service both to extension users and incoming callers declined rapidly. Today, the manual switchboard is generally found only in smaller premises.

The PABX has largely taken the place of the manual switchboard, and it performs automatically those switching functions that human operators carried out on manual switchboards. The first PABX was designed using Strowger technology in the 1920s.

The Strowger PABX consists of a set of electromechanical selectors. An extension user who requires either an internal number or an outside line can set up a path to this number through the PABX by dialling the appropriate digits. Each digit activates a selector switch in the PABX, and contributes towards the setting up of a physical path between the extension line and the required other telephone. Incoming callers are still intercepted by an operator before being redirected to an extension number through the PABX.

Although the Strowger PABX reduces the labour content from the telephone system, it considerably weakens control over outgoing calls. If, as a result, extension users use their phones to make private calls, or use their phones indiscriminately, higher telephone charges result. Successive generations of PABXs have attempted to reintroduce an element of control over outgoing calls and extension facilities to make it as easy for the extension user to make a call as it was when the switchboard was completely operated by a human being.

C Common Control PABXs

The switching and the control functions in a Strowger PABX are combined. Each selector acts jointly with others as a component of both the physical switching path and the control mechanism for setting up that path. The crossbar PABX, which dates back to the 1960s in Europe, separates these two functions.

The term crossbar refers to the switching circuits within the PABX which carry the voice signals. Each telephone line connects into a switching matrix in which paths are set up between different lines by closing a cross-point. The crossbar switching matrix is electromechanical, but it operates at a considerably higher speed than the Strowger selectors. Figure 1 below shows the crossbar switching.

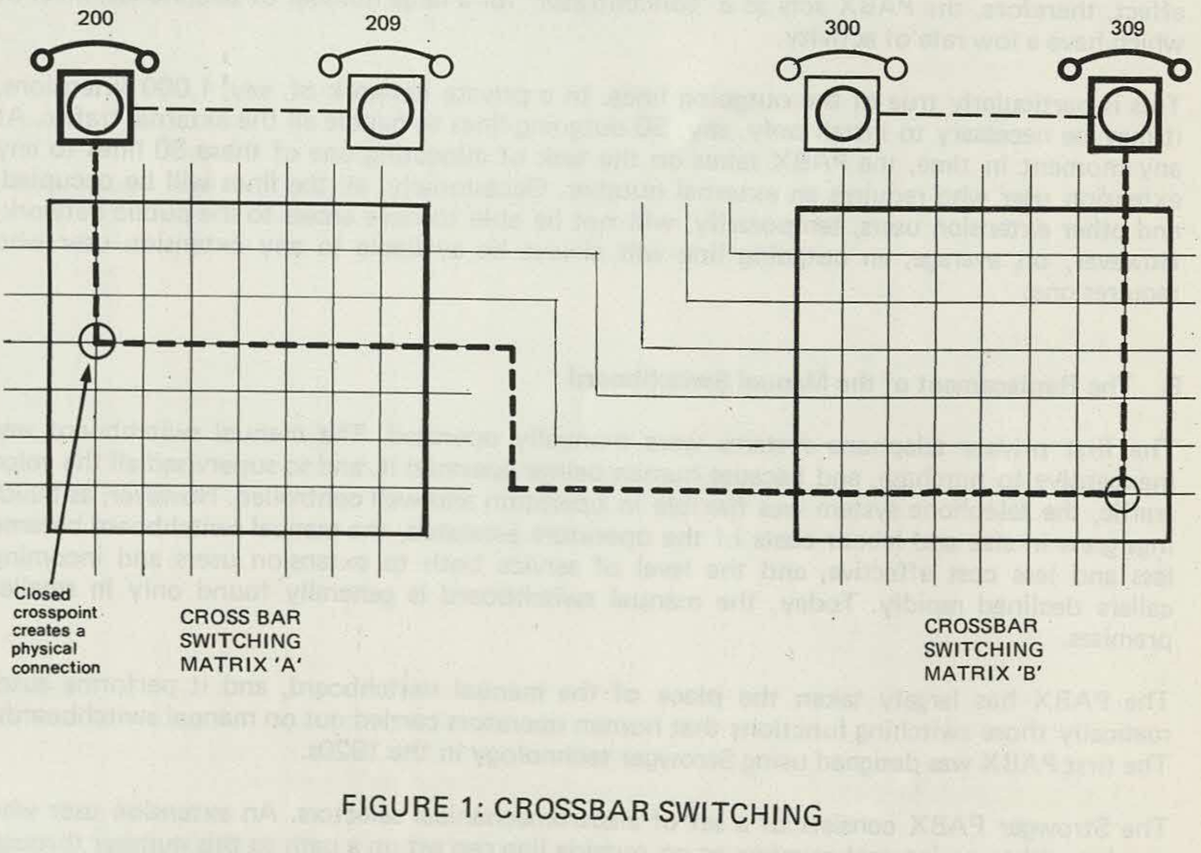

FIGURE 1: CROSSBAR SWITCHING

A separate control system supervises the crossbar switching matrix. An extension user sets up a call by dialling directly into the control system the digits of the telephone number of the person he is calling. The control circuits then activate a cross-point in the crossbar switch, and this connects the two parties together.

The advantage of isolating the switching circuits from the control is that it makes it possible to include common facilities in control which all users can use. The computer is especially suited to controlling the switching of telephone traffic because of its fast speed of operation and its inherent flexibility. However, in the 1960s, crossbar PABXs were designed with purpose-built electromechanical control circuits to operate the crossbar switching matrix.

In the electromechanical range of PABXs, crossbar has been succeeded by reed relay technology. Instead of a crossbar switching matrix, the reed relay PABX employs arrays of reed relays, with each relay acting as a cross-point in the switch. The advantages of the reed relay derive from the fact that it is encapsulated in an inert gasseous environment, and so is most reliable in operation. It is also able to switch at higher speeds than the crossbar switching matrix and, in addition, is physically more compact.

As mentioned in Section I B, the first computerised PABXs consisted of crossbar switching technology and computer control. The resulting PABX was not a commercial success, largely because the crossbar technology did not produce fast operating speeds. Reed relay switches, by contrast, are sufficiently fast, and are also compact enough, to be compatible with computer control. The Philips EBX 8000 combines reed relay switching and computer technology.

D The Electronic PABX

In an electromechanical PABX, a voice path is set up between two telephone lines by establishing a physical connection across the switching network. This is a slow-speed operation because it involves closing the network's electrical contacts by mechanical means. Because the switching operation creates a physical path in space between the two telephone wires it is frequently referred to as "space division switching". With a space division PABX, each voice signal is transmitted down a separate voice circuit.

Electronic PABXs use a variety of switching techniques including space division, time division, and frequency division. Section III C discussed electromechanical PABXs based on space division switching techniques. These techniques are also used in electronic PABX technology in which the switching circuits continue to use discrete cross-points arranged in a similar switching matrix to that illustrated in figure 1. Nowadays, these cross-points belong to one of the following types:

- Electromechanical
- Discrete electric components
- Large scale integration (LSI) devices

The technology used in the cross-point determines the frequency and power characteristics of the switching circuits. For example, reed relays, which are electromechanical devices, can transmit signals from several hundred kilohertz down to the frequency of direct current. They can also handle power ranges from the milliwatt levels that are associated with voice signals up to watts (ringing current levels). The line circuits necessary to interface with reed relay switching networks are comparatively simple, and they need only provide protection against very high voltage external signals, such as lightning strikes and power crosses.

By contrast, systems that use electronic cross-points (based on either discrete electric components or LSI devices) require more complex (and more costly) line circuits that incorporate high quality transformers. In most cases, very careful earthing is needed to minimise noise pick up. The electronic components are fragile and they need greater protection from external power surges.

By comparison with electromechanical technology, the solid-state switching matrix has many advantages. It is smaller, costs less, works at a faster speed, and lasts almost indefinitely. The recently-introduced LSI cross-point components have significantly reduced the size and physical complexity of space division PABXs.

As a recent development, low-cost silicon components have been introduced into both public and private networks, and with the use of these components voice signals are digitised. Instead of transmitting a continuous analogue voice signal, digital telephone networks transform these signals into streams of binary digits (Os and 1s). The low-cost silicon components (integrated circuits) are ideally suited to switching binary information – irrespective of whether this consists of voice or data. The switching of digital signals requires a time division technique which is described below. The digitisation of the public and private networks, external to the PABX, is described in Section V.

Time division switching is based on the fact that a frequency-limited analogue signal (such as a voice signal) does not have to be transmitted continuously in order to enable all of the information to be received. If the amplitude of the voice signal is 'sampled' at constant intervals in time, and the measured sample is transmitted instantaneously to the receiver, it is possible to accurately reproduce the original voice signal, providing that the time interval is small enough. Figure 2 illustrates this process.

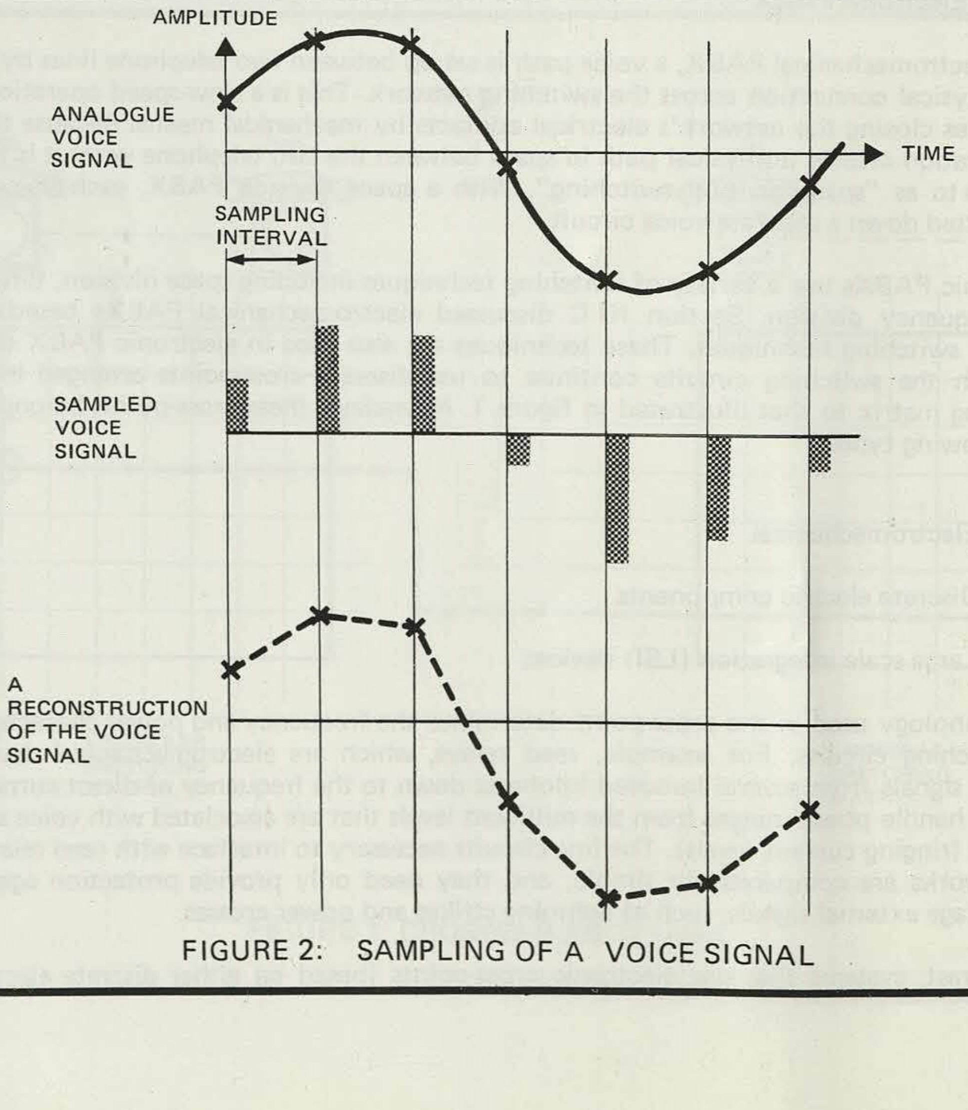

FIGURE 2: SAMPLING OF A VOICE SIGNAL

Once a voice signal has been broken down into discontinuous samples of the signal amplitude, digital telephone systems (including the commercially-available time division PABXs) convert these amplitude samples into binary information. This process is called pulse code modulation (PCM). A fixed number of binary digits are used to measure the amplitude of each voice sample. Although both eight-bit and twelve-bit binary PCM systems are available today, the PTTs have standardised on the eight-bit system. Figure 3 illustrates PCM signalling.

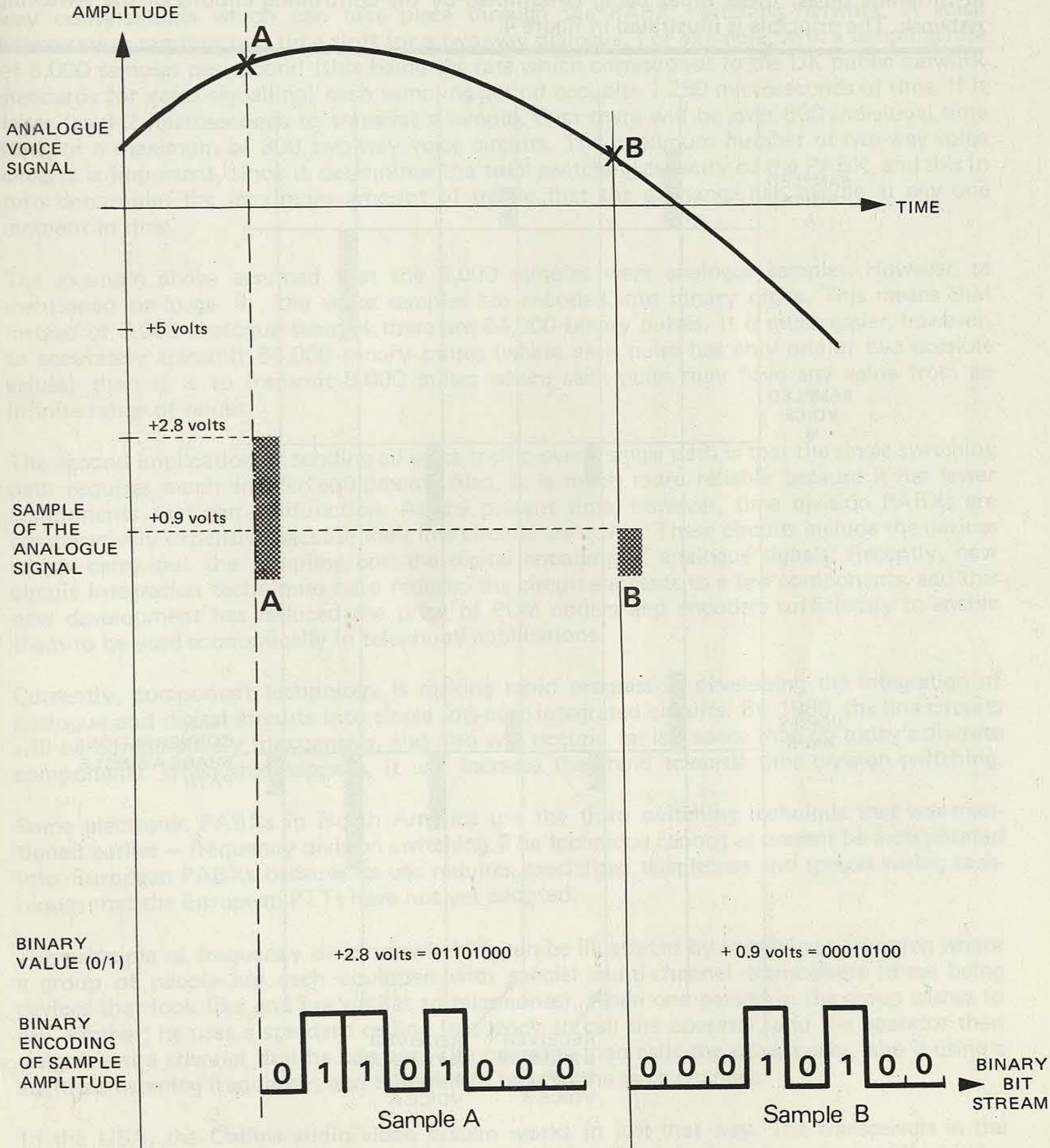

FIGURE 3: PULSE CODE MODULATION

As already mentioned in the first paragraph of this sub-section, with a space division PABX, each voice signal is transmitted down a separate voice circuit. With a time division PABX, by contrast, many different voice signals are transmitted down a common path. This is physically possible only when the continuous voice signals have been broken down into discontinuous samples, as described above.

Samples belonging to different conversations are communicated down the common switching path at different times. This method of interleaving signals in time on a common path is called time division multiplexing (TDM). The receivers of the signals pick off their respective signals at different times, these times being determined by the controlling circuits of the switching network. The principle is illustrated in figure 4.

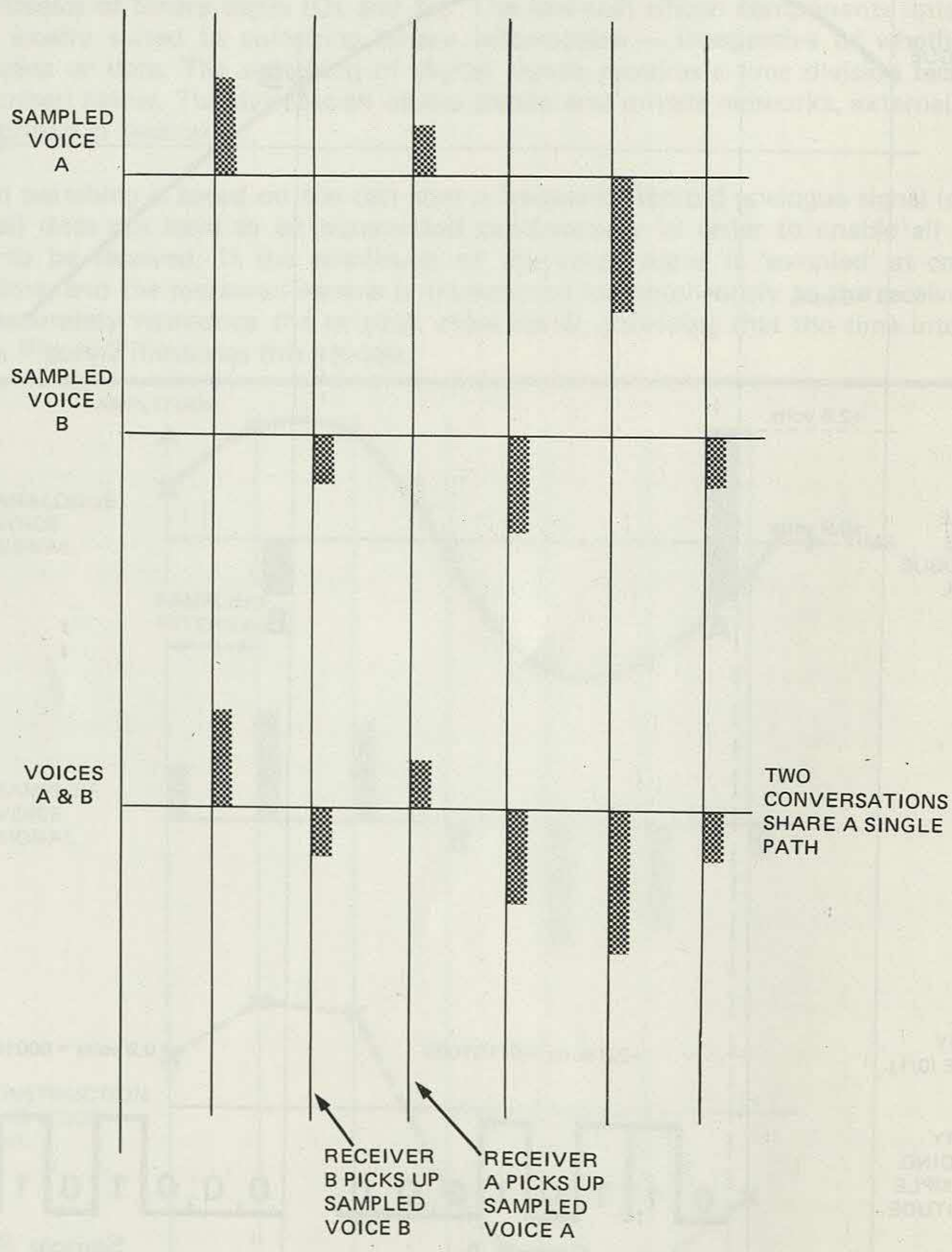

FIGURE 4: INTERLEAVING OF TWO CONVERSATIONS IN TIME

This method of sending all the voice traffic over a single path has two implications. The first implication is that the physical delay of transmitting individual samples down the path forms a significant proportion of the total sampling interval, and this limits the total number of samples which can be interleaved during one sample interval. In order to take account of the physical transmission delay that each sample experiences in travelling down the path, the sampling interval is subdivided in time into a number of 'time slots'. During each time slot, an individual voice signal is communicated from the sender to the receiver down the switching path.

The total number of time slots in a sampling interval determines the maximum number of one-way conversations which can take place through the PABX switching network. A voice conversation requires two time slots for a two-way dialogue. For example, with a sampling rate of 8,000 samples per second (this being the rate which corresponds to the UK public network standards for voice signalling) each sampling period occupies 1,250 microseconds of time. If it takes (say) 2 microseconds to transmit a sample, then there will be over 600 individual time slots, or a maximum of 300 two-way voice circuits. The maximum number of two-way voice circuits is important, since it determines the total switching capacity of the PABX, and this in turn determines the maximum amount of traffic that the exchange can handle at any one moment in time.

The example above assumed that the 8,000 samples were analogue samples. However, as mentioned on page 9 , the voice samples are encoded into binary digits. This means that instead of 8,000 analogue samples there are 64,000 binary pulses. It is much easier, however, to accurately transmit 64,000 binary pulses (where each pulse has only one of two possible values) than it is to transmit 8,000 pulses where each pulse may have any value from an infinite range of values.

The second implication of sending all voice traffic over a single path is that the single switching path requires much smaller equipment. Also, it is much more reliable because it has fewer components that can malfunction. At the present time, however, time division PABXs are comparatively expensive because their line circuits are costly. These circuits include the devices which carry out the sampling and the digital encoding of analogue signals. Recently, new circuit integration techniques have reduced the circuit elements to a few components, and this new development has reduced the price of PCM coders and encoders sufficiently to enable them to be used economically in telephony applications.

Currently, component technology is making rapid progress in developing the integration of analogue and digital circuits into single low-cost integrated circuits. By 1980, the line circuits will be comparatively inexpensive, and also will occupy far less space than do today's discrete components. When this happens, it will increase the trend towards time division switching.

Some electronic PABXs in North America use the third switching technique that was mentioned earlier – frequency division switching. The technique cannot at present be incorporated into European PABXs because its use requires specialised telephones and special wiring techniques that the European PTTs have not yet adopted.

The principle of frequency division switching can be illustrated by imagining a situation where a group of people are each equipped with special multi-channel transceivers (these being devices that look like and are similar to telephones). When one person in the group wishes to call another, he uses a standard calling frequency to call the operator, and the operator then assigns him a channel that he can use. The operator then calls the other party, who is using a standard listening frequency, and tells him to tune to the same channel.

In the USA, the Collins audio/video system works in just that way. The transceivers in the system are all connected to a single co-axial cable. The telephones are 'scanned', using a common control channel and, as required, they are allocated to individual user channels. This system is useful when the co-axial cable, with its huge bandwidth, is used to connect signals of varying types, such as TV monitors and data processing terminals.

In modern PABXs, the switching network provides the electronic circuits through which all the analogue signals are transmitted. As implied earlier, the only switching techniques available in European PABXs are space division switching and time division switching. In all PABXs, however, the control circuits that are used in setting up the switching paths are being replaced by digital computers.

E The Computerised PABX

The control of the Strowger PABX is incorporated into the selector switches. The distribution of control throughout the switching network reduced the risk that the complete system might fail. However, the common control PABXs (including crossbar, reed-relay and electronic) have separate switching and control circuits. This increasingly makes the system more vulnerable, because it places the responsibility for control into a common group of circuits (which, in the computerised PABX, consists of a single computer).

If a failure occurs in the computer control, the PABX will go off the air. Most computerised PABXs have partially overcome this problem by duplicating all the control circuits. The active circuits also have the facility to execute certain self-testing routines, and these can quickly and accurately diagnose hardware failures.

The computer control in a computerised PABX consists of a digital processor and an electronic store. In some PABXs there is also an external store, such as a magnetic disc. The processor performs tasks such as the allocating of switching circuits to incoming callers, the monitoring of outgoing traffic, and the testing of hardware within the PABX. It also provides all the facilities for the extension user and the operator that are discussed in Section IV. The electronic store contains those instructions that are necessary to execute all these tasks and provide the facilities through the processor. It also contains the numbering plan and the allocation of facilities to all extensions.

The computer control of computerised PABXs has advanced in step with the advance in computer technology generally. The early computerised PABXs, such as in the IBM 3750, incorporated physically large and powerful computers. Later computerised PABXs, however, were built around a minicomputer such as the Data General Nova in the Plessey PDX. The second generation computerised PABXs, which are now available, employ microprocessors instead of minicomputers. These PABXs represent a return to distributed control, where several microprocessors undertake a variety of dedicated functions. This methodology of distributing control to several separate elements increases the reliability of the system because the whole system is not closed down when individual elements fail. The ITT 4080 is microprocessor-based.

The computerised PABX (as described in Section IV) incorporates many of those features of control and flexibility that manual switchboards have always contained. The computerised PABX provides the benefit that it is fast and needs fewer operators than does the manual switchboard.

As the cost of the technology decreases, and the features and facilities increase, the computerised PABX will rapidly replace both the manual and the electromechanical telephone systems. The features and facilities of the computerised PABX are described in the next Section.

IV. FEATURES AND FACILITIES OF COMPUTERISED PABXs

A Introduction

Computerised PABXs offer many features and facilities that are of importance for the extension user, the operator, management control, system flexibility, network management, and maintenance. This Section briefly reviews the most important of these features and facilities (based on the experience of installations that have installed computerised PABXs), and briefly describes the form in which these features and facilities are offered in commercially-available PABXs.

B Features and Facilities for the Extension User

A computerised PABX improves the speed and the effectiveness of a private telephone network. It does this particularly by a number of features and facilities that enable the extension user to make a call more quickly, and that improves the chance that he will be connected (and connected quickly) with the person he is calling. Organisations that have installed computerised PABXs have found that extension users readily learn how to use some of these features and quickly adopt them. Other features are, however, a little bit more difficult to learn how to use and extension users, unless they are educated in their use, tend not to adopt them. Most extension users, therefore, do not take advantage of all the features that they could use, and each installation tends to favour a different set of the available features.

Because the computerised PABX is programmable, the manufacturer of a PABX arranges for the available features to be available to extension users in the form of different 'classes of service'. Each class of service comprises a different selection of features, and the computerised PABXs that are available, or are being sold at the moment, offer between 16 and 96 classes of service. The number of features available within each class of service is entirely at the discretion of the telecommunications management of an organisation, although the manufacturer will offer advice on the way features should be allocated to each class of service.

In order to use the available features of a computerised PABX most effectively, the telecommunications management of an installation needs first to decide the individual features that would go into each class of service, and then to allocate to each extension user the class of service that he needs to be able to use if he is to perform his job most effectively and most efficiently. Because the PABX is programmable, it is a simple matter subsequently to alter the features within a particular class of service, or to allocate a different class of service to a particular extension user.

The features that existing installations have found to be both most useful and most readily adopted by extension users are briefly described below:

— *Abbreviated dialling*
  The abbreviated dialling feature enables the extension user to dial those external numbers that he uses frequently, with an abbreviated code of (say) two or three digits, instead of having to dial the full number.

The abbreviated dialling feature is very popular with extension users in existing installations because it is easy to learn, and it saves them considerable time in looking up and dialling an external number. It must be pointed out, however, that although the user has merely to press two or three buttons on his push-button telephone in order to initiate the call, the time required to make the connection with the person being called is the same as if the extension user dialled the full number on a rotary dial telephone.

The abbreviated dialling feature varies considerably between different manufacturers' PABXs, and this difference generally arises because of the size of the store in the computer that is allocated to hold the abbreviated numbers. Generally it is possible for different departments in an organisation (for example, sales, production, and accounts) to have different directories of abbreviated dialling numbers, and for each abbreviated directory to comprise 100 or more different numbers all of which can be obtained by dialling a two- or three-digit code.

In addition to these common abbreviated directories, computerised PABXs also offer a limited number of personal abbreviated directories which certain authorised extension users can use. Because this feature makes a heavy demand on the computer store it is usually limited within an installation to a comparatively small number of directories with each authorised extension user being able to use only about ten numbers which he programmes on his own telephone. This personal abbreviated dialling feature could be made more widely available (without making special demands on the computer store in the PABX) through the development described in Section V C by which the telephone itself could be used to provide personal abbreviated dialling external to the PABX.

— *'Camp-on' or 'Ring-back when free'*
When an extension user dials another extension and finds that he gets the engaged signal he can, through the camp-on feature, dial two extra digits to signal that he wants to be connected to the other extension user when that extension user terminates his present conversation. Then, when the called extension user hangs up his phone, the connection is made automatically first to the extension user who is originating the call and then, when he answers, to the called extension user.

With some PABXs once an extension user camps-on he is not able to use his phone again if he wants to leave the camp-on in force. Other PABXs, however, allow the extension user to make other calls whilst being camped-on to another extension user. With some PABXs the extension user who is being called hears a warning tone when another extension camps-on to him. With other PABXs the extension user who is being called, and who is already speaking on his own phone, is not made aware that he is being camped-on.

— *Call transfer*
With the call transfer feature an extension user who has called another person can be re-directed by that person to a second extension without the need for operator intervention.

— *Call pick-up*
With the call pick-up feature an extension user who hears a nearby telephone ringing, and knows the extension number of that phone, can intercept the call and take it on his own phone.

— *Save and repeat*
With the save and repeat feature an extension user who dials an external number and finds that it is engaged can 'save' that external number. Some time later, when he decides to repeat the call, he can initiate that call merely by dialling a two-digit repeat code number and the call will be made automatically for him.

– *Third party conference*
The third party conference feature enables three or more people to participate at one time in a single telephone call.

– *Executive override*
This feature (which is allocated to only a limited number of extension users) allows a third party to enter a conversation that two other individuals are conducting between themselves.

Two other features for the extension user are worth mentioning here, even although extension users in existing computerised PABXs have almost completely neglected to use them.

The first of these is the call park feature. With the call park feature, an extension user who receives a call on his own telephone may arrange for the call to be 'parked' on another nearby telephone which is not at that moment being used. When he does this, the telephone on which the call is parked does not ring, and the extension user can then go to the other telephone and take his call on that telephone.

The second feature that is being very much neglected on existing installations is the do-not-disturb feature. This feature allows an extension user to ensure that, whilst he has that feature in force, his own telephone does not ring and the call is automatically transferred to another extension where that user will deal with the call. Perhaps the main reason this feature is being neglected is that, for practical and obvious reasons, it is being allocated to only a limited number of extension users in any installation.

As implied earlier, all computerised PABXs do not contain the whole range of the features discussed above. Almost certainly, however, each manufacturer will, from time to time, update the software available with the particular computerised PABX, and so enable those organisations that have that particular PABX to upgrade, or to add to, the features and facilities of their computerised PABX. It must be emphasised, however, that changes of this kind will need to be made by the manufacturer, and not by the management of the installation. Also, all changes of this kind require Post Office approval.

C Features for the Operator

For many organisations, the private telephone system is the front window to the outside world. The operator, therefore, has a major responsibility for presenting an efficient and intelligent response to all those persons who are making incoming calls. The incoming caller who has to wait several minutes to be connected to the required person, or who is connected to a wrong number by mistake, gains an unfavourable impression of the organisation concerned. The console of the computerised PABX enables the operator to deal speedily with incoming calls, and it provides her with the necessary information to make a correct and fast connection to the required person.

The electronic consoles associated with computerised PABXs are ergonomically designed to reduce the operator's arm movements. Also, the layout of the console is designed to be both attractive and efficient in operation. A visual display unit on the console provides the operator with information on each call that she is dealing with. For example, she may wish to forward an incoming call to an internal extension. The console will display the source of the incoming call (external, internal, private line, etc.) and the status of the telephone of the person who is being called (engaged, ringing, camped-on, etc.). Then, if the person to whom she has forwarded the call does not answer in a pre-selected time (say 15 seconds) the visual display will alert her to the fact that that person has not answered the call. By this means she is able, with the minimum delay, to inform the external caller that the person he is calling is not available.

The information on the console's visual display is continuously updated so that the operator always has comprehensive and up-to-date information in front of her. This information enables her to supervise efficiently a large number of calls, and she can react quickly to each individual call with an informed response to the external person who is calling.

With a few computerised PABXs the operator can also have a separate visual display terminal to assist her in locating desired telephone numbers. Both the IBM 3750 in this country and the Danray in the USA have a magnetic disc memory on which the names of all internal staff, together with their extension numbers, call billing information etc., can be recorded and updated on a day-to-day basis. This feature means that instead of having to spend time in searching through internal telephone directories, the operator can obtain the information on-line on her visual display unit. This not only saves her considerable time, but helps to eliminate the problems (particularly of wrong numbers) that arise when the internal telephone directory is in conventional printed form.

When the extension users make use of their own telephone features, such as call transfer, they release the operator from work which she would otherwise have to perform.

The combination of all the features above means that the operator can work more speedily and more efficiently, and with a reduced workload. This means that in a small PABX installation the operator can carry out other jobs, such as that of receiving visitors. It also means that in large installations fewer operators are required.

D Management Control

With electromechanical PABXs management has little control over the expenditure on telephone calls. In many organisations an extension user can pick up his telephone and make a long international call costing (say) £100, without anybody knowing that he has made this call. The computerised PABX, for the first time, has introduced into private telephone networks a comprehensive management control over the cost of telephone calls. This control can be established because outgoing calls can be monitored and selectively controlled, and telephone charges can be distributed to individual extensions. This control is achieved by two means: route restriction and call information logging, as discussed below.

1. Route restriction

The crudest form of cost control (which, however, has the merit that it restricts the extent to which extension users can use their telephones for improper or indiscriminate purposes) is to restrict the range of numbers an extension user can dial. For each user, this restriction would form part of his 'class of service'. According to the features in his class of service an extension user might be allowed to make telephone calls on only one of the following bases:

- Internal calls only
- Internal and external local calls
- Internal and national calls
- Internal, national and international calls.

In addition, with most computerised PABXs it is possible to 'bar' specific telephone numbers or sequences of digits, such as the number 100 for calling the operator.

2. Call information logging (CIL)

With a computerised PABX the details of all outgoing calls from each extension can be recorded on a magnetic disc or on magnetic tape at the time each call takes place. Subsequently, the information that has been recorded in this way can be analysed to produce reports for the following three purposes:

- *Cost allocation*
  All calls can be summarised by extension user, or charge code, or department, or profit centre.
- *Abuse detection*
  Calls can be analysed to look for calls made to certain specific numbers such as turf accountants' numbers, or the extension user's home number, or to look for calls made outside office hours, etc.
- *Call charge validation*
  Call charges can be listed and totalled to allow them to be matched with the telephone bills received from the Post Office.

The introduction of route restriction and call information logging will not necessarily produce an immediate and dramatic reduction in telephone costs. It may be (although it is most unlikely) that in a particular organisation all extension users use their telephones in a way entirely necessary to the business. In practice, however, management's ability to restrict and control outgoing calls, and to monitor the calls that are made, should produce a reduction in telephone costs. It should also ensure that the expenditure on telephone services is contributing towards the business, and is not subsidising personal calls.

E Features Providing System Flexibility

A computerised PABX provides system flexibility by enabling day-to-day changes to be made in the extension users' numbering plan and in the allocation of facilities. Through the use of a simple keyboard terminal facilities can be allocated without the need to make modifications to hardware.

F Features for Network Management

If an organisation either operates, or is considering operating, a private network (including private lines between all its major sites) a computerised PABX could increase the utilisation of private lines and, as a result, maximise the return of the telecommunications investment.

For example, a dialled number might be served by either a private line or an out of area exchange line. A computerised PABX can route the call over the cheapest possible trunk line available and therefore maximise the use of fixed tariff lines.

A computerised PABX has two facilities to help in network planning and utilisation: traffic tables and route optimisation, as discussed below:

1. Traffic tables

It is possible with a computerised PABX to compile records of traffic patterns in the private network. These would include the use made of outgoing lines (both public and private), the availability of switching circuits for traffic within the PABX, and the use of various features and facilities, etc. These records could be accumulated over a period of hours, or even days, and then analysed to identify overall trends, rather than specific call details. Subsequently, management could, by studying the analysed CIL information and the trends of traffic patterns, decide whether there were sufficient outgoing lines to meet peak traffic conditions, and whether it would be desirable to introduce additional private lines over frequently-used routes. From the traffic patterns, management also could see to what extent the extension users were taking advantage of the extension features available to them. They would be able to see from this whether it was necessary to provide training to familiarise extension users with the features that they should be using in order to improve their efficiency.

2. Route optimisation
Where it is a complicated matter to determine what the proper trunk group is for a call (e.g. private line, public line, out-of-area exchange line, etc.), it is sensible to program the procedure for doing this into the PABX and, by doing this, avoid the problem of training extension users or operators. This is particularly desirable in the USA because of the variety of trunking options that are available there. Even in this country, however, it can be of value in those large networks that use private lines and out-of-area exchange lines.

Where the class of service permits it, routing systems generally operate by selecting the most economical first-choice trunk group for a given destination and then, if that group is engaged, going to a secondary choice.

A valuable elaboration of route optimisation which increases the utilisation of fixed cost (e.g. private line) trunk groups is trunk queuing. Trunk queuing applies when an extension user dials a trunk group access code and finds that it is engaged. The PABX saves him the inconvenience of having to repeatedly dial that code by calling him when the particular trunk is free.

G Features for Easier Maintenance

A keyboard terminal located in a computerised PABX equipment room allows the Post Office's service staff to have access to maintenance information from within the PABX. Through the self-testing routine the PABX automatically informs the operator that a fault has developed in the hardware of the PABX. The operator can then telephone the Post Office engineer, who can then use the keyboard terminal to have the results of the self-testing routine printed out for him. From these results he can, with the minimum of delay, trace the fault to a particular hardware component.

The self-testing routine eliminates the need for regular maintenance inspections, and removes from extension users the responsibility for reporting faults. The keyboard terminal enables maintenance changes to be made, such as the activation of a spare circuit in the PABX cabinet.

The service keyboard can be connected remotely (across the telephone network) to the PABX. The Post Office have not yet, however, given approval for this in the UK.

H Features for New Application Areas

The flexibility of a computerised PABX system provides the opportunity for new applications of the telephone within offices and factories. In particular, the integration of a computer into the telephone network can assist in several ways with the management of traffic in the network. Three ways in which a computerised PABX can be used for this purpose are discussed below:

1. Automatic call distributing
The automatic call distribution (ACD) facility automatically queues incoming calls, and then allocates each call to the first extension user who is free to answer that call. This is a particularly useful feature for large systems such as airline, car hire, and hotel reservation centres, telephone directory assistance centres, credit card authorisation centres. It can also be applied with advantage to those organisations (such as computer manufacturers) that have a large field support service department. ACD monitors the traffic and, in some cases, determines the average delay before a call is answered.

ACD in a computerised PABX has the advantage that, through the service keyboard, it is a simple matter to adjust the number of answering positions.

2. **Voice and data**
The telephone network is increasingly being used to carry non-voice traffic. However, the majority of electromechanical PABXs make no provision for the communication of non-voice traffic beyond simply offering point-to-point voice circuits.

The communication of non-voice traffic (such as data, text and image) requires special facilities which are discussed in Section V F.

The IBM 3750 is one of the first European PABXs to offer non-voice facilities. Many of the organisations that have installed 3750s exploit some of these data features and other organisations plan to do so. The most apparent value of these features, however, has been in justifying the extra investment cost of the IBM 3750 over its earlier competitors.

Special characteristics of the 3750 which are not generally provided with PABXs — whether they are computerised or not — are:

— Extension lines are terminated not only in telephones but also in data terminals and contact monitoring devices, such as thermostats.

— A bulk storage device (a magnetic disc) is standard equipment with the control unit.

— A voice response unit is connected to the PABX. This voice response unit enables a computer to respond to a data enquiry with a verbal message that is transmitted to the telephone of the person making the enquiry.

— A communications link is available to a data processing system, and this link is, in fact, often provided with an organisation's 3750.

The 3750 has a basic capability for collecting data. Local terminals, attached to the telephone network, enter data which is checked and then stored on a magnetic disc in the PABX. Later, on request, the data that has been stored on the disc can be loaded into a standard computer peripheral device or (via a communications link) to a computer. (CIL information is usually handled in this way and this is the most common example of a data application with the 3750).

The 3750 also has available an optional data function which is known as 'Real-time data collection to DP systems'. This capability provides for terminals (either local or remote) to be switched through the 3750 (without local storage of information on magnetic disc) to a data processing system connected via a synchronous data communications link. The 3750 may also perform a number of error checks on the input data that is received from the terminals. In addition, the data processing system may give an instruction to the 3750 (via the data link) to direct the 3750's voice response unit to provide a verbal response to the terminal. This facility eliminates the need for a visual display on the extension user's terminal. This means that the telephone can be used to access information, using the push buttons to make a request, and using the handset to receive a verbal response.

IBM have developed a family of terminals that can be used on the shop floor to collect data. These terminals include the following:

— A magnetic stripe card reader.

— A cluster unit, which may consist of an alph-numeric keyboard, a punched card reader, and a magnetic stripe card reader.

These terminals are satisfactory for several applications, such as the use of a magnetic stripe card reader to act as an attendance recorder or to act as a device controlling access to a doorway. Some more complex data entry or data enquiry functions, however, require features that this limited terminal array do not provide.

The telephone has not yet been widely used as a data capture unit because it has certain deficiencies, such as a lack of visual display and hard copy.

The application of data terminals has also been inhibited because non-IBM terminals cannot readily be adapted to interface with the 3750. There are, however, several well-integrated systems that exploit the capabilities of the 3750. For example, one French bank uses the system for dealing with customer account enquiries, for building services (such as heating), and for controlling entry to car parks and buildings.

Organisations that have installed a 3750 have generally not developed sophisticated integrated applications. CIL is the most common data application on 3750s, and the next most common is flexitime recording, which is a simple data collection function.

The data facilities on the 3750 have several deficiencies such as inappropriate terminal devices, limited PABX storage capacity, and constraints on throughput for high-speed data. The 3750 has, however, been extremely valuable in identifying the kind of data facilities that need to be included in second-generation computerised PABXs.

3. Network configurations

Some PABXs offer those organisations that have multiple sites additional network features which can considerably enhance the voice network as a whole. For example, considerable economies can be made by introducing fixed tariff private lines into a private telephone network, always provided that these lines are optimally utilised. A computerised PABX enables this to be achieved by automatically managing route selection through route optimisation as described in Section IV F. Also, traffic tables enable the management of a computerised PABX to analyse traffic on a private network to see whether additional private lines are necessary in order to meet increased traffic demands.

As computerised PABX networks become more sophisticated it is possible to introduce control links between PABXs that are physically remote one from another, to enable extension features to function over several sites. For example, it is a relatively straightforward matter to introduce desk-to-desk dialling across several sites and to have one extension numbering plan which covers all internal telephones on all sites. Such a system has several advantages, a most obvious one being that an extension user on one site can arrange to have his calls automatically forwarded to an extension on another site.

V. FUTURE DEVELOPMENTS

A Introduction

The PABX is a small but nevertheless an important and integral part of the large nationwide telephone network which includes not only all PABXs, but also the telephone lines, the public telephone exchanges, and the telephone instruments. Any changes that are made in the services that are offered in the public network will affect an organisation's private network, including its PABX. So too will any developments that are made in the telephone.

Section V B discusses the current plans in this country for a digital public network, and the likely effect these plans will have on the implementation of organisations' private networks. Section V C examines likely developments in electronic telephones which, if they are introduced, will add new facilities to private networks. Section V D discusses those new technologies which could influence the design of PABXs, and which could lead to the development of a new generation of PABXs. Section V E discusses some general concepts concerning the design of communications systems, and so provides an understanding of the PABX's role in integrated voice and data communication systems. Section V F discusses the way in which these concepts apply to the integrated private communications networks (combining both voice communication and data communication) which are likely to emerge by the mid-1980s.

B The Public Telephone Network

Most European PTTs have similar plans for their communication services to those that the Post Office in this country has. These plans include the digitisation of the voice network, and the introduction of a specialised data communications network.

The Post Office has announced plans for gradually replacing all public telephone exchanges with computerised electronic exchanges — the electronic exchange being known as System X. The Post Office is scheduling the first installations for 1985, but because of the high cost and the large scale of effort that are involved in implementing a nationwide electronic exchange network, telephone users are not likely to see significant improvements in network facilities for at least ten years after the first installation.

In the USA, the first electronic exchange was installed a few years ago, and currently, AT&T are installing electronic exchanges at a rate of about one a day. So far, however, only in the major metropolitan areas in the USA have telephone users had their rotary dialling telephones replaced by key phones, and almost no new facilities have been introduced as a consequence of the introduction of computerised PABXs. AT&T are waiting for Western Electric to introduce computerised PABXs on a nationwide scale before they offer, on a commercial basis, certain of the telephone facilities described earlier in Section IV of this report.

Similarly, the Post Office in this country will delay introducing new facilities until it can offer them on a nationwide basis and, in our opinion, this will not happen until at least the early 1990s. The digitisation of the public network, including the electronic exchanges (employing time division switching technology) will take place initially over major inter-city trunk routes and at group switching centres. All of this development will have little impact on the telephone user until the digitisation reaches the local exchanges, and this will not occur until towards the end of the replacement programme.

It follows from what has just been said that those organisations that purchase a PABX in the next year or two, so that they can use it over the next decade, will receive little if any benefit from the Post Office's plans to computerise public telephone exchanges. Those organisations may, however, receive benefits from the Post Office's plans to introduce additional data services (including Packet Switched Service (PSS)) and private digital lines, which were discussed in Report 7 on Public Data Services. These two services are discussed in the next two paragraphs.

In the next ten years the Post Office service that will have the most important effect for those organisations that have computerised PABXs will, we believe, be the introduction of high-speed digital lines. These (as figure 5 shows) will probably be first introduced in 1982, and they will be available for private use between major cities in this country. Section V F mentions the way in which these high-speed private lines might bring about the introduction of digital private networks much earlier (probably by a decade) than the introduction of the public digital network.

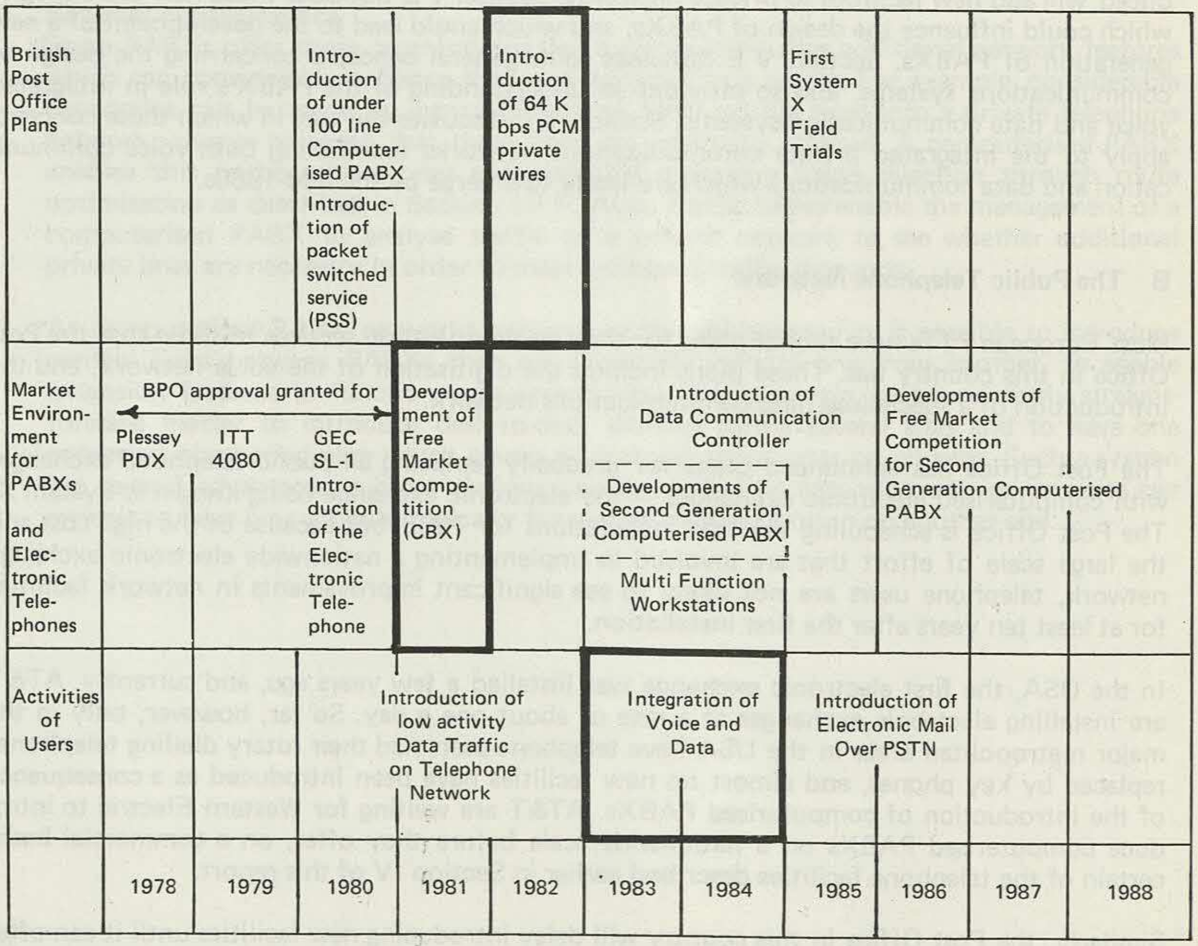

FIGURE 5: THE FUTURE OF TELEPHONY IN THE UK

The packet switched service, which (as figure 5 shows) is likely to be introduced in 1980, could have a marginal impact in encouraging organisations to attach more low-activity terminals to their voice networks. This will, however, only affect the traffic volumes through an organisation's PABX. It will not affect the signalling, since PSS will operate at data rates well within the voice bandwidth of three kilohertz.

C The Specialised Telephone

Specialised telephones are available in the USA on a large scale. Two of the computerised PABXs that are available in the UK originate from North America, and these could bring with them to this country the specialised telephones which are offered with those PABXs in the USA. These PABXs include the Plessey PDX (licensed from Rolm, California) and GEC's SL-1 (licensed from Northern Telecomm, Canada).

The Post Office has not yet given approval for any specialised telephones to be attached to the UK public network. We consider, however, that the Post Office will give its approval in the next five years or that, alternatively, the Post Office will introduce a specialised telephone of its own within that time. Since computerised PABXs that are selected today will still have many years' useful life left in them in five years from now, it is worth describing here some of the opportunities that specialised telephones will provide.

At an elementary level, the standard Post Office rotary or push-button telephone can have added to it 'dedicated' buttons to enable the user to call up special features. This eliminates the need for the extension user to remember long and complex feature access codes.

The telephone with the SL-1 does not contain any special features, but it can facilitate the use of the features that are included in the SL-1 PABX itself. The SL-1 telephone has between ten and thirty extra buttons and lamps. Each extension user can decide for himself which features he wants to use most often, and the buttons on his telephone set can be programmed to enable him to use those features. For example, if he wants all his calls to be transferred to another extension he can press a button marked 'transfer', rather than have to remember a complex code to do this. When he presses the button a lamp on his telephone lights, and stays alight, to remind him that this feature is in operation.

Most of the microprocessor-based telephones that have been introduced recently include features additional to those that the PABX contains. For example, Rolm have recently announced an electronic telephone (the ETS-100), which is considerably more sophisticated than the telephone with the SL-1. The ETS-100 is built around a microprocessor, and it incorporates both an alpha-numeric display and a set of programmable function keys, in addition to the standard key pad. On this display an extension user, when his phone rings, can see before he lifts his receiver the extension number of the person who is calling him.

Also, if for any reason an extension user does not answer his phone when it rings, the person calling him can leave a visual message on the extension user's display asking him to return the call to the number shown on the display. By means of the display, also, the extension user can visually verify pre-stored telephone numbers and account codes.

The Rolm ETS-100 is connected to the PABX by separate voice (analogue) and data (high-speed digital) links. The first-generation specialised telephone (such as the ETS-100) will use its microprocessor intelligence to extend the voice facilities of the standard telephone. For example, Bell offers a keyphone that has its own abbreviated dialling feature incorporated into the instrument, and the extension user can programme this to suit his own requirements.

The specialised telephone that offers common extension features (such as abbreviated dialling, camp-on and call forwarding) removes a considerable load from the computer control of a

PABX. A specialised telephone also has the advantage that, if the PABX on a particular site does not have all the features that that site requires, they can be supplemented by the features on the specialised telephone.

The advent of the microprocessor and its impact on the telephone has been discussed in Report 5, on The Convergence of Technologies, and in Report 4, on Office Technology. Some time in the future, probably, telephones such as the ETS-100 will be upgraded in several ways. For example, with its built-in microprocessor and memory, the ETS-100 could easily be upgraded in several steps towards Rolm's stated objective of "performing future telecommunications and data transmission tasks that include word processing, electronic mail, and digital facsimile transmission and reception".

The next step will be to provide a direct digital control link between the microprocessor in the telephone and the PABX, down which data can be transmitted from a terminal (such as the telephone keypad itself). This is already possible with the ETS-100.

The final step towards digitising the voice network will be the digital encoding of voice at the telephone and, in the USA, the technology to do this has already been developed. This process will complete the integration of voice and data within the telephone instrument. It will then be necessary for the PABX to administer the separate voice and data connections according to the demands of the traffic.

The Post Office's policy on specialised telephones will determine the timing of their introduction in the UK. It seems likely that the Post Office will give favourable consideration only to those electronic telephones that supplement existing network facilities — such as abbreviated dialling. One UK manufacturer has designed such a device and is now awaiting Post Office approval.

Report 4, on Office Technology, mentioned the Nixdorf Datatel terminal, which is both a telephone and a data terminal. The Datatel is a European product, and it is considerably more advanced in the facilities it has than is the Rolm ETS-100.

Large organisations will be applying pressure on the Post Office for approval of the introduction of voice/data terminals. The Post Office has already given IBM approval to attach simple data terminals to the 3750 PABX network, and Nixdorf hope to introduce the Datatel during the first half of 1979.

Fully-digital telephones are not likely to be introduced into the UK market in much under ten years, although they are already in the design stage in the USA. If, however, the Post Office adopted a more liberal approach in its attachment policy, the number of specialised telephones in use in the UK would escalate by the early 1980s, since they would be commercially available in the USA at that time. Once the Post Office has given approval for specialised telephones to be introduced, their role will increase as more features and facilities (such as the ability to handle data) become available in private telephone networks.

D Developments in PABX Technology

An organisation that is considering installing a computerised PABX will obviously be concerned about whether the technology in one of today's computerised PABXs will become obsolescent in the next five to ten years. The introduction of silicon technology into the telephone exchange has brought about rapid change in the telecommunications industry recently. It is, therefore, appropriate to examine here what the next developments in PABX design will be following the first-generation computerised PABXs that are already available in this country.

Digital signalling and digital computer control will be permanent features. Evidence of this is provided by the rapid reductions that have occurred in the costs of semi-conductor components, and by the PTT's plans to digitise the public networks in the next decade.

Electromechanical PABXs have a limited future because manufacturing them involves high labour costs. The electronic PABX — and especially the digital time-division PABX — will benefit from the decreasing costs of semi-conductor components. By contrast, labour costs (which, as indicated above, form such a high element in the cost of electromechanical PABXs) will continue to rise in the future. This cost differential will further encourage manufacturers to introduce silicon technology into telephony equipments.

Changes in PABX technology are most likely to arise from integrating components. Second-generation computerised PABXs will be based on large-scale integrated devices, such as the microprocessor and the single chip PCM encoder and decoder.

A generation of digital computers based on the microprocessor is emerging, and microprocessors will be used in the telecommunications network. Already, one computerised PABX (the ITT 4080) is based on microprocessor control. The ITT 4080 does not have a centralised minicomputer, but instead has several single-function microprocessors that perform different tasks (such as line status monitoring and call set up) within the PABX. This approach — which will be embodied in second-generation computerised PABXs — is known as distributed control.

The next logical step is for microprocessors to be included in telephones, and then for a control link to be installed between the PABX and each extension, as has already been discussed in Section V C. Through this approach, control will become increasingly more distributed throughout the telephone network, and this will bring the benefits of increased flexibility and higher system reliability.

The low cost of semi-conductors will, with the PTT's programme to digitise the public telephone network, favour time division switching in the PABX. Assuming, therefore, that the time division switching technique will be the most generally accepted in the next decade, the majority of the switching circuits used will be the PCM encoders and decoders. Large-scale integration techniques have already reached the design stage at companies such as Motorola in the USA and, with these techniques, PCM encoders and decoders could become a single-circuit component. It will be possible to achieve considerable savings in both space and costs by integration within the switching network of the PABX.

The combination of continuing component integration and distributed control through the use of microprocessors will make it comparatively easy to expand a PABX. System design will become increasingly more modular, and this will produce a more gradual cost curve for those PABXs that have a higher line capacity. Unlike what happens in the present systems there will be no major discontinuities in cost per line when a second minicomputer is introduced.

The concept of distributed switching is also being applied to the signalling path within time division switches. The SL-1 switching highway can be extended to remote sites using a 32-channel PCM link. Extensions in the remote site can be interfaced directly into the main PABX through the common switching highway.

The second generation of computerised PABXs will use distributed processing in the form of microprocessor elements, and distributed switching. The switching technology will be predominantly time division, so that it will be compatible with public network facilities.

Over the next five years the number of available computerised PABXs is certain to increase, and figure 5 highlights some probable events that will be significant over that period and beyond. The first event will be that the Post Office will approve all those computerised PABXs that are presently undergoing field trials. Once several products have been approved, manufacturers will undoubtedly reduce their prices to a competitive level — and they will be helped in doing this by the continuing reduction in the cost of components. At the moment, compared with the USA, there is an artificial price premium on European PABXs. This premium exists partly because the European market is smaller, and partly because there is limited competition between manufacturers. Currently available products are likely to fall considerably in price from 1981. In addition, within the next five years manufacturers will introduce add-on units to those products to handle data traffic, and figure 5 shows some likely developments in data services.

To remain competitive all manufacturers will have to develop second-generation computerised PABXs (comprising microprocessors and large-scale integrated switching components) by the mid-1980s. Second-generation PABXs will develop as a consequence both of new low cost silicon component technology and the manufacturers' need to remain competitive. The second-generation computerised PABXs will probably include data facilities.

E The Components of an Integrated Communications Network

Computerised PABX networks can offer new opportunities for integrating voice, data, text and image communications in the voice network. They may, however, also impose certain limitations on the telephone network which could impede future developments. A brief look at communication networks in a more general context will make it easy to understand the possible limitations.

The common features of any communications network include input and output devices, transmission links and switching centres. The facilities and the performance required of each of these components are determined by the nature of the information source concerned. For example, in a voice network, the input/output device is a simple analogue transducer (the telephone) which converts speech into electrical signals. The transmission of voice signals requires a bandwidth of three kilohertz. The transmission links (telephone lines) are designed to accommodate signals within the three kilohertz voice bandwidth. The switching centres (telephone exchanges) provide direct voice paths between the transmission links.

The information source in data communications has quite different communication characteristics. Data, unlike voice, does not always need to be transmitted in real time. In addition, the wide variations in the volumes of data that originate from, say, a magnetic card reader terminal and a main frame channel link require greater flexibility in bandwidth allocation within the communications network.

This means that the components of a data communications network are likely to be quite different from those of a voice network. A common feature of a data network is that the switching centre has a storage capability. The store is able to buffer incoming data traffic until such time as there is spare capacity on an outgoing line. This technique maximises the use of available bandwidth, and this is an advantage since bandwidth is a costly resource in any communications network. It is possible to use the technique of local buffering, however, only when the information does not need to be transmitted in real time. The same constraint applies when text is transmitted.

A different approach is used when two different information sources, such as voice and data, are combined. A voice conversation requires a direct link between two telephones over a fixed bandwidth circuit. Data, however, can be transmitted in bursts, and can be sorted en route to the receiver. With this approach, short bursts of data are transmitted during the time that voice circuits are idle. The computer control of a PABX can allocate idle voice circuits for just this purpose, and can retrieve them later when they are required by the users of voice circuits.

This approach presents two inherent problems. The first is that a PABX is designed to handle only the peak level of voice traffic and, at any one time, this may mean that, at most, 10% of all the telephones are being used for conversation. If extra data terminals are added to the PABX network it is probable that the demand caused by this increased traffic will cause congestion in the voice network at peak periods.

The second problem concerns bandwidth. Data transmission rates depend on the data source. Increasingly, data terminals are becoming more sophisticated, and their use demands higher transmission rates. Typically, a remote job-entry terminal operates at 9,600 bits per second. The Post Office's plans to digitise the public telephone network will include installing, in the early 1980s, high-speed digital circuits of up to 64 kilobits per second. The signalling techniques employed within the PABX must be able to transmit data at rates that are equivalent to those of the public network. In addition, the PABX must also be equipped with extra capacity to handle data, text and image traffic. The PABX will also require extra computer facilities to control the flow of data, text and image traffic.

F The Prospect for Integrating Voice and Data in the Private Telephone Network

Until recently the PABX has been exclusively dedicated to switching voice traffic. In Section

III C, the PABX function was described as that of a concentrator in allocating outgoing lines to those extension users who require an external number at a particular time. The PABX can, in the same way, provide access to computer facilities for data terminals that are connected to the voice network. By dedicating a limited number of outgoing lines to this data traffic, the user of a data terminal can communicate with a computer through the medium of one of these lines.

If the terminals are used only infrequently, the extra traffic will be less likely to interfere with the PAHX's primary function of serving voice users. It will, however, act as a valuable concentrator for data terminals, and it will direct all data onto a few highly-utilised lines between the PABX and the computer facilities. The only limitation on the terminals will be the three kilohertz bandwidth available to transmit data across voice circuits. This bandwidth constraint can be overcome by connecting the PABX directly to the digital private lines which will shortly become available from the Post Office network.

Those PABXs that are based on time division switching and use PCM signalling are particularly suitable for transmitting data. In the interface to the PABX, the line circuits are encoding incoming analogue signals into digital bit streams. It is a comparatively straightforward matter to remove the analogue interface (the PCM encoder) and to connect data terminals directly onto the digital switching path. Doing this removes the limiting effect that the voice network has on the rate at which data can be transferred (up to 9,600 bits per second on private lines), and enables data to be transferred at rates up to 64,000 bits per second. When the Post Office network provides digital lines directly into the PABX, this will remove the need for such an analogue interface into the public switched network.

These digital lines (working at rates up to 64 kilobits per second) will have immediate application to those organisations that operate a private data network. An organisation that has a PABX with a signalling system compatible with the 64 kilobits per second digital voice lines, will be able to use those lines for voice and data at different times during the day.

An organisation that has digital private lines and electronic telephones (encoding speech and data into PCM signals) will be able to integrate voice and data in a single communications network, with a resulting saving in costs. This integration can be achieved by multiplexing common leased lines between voice traffic and data traffic. These two different kinds of traffic have almost complementary characteristics because voice traffic must be communicated in real time, whereas most data traffic can tolerate delays ranging from seconds (on interactive terminals) to hours (on remote job entry applications). The PABX will undertake the scheduling of these two kinds of traffic over a common network.

The facilities that a computerised PABX needs to have in order to handle data are listed below. The list is not exhaustive, but it indicates the items that telecommunication planners need to consider.

1. PABX control features

   — Store and forward capability (at least one megabyte)

   — Access control (class of service restrictions on data terminal connection)

   — Protocol and speed conversions (to enable different manufacturers' terminals to communicate with a common data processing facility)

   — Traffic scheduling (multiplexing data traffic on voice circuits)

2. PABX switching network

   — Additional traffic capacity to that required by voice traffic alone

- Appropriate bandwidth for the terminals attached to the network (300 baud up to 9600 baud)

- Wideband transmission for high-speed data terminal equipments (64 kilo baud)

- Compatibility with public data circuits

Data facilities, such as flexitime recording and data capture, are currently being sold by IBM for specific applications. We believe, however, that the PABX network will be best suited for handling general-purpose low-activity data terminals. Examples of these include applications in, say, a factory or a bank which involve interrogating files of information on a random and not too frequent basis. In applications such as these, the PABX will act as an intelligent terminal concentrator which could then front end onto the data network.

When the private telephone network becomes digital, the PABX will assume a more central role. It will act as both a data concentrator and a message switching device, to which both terminals and computers will be attached. The PABX's eventual role will be to carry all traffic that originates in the voice network, whether it originates from data terminals, word processors, or the telephone itself. The PABX will then become a communications controller and, in that role, will have the responsibility for efficiently utilising all outgoing transmission facilities (including analogue and digital leased lines, and public network trunk lines).

VI. THE JUSTIFICATION FOR INSTALLING A COMPUTERISED PABX

A Introduction

In Europe, computerised PABXs are today considerably more expensive than are electromechanical PABXs. To compensate for this, however, they offer several additional features and facilities which were described in Section IV and which can be of significant value to many organisations, and these features and facilities may, for some organisations, justify the extra cost that is involved in purchasing a computerised PABX. Section VI B discusses the advantages that computerised PABXs have, because of their features and facilities, over electromechanical PABXs.

Section VI C discusses the aspects that an organisation needs to consider when trying to decide whether it is justified in purchasing a computerised PABX to meet its present needs.

As was mentioned in Section II A, when an organisation decides to install a PABX it is entering into a commitment that extends over ten or more years. During that time an extra demand will be placed on the voice network which may include data, text and image traffic. In addition, it is likely that developments in public services and telephone terminals will also make demands on an organisation's PABX.

It follows then, that an organisation that is considering installing a computerised PABX should not only have regard to its present needs but also to its needs over, say, the next ten years. Many organisations will be able to justify a computerised PABX in the long term, particularly since (as already discussed in Section V D) the cost of computerised PABXs will be reduced through the reduced cost of components and freer market conditions. Section VI D, therefore, discusses the longer-term justification for installing a computerised PABX.

B Advantages of Computerised PABXs Over Electromechanical PABXs

Modern electromechanical PABXs (such as crossbar) offer most of the facilities for the extension user and the operator that computerised PABXs provide. In addition (as described in Section V C), when specialised telephones become available they will probably be able to provide some of the facilities that are not available with electromechanical PABXs. This means that the features and facilities that benefit the extension user and the operator will not, in themselves, contribute much to the case for installing a computerised PABX. More important that these are the other features and facilities described in Section IV C that affect management control, system flexibility, network management and easier maintenance.

In addition, computerised PABXs are silent in operation, whereas electromechanical PABXs are not, and computerised PABXs require much less space. The saving in space may not be at all important if space is not at a premium (such as where the PABX is located on the large industrial site) but where the PABX is located in the heart of a city the saving in space can represent a significant saving in cost.

A comparison of the features and facilities of computerised PABXs and electromechanical PABXs is given in figure 6. The most important advantages a computerised PABX provides over an electromechanical PABX are discussed below:

— *Management control*

With an electromechanical PABX management have only two alternatives regarding outgoing calls. They can either arrange that extension users are not permitted to dial any external numbers for themselves, or they can allow extension users to dial their own calls direct without management having any control at all over the outgoing calls that extension users make. By contrast, with a computerised PABX management can allocate several different levels of outgoing access (discussed in Section IV D), ranging from an extension user who is allowed to make only internal calls to an extension user who is allowed to make any kind of call, including an international call.

In addition, the computerised PABX can record each outgoing call so that subsequently a full analysis of call charges can be made. A record of outgoing calls can only be made with an electromechanical PABX if additional hardware, such as a minicomputer, is incorporated into its trunk circuits.

— *System flexibility*

With an electromechanical PABX, changes to the extension numbering plan and to the class of service can only be made by making adjustments to the hardware. This requires the attendance of a Post Office engineer and will usually be the subject of a delay. As was discussed in Section IV E, with a computerised PABX alterations such as these can be made by entering simple instructions into the keyboard terminal. Also, unlike the electromechanical PABX, additions or modifications can be made to the software of a computerised PABX, either to introduce new features and facilities or to re-define existing ones. This offers an organisation some protection at least against obsolescence of its PABX.

— *Network management*

Many of the non-voice features discussed in Section IV H (for example, the integration of voice and data) that can be achieved by adding local data storage in the PABX, are not available in electromechanical PABXs. Also, computerised PABXs, unlike electromechanical PABXs, allow fixed tariff lines (such as out-of-area exchange lines) to be used efficiently. This is achieved by facilities such as route optimisation.

The combination of instantaneous traffic supervision and the collection and analysis of call data (which computer control makes possible in a computerised PABX) enables the computerised PABX to offer a more efficient and more cost effective private telephone network than does the electromechanical PABX.

— *Easier maintenance*

Because of the features discussed Section IV G, the organisation that has a computerised PABX is guaranteed a higher level of service, in general, than is obtainable with an electromechanical PABX. With the latter, maintenance relies entirely on the visits of Post Office engineers to determine faults, and these faults occur frequently because of the high proportion of moving parts that are employed in an electromechanical PABX.

	ELECTROMECHANICAL PABX	COMPUTERISED PABX
EXTENSION USER	INFLEXIBILITY IN THE ALLOCATION OF FEATURES TO EXTENSIONS	EXTRA FEATURES SUCH AS ABBREVIATED DIALLING; PROGRAMMABLE FEATURES FROM TELEPHONE - CALL FORWARD
OPERATOR'S CONSOLE	LABOUR INTENSIVE; ANSWERING DELAYS FOR INCOMING CALLERS	PERSONAL SERVICE POSSIBLE THROUGH VISUAL DISPLAY OF CALLING PARTY'S IDENTIFY; AUTOMATIC CALL SUPERVISION REDUCES LOAD ON OPERATOR
MANAGEMENT CONTROL	POTENTIAL ABUSE OF OUTGOING LINE ACCESS BY EXTENSION USER	MONITORING OF COSTS AND DETAILED CONTROL OF TRUNK LINE ACCESS SAVES MONEY
SYSTEM FLEXIBILITY	CHANGES REQUIRE HARDWARE ALTERATIONS WITH ASSOCIATED DELAYS	KEYBOARD COMMANDS TO ALTER NUMBERING PLAN AND FEATURE ALLOCATION
NETWORK MANAGEMENT		AUTOMATIC SELECTION OF PRIVATE WIRES INCREASES THEIR UTILISATION
MAINTENANCE	MOVING PARTS REQUIRE CONTINUOUS MAINTENANCE	SELF TESTING ELIMINATES ROUTINE MAINTENANCE
PHYSICAL CHARACTERISTICS	ELECTROMECHANICAL PABX REQUIRES MUCH MORE SPACE THAN ELECTRONIC PABX	COMPACT; HIGH POWER CONSUMPTION

FIGURE 6: COMPARISON OF ELECTROMECHANICAL AND COMPUTERISED PABXs

C Justifying a Computerised PABX in terms of an Organisation's Present Needs

An organisation that purchases a new PABX does so either out of necessity (because the present equipment can no longer be maintained, or can no longer be maintained economically) or because the organisation wishes to take advantage of the new technologies, and of the features and facilities that the new technologies provide. For whatever reason an organisation purchases a computerised PABX, it will have to pay a premium price for it, and this price will need to be justified to senior management in terms of the benefits that the organisation will derive from installing the computerised PABX. These benefits will be of two kinds: tangible benefits (such as reduced telephone bills) and intangible benefits (such as increased business efficiency and improved service to, say, customers, clients, suppliers, etc.).

At the present time there is no substantial evidence that the installation of a computerised PABX can be justified by the tangible benefits the computerised PABX provides. However, the fact that IBM have sold over one hundred 3750s, and that four other manufacturers are introducing computerised PABXs provides support for the view that many hold, that effective communications contribute to a better working environment, which in turn increases productivity. As a result, many organisations have decided, or currently are in the process of deciding, that the purchase of a computerised PABX at the present time is an investment opportunity, and that expenditure on a computerised PABX now will produce future savings in the telecommunications budget.

In attempting to quantify this investment opportunity it is necessary to assess the total cost of installing and operating a computerised PABX and, following this, to estimate all possible cost savings that the installation of a computerised PABX will produce. The most effective method of quantifying the investment opportunity is by a discounted cash flow analysis over the expected life of the computerised PABX. The following paragraphs discuss the areas of expenditure and the likely cost savings which should be included in the analysis.

1. Potential savings from a computerised PABX

Over the lifetime of a computerised PABX savings will come from the following:

— *Telephone bills*
The call information logging and route restriction facilities should produce savings of between 10% and 15% of the annual Post Office bill.

— *Utilisation of private lines*
Organisations that employ large private networks can almost certainly justify replacing all their electromechanical PABXs by computerised PABXs on their major sites by the cost savings they will derive from a higher utilisation of private lines. Clearly, the amount of saving depends on the number of lines that are attached to a PABX.

— *Operator efficiency*
On large sites it should be possible to save at least one operator position, which will mean a saving in both salary and overheads.

— *Improved maintenance*
There will be a saving in Post Office labour costs because Post Office engineers are no longer required to make simple changes to extension numbers and facility allocations. The saving may amount to only a few hundred pounds annually, but the elimination of lengthy delays that are necessary when changes are to be implemented is an additional benefit.

— *Space*
In a city location, where space is at a premium, a computerised PABX can release valuable office space. Some organisations that have installed a computerised PABX decided to do so largely on the basis of this factor.

Other benefits which cannot be quantified, but which are nevertheless important to an organisation, are:

— *Rapid setting up of outgoing calls*
Those features of a computerised PABX which reduce the amount of time necessary to set up a call (as discussed in Section IV B) contribute to increased productivity. This has the psychological benefit of producing more efficient and more effective communications, which lead to a more satisfying work environment and to improved business efficiency.

— *Rapid and informed response to incoming calls*
The improved service that the operator can give with a computerised PABX is most important in creating an image of efficiency and in building good will with customers, clients, suppliers, etc.

2. Additional costs associated with installing and operating a computerised PABX

When an organisation installs a computerised PABX the most obvious and the most significant costs involved are the purchase price of the PABX itself and the costs of providing any special environmental facilities, such as stand-by power, air conditioning, and false floors, etc.

The extra costs of operating a computerised PABX compared with operating an electromechanical PABX may include:

— *Extra power requirements*
Computerised PABXs have continuous 24-hour power requirements, and these are greater than the power requirements of electromechanical exchanges.

— *Data processing*
Call information and traffic data will need to be processed and analysed regularly (probably monthly), and this will require both data processing staff and computer time.

— *Maintenance costs*
The Post Office is, at the moment, charging higher rates for maintaining computerised PABXs than for maintaining electromechanical PABXs.

An organisation that is considering installing a computerised PABX needs to quantify, so far as it is possible to quantify, all the factors mentioned above, and then to produce a discounted cash flow analysis over different periods such as five years, ten years, and fifteen years. This analysis will show whether an investment in a computerised PABX at the present time is likely to prove to be a profitable one.

If the discounted cash flow analysis shows that the investment is likely to be a profitable one, and if the assumptions used in producing that analysis are soundly based, then the intangible benefits will reinforce the case for installing a computerised PABX. If the organisation decides to go ahead it should use the assumptions used in the discounted cash flow analysis to produce targets for monitoring the project.

D Justifying the Installation of a Computerised PABX in terms of Future Trends

As was discussed in Section V D, the price differential between computerised PABXs and electromechanical PABXs will decrease in the next five to ten years because component costs will fall and labour costs will rise. Also, the freer market conditions mentioned in Section V D will also mean that computerised PABXs will, in the future, provide a better price/performance than they do today.

The need and opportunity to integrate voice and data in an organisation's private network (which was discussed in Section V F) will further justify the case for installing a computerised PABX that employs time division switching.

Also, a computerised PABX could contribute to the overall planning of an organisation's total business communication systems (including voice, telex, data, and other media). It could do this by providing valuable information on voice traffic, which could assist an organisation's management in encouraging the use of alternative communications media. For example, in certain circumstances it is just as efficient, and less costly, to send a telex message instead of making a telephone call.

An organisation needs to consider its total communication requirement, bearing in mind that the telephone forms just one component of this. Only through a detailed analysis can an organisation find the long-term solution to the problem of minimising its total communications bill. A critical element of this analysis is detailed information on the different communication services, including the telephone. A computerised PABX has (as has already been discussed) the facilities to provide the necessary information and perform the detailed supervision of traffic.

VII. SELECTING A COMPUTERISED PABX

A Introduction

The purpose of this Section is to provide information which will assist the telecommunications management of an organisation in making an informed choice between those computerised PABXs that are either available in the European market today or are likely to be available in the next five years. Much of the detail of the features and facilities that are available with these products has been deliberately omitted because they are constantly changing and, instead, general guidelines are given to assist in the selection process.

Section VII B discusses the project management aspects of the process of selecting a computerised PABX. Section VII C discusses the technical features that an organisation should consider when it is selecting a computerised PABX. Section VII D discusses the features and facilities that are available in the computerised PABXs that are either available today or are likely to be available in the next five years.

B Managing the Selection Process

The process of selecting a computerised PABX can be a lengthy one. An organisation needs to start the selection process at least 18 months before the desired date of installation, since manufacturers generally require an average of about a year between the date of receiving an order and the date of installing a computerised PABX. The lengthy delivery period which is required for those computerised PABXs that are still awaiting Post Office approval will, however, be significantly reduced when the respective manufacturers receive Post Office approval for their products.

Figure 7 illustrates the steps that are necessary in selecting a computerised PABX network, based upon an actual case history. The particular project involved required three months to formalise the case for the selected PABX, and the installation of the network is being phased over a five-year period.

Typically, the steps that are involved in selecting a computerised PABX will include:

- Specifying the PABX and, where applicable, specifying the network (where there are private lines and more than one PABX).
- Requesting the suppliers to tender against the drawn-up specification.
- Evaluating the various manufacturers' proposals, including visiting and holding technical discussions with selected manufacturers.
- Making a recommendation to senior management, including an outline of alternatives and a firm recommendation for the preferred manufacturer.
- Agreeing with the selected manufacturer details of price, delivery, and final specification.

UK TELEPHONE PROJECT

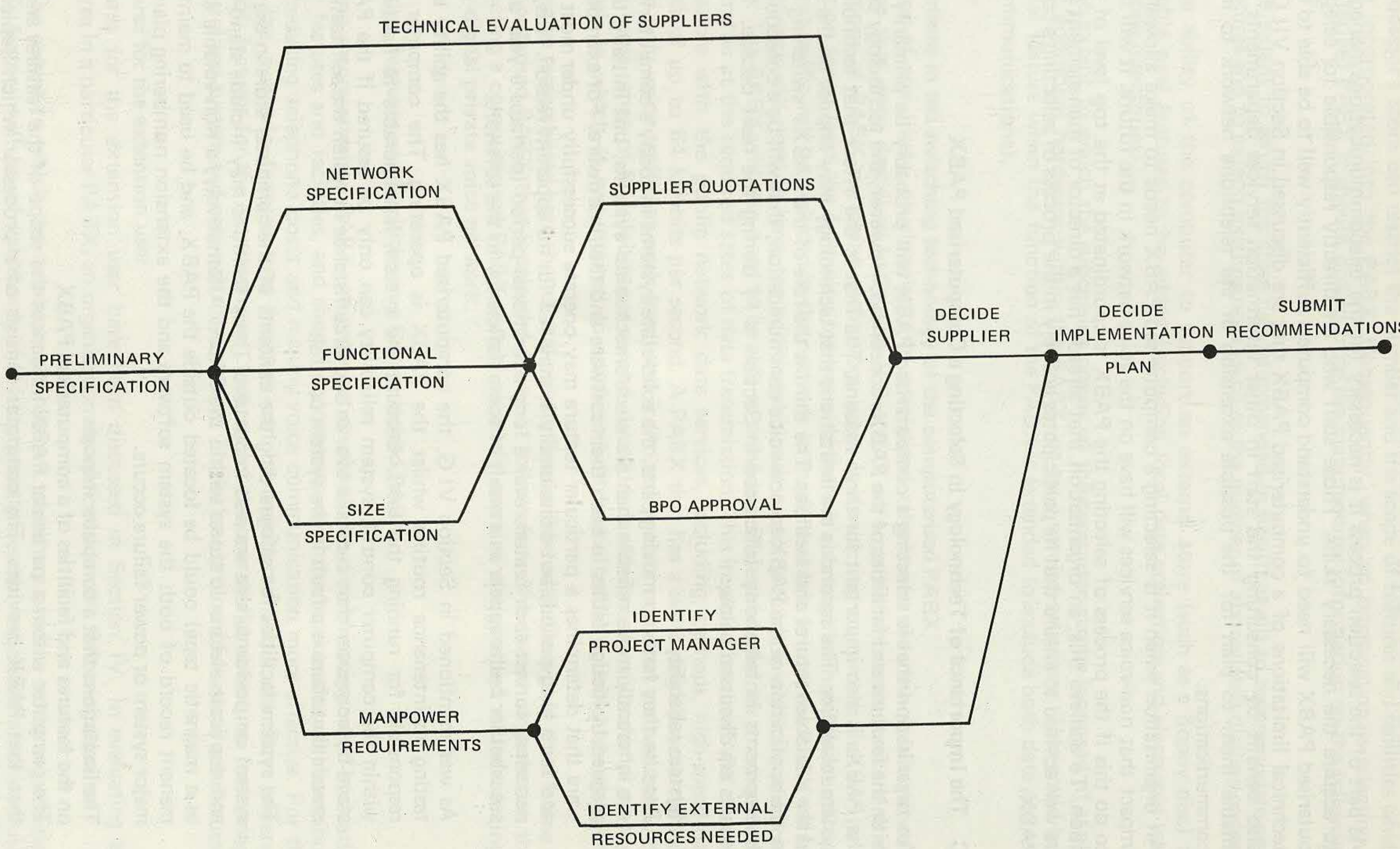

FIGURE 7: THE SELECTION OF A COMPUTERISED PABX

— Preparing and signing the final contract.

As part of the selection process it is necessary for the telecommunications management team to acquire the necessary skills. Those staff who are directly responsible for selecting a computerised PABX will need to understand computers sufficiently well to be able to evaluate the technical limitations of a computerised PABX that are discussed in Section VII C. They will also benefit by consulting the staff in other information services departments in order to enable them to plan for the possible extension of the telephone network to include data communications.

An organisation when it is selecting a computerised PABX needs to make allowances for the impact that non-voice services will have on the voice network in the future. It will only be able to do this if the process of selecting the PABX is coordinated at the top level of the organisation. To achieve this, an organisation that already has a director of management services will be well advised to ensure that he participates actively in the process of selecting a computerised PABX.

C The Importance of Technology in Selecting a Computerised PABX

An organisation that is selecting a computerised PABX will probably be primarily concerned with the features and facilities of the PABXs concerned. However, the technology embodied in the PABXs is also important for three reasons. The first is the effect that technology has on system reliability. The second is the limitations that technology may impose on the application of the available features and facilities. The third is the role of the PABXs' switching technology in the application of the PABX to non-voice communication, that will be a consequence of the developments in telephony (discussed in Section V F) during the next decade. These three aspects are discussed below:

1. System reliability

Because they have no moving parts, the solid-state systems in today's computerised PABXs are inherently more reliable than are electromechanical systems, but initially they can be plagued by design faults in both their software and their hardware. For example, the software that determines a particular feature may operate successfully under most conditions and for a long period, but occasionally it may fail for no apparent reason. It is, therefore, necessary to test each feature over a long operational period (perhaps a year or more) to see whether faults appear as a result of some deficiency in the software.

As was mentioned in Section VI G, the computerised PABX has the ability to run self-testing maintenance routine whilst the PABX is operating. The computer control is responsible for running the tests. Because the system is vulnerable to hardware faults within the computer control, system reliability can only be assured if the PABX has a stand-by computer that can take over in any circumstance in which the self-testing routine reveals that there is a fault in the system control.

The system facilities for safeguarding the contents of the computer store in the event of a system or power failure are also important. These facilities may include stand-by power, and duplicate electronic stores within the PABX. Alternatively, a non-volatile store (such as a magnetic tape) could be located outside the PABX, and be used to maintain a permanent record of both the system software and the extension numbering plan in case a major system or power failure occurs.

2 The limitations that a computer imposes on the features and facilities of a computerised PABX

The computer within a particular PABX influences the scope of the features and facilities that that PABX provides. The computer consists of a processor which implements the features, and a store which holds the software that controls the operations of the features.

The processor's store can restrict the number and the scope of features and facilities which can be incorporated into the PABX. Consequently, when an organisation is selecting a computerised PABX it should obtain from the manufacturer information on the following matters:

- The extent to which the store can be expanded in size (if at all) to accommodate new features and to extend existing ones (such as the number of abbreviated dialling codes).
- The ability of the computer to support an external store (such as a floppy disc) to enable new features to be added (including local data collection and electronic telephone directories).
- The extent to which the processing power of the computer can be increased (if at all) by additional hardware within the PABX, or by a second processor. This could be a vital feature when the function of the PABX is extended to include both data and text communications).

3. Limitations in the switching technology of the computerised PABX

Because of the likely developments in specialised telephones and new public network services that were described in Section V B and C, an organisation needs to examine the limitations of PABX switching technology when it is selecting equipment that will be in operation for at least the following ten years. If there is a strong likelihood that both data and text traffic will be included in the network in the foreseeable future, the PABX switching network will need to have the additional circuit capacity to cope with this additional traffic. The PABX will also need to be able to provide sufficient bandwidth to transmit the data traffic at the required rates of data transmission. This implies that the PABX must be compatible with the public network data services, including, perhaps, high-speed data circuits of up to 64 kilobits per second. A PABX that has a switching network that can handle only voice traffic at peak load, and is limited to data rates that are well below the digital voice range of 64 kilobits per second , would be unlikely to be suitable for a private network in which it was desired to combine both voice traffic and high-speed traffic.

It must be remembered here that digital private lines will be available within the lifetime of a computerised PABX that is selected today. It follows from this that an organisation that is selecting a computerised PABX should seriously examine the prospect of introducing a partly-digital private voice network.

D Selecting Features and Facilities in a Computerised PABX

In selecting a computerised PABX, an organisation should be discriminating when evaluating the many features and facilities, and should concentrate on those aspects that will contribute most to reducing telephone costs and making voice communication more effective. For this purpose, the available features and facilities can be considered under the three separate headings of: features for the extension user, features for the operator, and features for management control and system and network management. These three groups of features are discussed below:

1. Features for the extension user

Features for the extension user have been discussed in Section IV. In evaluating the features in a particular PABX, an organisation should consider the following aspects:

- The extent to which the databases are relevant to and are of value to the organisation. (A feature will be of value only if it is constantly needed, otherwise extension users will not be motivated to learn the appropriate access code that is required to operate that feature).

– The suitability of the specification of each feature to meet the special needs of the organisation. (For example, the camp-on feature discussed in Section IV B is available in several different forms. An organisation needs to select the one that is most appropriate to its extension users' needs).

– Any limitations the available features have that might impair their usefulness to the organisation. (For example, the abbreviated dialling feature may have too few abbreviated codes to satisfy the needs of a large organisation).

Having considered these aspects, an organisation then needs to compare the price of the different available features in the computerised PABXs that are being considered. Different manufacturers have different policies regarding the features available on their PABXs. Features which one manufacturer provides in the basic price of the PABX may be subject to an additional charge on another PABX. For example, Plessey on their PDX provide, as a standard feature, the ability to set up eight simultaneous six-party conferences, whereas IBM on their 3750 provide conference facilities only as extra add-on units, with each unit enabling two three-way conferences to be conducted.

Some manufacturers provide free training of extension users as part of their basic package. Since this training would otherwise involve an organisation in considerable cost and effort, this could be an important consideration when selecting a computerised PABX.

2. Features for the operator

The consoles of the computerised PABXs that are being sold today all have very similar features for the operator. The telephone supervisor in an organisation is the most obvious and the most qualified person to choose between the relative merits of different consoles. It is, therefore, sensible to secure her co-operation in the selection stage, particularly since she will have much of the responsibility for demonstrating new features to extension users and for training operators.

The differences between the different consoles do not make the overall performance of one computerised PABX either better or worse than another.

3. Features for management control and system and network management

As described in Section IV D and F, a computerised PABX offers features and facilities for controlling day-to-day outgoing call charges, and for maximising the utilisation of an organisation's private network.

This will involve (as described in Section IV D and F) analysing call logging information and traffic patterns on outgoing lines.

The manufacturers of computerised PABXs have not, up to this time, provided the necessary software for the required analyses, and this is likely to be the responsibility of the customer for the foreseeable future. Therefore, unless the manufacturer supplies the software, either the telecommunications staff or the data processing staff will be involved in producing the necessary software. Also, as the planning of private networks becomes more complex (with private voice and data lines) the need for computer simulation will arise if an organisation is to operate an efficient network. Simulations will, for example, include modelling peak traffic conditions in the network to determine the levels of service that should be provided and the utilisation of private lines. The telecommunications staff will also need to be involved with running these simulations.

As an alternative to using either the telecommunications staff or the data processing staff to produce the software, however, an organisation might arrange for this to be produced by a suitable software house.

In comparing different computerised PABXs, an organisation should, therefore, ascertain what support the different manufacturers can provide in this field.

E Other Matters that Require Consideration in Selecting a Computerised PABX

Before deciding on a particular computerised PABX, an organisation should satisfy itself that the product has been thoroughly field tested. For this purpose, an organisation should ask the manufacturer for introductions to other users of the product that is being considered, and should then set up meetings with some of those users to establish whether their experience with the product has been satisfactory or, alternatively, what difficulties they have experienced with the product.

Large organisations may well employ several PABXs in their telephone networks. Increasingly, the choice of a PABX for one location influences network features such as desk-to-desk dialling throughout the organisation. Therefore, in selecting a PABX today an organisation needs to try to ensure that all the PABXs it installs in the future will be compatible. This means that it will be necessary to standardise on one or two products that employ common technologies, and an organisation needs to take this into account when selecting a PABX today.

Finally, an organisation will wish to ensure that the price of the product that it chooses compares favourably with similar products. In making a cost comparison between products, cost per line is as good a measure of cost as any.

VIII. CONCLUSION

A The Need to Consider a Computerised PABX

The availability of computerised PABXs has attracted the attention of management in nearly all those organisations that have a private telecommunications network. In most cases, those members of management are wondering to what extent they should themselves examine the case for installing a computerised PABX. Our view is that management of any organisation that has a private telecommunications network should now examine the case for installing a computerised PABX for the following two reasons:

1. In the office of the future, multi-function devices will generate new patterns of traffic (data, voice, text and image). When this happens, the computerised PABX will play a central role in the office. It can intelligently handle mixed traffic, and it can enable multi-function devices to be implemented and integrated into telecommunications networks. This will become increasingly important in the future because developments in the office will produce an increasing volume of data and text traffic, all competing for spare capacity in the voice network.

2. The computerised PABX has sophisticated features that benefit the extension user and the operator, and that provide a high level of management control, particularly of the network. This means that it provides the opportunity for a considerable improvement in the efficiency and the cost effectiveness of communications.

B The Case for Installing a Computerised PABX

At the present time, computerised PABXs are considerably more expensive than are their electromechanical counterparts. Because of this, not all organisations will be able to justify replacing their electromechanical exchanges by computerised PABXs in the short term. For example, a large administrative office in a city centre (say, the head office of a large building society in the centre of London) will be more likely to be able to justify installing a computerised PABX than will a manufacturing organisation on an industrial estate thirty or so miles from London.

Even so, the case for installing a computerised PABX already looks attractive for many organisations, and those organisations that have large private networks could achieve significant cost savings by introducing computerised PABXs throughout their network. The case will become more attractive as the prices of computerised PABXs drop in comparison with the prices of electromechanical PABXs.

It is most unlikely that computerised PABXs will be superseded in the foreseeable future, as were crossbar exchanges and reed relay exchanges in their respective lifetimes. There is very little doubt that the computerised PABX will still be in service in twenty years from now. This will happen partly because the technology is much more flexible than were the earlier technologies, and partly because the PTTs have committed themselves to adopt this technology in the public networks.

Although (as mentioned in Section V D), second generation computerised PABXs will be developed in the mid-1980s, an organisation that decides to install a first-generation computerised PABX need have no fears that its PABX will become obsolescent. All manufacturers will almost certainly develop both new hardware and new software to upgrade first-generation computerised PABXs, both to prolong the life cycles of their products and to handle non-voice traffic.

C The Selection of a Computerised PABX

Because of the factors discussed in this Section above, the selection of a computerised PABX is now a matter which is of strategic importance to the future development of information systems, and therefore is of concern to most large organisations.

We advise all organisations to take the following action:

1. To review the existing allocation of responsibilities for planning voice, data, text and image communications. These planning activities need to be co-ordinated so that the plans for equipment and services take into account the overall pattern and volume of traffic.

2. To ensure that the necessary skills exist, or are developed, within the organisation so that the process of selecting a computerised PABX can be carried out correctly and efficiently.

3. To ensure that the selection process takes into account the potential communication traffic needs of the organisation (voice, data, text and image). This means ensuring that the selected computerised PABX has the two following features:

   — Sufficient traffic handling capacity to cope with the extra traffic which non-voice applications can be expected to add. A PABX that is highly modular in design would be best equipped to meet changes in traffic volumes.

   — Compatibility with digital voice lines to enable the organisation's private network to be partially or even completely digitised to enable it to include both voice traffic and data traffic over the private lines and extension circuits.

In addition, we advise any organisation that decides to purchase a computerised PABX in the next couple of years or so to pay particular attention to the following criteria when selecting a computerised PABX:

1. Proven field trial experience of the PABX in the UK, or in the European environment.

2. Appropriate back-up for system features and facilities.

3. Training facilities both for extension users and operators, to ensure that extension users and operators take full advantage of the features of the PABX.

Finally, as already mentioned in Section VII E, when selecting a computerised PABX an organisation should try to select a product range on which it will standardise for the remainder of its installations.

D Deciding When to Buy a Computerised PABX

Any organisation that is planning either to replace an electromechanical PABX or to install a computerised PABX in a new site will need to decide on the best time to purchase.

We would advise all those organisations that do not need to replace their existing electromechanical PABXs meantime, not to purchase a computerised PABX before 1981. Between now and then, several new products will become available and as a result the market will be more competitive than at present. We anticipate that prices will fall. Delivery periods will also be substantially reduced once all the products have received the approval of the Post Office. Manufacturers will need to offer PABXs that have a wider range of features and facilities, and extensive back-up support to make their products more attractive than those of their competitors.

If, however, an organisation decides to install a computerised PABX earlier than 1981, we recommend that the organisation should look ahead at likely price trends and likely developments. If an organisation will be purchasing additional PABXs later, those trends and developments may have a considerable bearing on the product that the organisation chooses either today or in the near future.

Finally, in deciding when to purchase a computerised PABX, an organisation should not underestimate the time that will be required to select a computerised PABX, to have it delivered, to have it installed, and to have it commissioned.

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Abstract

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The Selection of a Computerised PABX

by Roger Camrass
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With the introduction of computer-based technology the nature of the private automatic branch exchange (PABX) has changed. These devices offer a new set of opportunities for information systems of the future and for this reason are of particular significance for the management services manager. At the same time, new questions are posed for the telecommunications manager, or any other individual concerned with the selection of such equipment.

Computerised PABXs provide some additional facilities for voice communication – at a cost – but they also offer completely new facilities which may be of strategic importance. Above all, they offer the opportunity to mix and control voice, data, text and graphics traffic on a single network.

This report describes the evolution of these exchanges, explaining the technology involved and the essential differences between it and that of the preceding generations of electro-mechanical equipment. The report describes the features and facilities which computerised PABXs offer and explains the additional opportunities which these facilities can provide. The justification for installing such equipment is examined and guidance given on the selection process and its management.

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