British Telecommunications Engineering

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1 SEPTEMBER
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CULTURAL CAPITAL OF EUROPE

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Enquiries
BTE Journal
3rd Floor
Blossoms Inn
23 Lawrence Lane
London EC2V 8DA

Telephone: 071–356 8050

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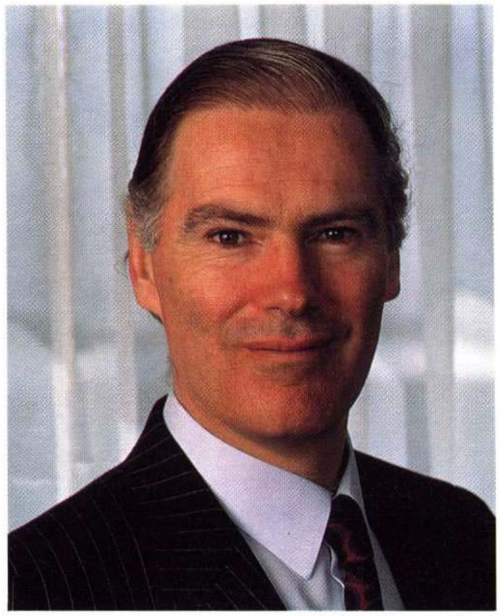
Message from the Chairman of British Telecom



I am delighted to introduce this special issue of the *Journal*, enabling readers to benefit from studying the many technical papers being presented during FITCE's 1990 Annual Congress. As the principal supplier of public telecommunications services throughout the UK, British Telecom is pleased to be an active supporter of this Congress on its first visit to Britain. I look forward to taking part in the Opening Ceremony, and welcoming some of you to Glasgow—Scotland's largest city and the 1990 Cultural Capital of Europe.

The primary objective of any telecommunications provider is to satisfy customer needs in a timely and quality manner. Engineers have a vital role in achieving this objective. It is therefore appropriate that the theme of this 29th European Telecommunications Congress—Networks 2000—should be focused upon developing networks to meet customer needs, with particular emphasis upon customer services and personal communications.

The Federation's visit to Glasgow comes during a radical restructuring of our British Telecom business—including the management and operation of our network. Our Project Sovereign reorganisation recognises and reflects the same fundamental premise—that everything we do, in networks as in any other facet of our activities, must take as its focus our customers and be geared to meeting their needs.

This decade will bring profound changes in Europe's telecommunications networks. As we look towards the year 2000, this is a most exciting and challenging period for engineers to be debating and identifying the key developments which will enable operators to offer new technological solutions through networks better able to satisfy customer needs.

British Telecom is in a period of continuing record investment in UK network modernisation and development. We have just become the first major country whose long distance network is wholly digital. We have installed in our network more than one million kilometres of optical-fibre cable and have brought into service our ten millionth customer line on a digital local exchange.

This demonstrates our commitment to giving our 25 million customers the full benefits of modern digital technology and is a tribute to the skills of all the engineers involved in this achievement.

We are now offering more of our business customers the advantages of an integrated services digital network and Advanced LinkLine facilities. And it is a matter for Scottish pride that, with help from Government funding, we are bringing digital service benefits to customers in the most rural areas of Britain such as the Highlands and Islands, who will have a fully digital network as advanced as any in Europe by 1992.

I hope that the 1990 Congress will be a productive one for all members of the growing European telecommunications engineering fraternity who take part in it—and for all readers of this *Journal* who have the opportunity to share in the wealth of knowledge offered by the authors of the following papers.

IAIN VALLANCE
Chairman, British Telecom

Message from the President of FITCE

It is a pleasure for me to address myself to you on the occasion of this special issue of the IBTE *Journal*; both to those who participate in the 1990 Glasgow Congress and those who are regular readers of the *Journal*.

For those attending the FITCE Congress, this issue will be a valuable tool in helping them understand and digest the papers being presented during the Congress. Last year in Lisbon, our Portuguese colleagues produced a similar special issue and this was very much appreciated. This year, the FITCE Board appointed a Selection Committee which made a selection from a total of 56 papers offered. This procedure resulted in a consistent and well balanced programme and was an important contribution to further enhance the professional level of the Congress. It also meant however that we had to disappoint a number of authors whose papers were not selected and I would like to thank them for the effort they made.

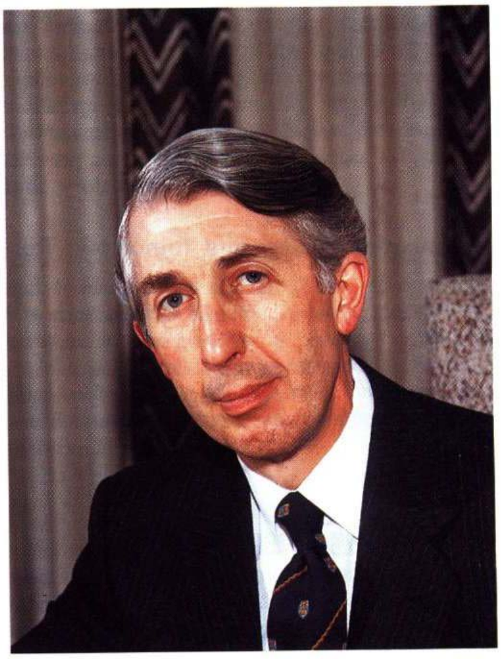
For those regular readers who do not know FITCE, I will take the opportunity to tell them that FITCE is a French acronym standing for 'Fédération des Ingénieurs des Télécommunications de la Communauté Européenne'. It is an association of telecommunications engineers of university degree level or equivalent and was founded in 1961 by engineers from the PTTs of the founding six members of the European Community. Membership has since grown with the growth in member countries of the EC. Associate membership of FITCE is open also to those telecommunications engineers not working in one of the PTT organisations. The main objectives of FITCE are scientific—'to further the growth of science in the field of telecommunications'; social—'to further cultural bonds and to encourage friendly relations'; and furthermore—'to study problems with the areas of recruitment, training, work assignment and career structures' and more generally—'to benefit from the exchange of ideas'. FITCE is not a trade union and does not engage itself in political matters.

The annual Congress is our big event usually attracting 600–800 persons (both members and accompanying persons) and is held each year in a different EC country—this year for the first time in the United Kingdom. In 1991, France will host the Congress in Strasbourg and in 1992 Spain in Seville. The FITCE Review is published four times a year and members can participate in the work of the Study Commissions (four at the moment). Current FITCE membership is nearly 5000 and the Federation is managed by the General Secretariat in Brussels.

I am sure this issue of the *Journal* will be of value to participants and to regular readers alike. To those who now consider joining FITCE I say WELCOME TO FITCE.

PETER HAMELBERG
President, FITCE

Message from the President of IBTE



Progress towards European integration into a single market is gaining momentum and one of the most significant features is the liberalisation of telecommunications, driven not only by political desires but also developments in technology.

The 1990 FITCE Congress is an opportunity to review achievements in this new era and to look forward to European developments in the next decade.

For a combination of political, technical and operational reasons, the United Kingdom has been in the forefront of all of these changes and the Institution of British Telecommunications Engineers has had to adapt to a completely new environment in which change is the norm. Adapting to change is the key to success in this new environment for telecommunications. The Institution has a long tradition of assisting engineers to fulfill their potential, mutually to their benefit and that of the telecommunications operator. This it has done by learned society publications and activities through national and local centres. It is more important now than ever before for telecommunications engineers to have the chance to exchange views on topics of common interest. IBTE has always recognised the importance of this dimension of technical interchange by hosting and fostering visits within Europe. It strongly supports FITCE and is pleased and proud to host the 29th European Congress of FITCE, for the first time being held in the United Kingdom. It is appropriate that the Congress is being held in Scotland, a country that is the focus for a number of advanced telecommunications initiatives, and in Glasgow, a city currently celebrating a renaissance of its own tradition of technology and culture.

The *Journal* is an essential feature of the Institution and over its long history it has provided a unique record of the major developments in UK telecommunications. This special issue has been produced to mark the FITCE Congress by publishing the technical papers which are being presented at Glasgow thus making them available to a wider audience.

CLIVE FOXELL
President, IBTE

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The single European market of 1992 will be characterised by the free movement of people, goods, capital and services. It will be possible in the future for users to choose the best offer at the best price, from any of the service providers in the entire European Community. Among services, telecommunications represents one of the most important challenges in the creation of the European single market. With the publication of the Green Paper on Telecommunications, a wide debate has started to define a new regulatory framework for networks, services and terminals. This paper examines the proposals presented by the Commission of the European Communities for regulation of the sector, the decisions, the recommendations and the directives already adopted and those to be adopted in the future.

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R. URQUHART

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J.-D. BÜCHS

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SIMNET simulates the operational performance of a system of interconnected exchanges and is used as a tool for network management. It allows the user to enter parameters and calculate performance without performing expensive changes to a real network. It operates under general and specific arrangements of a network topology of up to 200 nodes and with or without common-channel signalling. Parameters describe the total traffic over a link or each individual constituent of this traffic. SIMNET is used by the Hellenic Telecommunications Organisation (Greece) to evaluate optimum traffic schemes planned for their network.

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W. FROST

User trends show increasing demand for enhanced features, services and shorter and more flexible availability of required bandwidth or services in public telecommunication networks. These demands are driving intelligence and functionality of public networks down to the access network. Northern Telecom has proposed a new fibre-based network architecture—FiberWorld—that can be used as a model for the new evolving telecommunication networks and their typical characteristics to match the new demands driven by business users and business services. The FibreWorld network architecture will simplify the operation, administration, maintenance and planning of telecommunications networks by reducing the number and types of network equipment and interfaces, while at the same time enabling new wideband and broadband services.

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M. R. GARDNER
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Meeting Customer Needs in a Changing Environment

W. G. T. JONES†

BUILDING THE RIGHT PLATFORM

For telecommunications engineers the greatest interest probably lies in building and operating the network, and associated equipment, which will deliver the services to customers. Recent years in the UK have seen massive investment to modernise the network and ensure it provides the right platform, both for the services of today and those which can be expected in the future.

Digital switching and transmission were introduced first in the trunk network, building an overlay of about 60 large digital exchanges, fully interconnected. More than 99% of trunk traffic is now carried by this network while the analogue equipment will be withdrawn during 1990.

As recently as 1985, two thirds of local lines were on Strowger exchanges with the remainder on analogue SPC. Today, however, about 40% of lines are on digital exchanges with the total of some 2600 digital exchanges and concentrators being increased at the rate of two a day. All the digital switches have a basic capability for ISDN, with a growing number of PBXs connected by primary rate at 2 Mbit/s, while basic rate with two 64 kbit/s B-channels and a 16 kbit/s D-channel was introduced during 1990.

All the digital exchanges, local and trunk, are connected by common-channel signalling using CCITT Signalling System No. 7, for which the UK has almost certainly the largest network in the world. Analogue SPC exchanges are currently being equipped with CCITT No. 7, which is also used to interconnect with other networks such as the cellular systems operated by Cellnet and Vodaphone. For local signalling, customers on digital and analogue SPC exchanges can have any mixture of MF tone and 10 impulses/s telephones on their lines, while all the telephones which BT currently rents can be switched to either method by the customer.

Optical fibre was introduced into the trunk network at an early stage and is now very widespread with over 1M fibre km, the systems operating at up to 565 Mbit/s. Only monomode fibre is used and for several years all cable has had windows at both 1300 and 1500 nm. Field trials have been made of wavelength division multiplexing so it is known there are no major problems in increasing the traffic on the cables already in the ground. About 7% of the total fibre cable is in local lines, extending optics right into the premises of large customers.

Emphasis has also been placed on support systems, with a comprehensive network management system across the whole country linked to a national centre. The Customer Services System (CSS) is now in use throughout the country, allowing customer queries to be dealt with at a single point of contact. If the customer has a fault, the procedure at service centres ensures the line is tested immediately, usually before the customer has finished describing the problem. For billing, many customers on digital and analogue SPC exchanges have taken up the choice of bills which itemise the details of calls costing more than about £0·50.

Overall, an excellent platform has been built and it is rapidly being improved still further. But will it meet the needs of customers, and why should we try so hard to find out their requirements and to satisfy them?

WHY SATISFY CUSTOMER NEEDS?

In the days when the British Post Office was the monopoly provider of the telecommunications network and all telecommunications services in the UK, little real attempt was made at understanding the customer or at marketing. Provided the range and quality of services was reasonably comparable with other developed countries, the expenditure was within the limits allowed by government, and the financial returns were adequate, the Post Office was considered to be performing satisfactorily. Research and development were undertaken to reduce costs and develop new capabilities, but driven by a technology and engineering background.

The same attitude today would probably lead to a rapid decline in the situation for British Telecom, for two distinct reasons:

- the customer, whose needs and attitude are changing; and
- external forces, such as liberalisation, regulation and competition.

As a private company, BT has to satisfy a variety of stakeholders. In addition to the customers there are, for example, shareholders, employees, regulators, and the community at large in which BT operates. Since there is now competition in every single area of BT's activities, it is only by putting customers first, and balancing the needs of the other stakeholders, that the company can survive, prosper and grow.

WHAT IS HAPPENING IN THE CUSTOMERS' ENVIRONMENT?

Before examining how one can determine customers' needs, it is important to understand the environment in which the customer exists, since the supplier of telecommunications services must operate in that environment too. In the UK the government is strongly in favour of competition and has thus liberalised the telecommunications sector more than perhaps any other country except the USA. The European Commission is also in favour of liberalisation, coupled with harmonisation to ensure an effective single market.

For business organisations, telecommunications is playing an increasingly important role in keeping costs down, helping them to operate more effectively and maintain their competitive advantage. For the individual, almost every home has a telephone while more sophisticated items, such as answering machines and facsimile machines, are becoming common in the home too. The person who uses advanced telephone services at work, and IT equipment, wants to have the same capabilitites when away from the

† British Telecommunications plc, UK

office. On the move, the cellular telephone is available, while the lap-top personal computer is used on the train, in the hotel, and at home. The person probably does some work at home, bringing the advent of telework.

The person we are talking about is principally the *knowledge worker*, who adds value by dealing with information. The growing number of knowledge workers, and the link they form between business operations and consumers, are causing the market arenas for telecommunications to overlap and merge, as illustrated in Figure 1.

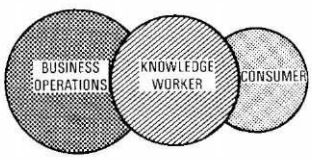


Figure 1—Merging market arenas for telecommunications

The telecommunications user naturally prefers to have competitive supply, which is available with liberalisation. The customer wants choice, coupled with flexibility of access and flexibility of use. The combined effect of these factors is shown by the growth of UK telecommunications in recent years, not simply in general usage but also in the number and type of services, and the number of suppliers and operators, as indicated in Table 1. Each area listed has grown in the size of the market **and** in the number of suppliers.

TABLE 1
Areas of Growth in UK Telecommunications Markets and Suppliers

- Fixed networks
- Mobile networks (cellular, telepoint, PCN)
- Cable TV, with telecommunications
- Local and wide area data networks
- Information services
- Managed network services

A particular problem for BT is that is has an obligation imposed by the regulator to provide universal service at uniform prices. The competitors do not have this constraint, so it is especially important for BT to understand its customers and meet their needs at the right price and the right quality.

FINDING OUT CUSTOMERS' REQUIREMENTS

For telecommunications operators, as with many other companies, much of the revenue comes from a small proportion of the customers. At present, the major revenue providers are the larger organisations, but attention must also be focussed on the individual as more work is done away from large office buildings and people make greater use of communications in their private lives.

These major users can be termed the *information intensive* customers, both organisations and individuals. They are inevitably the ones on which the new competitive operators will concentrate. Understanding and meeting the intensive customer's needs is thus of paramount importance, but it must be done in a way which allows the universal service obligation to be fulfilled too, in the most cost effective way.

The final type of customer is the service provider, since in a liberalised market a network operator will not be the only one to offer services to end users. Indeed, a network operator can gain significant revenue from service providers who are unable or unwilling to operate their own network. To match the market, it is therefore necessary to characterise all the sectors of the matrix shown in Table 2.

TABLE 2
Telecommunications Market Matrix

	ATTRIBUTES	
CUSTOMERS	Location	Requirements
Intensive organisations		
Intensive individuals		
Less intensive users		
Service providers		

The network operator knows where its customers are and can list them by revenue, indicating the intensive users. In addition, the business customers can be coded by the nature of their activities: manufacturing, finance, retail, and so on. The individuals can also be characterised, for example by their membership of professional institutions, their share ownership, their newspaper and magazine subscriptions, or the type of house they live in.

Having compiled databases of the customers, with their type, usage and location, it is then necessary to study only representative samples of each type to find out their requirements and how those may change over time. The computer can then be used to map the requirements on to all the customers of a similar type.

ENHANCING THE PLATFORM—IN THE RIGHT WAY

When the customers' needs have been determined, the engineer begins to play a major role. The platform for the services has been built, but now we know where it can be applied most effectively. There is a wide range of technologies available, or which can be developed, some of them indicated in Table 3. By studying customers we can see which technologies will be needed most and should therefore form the focus for development and deployment.

TABLE 3
Examples of Technologies to be Considered

- ISDN, narrowband and broadband
- Terminal facilities versus network services
- Fibre versus radio
- Satellite, one way and two way
- Millimetre wave distribution, one way and two way
- Cellular and microcellular
- Radio PBXs and centrex
- LANs, MANs, and WANs
- Intelligent networks
- Circuit switching versus asynchronous transfer mode

To take a practical situation, optical fibre to the customer's premises is costly, but now we can predict which customers will need it and in which locations there are groups of customers in close proximity. Will broadband switching be required? If so, we can focus development on switches of the right capacity and bit rate, with subsequent siting of the initial switches where there is likely to be the greatest demand. Capacity in the trunk network can be increased at a rate, and in the locations, most appropriate to match the growing requirements.

Although BT has an obligation to provide universal service for conventional telephony, it will be a long time before all customers want the same capability as today's most advanced users. Indeed, there will always be some 10 to 20% of customers who are more information intensive than the majority. However, if network capabilities are provided universally, there is bound to be inefficient use of capacity and a waste of investment funds. By examining requirements in the manner described, the operator can target new services where they will be wanted, and thus stand the greatest chance of achieving the overall objectives:

- providing services of the type wanted by customers,
- anticipating future needs,
- providing sufficient capacity to meet demand,
- avoiding the provision of equipment where it will be under utilised,
- making the best use of investment funds,
- making an adequate return from the network, and
- countering the competitive threat.

The existing network operator starts with a major advantage. He already has a customer base and he knows where the customers are and what they do. By making good use of that knowledge and extending it, the operator will be able to survive, prosper and grow, thereby satisfying not only the customers but the other stakeholders too, all of whom want the company to succeed.

Telecommunications Today and Tomorrow: Trends and Opportunities

G. BRAGA†, G. CARAFFINI†, and V. LISERRE*

FOREWORD

Public telecommunications networks, through more than a century of evolution, have become a worldwide structure fundamental for an organised and modern society.

Today, the world public telephone network accounts for over 500 million access lines, connecting an estimated 630 million telephones. This means that, on average throughout the world, there is one terminal available to every seven people.

In the last 20 years, the world telephone network has grown at an average rate of 5·5% per annum, and is expected to grow, albeit at a slightly slower rate, for many years to come. This growth is higher than the increase in gross domestic product, probably due to the rapid expansion of services all over the world.

Major investments are required to confront these market conditions. In fact, the total worldwide capital expenditure for both public and private telecommunications in 1989 was $106 billion and will continue to grow during the next five years at an annual rate of 4·7% (Figure 1).

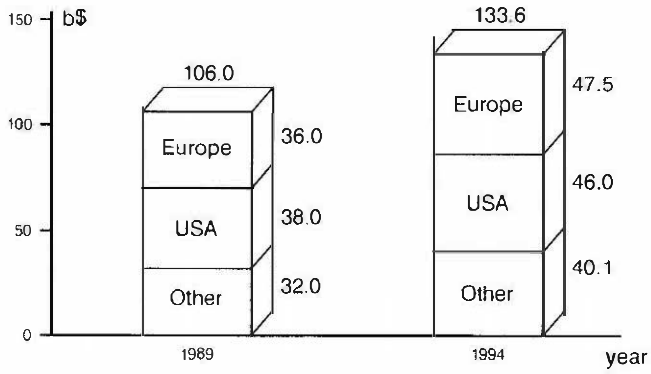


Figure 1—World telecommunications equipment market

Europe plays an important role in this market, with a share of 34%, not far from that of the United States.

At present, promising European market-places appear to be:

(*a*) Italy, which has launched a plan to improve substantially both quality standards and the number of offered services;

(*b*) West Germany, where the introduction of digital switching is still in an early phase, and the future reunion with East Germany will provide new expansion opportunities; and

(*c*) Eastern Europe, because of the need to make up for lost time and replace old systems; the recent important political events are expected to favour this trend.

What the market-place demands of telecommunication networks is, after all, the capability to transfer voice, data and images in any combination, anywhere, at any time, with convenience, quality and reliability; this imposes a number of requirements on technology and on network concepts.

This article illustrates some network solutions mainly aimed at implementing more 'intelligent value', in order to obtain a higher level of flexibility, thus producing benefits for both the users and the services operators.

ISDN AND OVER-VOICE ACCESS

ISDN represents an evolution of digital telephone networks, where digital access is extended to the user's premises.

ISDN is able to provide the users, through a limited number of standard interfaces, with an integrated set of basic telephone services and new telecommunication services (Figure 2).

From the technical aspect, ISDN requires the existence of two prerequisites:

- the presence of a widespread digital network, and
- the presence of a common-channel signalling system.

Even if its technological structure has never been called in question, some objections have been raised about the actual utility of ISDN compared to that offered by existing telecommunication networks.

ISDN gives the opportunity to improve the quality of the present telephone services providing a reliable and inexpensive base for data transmission and many other new services.

How much ISDN will be successful is not purely depending on technical matters or the amount of investment in hardware and software needed to adapt digital networks over large areas, but also heavily on the promotion activities to potential users.

In some European countries, telecommunications operators have already established interesting tariffs for both basic and primary access (144 kbit/s and 2 Mbit/s).

The major market opportunity for ISDN is represented by the possibility of using similar terminals and technological solutions for many applications all over Europe and in the rest of the world.

The priority today is given to business users, while residential users are the long-term goal.

EEC sources have predicted that ISDN penetration by 1993 in Western Europe will equal 5% of the POTS lines installed 10 years before (that is approximately 5 million). More recent and conservative estimations show that by 1993 little more than 1 million of ISDN lines will have been installed.

† Italtel SIT
* Ministero delle Poste e Telecomunicazioni, Italy

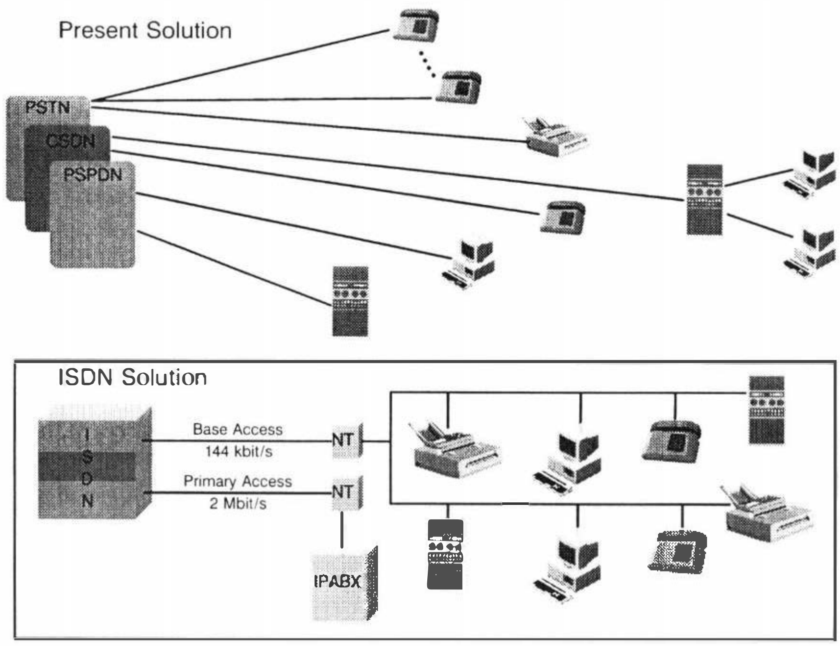


Figure 2—Integration of basic and new services

But, after all, it is important to underline that ISDN is unanimously recognised as the new global standard for telecommunications services.

In the future, ISDN will replace, even if gradually, the present telephone interface, which has practically remained unchanged until now.

The Italian situation is summarised by Figures 3(*a*), 3(*b*), 3(*c*).

ISDN will evolve towards broadband, aimed at sophisticated business users. Fibre optics, synchronous digital hierarchy methods and new fast packet switching techniques are all encouraging factors for a future commercial reality.

Broadband ISDN will provide subscribers with a large number of advanced services, such as videoconference and high-speed data transmission for publishing, CAD/CAM operations, health care, image-bank retrieval, etc.

Nevertheless, to satisfy immediate market needs, some broadband specialised networks using established technologies are produced for metropolitan or geographical areas, principally to connect local area networks.

During the last few years, the demand for telematic services and applications has increased in small and large businesses.

A large number of such applications require a data transfer characterised by low traffic, low speed, short connection time, high security, moderate investments and operating costs.

Market opportunities for these applications are offered, for example, by simple financial transactions (EFTPOS in supermarkets, petrol stations, etc.), public telephony, teleactions, telealarms, telelectures, health aid, for which the use of the over-voice access technology seems to be both timely and appropriate, without having to wait for the commercial development of N-ISDN.

In fact, the mentioned applications will find their most valid support in ISDN, probably using the D-channel.

The basic architecture of this particular access network

- Initial configuration: 2500 basic accesses and 100 primary accesses
- Interconnection with: ITAPAC (Italian PSPDN), PSTN, RFD (a specialised data and speech network), international ISDNs
- Limited extension of ISDN to 10 metropolitan areas
- Trial with friendly users, starting in summer 1990
- Opening of commercial service in 2nd half of 1991

3(*a*) ISDN in Italy—short term planning

- 64 kbit/s transparent connection
- Extension to ISDN customers of supplementary services already available for POTS users
- Availability of a limited set of supplementary services, developed especially for ISDN (calling line identification etc.)
- Packet services on the B-channel
- Supplementary services for packet connections like those available in the Italian PSPDN

3(*b*) ISDN in Italy—short term planning (technical features)

- Progressive extension of ISDN all over the country
- Interconnection with 20 countries (MoU), based on complete alignment to ETSI standards
- Additional extension of supplementary services
- Extension of packet services to the D-channel
- Introduction of value added services (to be defined) for ISDN customers

3(*c*) Large scale ISDN in Italy—1993

Figure 3—ISDN in Italy

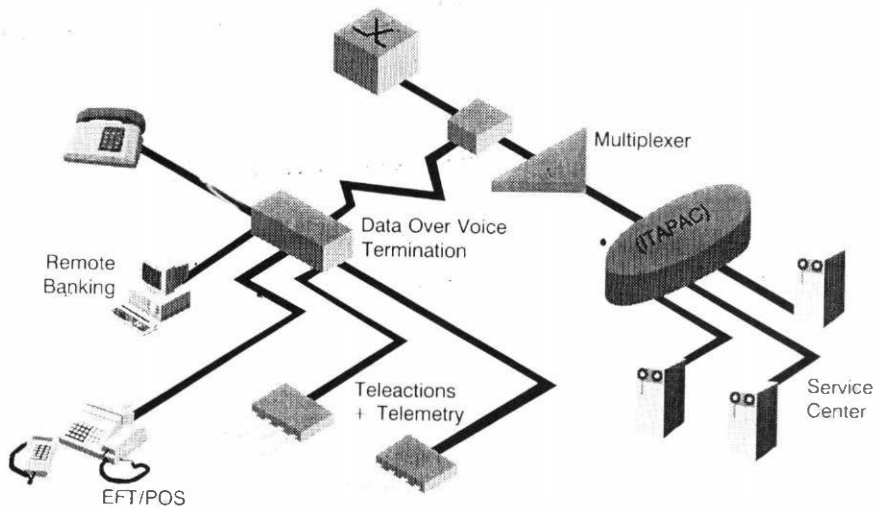


Figure 4—Data over voice system

is shown in Figure 4. Terminals are connected to the nearest switching centre through a special network termination (OVT), utilising the over-voice modulation technique (4800 bit/s, half-duplex) to convey both speech and data over the same analogue user loop.

Close to the switching centres, statistical multiplexers and concentrators collect the data coming from the OVTs and transfer them to service centres through the packet switched public data network (PSPDN) (ITAPAC in Italy).

INTELLIGENT NETWORKS

While ISDN represents the new frontier for the advanced digital technology for multi-media information transfer, a second development pole for the communications of the 1990s is represented by the widespread use of information processing technology in telecommunications networks.

In a modern digital telephone network, the interchange of information between the processors which control the switching nodes is realised through a separate common-channel signalling network; besides, the utilised databases are distributed among all the exchanges of the network.

A wide range of enhanced custom-tailored value-added communications services can be provided by concentrating databases in specialised centres and by adding advanced intelligent features to the network exchanges. Such a network architecture is normally referred to as the *intelligent network* (IN).

A typical IN function is the virtual network access concept, based on the use of 'logical addresses' independent from the 'physical access points' of the called subscribers. This opens the way towards customised services (Figure 5).

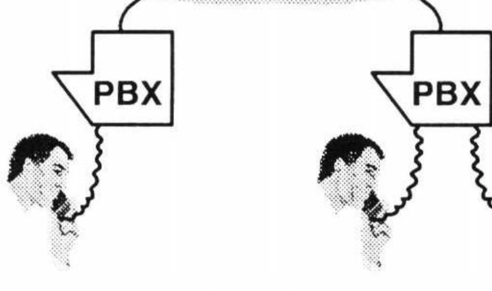
In the personal number service, for example, each subscriber is assigned a logical number. Wherever a subscriber may move, the network can locate him/her at any moment, enabling incoming calls to be routed automatically to the right geographic point.

Another example is the universal number, whereby a subscriber can call a company using the same telephone number for all its locations throughout a country or region. The network will automatically forward calls to the most convenient site according to the company's needs and organisation. Depending on such parameters as listening turns, call origin, date and time, calls are routed to different destinations, applying rules and programmes that can even be directly established or modified by subscribers, without any intervention of network operators.

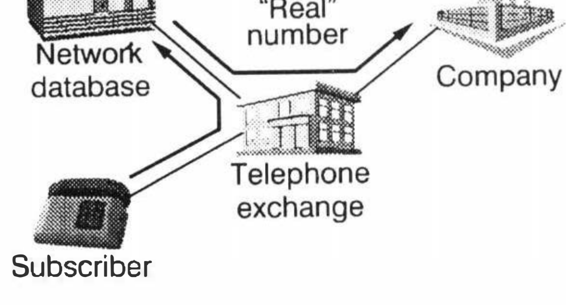
A common-channel signalling network, complete with the necessary OSI layers for the interchange of connectionless messages, represents the indispensable framework to adequately support intelligent exchanges and nodes.

The functional structure of an intelligent network is schematically represented in Figure 6.

A service switching point (SSP) recognises calls that require the assistance of the IN logic for further processing to perform the requested services.



Private virtual networks



Universal number

Figure 5—Intelligent network services

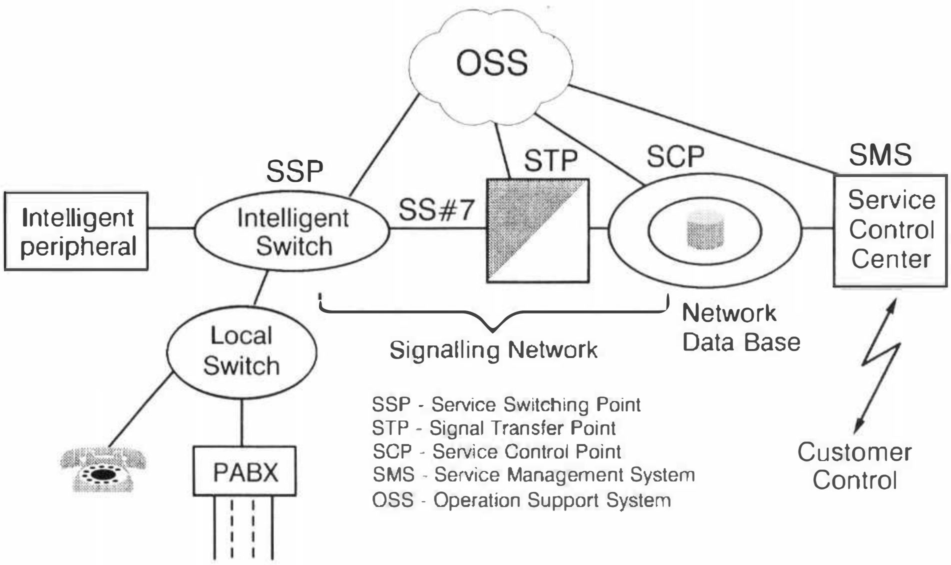


Figure 6—Intelligent network

SSPs reach intelligent nodes, named *service control points* (SCPs), which send back to SSPs messages containing the necessary instructions.

Signalling transfer points (STPs) permit complete accessibility to SCPs from any SSP. Each SSP can therefore send messages towards an STP, which has the task of routing them forward to the SCP predisposed for that particular intelligent network service.

To manage the databases of SCPs and to obtain statistical and operational data, a service management system (SMS) function is provided by general-purpose computers.

This function can be utilised both by the operating staff and, through remotised terminals, by the customers themselves (customer control).

The operation support system (OSS) is an integrated information system supporting the management of the entire network.

Finally, to provide special services such as customised announcements, it may also be useful to introduce intelligent peripherals, directly connected to the SSPs and controlled by SMS/OSS.

Briefly, all that is needed to obtain an IN functionality is to provide the existing digital exchanges with new software modules implementing SSP functions, to install intelligent nodes (SCP), and to have a common-channel signalling network switched by STPs, as well as management and control centres (SMSs and OSSs).

Figure 7 summarises the first IN services which are foreseen to be introduced in Italy.

- Green number
- Universal number
- Premium charging
- Split charging
- Private virtual network
- Mass calling
- Televoting
- Personal number
- Calling card

These services can be monitored and controlled by SIP and, if desired, remotely by the service subscribers via the customer control service

Figure 7—IN services provided by SIP in the near future

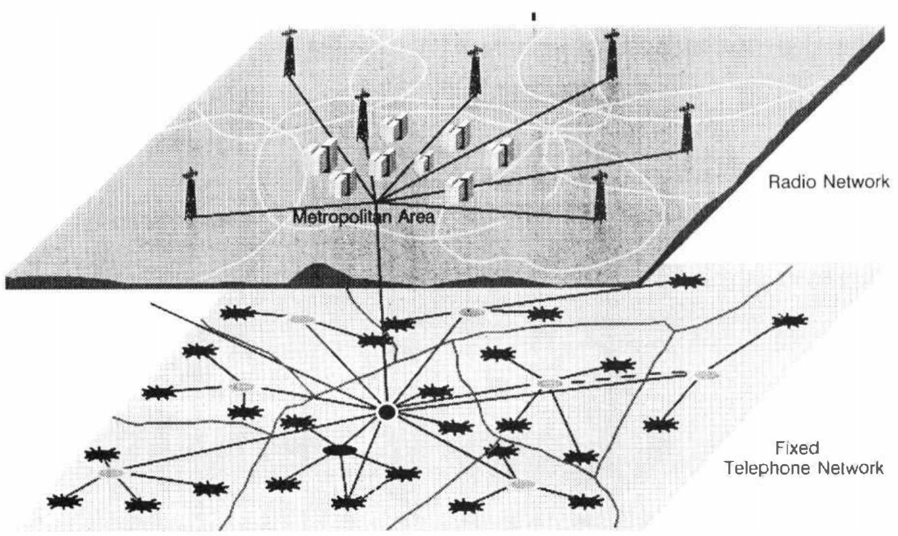


Figure 8—Interconnection between radio mobile network and fixed telephone network

Since performance efficiency is increased by spreading as many as possible SSPs into the network, the above-mentioned functionalities will be introduced, in a very first phase, in a share of switching exchanges. Shortly afterwards, SSPs will be installed in all of the largest exchanges, which control up to 100 000 users, connected either directly or through remote concentrators.

In North America, intelligent networks are extensively employed both to provide new value-added user services and better support network operators.

PERSONAL COMMUNICATIONS

Cellular mobile systems, cordless telephones and paging networks are all experiencing an explosive growth, which has already surpassed the most optimistic predictions and is expected to continue.

It is realistic to estimate that by the end of this century there will be at least 100 million mobile subscribers in the world, nearly half of which in Europe.

In a cellular system, radio base stations provide both radio coverage for the mobile user, and the interconnection to the public telephone network (Figure 8). Since only a limited number of radio channels can be made available within an area, or *cell*, cellular systems are subject to saturation.

For example, the Italian nationwide 450 MHz RTMS system is approaching now its saturation level, calculated at about 100 000 subscribers (Figure 9). To meet the rapidly increasing demand, an interim system in the 900 MHz band has already been introduced, in expectation of the next digital pan-European system.

In Europe, in March 1990, 2·5 million subscribers were connected to eight different systems. Figure 10 shows details of this fragmented situation in Europe. At the same date, the subscribers' base was about 3·5 million in the

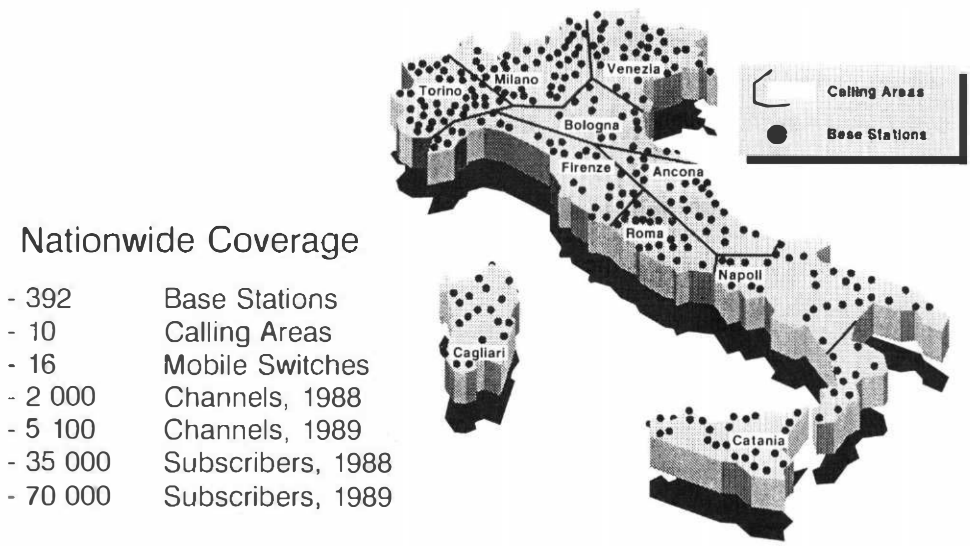


Figure 9—RTMS nationwide 450 MHz cellular system

System type	Countries	Subscribers	%
TACS-900	UK, Ireland, Italy, Austria	881,100	37.6
NMT-450	Austria, Belgium, Denmark, Finland, Iceland, Luxembourg, Netherlands, Spain and Sweden	672,630	28.7
NMT-900	Cyprus, Netherlands, Scandinavia, Switzerland	362,370	15.5
RC 2000	France	168,560	7.2
C-450	Gemany, Portugal	166,220	7.1
RTMS	Italy	65,200	2.8
Comvik	Sweden	16,000	0.7
NMT - F	France	10,000	0.4
Total		2,342,080	100.0

Figure 10—European cellular system summary (end December 1989)

USA, according to the latest estimates, and some 500 000 in Japan.

Both Europe, with *groupe spéciale mobile* (GSM), and the USA, with the Cellular Telecommunications Industry Association (CTIA), are developing their own standards for new-generation digital systems with more traffic capacity and new services capability.

GSM will offer a pan-European 'roaming' facility, which means that subscribers will be able to use the same terminals and procedures across all of Europe. ISDN integration is also foreseen.

Although the 900 MHz GSM system can supply about five times more channels than analogue systems, it is foreseen to be unable to cope with the long-term demand, since it is likely to serve no more than 15–20 million subscribers throughout Europe.

Cordless Telephony Concept

In short, *cordless telephony* means the use of the same portable wireless telephone at home, at work and in public places (Figure 11).

There are two different techniques: CT2, which is available now and is going to become a *de facto* standard, and DECT, which is under study as a possible common European standard.

CT2 has been introduced in the United Kingdom, where it is known as *telepoint*. It is aimed at allowing subscribers to use the same hand-held telephone in public places as well as at home, using a sort of 'wireless pay telephone'. To this end, relatively inexpensive base stations are provided at places such as petrol stations, hospitals and airports. Any subscriber located within some 200 m of these stations can activate a personal communicator, similar to today's cordless handset, to make a call that is routed via the public switched telephone network. At present, only mobile originated communications are possible.

CT2 operates in a time-division duplex technique at 864–868 MHz, with a transmission power as low as 10 mW. Until now it has suffered—mainly from the lack of a common air interface (CAI), with the subsequent incompatibility between different proprietary networks. Although no CAI will be operating before 1991, the UK administration is pressing the introduction of this service in other European countries. Seven European administrations (France, West Germany, Belgium, Spain, Portugal, Finland and Italy) have recently signed a memorandum of understanding to conduct CT2 field trials by the end of this year. The use of a common air interface will enable subscribers of telepoint to communicate between signatory countries.

The other standard, called ***DECT*** (digital European cordless telecommunications), was proposed by the Conference of European Postal and Telecommunications Administrations (CEPT) and is currently under development at the European Telecommunications Standards Institute (ETSI), with the aim of harmonising cordless telephone standards across Europe. Working at 1·8–1·9 GHz, it offers more bandwidth than CT2. Although useful for residential cordless telephones and wireless public access systems (telepoint), DECT is particularly suitable for use in wireless private branch exchanges (PBXs), allowing employees to carry their telephones around in their offices. It offers full two-way communication, with hand-off between cells.

DECT could form a basis for the evolution of personal telephony, by supporting a cordless concept in the PABX environment initially, and then, as telepoint networks are developed, by providing an inexpensive means for personal communications in urban areas. Finally, wireless PABX and cellular systems could merge to create one single network.

'Phones on the Move'

In January 1989, the UK Department of Trade and Industry (DTI) brought out a discussion document called *Phones on the Move*, seeking proposals for a new competitive scenario in personal communication services.

The document suggested that spectrum could be made available at 1·7–2·3 GHz. Proposed systems were requested tobe more sophisticated than telepoint, but less expensive than present cellular systems, although providing a complete two-way territorial coverage, aiming at creating a mass market for mobile communications.

Two important technical solutions for PCN have been proposed to the DTI, one based on GSM and the other on DECT.

The first one is a modified version of GSM operating at higher frequencies and based on a combined structure of microcells (1 km diameter) covering urban areas, and overlaid macrocells (5 km diameter) covering both urban

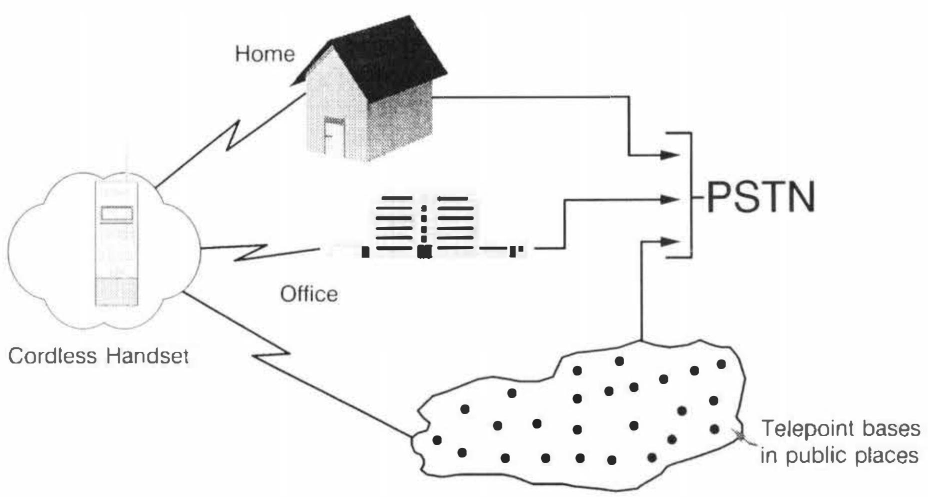


Figure 11—Cordless telephony concept

and rural areas. Macrocells are charged with two basic tasks, linking microcells and providing communication capability for mobiles.

The second proposal refers to a less ambitious network architecture, employing only microcells in urban areas. The rest of the territory would be served by an 'intelligent' paging network, with the capability of instantly locating and reaching any mobile receiver. DECT would be used for this application, requiring considerably lower costs compared with the GSM solution, and with favourable implications for call charge perspectives.

At the end of 1989, the GSM solution has been selected for all the three consortia that have got a licence to operate PCN networks. The ETSI/GSM Technical Committee has been charged with the task of producing a European standard for the GSM-1800 system, officially named *DCS-1800*.

Pocket terminals are obviously a key factor in personal communications, playing a major role in its diffusion. Many technological advances can help obtain advanced features.

Another key factor to allow populations of some tens of millions of subscribers roaming Europe-wide, is the progress of intelligent networks utilisation in the fixed network with the capability to provide large and standardised location/authentication registers. Chip-card personal identification numbers can 'personalise' different kinds of terminals, thus allowing the network to follow the personal mobility.

FLEXIBLE TRANSMISSION

The architectural features of a modern digital transmission network are based on the following fundamental points:

- maximum structure flexibility,
- reliability at all network levels, and
- central management capability.

The technological evolution creates large possibilities for the achievement of these goals, thanks to the widespread use of optical fibres laid up to new user equipment (digital loop carriers, flexible access systems, etc.) and to the new digital transmission equipment using the synchronous digital hierarchy (SDH) standard.

The SDH will in fact allow a simplification of transport and multiplexing equipment and, above all, a higher network management flexibility, giving substantial improvement in comparison with line equipment and multiplexers based on present plesiochronous techniques.

Through the SDH standard, the direct accessibility to multiplexed components allows for inserting or dropping channels at lower levels; furthermore, efficient service channels allow for transmission quality monitoring.

The SDH is capable of transporting within flows at 156 Mbit/s or its multiples, plesiochronous flows at lower speeds, even those belonging to different standards (American or European).

Among the new basic elements which are fundamental to the achieving of a higher network flexibility, an important role is played by digital cross-connect systems (DCSs), which allow network reconfiguration in a 'predetermined' manner, avoiding expensive manual interventions (Figure 12).

They supply an automatic and adapting reconfigurability of the network through a local command controlled by a remote central management.

The advantages which derive from it for the operator and/or the end user basically are the following:

- a decrease in the user costs,
- a more rational distribution of investments on the part of the network operator,
- a greater network reliability, and
- a more rapid supplying of transport services as requested.

The DCSs are essentially a switching matrix of digital channels which allows for the changing of the network configuration for limited intervals, up to weeks, days and even hours. They are generally supplied with interfaces both for the plesiochronous world and for the synchronous one (SDH). There exists a complete range of DCSs depending on the possible combinations between switching and access levels (Figure 13). At one extreme, there are the 1/0 DCSs, preferably used for offering custom solution to business users. At the other, there are the 4/4 DCSs, above all employed in trunk lines for the protection of a large number

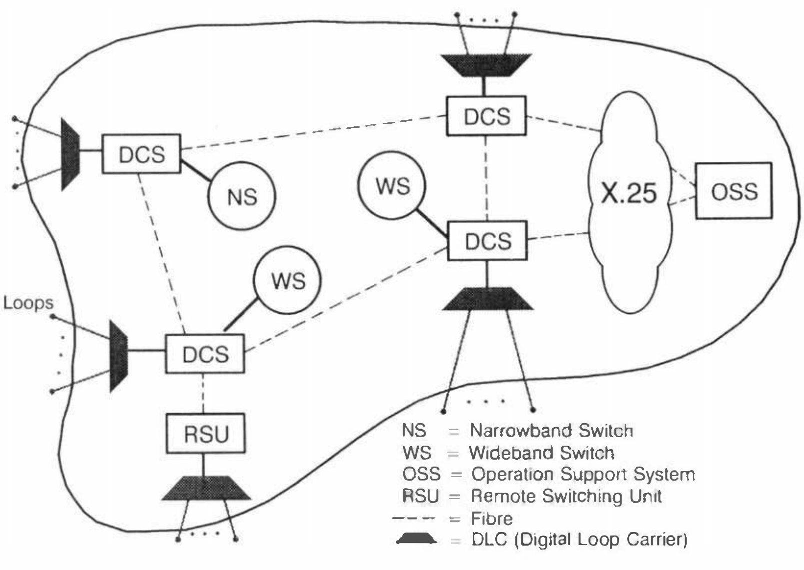


Figure 12—Flexible network employing digital cross-connect systems

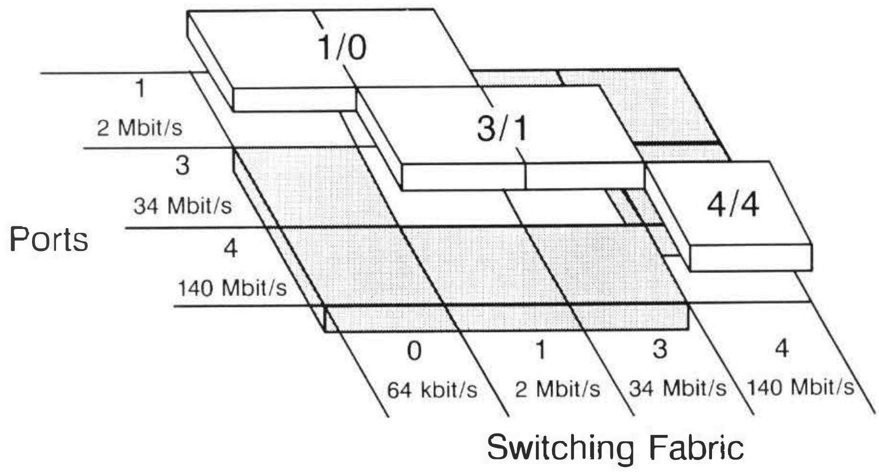


Figure 13—The DCS matrix

of channels; in this case, they provide a self-healing function.

CONCLUSIONS

A panoramic view has been given of some areas of significant importance in which there could be major changes in the next few years.

The most advanced countries will be able to offer narrow-band ISDN on a large scale by the next two or three years. Business users may find some difficulty in functioning without it in the future; outside that group, customers' demand may be limited for some years to come. Waiting for a full ISDN deployment, it seems both timely and appropriate to make other solutions available; the over-voice access represents an example of confronting now the pressing demand for a lot of low-throughput telematic services.

The commercial success of ISDN in the individual countries will depend on the capability and speed of:

- implementing all existing digital telephone switching nodes with additional ISDN hardware and software,
- producing a complete range of ISDN terminals at low costs, and
- promoting ISDN to potential users through suitable marketing activities involving operators, service vendors and equipment manufacturers.

At the end, a broadband structure will increase the value of ISDN, its main role being that of supporting more sophisticated services such as videoconferencing and high-speed data transmission.

Intelligent networks are providing new value-added services (advanced freephone, private virtual networks, credit card verification, network-wide centrex, and so on) quickly, cheaply and easily, not only in the areas of greater demand, but wherever they are needed.

The area of personal communication is probably the most significant of all. This article has summarised some ideas and studies in the fascinating field of personal communications, recalling the cellular radio mobile and the emerging concept of the cordless telephony, which widens the range of the radio mobile market.

Cellular systems will be unable to meet the exploding demand for mobile communications of the future. New concepts in wireless communications are being introduced, for example, cordless telephony, which means the use of the same portable telephone at home, at work, and in public places. Two systems (CT2 and DECT) have already been proposed as a possible European standard. Personal communications systems of the future will be based on the idea of the 'pocket communicator', that can be carried about and used to make or receive calls anywhere: it could simply consist of a personal number which can be 'linked' to any suitable terminal.

Finally, this article has underlined that flexibility and reliability are two fundamental requisites in modern digital transmission networks. Among the new network elements, DCSs play an important role. Thanks to them, the network operator has to be able to provide modified services quickly, without the need of manual intervention, according to customer's needs, that may change on a day-by-day or an hour-by-hour basis, automatically rerouting traffic in case of any failure in the network.

Modernisation of the London Network

B. HAIGH, and W. MEDCRAFT†

INTRODUCTION

London is high in the ranking of major cities of the world. Few others compare with London in terms of a combination of features such as major financial and entertainment centres, geographical size, working and residential populations.

The area covered by the London telephone network is 2927 km^2 (1125 square miles) and serves a population of 8 million people. (Figure 1). This includes the central city business, West End entertainment and shopping areas, Docklands, and a heavily populated area extending out to a radius of some 31 km (19 miles). To put this into perspective, the M25 orbital ring motorway is roughly 17 miles radius from the centre of London.

There are currently 4·6 million customers telephone lines in London, varying from the specialised requirements of the central business areas through to the large diverse residential population on the periphery.

Many major international as well as national companies have their headquarters located in London.

Telecommunications usage within London is much greater than the average for the rest of the country, not only in terms of intra-London traffic, but also for incoming and outgoing traffic from the rest of the UK and from overseas. There is a continuous demand for the latest telecommunication facilities for voice telephony, data communications and video applications from the business population. A modern high quality telecommunications infrastructure is essential for the continuous development and prosperity of London as a major world city.

† British Telecommunications plc, UK

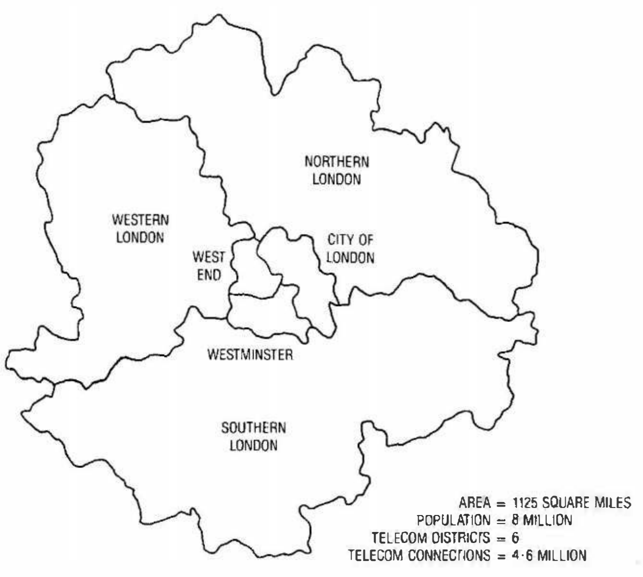


Figure 1—British Telecom London Districts

CUSTOMER SERVICES

PSTN

The main demand for telecommunications services continues to be for voice telephony over the public switched telephone network (PSTN). In recent years there has also been a significant increase in use of the PSTN for other applications using dial-up connections. Data communications and facsimile services are two key examples, the latter enjoying explosive growth in the last 2–3 years facilitated by the emergence of established international standards and high quality, cost effective terminal equipment. ISDN will provide opportunities for new service applications now that standards are being established. Network coverage will be extensive.

Private Circuits

A close second to the importance of the PSTN in London is the demand for private circuits (leased lines). There has been a phenomenal growth in demand in recent years for private circuits for data communications, in particular spurred on by the introduction of more and more data processing applications requiring wide area access to high street businesses, as well as between national and international major centres. Many large companies have built national and international networks linking into London, and the Megastream 2 Mbit/s digital private circuit facility in particular is popular for providing trunks between such major centres.

Competition and Interconnect

The competitive environment is now well established in the United Kingdom, and London is the focus of competition with a variety of value added services operated by competitors as well as BT. These services also make use of BT's leased lines. The two major cellular radio operators also concentrate their networks on London, and again require extensive networks of leased lines as well as large interconnect gateways with British Telecom's PSTN.

Capacity and Flexibility

Uncertainty of demand in both quantity and location for all these various customer services means that a highly flexible and resilient network is required, able to offer the latest facilities, adequate capacity and high quality of service over the whole geographical area covered by the London network.

THE LONDON NETWORK INFRASTRUCTURE

The most recent phase of modernisation of the London network commenced in the mid-1980s, and has entailed the virtual rebuilding of a large network that had evolved over many years. The introduction of digital technology for both

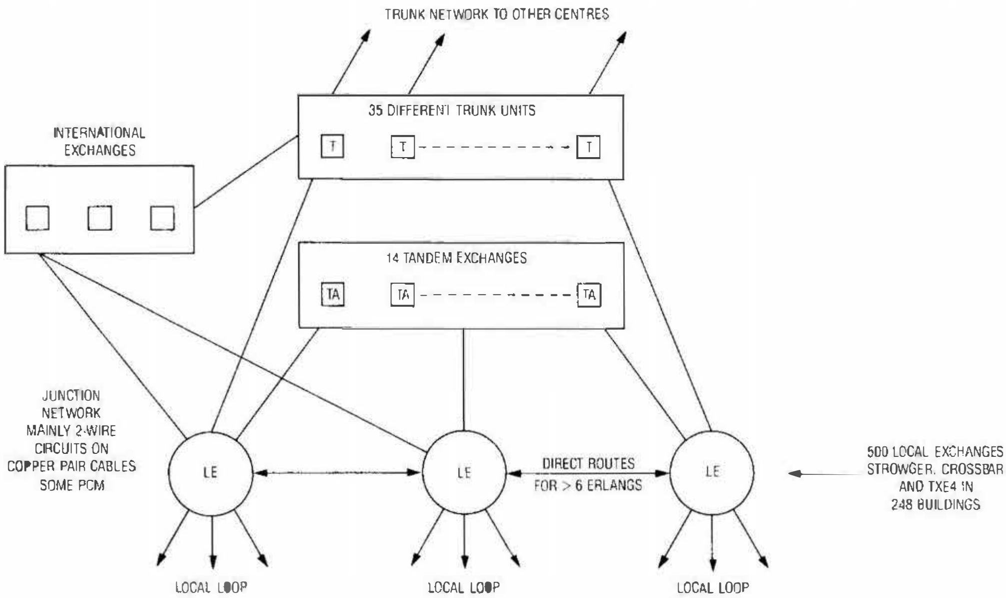


Figure 2—Old London network

switching and transmission systems enabled the radical restructuring of the network into a fully integrated system. This restructuring had been heralded by improvements in the trunk network, but the potential benefits to be derived from modernisation of the London junction network were even greater because of its size and complexity.

The Network Prior to Digital Modernisation

The existing network (Figure 2) consisted mainly of electromechanical step-by-step Strowger local exchanges, crossbar and Strowger tandem exchanges, and a complex inter-exchange (junction) transmission network mainly composed of multi-pair copper wire cables, supporting individual inter-exchange traffic circuits. Although PCM systems were used on quite a large scale to achieve better utilisation of cable capacity, the majority of short routes were served by multi-pair audio cables.

The existing network had grown rapidly over the years and had experienced a number of generations of overlay modifications, coinciding with various developments such as completion of national automatic customer direct dialling and international customer direct dialling. The performance of elements of the network had been improved significantly over the years by the introduction of electronic reed relay exchanges (STC TXE4s), which had achieved a 39% penetration. However, the network was still essentially an analogue transmission system with the majority of switching performed by slow step-by-step electromechanical switching systems. The inter-exchange junction network in London linked 248 exchange buildings accommodating nearly 500 exchange switching units in total.

PSTN Traffic Routing on the Old Network

Public switched telephone traffic levels are higher than national average in any large capital city, and the routings across an urban conurbation are more complex. Typically 90% of the traffic on any central London exchange is destined for or originates from outside the local exchange area. The junction network carries local London inter-exchange traffic, traffic to and from local exchanges to the national trunk exchanges, and to and from the international gateway exchanges.

In the old network, because of the number of step-by-step switching systems involved, and for transmission considerations, direct traffic routes between individual exchanges were justified at fairly low traffic thresholds (greater than or equal to 6 erlangs). This resulted in a multitude of direct traffic routes between exchanges. Tandem routings for the lower level inter-exchange traffic were grouped together and routed via various generations of tandem switch configurations that had been introduced over the years, the most recent being crossbar units located at seven sector switching centres distributed around the periphery of London. Trunk traffic in and out of London was routed via seven combined incoming and outgoing trunk units, also situated at the sector switching centres, and a number of separate incoming and outgoing trunk units located in the centre of London.

Transmission Quality

Transmission quality on long distance calls to and from London local exchanges was variable, mainly because of the differing lengths and transmission characteristics of 2-wire analogue junction circuits connecting trunk to local exchanges, routed on a variety of cables and PCM systems. The cables and transmission systems also had to accommodate private circuits for which there is a very high demand in central London, and which in the analogue environment experienced varying characteristics and quality depending on routings.

Restructuring Junction and Trunk Networks with same Technology

The technical performance and low cost of modern digital systems makes them suitable for the shorter junction network as well as the inter-city trunk links. This provided the opportunity to replace the hitherto different analogue junction network and local exchanges with similar technology to that used in the trunk network, and thereby progressively introduce a totally integrated homogeneous system. Such a system is capable of offering higher and more consistent quality end-to-end transmission down to and including local exchanges, as well as very high speed signalling. This new infrastructure also forms the foundation for support of BT's plans to roll out new services and the ISDN.

By the mid-1980s the modernisation of BT's national long distance inter-city network had made a good start. The old analogue network, comprising 454 group switching centres (GSCs) using electromechanical switches, interconnected with FDM analogue transmission systems, was being replaced by 53 centres accommodating digital main switching units (DMSUs) based on GPT's System X switches. These new DMSUs were linked together by 2 Mbit/s channels routed over a completely new digital transmission hierarchy comprising 140 Mbit/s and 565 Mbit/s systems on optical-fibre cables and digital radio systems. London and the South East was the first region to complete its GSC closure programmes.

The plan for the larger and more complex London junction network has involved progressive conversion from a copper-wire based analogue network, which had many traffic routes directly connecting individual exchanges to a largely fibre-cabled digital transmission network with fewer, larger individual traffic routes.

The New Traffic Routing Plan

Previously, London exchanges had many direct junction routes of varying sizes of circuit and traffic capacity. Some of the larger exchanges had in excess of 300 separate routes because traffic levels greater than 6 erlangs justified direct routes as described earlier. With the advent of the digital network the opportunity has been taken to reduce the number of switching sites (nodes) by having a small number of large processors each serving a number of satellite concentrator units. A larger proportion of the inter processor traffic is being routed via intermediate digital tandem switches.

This new routing plan for traffic between telephone exchanges with its simplified and concentrated routings has enabled a different supporting transmission infrastructure to be developed.

The New Junction Network

The main feature of the new network (Figure 3) is the linking together of the ten key switching sites in the centre and around the periphery of London with high-capacity 96-fibre cables. An outer 'ring main' links the seven sites on the periphery whilst a smaller ring has been established to link the inner three sites. Between the two rings there are direct links similar to the spokes of a wheel. This provides a powerful high-capacity 10-node core transmission network capable of supporting not only the public switched telephone network traffic routes, but also the ever increasing demand for private circuits. The seven peripheral buildings accommodate digital main switching units and digital tandem exchanges. The former provide switching to and from London to the rest of the UK national network, and the latter switch tandem traffic between London local exchanges. The three central sites each have digital switching units (DSUs) that can switch both tandem and trunk traffic. The British Telecom International gateway exchange buildings are also connected to the 10-node network via optical-fibre cables.

The multitude of copper wire cables existing for the analogue network interconnecting the 200 or more exchange buildings in London are being replaced with high capacity optical-fibre cables and associated digital transmission systems which link into the two rings.

British Telecom offers digital private circuit customer services at transmission rates of 2·4, 4·8, 9·6, and 64 kbit/s via its KiloStream service, and 2 Mbit/s transmission rates via its MegaStream service. Both these services utilise transmission routings over this new optical-fibre transmission infrastructure.

Links from the Core Network to Processor and Remote Concentrator Sites

The new digital local exchange processor sites serving specific areas of London are then connected to the 10-node

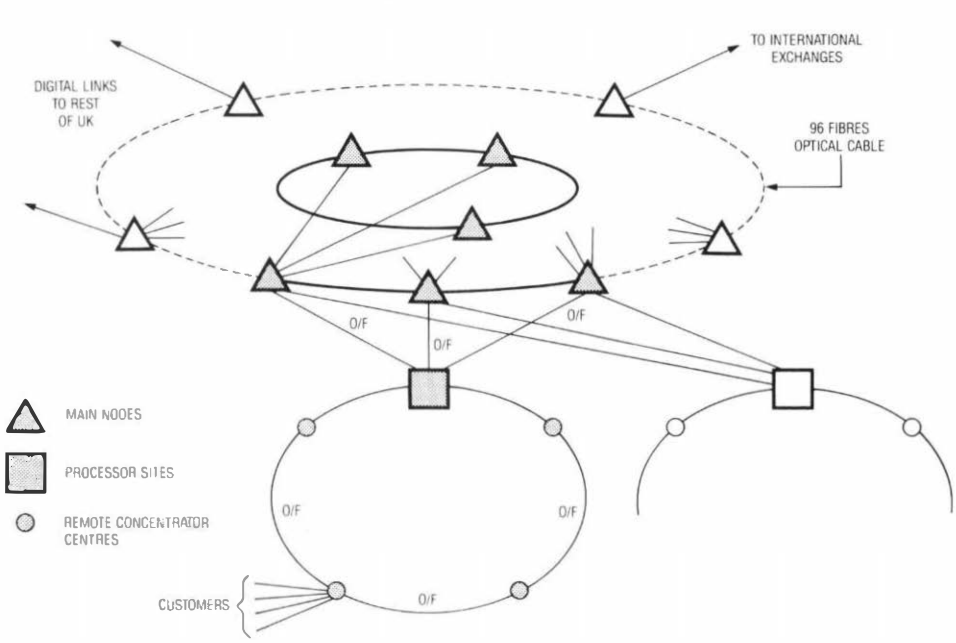


Figure 3—New London digital network

transmission network via 96-fibre cables, each individual processor site having separate independent routings to three of the 10 main nodes. This diversity gives a very high degree of resilience to the network, a feature totally in keeping with the importance of the traffic carried over these links.

Finally the dependent local exchange concentrator sites in individual processor site areas are connected to their parent processors via optical cable local rings.

Rebuilding of the London transmission network has been and continues to be one of the major activities supporting modernisation and conversion of the exchange network from analogue/electromechanical to a fully integrated digital system.

PROGRESS OF SWITCH MODERNISATION

In 1980, prior to commencement of modernisation, there were a total of 3·29M exchange lines in London of which 2·55M (77·5%) were connected to Strowger step-by-step systems, 0·55M (16·7%) connected to crossbar exchanges, and 0·19M (5·8%) connected to STC reed-relay systems (STC TXE4 exchanges). (Figure 4.)

The first GPT System X digital exchange was introduced into the City of London in 1985. It provided only 3500 lines to cater for growth in the immediate vicinity. Since then the number of digital lines provided each year has accelerated rapidly.

By 1987, the total number of customer lines in London had grown by 25% to 4·13M lines, and the proportion served by System X was only 2%. In 1988 the first Ericsson AXE10 digital exchange was introduced at Harrow in Western London serving 10 000 lines and replaced a Strowger unit at that site. By the end of March 1989, London had a total of 493 telephone exchanges in 248 buildings serving a total of 4·4M lines of which 216 exchanges (43·8%) were digital. A year later, at March 1990, 331 exchanges (67·1%) were digital serving 47% of the customers lines. Of the remaining analogue units, 118 are STC TXE4 reed-relay systems which have been enhanced with add-on processor units to give itemised billing and CCITT No. 7 signalling capability. These units are capable of integrating well into the new network and are well proven, economical to operate units. It is the intention to retain most of them during the 1990s.

By mid-1992, all the Strowger and crossbar units will have been replaced by digital units. The network will then be totally digital switching plus the retained TXE4 units.

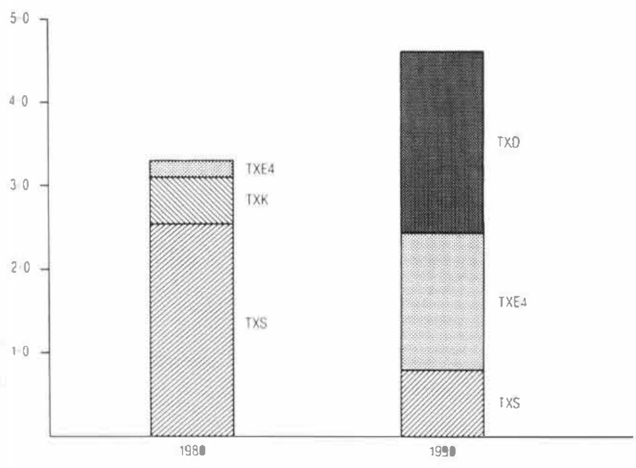


Figure 4—Modernisation progress

BENEFITS AND NEW FACILITIES OFFERED BY MODERNISATION

Modernisation is therefore well advanced in London and already the benefits are apparent and beginning to be realised.

Improvement in Customer Service

Overall end-to-end transmission performance on the digital connections is superior to the best achieved in the analogue network. This is demonstrated by improvements in not only intra-London calls, but also national and international calls originating or terminating in London. Most importantly the performance is very much more consistent call by call. The combination of digital switching and CCITT No. 7 signalling enables high speed call set-up times (less than 1 second on average compared with 15 seconds average in the old network). Replacement of customers telephones with new instruments capable of MF signalling, now readily available in the open competitive market existing in the UK, enables customers to experience the advantages of high speed call set-up.

The introduction of MF telephones also enables customers to access new facilities built into the new digital network. Typical of these are the *star services*. The most powerful and popular of the star services are those which can only be provided within the network; for example, optional incoming call diversion (either for all calls, calls receiving no reply, or on receiving busy). Each feature can be selected and de-selected by a customer as and when required. Another popular star service facility is 'call waiting' enabling the customer to answer another call when engaged on an existing conversation, and '3-way calling' enabling three customers to link together on one call.

Itemised billing is also a popular facility available on digital exchanges and the modernised TXE4 exchanges.

Platform for ISDN

The modernised network already provides a sound economical platform for roll out of ISDN. There has been much speculation over recent years about the market for ISDN, but there can be no doubt that a telephone network capable of providing high quality end-to-end 64 kbit/s transmission on a call-by-call basis, opens up many new opportunities for data and video applications. Multi-line IDA, that is, 30 channel plus signalling ISDN links into customers ISPBXs, is already available in London, and single-line ISDN to CCITT latest standards has been launched this year. (Figure 5.) BT already had a pilot system operational since 1985.

Operational Benefits and Management

The modernised network enables BT to manage its network operations more efficiently. The switching hardware requires considerably less maintenance than the old electromechanical systems, whilst network management systems enable the overall network and individual exchange components to be monitored and controlled remotely from a few key centres. A particularly powerful feature of a modern SPC digital network is the ability to monitor and control traffic flow. Public events which generate large amounts of traffic suddenly at short notice to particular customer sites are not infrequent. For example, national catastrophes and

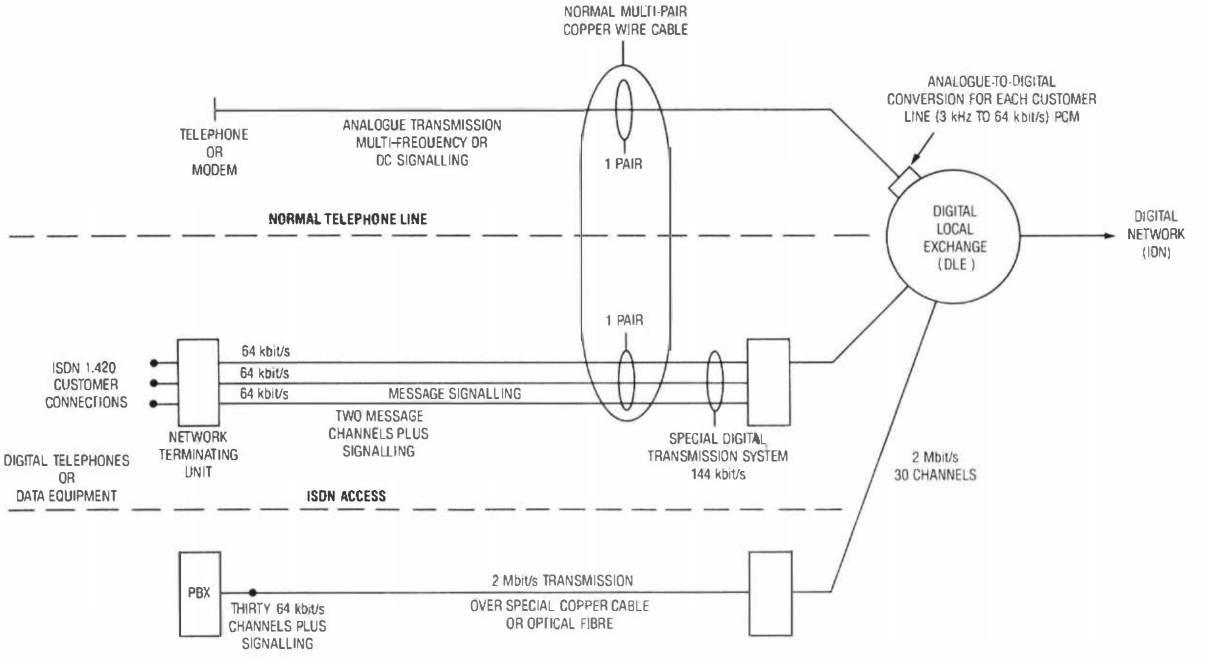


Figure 5—ISDN access

emergencies, rail accidents, radio and TV phone-in programmes, and advertisements encouraging telephone applications for tickets for pop concerts all generate traffic levels far in excess of normal. The central management centre is able to monitor the traffic flows caused by events of this nature and identify hot spots in real time over the whole network. It is then possible to control the traffic in real time and only allow as much to flow to the receiving customer as he is able to handle at any time, the rest being held back nearer to the originating sources preventing congestion of the network for other users.

CHALLENGES ASSOCIATED WITH MODERNISATION

In order to progress such a massive modernisation programme in a timely and orderly manner, a number of major problems have had to be addressed.

Not least has been the need to address the almost total change of skills required to support the installation and subsequent maintenance of computer-based digital exchanges. This has necessitated a well co-ordinated training programme and planned redeployment of staff, whilst maintaining the performance of the remaining electromechanical exchanges in the rapidly changing network configuration.

The rapid change-out of analogue to digital systems has required disciplined management in order to build a robust infrastructure whilst maintaining a reliable service to over 4 million customers. In 1989 there were no less than 75 separate change-overs in London as electromechanical exchanges were replaced by digital switches. Each one had to be meticulously planned with special attention paid to the customer interface and network capacity. Customer premises equipment now has a wide range of line conditions and for each of these there has to be a perfect match with the digital exchange. Network capacity has to be carefully designed and put in place before cut over to ensure conversions are done smoothly with no adverse effect upon the service to customers. A rigorous disciplined interface with the switch suppliers has enabled early teething troubles to be diagnosed quickly and remedial action prioritised to effect rapid but reliable fixes to software and hardware.

All this has taken place in an environment in which growth of demand for both switched and digital leased line services has reached levels higher than originally forecast.

The unprecedented growth, together with the obligation for BT to release numbers for use of other operators and new services has necessitated a major London code change, separating the previous '01' London numbering areas into two areas coded '071' and '081'. (Figure 6.) This code change with all the attendant re-routing and translation

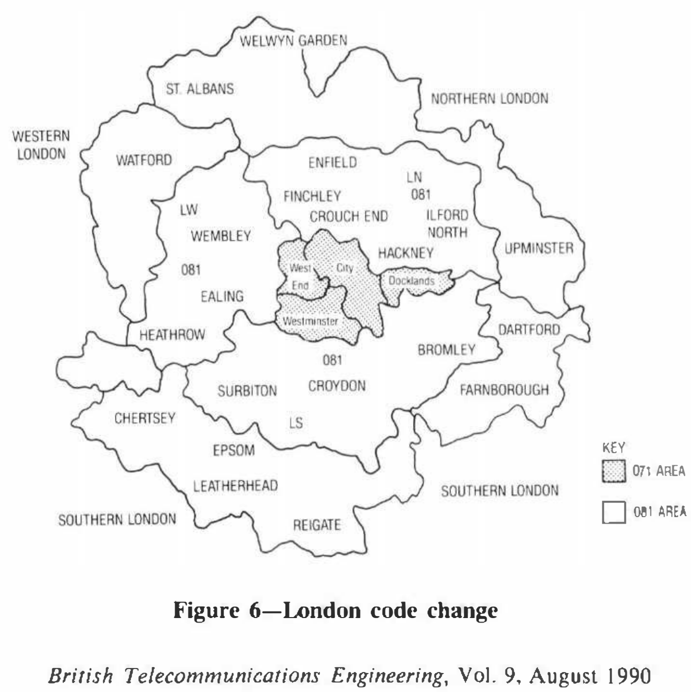


Figure 6—London code change

requirements had to be carried out in parallel with and as a part of modernisation and was successfully brought into operation in May 1990.

THE DIGITAL DERIVED SERVICES NETWORK

Within the London network there is a major node of the DDSN a national network introduced in 1988 to support the 0800 freephone and 0898 premium services for which there has been tremendous demand. The network was first launched in analogue mode in 1985 using a temporary Strowger-based network. The new replacement DDSN uses AT&T 5ESS PRX switches, linked together through the digital transmission network, and offers a range of extra enhanced facilities as well as more efficient operation linking effectively into the national digital PSTN. The derived services network carries a rapidly increasing number of 0800, 0345 and 0898 calls to a wide range of service providers. Experience with these services is being exploited to form the platform for development of intelligent network services in the 1990s.

THE FUTURE

The Inter-Exchange Network

The network modernisation described in this article focused on the radical transformation of the inter-exchange network and the local, tandem, and trunk switching components, as well as the core transmission junction and trunk inter-exchange infrastructure. This powerful new network in itself realises many opportunities for new services, better performance on existing services, and more efficient management of the various telephony services using that network, including private circuits as well as the PSTN. In order to realise the full benefit of this vastly different network, BT has not only had to address the new topology but also evolve a new supporting organisation, with new work practices, training, etc. With this more appropriate organisation and spurred on by new technical developments, the core London network, together with its national counterpart, will form a platform for the launch of many radically new services offerings based on the intelligent network concepts.

Technology never stands still, and BT is already planning the phasing in of a synchronous digital hierarchy (SDH) in the 1990s. Synchronous multiplexing will provide many features offering much more flexible provision of transmission capacity particularly applicable to private circuit provision. Synchronous multiplexers will also provide an even more economically attractive solution for dealing with large quantities of circuits that have to be dropped and inserted over short distances in an urban environment.

The Local Loop

The next radical change in the network infrastructure will be in the local loop which so far has not been addressed in this article. Already within London, optical fibre is used to link large customer sites to the core network for specialised wideband services such as MegaStream private circuits, and multi-line ISDN access to the telephone network. BT has installed an extensive local fibre network within the City of London which is capable of supporting a range of existing and new services to major sites. In effect fibre enables the already homogeneous trunk and junction networks to be extended out to key customer sites, so that transparent 2 Mbit/s channels can be effectively used to give ubiquitous coverage. Much work is being done within British Telecom to develop new features and facilities in this fibre local access, and cater for wider band services as demand expands and matures.

However, the extensive copper wire network well established in London is still the major access medium to the core network for the small business and residential customer and is capable of supporting 64 kbit/s private circuits as well as single-line ISDN access in its current form. Expansion of this copper network is therefore still a major part of BT's ongoing commitment in London.

CONCLUSIONS

In this article we have attempted to describe modernisation of the London network, progress to date, and the opportunities and challenges presented by the planning, construction and operation of this new radically different network. The creation of this new infrastructure is just the beginning of a new era, and provides a platform for a whole range of new services and specialised network features that customers will demand as we enter the next century. The challenge BT is facing in the UK is one that faces all telephone network operators and telecommunications equipment suppliers in Europe and worldwide.

New Telecommunications Services by Means of Increased Intelligence in Networks

H. OBERSCHEIDT†

PRESENT SITUATION

Telecommunications authorities (PTTs) and service providers are, at the moment, developing worldwide strategies, such as the introduction of new services based on intelligent networks (IN).

At the International Switching Symposium (ISS) in Stockholm, in May 1990, as many as five sessions were devoted to the following IN topics:

- Evolution
- Service and Data Management
- Implementation
- Services

At the ISS in 1984 there were, on the other hand, no papers given on IN and in 1987 in Phoenix there were only very few papers on the subject.

What has happened in the meantime? Why are almost all PTTs occupied at the moment with concrete plans for the introduction of IN services? Attention is focused upon the following applications:

Advanced Freephone

With the advanced Service 130 (also 800 Service or green number) the service provider can independently change, for example, the routing parameter.

Mass Calling

Mass calling is an important instrument in today's opinion polls to establish subscriber behaviour.

Televoting

Televoting allows the co-ordination of certain facts and information with a simple yes/no answer.

Teledialogue

The teledialogue makes it possible to conduct targeted interviews (from chosen districts, within certain time periods etc.).

'Kiosk' (Information Bureau)

Kiosks offer the user information at a fee comparable with the sale of newspapers and magazines at a news stand.

Credit Card Calling

In the verification of credit cards it must be established whether the card is still valid and whether the user is authorised (identification code). It is also necessary to check entitlements and to handle booking procedures.

Personal Number

All calls to the personal telephone number will be passed on to the last given location.

Universal Number

The service subscriber receives a universal number. Independent of time of day, date or place, telephone calls will be transferred to any one of the locations stipulated by the subscriber.

Virtual Private Network

A virtual network is embedded in the public network and makes available to the subscriber a quasi 'private' network configuration.

In the Federal Republic of Germany the topic of IN is also being pursued with great energy. In the Deutsche Bundespost Telekom Charter, a project group has been established in the Central Telecommunications Administration (FTZ) to work on the rapid implementation of IN and two further main points:

- technology; and
- services.

Similar activities can be observed in other countries, among them Norway, Sweden, Great Britain, Holland, Spain, Portugal, Italy, Switzerland, France and Belgium. On an individual scale, the first pilot projects have been commissioned. It is the general aim of the PTTs to undertake the first acceptance tests in 1991–1992 and from 1993 to introduce the first services on a regular basis.

With SYSTEM 12 and the Alcatel 8300 processor system, SEL-Alcatel offers a complete solution for the creation of an IN.

THE MARKET AS A DRIVING FORCE

How can we explain this worldwide IN euphoria? What has been taking place?

The idea of IN, upon which all present strategies are being planned, comes originally from BELLCORE.

Today's telecommunications networks are not capable of meeting all requirements. For example, one should mention here mass calls to particular areas or the handling of mass calls within a short interval of time.

Also, the market is starting to demand a universal access number for companies or service units with geographically distributed offices.

The connect time needs to be very close to current expectations (under 1 second); that is, the connected systems

† Alcatel-Standard Elektrik Lorenz AG, Federal Republic of Germany

should be able to handle more than 100 000 interactions per second. Subscribers wish to have greater personal control and to have easy-to-use services available which can be, if necessary, supported by IN.

A further decisive requirement is to realise these new services in conjunction with conventional and SPC services already existing in the network, and to do this as quickly as possible. The concept of IN provides the desired answer. The prerequisite is the availability of a central channel-display network with CCITT No. 7 signalling. An important aim in the case of mass calling is also to handle every call successfully and not to hold up telephone traffic by employing overload prevention measures.

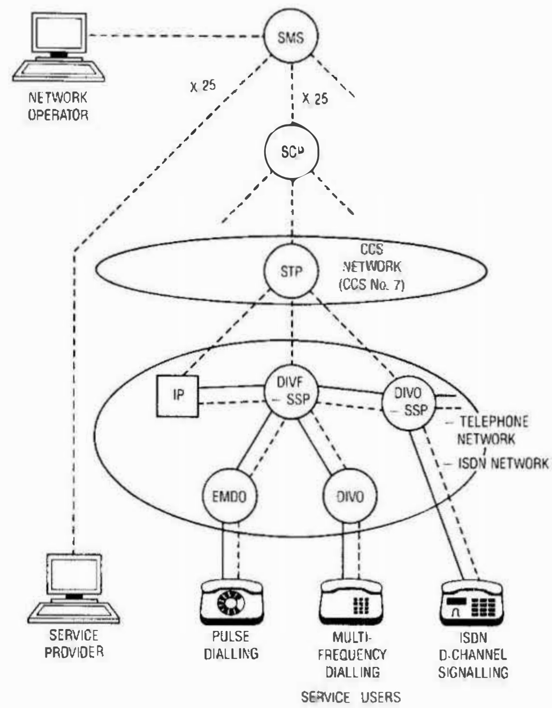
ADDITIONAL NETWORK INTELLIGENCE AS AN ANSWER

By means of additional intelligence in the network, through the 'intelligent network', the requirements of the marketplace can be met:

- for an SPC exchange connected subscriber
- for an electromechanical exchange connected subscriber
- countrywide realisation of a new service within a short time.

THE FUNCTIONS OF THE IN

The structure of the IN and the way in which it functions can be seen from the following illustration:



CCS: Common-channel signalling
DIVF: Digital toll exchange
DIVO: Digital local exchange
EMDO: Electromechanical local exchange
IP: Intelligent peripheral
SCP: Service control point
SMS: Service management system
SSP: Service switching point
STP: Signalling transfer point

Figure 1—Structure and components of intelligent networks

A New Regulatory Framework for Telecommunications in the European Community

G. CORDARO†

INTRODUCTION

The European single market of 1992 will be characterised by the free movement of people, goods, capital and services.

It will be possible in the future for the latter to be offered by the service providers in the whole European Community and the users will be able to choose freely the best offer at the best price.

Among services, telecommunications represent one of the most important challenges in the creation of the European single market. With the publication of the Green Paper on Telecommunications a wide debate was initiated with the aim of defining a new regulatory framework for the offer of telecommunications services and terminals within the European Community.

By January 1988 more than 45 organisations in the field, both at Community and national level, had responded to the Green Paper: users; telecommunications administrations; telecommunications, data processing and services industries, and the trade union and other organisations which represent the social interests.

This consultation process achieved agreement on the following basic orientations:

- New services and terminal equipment require market conditions which favour innovation, experimentation and a high degree of flexibility.
- The current and future integrity of the basic network infrastructure must be maintained or created. This implies in particular a continuing strong role for telecommunications administrations in the provision of network infrastructure, and strong emphasis on Europe-wide standards in this area. It also implies safeguarding the financial viability of telecommunications administrations in order to ensure the build-up of the new generations of telecommunications infrastructure and the necessary level of investment.
- Securing a wide range of choice for the consumer requires that telecommunications administrations be able to provide, alongside other suppliers, those services which are opened to competition even if this may involve complex problems of regulation.
- Employment growth requires a growth-oriented policy, particularly in the future conglomerate sector of information technology and telecommunications within which jobs will shift from traditional activities to new opportunities.

On 30 June 1988, the first anniversary of the Green Paper's publication was marked by the approval by the EC Council of Ministers, representing all Member States of the European Community, of a Resolution on the Development of the Common Market for Telecommunications Services and Equipment up to 1992. With this resolution, the Ministers responsible for telecommunications gave the green light to the main proposals of the Green Paper and its overall policy approach.

On 14 December 1988 the European Parliament passed a resolution on Posts and Telecommunications supporting the main policy lines set out in the Green Paper.

A broad consensus has developed on the fundamental principles determining the course of the reforms in Europe. In this process the Green Paper has served Europe-wide as a yardstick, with its proposals for introducing competition into the terminals and services markets, while maintaining network integrity.

The broad lines of the Green Paper's proposals cover:

(*a*) complete opening up of the terminal equipment market to competition;

(*b*) substantial opening up of the telecommunications services market, excluding a number of basic services considered essential to ensure current public service goals and objectives;

(*c*) continued exclusivity or special rights for telecommunications administrations to supply and operate the network infrastructure; recognition of their central role in establishing future generations of infrastructures;

(*d*) clear definition of general requirements imposed by telecommunications administrations on providers of competitive services for use of the network, including definitions regarding network infrastructure provision;

(*e*) clear separation of regulatory and operational functions of telecommunications administrations;

(*f*) strengthening of the standardisation process;

(*g*) using telecommunications to accelerate economic development of the less favoured regions of the Community.

TERMINAL EQUIPMENT

In May 1988 the Commission issued a Directive to open up EC-wide the market for terminal equipment to competition within its mandate under EC-competition law.

This directive is currently the subject of an Appeal for partial withdrawal in the European Court of Justice, by the French Government, joined subsequently by Belgium, the Federal Republic of Germany and Italy.

This appeal concerns only the legal technicalities of the Directive: whether Article 90 (3) or Article 100 A is the appropriate Treaty basis for the actions proposed.

There is no disagreement on the substance of the Directive's aim, to open up the terminal equipment market to increased competition.

The deadline for achieving such increased competition remains in force: by the end of 1990.

The opening of the market for satellite receive-only dishes not connected to the public network is included in

† Commission of the European Communities, Belgium

the Commission Directive on the liberalisation of the terminal market.

An open Community-wide telecommunications terminal equipment market depends not only on the new competitive environment but also on fair type-approval procedures required for the connection of equipment to the network.

In July 86 the EC Council issued a Directive on the initial stage of the mutual recognition of type approval for terminal equipment. This Directive established the principles and procedures for the mutual recognition of the results of conformity tests of terminal equipment intended for type approval. Furthermore this Directive envisaged a further stage for the mutual recognition of type approval certificates for terminals.

This further stage was reached with the Council Directive of July 89 on the approximation of the laws of the Member States concerning the placing on the market of telecommunications terminal equipment, including the process of mutual recognition of type approval of terminal equipment.

TELECOMMUNICATIONS SERVICES

The liberalisation of telecommunications services is one of the most difficult and important objectives.

In its Resolution of 30 June 88 the EC Council of Ministers set out the objective as follows:

> 'Creating progressively an open, common market for telecommunications services, particularly for value-added services. Due account must be taken of the competition rules of the Treaty. Rapid definition, by Council Directives, of technical conditions, usage conditions and tariff principles for Open Network Provision, starting with harmonised conditions for the use of leased lines, is of crucial importance and closely linked with the creation of an open common market for non-reserved telecommunications services'.

In the middle of 1989, the Commission specified its approach in this field, issuing two proposals for directives; the first one, a Commission directive based, like the directive on terminal equipment, on Article 90 (3) of the Treaty, concerning the opening of the telecommunications services market to competition; and a second one, a Council Directive, based on Article 100 A, concerning the harmonisation of access conditions to the networks (Open Network Provision (ONP)).

In order to provide for a parallel development between liberalisation and harmonisation, the Commission is oriented to have the Services Directive entering into force at the same time as the ONP Directive.

The basic concept of the Services Directive is that the exclusive or special rights of the telecommunications administrations in the field of telecommunications services have to be abolished, with the exception of voice telephony and the network infrastructure.

The Services Directive does not apply to Telex, radio-telephony, paging and satellite services, and allows the Member States to prohibit, for a transitional period, the simple resale of capacity of leased lines; that is, the commercial provision of leased lines for the general public for data transmission.

On 7 December 1989, The Commission and the EC Council of Ministers representing all 12 Member States reached a unanimous compromise on the approach to be taken to the introduction of competition into the services market and Open Network Provision. This compromise is based on the following elements:

- rapid and full introduction of competition for all value-added services;
- progressive liberalisation of data communication services;
- simple resale (non-voice) allowed from 1 January 1993, with possibility of extension of transition period to 1 January 1996 in Member States with undeveloped public data networks;
- Member States to be able to require providers of data communication services to meet obligations such as quality and coverage—but Commission to scrutinise these obligations to ensure they are based on objective criteria, are non-discriminatory and are proportionate to the objective of general economic interest which motivates the imposition of obligations;
- general principle that technical interfaces and service features will be subject to standards of a voluntary nature. Reserve power for Commission to make reference to standards mandatory only to the extent necessary to ensure basic interoperability.

Open Network Provision (ONP)

As set out, ONP is directly linked to the development of a Europe-wide market for services, and an essential element thereof. A common position was reached in Council on 5 February 1990, around the positions of the 7 December 1989 compromise in the Council of Ministers.

The basic principles of ONP are the opening and harmonisation of conditions of access to the network infrastructure, for new service providers or for users. This harmonisation is to apply in the three areas of technical interfaces, usage conditions and tariff principles. This will open the way for the development of pan-European services, in which service providers will be able to make use of network in the different Member States according to common principles and forms of access.

As stated in the common position of February 1990, ONP will initially be defined for leased lines and the voice telephony service through the adoption of specific Directives. For packet-switched data services and ISDN, harmonised technical interfaces and/or service features will be implemented by 1 January 1991. By 1 July 1991, Council will adopt a recommendation on the supply of technical interfaces, conditions of usage and tariff principles applying to provision of packet-switched data services complying with open network principles, calling in particular on Member States to ensure that at least one such service be provided on their territory.

During 1992, Council will adopt a similar recommendation on ISDN and will examine specific directives on ISDN and packet-switched data services.

Separation of Regulatory and Operational Activities

The principle is now generally recognised and integrated in all Member States' reform projects, albeit in varying forms. As regards the separation of terminal equipment approval authorities, this is included in the terminal equipment Directive. As regards authorisation of services, this is included in the new Commission Directive on competition in the telecommunications services market.

Introduction of Value-Added Tax to Telecommunications

The introduction—where this does not yet apply—of value-added tax to telecommunications was planned to be achieved by 1 January 1990 at the latest. This was foreseen in Communications and draft Directives submitted by the Commission in 1984 and 1987.

In the meantime, due to the difficulties inherent in VAT harmonisation, this approach has now been amended. It is now being planned that the Commission will submit by 1990 a report to the Council of Ministers on the distortion of competition which may result from any non-application of normal VAT procedures remaining at this date, and make appropriate proposals.

Opening of Procurement

In August 1989 the Commission submitted to the EC's Council of Ministers revised proposals for a Directive for the opening of procurement procedures, in the areas of telecommunications, water, energy and transport. For telecommunications, this aims at a progressive opening of procurement to bidders from other Member States up to 100% by 1992. The aim is to eliminate undue—and discriminatory—influence on procurement decisions and to base procurement decisions exclusively on commercial criteria.

A common position on this proposal was reached by the EC Council of Ministers on 29 March 1990.

NETWORK INTEGRITY

As regards the telecommunications infrastructure, the integrity of the network must be safeguarded: an objective strongly endorsed by the EC Council of Ministers in its Resolution of 30 June 1988.

The promotion of a strong Europe-wide network infrastructure has been one of the main goals of the European Community's telecommunications policy.

In this context the Commission has taken a lot of initiatives in favour of:

- the co-ordinated introduction of ISDN;
- the co-ordinated development of mobile communications;
- the promotion of a strong European standards system in telecommunications;
- the strengthening of Europe's technology capability in the sector; and
- the promotion of telecommunications investment in the peripheral regions of the Community, with the STAR programme.

As regards ISDN, considerable progress has been achieved from 1986, the year in which the Commission adopted the recommendation on the Co-ordinated Introduction of the Integrated Services Digital Network in the European Community.

The Council of Ministers and the European Parliament have dealt with this subject many times and in July 1989 the Council adopted a Resolution on the further strengthening of the co-ordination that now constitutes the clear guidance for the measures required for a successful implementation of ISDN in Europe by 1992.

At the same time a Memorandum of Understanding has been established within the framework of CEPT, aiming at the implementation of a European ISDN service by 1992, signed by 23 telecommunications organisations from 18 European countries, including all Community Member States.

As stated in the second annual report on ISDN to the European Parliament: a full pan-European ISDN service by 1992 can be expected to be available in time.

Also in the sector of mobile communications the European Community has played an important role for a co-ordinated development of mobile services. In this area a certain number of recommendations associated with directives for the reservation of the necessary frequency bands have been issued:

- Council Recommendation of June 1987 on the co-ordinated introduction of public pan-European cellular digital land-based mobile communications in the Community and Council Directive on the frequency bands to be reserved for the co-ordinated introduction of public pan- European cellular digital land-based mobile communications in the Community (GSM system).
- Council recommendation of June 1989 on the co-ordinated introduction of pan-European land-based public radio paging in the Community and Council directive on the frequency bands to be reserved for the co-ordinated introduction of pan-European land-based public radio paging in the Community (ERMES system).

The adoption of the Recommendation and associated Directive on the ERMES system is foreseen by the middle of 1990.

Other initiatives are in progress, among which a proposal for a Council Recommendation on the Co-ordinated Introduction of Digital European Cordless Telecommunications in the Community and proposal for a Council Directive on the frequency bands to be reserved for the co-ordinated introduction of Digital European Cordless Telecommunications in the Community.

As regards the promotion of a strong European standards system in telecommunications, the proposal contained in the Green Paper for the creation of a European Telecommunications Standards Institute has resulted in a major reform of the standards-setting process in the sector, with the establishment of ETSI in Sophia-Antipolis, in France in April 1988.

By mid-1990 ETSI had developed an extensive operation, which was already playing a determining role on the European telecommunications standards scene.

With the RACE programme, the European Community wanted to contribute to the strengthening of Europe's technology capability in the sector of advanced telecommunications, focusing on integrated broadband communications. The RACE main programme was adopted in December 1987 and subsequently about 50 projects for a global 3500 man years effort were signed, with the involvement of more than 40 universities and research centres and over 110 companies.

In December 1989 the Council of Ministers of the European Community agreed a new Framework Programme for the period 1990–1994, which includes a budget line for communications technologies. Further consultation processes and Council decisions are expected during 1990 and 1991, leading to the adoption of the specific programmes within the Framework.

As regards the promotion of telecommunications investment in the peripheral regions of the Community, a five-year programme (the STAR programme) for the development of certain less-favoured regions of the Community by improving access to advanced telecommunications services was approved in October 1986, with the major aim to improve the communications infrastructures.

780 million ECU is the Community contribution to the programme that is active in seven Member States (France, Greece, Ireland, Italy, Spain, Portugal and United Kingdom).

The current programme will end by 1991.

In the light of the results of the evaluation of STAR, the Commission will examine the possibility of a proposal for a continuation of such a measure beyond 1991.

CONCLUSION

During the decade just initiated the telecommunications sector will see an extraordinary evolution: new services and new applications will become available for the users; the network infrastructure will evolve more and more rapidly towards a greater degree of digitalisation; new private service providers will offer competitive services, in particular value-added services; the European industry of the sector will benefit of the single Europe-wide market that from 1992 will become a reality.

In this context, the Commission will continue to play an important role, for the benefit of the European telecommunications.

Private Communication Consultancy Towards the Year 2000

D. M. VIDAL, P. S. PALHARES and J. P. C. B. MENDES†

INTRODUCTION

In the last few years, digital technology has made possible the implementation of private telecommunication networks at perfectly reasonable costs. This growing procedure has enabled companies to overcome the difficulties concerning negotiation with telecommunication operators and some limitations on public networks.

Many companies choose to develop and implement their own integrated networks of advanced services, adjusted to their medium-term targets. The main reason for this procedure lays on the degree of control exercisable by the company over its conception and introduction. Sometimes the inaptitude of the public operators to fulfil completely the needs of these companies (for example, concerning availability, feasibility, reliability, flexibility, economy, operationality, and maintenance) is also taken into account.

More recently, telecommunication operators placed at the disposal of the companies new structures and facilities which enable the implementation of advanced private solutions backed on the public network with technical and economic feasibility.

The majority of these companies do not have sufficient know-how to identify their operational needs, and to conceive their own integrated networks in accordance with the technical solutions presently available.

The companies of consultancy on telecommunications new services (TNS) handle this task, giving all the required assistance from the development to the operation of communication systems suitable to the customers' strategy, with technical and economic feasibility.

PRESENT TECHNICAL SOLUTIONS

Overview

Nowadays, the technical solutions available for the conception of private networks have such a large spectrum that they enable the fulfilment of the majority of companies' strategic needs.

More and more companies are acquiring the latest generation of PABXs. These private switching systems, using already digital signalling standards, are capable of controlling ISDN typical facilities, as well as computer local networks and all kinds of integrated services.

In order to get easier handling, it is current to structure ISDN into several layers. Figure 1 shows the division of an advanced private network into three general layers: service, logical and physical.

Services

The first layer comprises the package of voice, data and image services and applications, specifically developed in accordance with the company activity.

† TDC - Technologia das Comunicaçöes, Portugal

From this rank of new services and applications we can detach telefax, videotex, (local or external), video-telephony, photo-transmission, private video broadcasting, interactive video training, videoconferencing, local microcomputing facilities, general database access, data external connections (private point-to-point or X.25), typical digital exchange facilities, specific applications according to the business activity (office, commerce, industry, tourism, etc.), telemetry/telecontrol, paging and radio mobile services.

Switching

The logical layer comprises the private networks of narrowband and wideband digital switching.

The private exchanges selected for a company depend on required specific services and dimensioning (for example, quantities of extensions, terminals, gateways, junctions, etc.). Nowadays we have available modern key systems and more avanced PABXs able to control private ISDN. Some of these PABXs can control wideband switching units (for example, 140 Mbit/s), and they are selected to process video services applications (for example, video telephony, videoconferencing, etc.).

Centrex service (private switching service offered by the telecommunications operator) can also be a good solution for some of the medium and small companies.

Transmission

The last layer refers to the physical network and contains the actual transmission facilities.

Digital transmission systems (for example, TDM, statistical multiplexing, high-level multiplexing) can use as support coaxial cable, optical-fibre cable and VHF/UHF, microwave and satellite links.

As an alternative to the private transmission networks, there are the (DCCS) digital cross-connect systems based networks. Recently, public operators placed these networks at the disposal of customers. DCCS networks can support integrated services, and already make indivisible parts of private telecommunication networks of many companies.

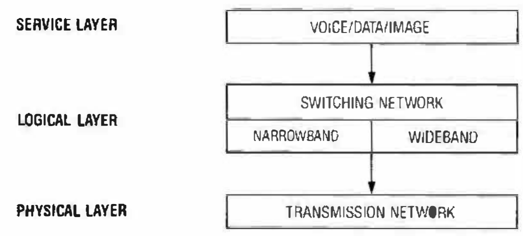


Figure 1—Private ISDN layers

The companies that operate with private telecommunication networks can use DCCS networks for their long-distance communications, with more efficiency and economy.

The customers can still use the possibility of controlling their own traffic routing throughout DCCS networks having access to an application known as *customer-controlled reconfiguration* (CCR).

CONSULTING SERVICES

The TNS consulting company has as main objectives to meet promptly the specific needs of the customer with high technical qualified solutions, which should have economical feasibility.

These objectives are achieved by TNS consulting company, exactly as it was described in the paper 'Telecommunication New Services Consulting' presented to the XXVII FITCE Congress.

In a general way and in what concerns consultancy services they can be organised into six stages: planning, engineering, procurement, implementation, training and maintenance assistance, as we show in Figure 2.

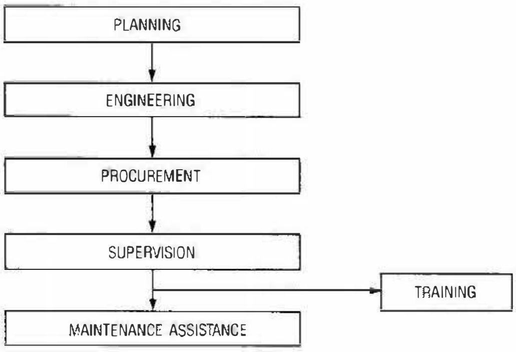


Figure 2—Consultancy stages

In the next sections we will make a detailed description of the contents of each stage, aiming at the development and implementation of advanced private communications.

PLANNING

Data Collection

The development of a medium-term integrated plan of private communications is the first step to the supply of consultancy services.

For the execution of this vital plan it is necessary to proceed to an exhaustive collection and data organisation, so that the equation of the remaining task should be possible.

Data elements to be collected lay basically on the users' features, typical procedures and survey of new services and telecommunication facilities required, according to the company activity and strategy.

All the collected information is organised into databases for further handling and processing through a computer-aided planning and design package[2] (Figure 3).

Network Structure

The structure of the private network is designed for several evolutive scenarios with the aid of the software package referred in the previous section.

Firstly, switching network architecture is established by economical optimisation. Namely, we define the switching nodes quantity, location and hierarchical dependence, as well as the required link dimension and network routing.

Secondly, the transmission network is economically optimised as well. Generally, this network can be composed by private transmission systems or to make use of the DCCS placed at the customer's disposal by telecommunications operators.

As result of this phase, we get the transmission network layout, the transmission systems and the multiplexing levels.

Forwarding, the network distribution plan (inside and outside plant) is conceived, referring to the kind of systems and estimation of quantities to be used. The project of the distribution network is executed in detail during the engineering stage.

Finally, an estimation of the terminal equipment is performed in order to complete the cost evaluation of the private communication network.

From this integrated plan, it is possible to identify the projects and to define an execution schedule, considering the company priorities and strategies.

ENGINEERING

Objective

In the sequel of the planning stage, the TNS consultancy company will rend detailed engineering services aiming at the systematisation of technical questions and project organisation. These procedures will allow the bidders to present realistic and comparable offers.

The advanced services engineering developed by the TNS consultancy company has as its fundamental goal the use of proved technics and the minimisation of system failures and temporary solutions, granting a high standard quality of service.

During the engineering stage a technical document is prepared, in which the project description is formulated, containing all detailed information, as well as the related systems and equipment specifications are stressed (for example, switching, transmission and power systems, terminal equipment, etc.).

The project description is complemented by the equipment quantity list and a cost estimate for TNS consultancy company usage.

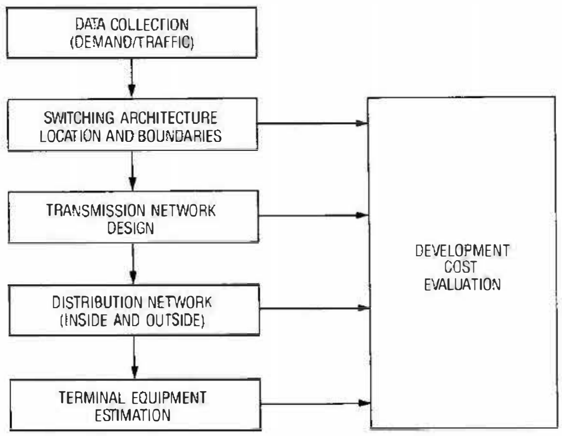


Figure 3—Computer-aided planning and design package

Technical Specifications

The technical specifications establishing the rules and guidelines for the engineering of the systems and their components should be strictly followed by the bidders.

The guidelines must be established considering the good quality of engineering methods, the system and equipment reliability and availability, in a perspective of economical optimisation.

The equipment technical specifications have to meet the international standards (for example, CCITT, CCIR), considering vital factors for the success of the systems operation (for example, lifetime, MTBF, MTTR, references, etc.) and they must be in accordance with the most recent state-of-the-art.

PROCUREMENT

Tender Documents and Bidding

After the engineering stage, TNS consultancy company can start with the preparation of the tender package, which contains the technical tender documents (for example, project description, system and equipment specifications and list of quantities), financial forms (for example, bid form and price schedules) and commercial requirements (for example, instructions for bidding, general and special conditions, draft contract, etc.).

During the bidding period, in general the locations connected with the systems installation are visited by the bidders, so that they can have answers to site specific questions. TNS consultancy company is completely available to give all the technical information to the bidders.

Bid Evaluation

All the received bids are evaluated taking into account the fulfilment of the tender requirements. TNS consultancy company prepares a bid evaluation report containing a comparative analysis study under the technical, financial and commercial point of view.

Each bid is evaluated considering the deviations from the required technical specifications, characteristics and quantities of the offered systems and equipments, delivery term, implementation schedule, technical assistance and maintenance, prices, payment conditions, bidders background, etc.

This study is performed under the most recent methods of technical and economical weighed evaluation, with systematic recurrence to sensitivity analysis.

Contract Award

The contract negotiation starts after the customer's decision concerning the selected bidder. During this period, eventual technical, financial and commercial adjustments are debated with the supplier, considering the proposed alternative solutions. The project is revised according to the accepted modifications.

TNS consultancy company prepares the final draft contract, which will be signed between the customer and the selected supplier.

Generally, this draft contract contains the obligations and rights of the parties, customer and supplier, during the implementation and operation stages (for example, technical specifications, factory inspections, supplies, delivery conditions, installation works, acceptance tests, training, maintenance, etc.).

SUPERVISION

The main tasks committed to the TNS consultancy company during the supervision period are the approval of detailed documentation offered by the supplier, factory inspections, checking of supplies, installation supervision, and acceptance tests.

Approval of Detailed Documentation

The supplier must organise and submit a package of essential documents for the project implementation stage, as it is specified in the contract (for example, system descriptions, equipment details, technical designs and plans, work schedule, list of equipment, test equipment, tools and spares, installation and acceptance test procedures, training plans, etc.).

All these documents are checked, evaluated and approved by TNS consultancy company.

Factory Inspections

TNS consultancy company defines the conditions of factory inspections, which must include the supervision of all functional and quality tests applied to the integrated systems, sub-systems and equipments. The supplier must replace unsatisfatory products.

After the conclusion of these procedures, a final factory inspection report is submitted to the appreciation of the customer.

Installation Supervision

The supplies are checked considering the quantity list referred in the contract.

Systems and equipments installation are performed according to highly qualified professional profiles. TNS consulting company places at the customer's disposal a team of experienced field experts. The main tasks of this team are the equipment installation supervision, quality control of installation works and control of work schedule, as it is stated in the contract.

Acceptance Tests

The test procedures for the acceptance of the integrated system, sub-systems and equipments are prepared by the supplier and submitted to the consultancy company for approval. These procedures are stated in a document which is a part of the package referred in the section on 'Approval of Detailed Documentation'.

The supervision team of experts takes part in preliminary and final acceptance tests (for example, functional and performance tests, simulated failure recuperation, measurements, etc.), which are performed by the supplier in the presence of customer representatives.

Finally, the integrated system, sub-systems and equipments are checked during operation, to ensure that the implemented project fulfils specified requirements.

TRAINING

The operation with success of an advanced private telecommunication network demands highly qualified experts. To reach this purpose, effective training is needed. The customer must be endowed with the essential know-how to perform all technical functions.

The main aim is to provide the customer with enough trained personnel to manage efficiently the integrated network. This task is normally divided between TNS consultancy company and the supplier.

Training is directed to different categories of personnel such as users of the communication system, system operators and managers, maintenance staff, etc. The most recent training methods are used, in which suitable theoretical basis is supplied complemented by on-job training.

MAINTENANCE ASSISTANCE

After the commissioning of the private telecommunication network, TNS consultancy company presents to the customer a final project report. This report includes the list of essential post-implementation services needed for the success of network operation.

Generally, maintenace is guaranteed by the equipment supplier under the conditions stated in a specific maintenance contract, referring obligations and penalties.

The highly performing operation of advanced private telecommunication networks demands specialised maintenance executed under organised and efficient procedures, supported by suitable infrastructures and logistics.

TNS consultancy company is in a position to supply all the maintenance assistance for the integrated system, sub-systems and installed equipments (for example, establishment of repair centres, maintenance organisation, development of maintenance routines, maintenance evaluation, etc.).

CONCLUSIONS

Recently, many companies have been introducing their own advanced telecommunication networks adjusted to medium-term strategic demands.

Development and implementation of such networks are achieved with the support of consultancy services performed by high-profile experts endowed with the knowledge of the latest state-of-the-art.

The success of 'Private Communication Consultancy Towards the Year 2000' is obtained with precise evaluation of customers' operational needs and complete resolution of their communication problems using advanced cost-effective solutions.

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Message Handling Services Offered by the RTT (Belgium)

J.-P. LEVAUX†

INTRODUCTION

The use of computers and terminals for fast document delivery has dramatically increased over the last decade. Messaging systems have been developed on powerful data processing systems, where user's documents are stored on magnetic media in individual mailboxes.

Messages can be edited, put into the mailbox of other users and retrieved later on for reading. These main features are available from simple terminals and from personal or mainframe computers as well. However, many message handling systems have been developed independently by several companies and, in most cases, are not compatible with each other.

The increasing interest in messaging systems, and the explosion in the use of personal computers for business, demand that such systems be able to exchange messages in a convenient and reliable way with each other.

Designers and operators of messaging systems have built up a set of standards in this field. In 1984, the CCITT issued the X.400 series of Recommendations, defining inter-system communication protocols, not only for exchanging character-coded messages, but also for the transfer of other information, such as facsimile images. Software, conforming to these standards, is now available for the exchange of text. Furthermore, CCITT standards were updated and extended in 1988, in co-ordination with the relevant new ISO standards.

RTT has offered the *DCS.MAIL* service to customers since 1985. Initially, this system was a central mailbox service, accessible through DCS, the Belgian public packet-switched data network.

Since mid-1988, a message transfer service linking DCS.MAIL to other mail systems has been available under the name *DCS.400*. This service, conforming to X.400, allows access to and from private mail systems in Belgium as well as other similar systems in other countries.

The interworking between this new service and other text communication media allows the following features:

- messages can be sent to or received from the Telex network;
- communications with the Teletex service are also possible; and
- DCS.400 users may send messages to Group 3 facsimile.

This paper does not emphasise the standard architecture defined by X.400, because the subject is already well documented. However, the features available today on DCS.MAIL and DCS.400 are highlighted. Attention is drawn to the relationship between the organisation of messaging systems and the regulatory environment, particularly in the context of the Single European Market.

† Régie des télégraphes et des téléphones, Belgium

APPLICATION OF X.400 CONCEPTS IN THE BELGIAN ENVIRONMENT

Access to messaging systems is provided via data telecommunication media like the public switched telephone network, the Telex network, and packet-switching networks. The latter can generally be reached from other networks, from any location in the country and even from similar networks in foreign countries.

Belgium is small in size (maximum distance between two border points is 350 km). The tariff for a national telephone call is not very different from that for a local call. Telex and packet-switching tariff rates are uniform over the country.

The Brussels area has well over half of the data communication devices in Belgium. This is due, among other reasons, to the role of the city in regard to EC institutions, which are connected to a variety of telecommunication networks, and which attract a number of foreign, political and industrial organisations.

All these considerations have led the RTT to locate the DCS.MAIL and the DCS.400 services in Brussels only and to provide access to these systems by connecting them to DCS, the Belgian packet-switching network.

THE DCS.MAIL SERVICE

In X.400 terminology, DCS.MAIL is a *user agent* (UA) of the *interpersonal messaging system*.

What is interpersonal Messaging (IPM)?

Interpersonal messaging is a feature of electronic mail systems which enables the communication:

of written messages
from person to person
by the use of computer-operated message handling systems
through data networks.

How are messages exchanged?

The sender enters a message in the messaging system to which he is connected, either:

(*a*) from his personal computer, or
(*b*) using an editing facility incorporated in the messaging system.

The message is put in the receiver's mailbox.
The receiver retrieves and reads the message sent to him.

What are the benefits ?

- Any user acts independently of any other, and in his own time-frame.
- Any user can interact with the system from any location where suitable terminal equipment and network access are available.

- The message can be read a few seconds after it has been sent.

For whom ?

- For everybody (the system must be user-friendly and is not to be designed for computer-specialists only).
- For itinerant users.
- For users working in different countries and operating in different time-zones.

The DCS.400 Service.

In X.400 terminology, the DCS.400 service is a *message transfer agent* (MTA) within the *administration management domain* (ADMD).

What are X.400 Message Handling Systems (MHS)?

X.400 systems have been devised to interconnect different types of electronic messaging systems.

They are an answer to the proliferation of incompatible E-mail systems, which result in users having to have personal mailboxes on several systems.

The application of this concept means that:

- a user only has to own a mailbox on a single system,
- messages are transferred between systems using standard communication protocols.

What is the architecture of X.400 systems?

Message handling systems are designed to handle messages belonging to several types of applications. IPM is an example of such an application.

MHS functions are divided into two groups:

- The message transfer agent (MTA) routes and transfers messages by using general, application-independent store-and-forward mechanisms.
- The user agent (UA) sends and receives messages according to application-specific protocols.

Several MTAs form a *message transfer system* (MTS).

A MTS and the various UAs connected to it together form a *message handling system*.

The qualities expected from a message transfer system:

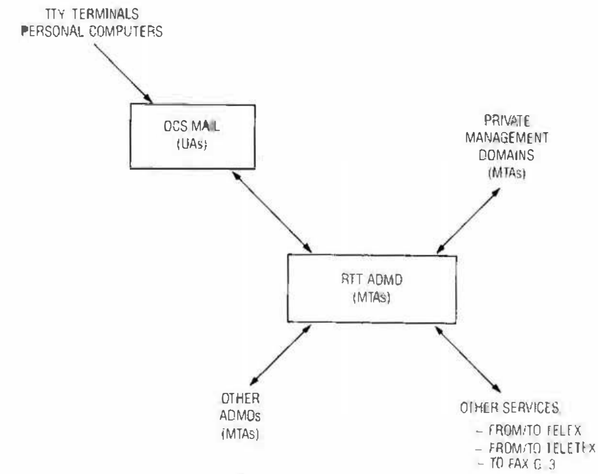
- designed for general use (application independent);
- provides global coverage;
- based on a store-and-forward mode of operation;
- forwards positive and negative notifications;
- demonstrates high quality and reliability of service;
- allows cost-effective communications.

Is it possible to build a global MTS?

Direct connections between all MTAs look to be impractical, because there are too many potential relationships between MTAs.

The use of partial interconnection provides easier resolution of problems concerning:

- routing through relay MTAs,
- accounting of resources.



RTT X.400 ADMD

The functions of DCS.400 (the ADMD service of the RTT)

(*a*) DCS.400 access protocols:

- The PRMDs are connected using the P1 (MTA) protocol.
- They can transfer messages of any content type, for instance P2 (IPM).

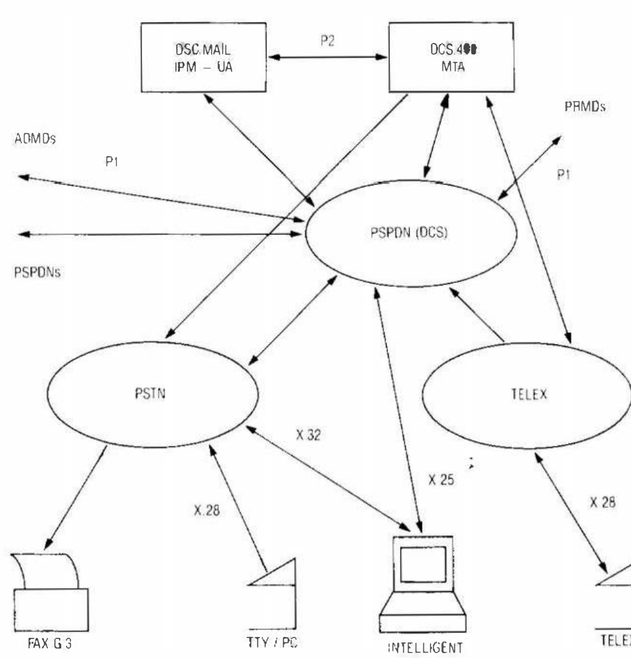
(*b*) The DCS.400 service organisation:

- The service uses fault-tolerant machines (TANDEM Non-Stop systems).
- The service is available 24 hours a day, 7 days a week.

(*c*) The DCS.400 provides access:

- to and from other ADMDs in:

Australia	Italy	Norway	Sweden
Finland	Japan	W Germany	Switzerland
USA (several carriers)		(others will follow)	



RTT X.400 message handling system

● to and from Belgian PRMDs (ten or so products are operational or under test)
● to and from the DCS.MAIL service (RTT-operated IPM UAs) available to asynchronous terminals and personal computers via the public packet-switched networks (in Belgium: DCS).

INTERWORKING WITH OTHER SERVICES

Why provide bridges to access interpersonal messaging?

● UAs belonging to the IPM application will interact according to a standard communication protocol.
● Interworking of the IPM application with other text-communication services, like the Telex and telematic services, is desirable.
● This interworking should be provided as a common facility; therefore, the bridges should be connected to a MTA.

DCS.400 provides access:

● to and from the Telex service and the Teletex service;
● to the Group 3 facsimile service.

X.400 MANAGEMENT DOMAINS

Management of the MHS is simplified by defining smaller entities to be managed independently.

The MHS is therefore divided into *management domains*, each being of a size which permits rational management.

In such a domain, a single unique name is allocated to each user; a domain comprises at least one MTA, presenting the X.400 interface to MTAs belonging to other domains.

Types of X.400 domains

X.400 standards distinguish:

(*a*) The administration management domain (ADMD)—a public service, offering links to other national and international MHS and allowing a proper use of the name structures listed in directories.

(*b*) The private management domains (PRMDs)—generally established and managed by private enterprise or academic organisations.

The hierarchical relationship between the PRMD and the ADMD means that:

● the number of connections per domain is reduced
● ADMDs are used as relaying domains by PRMDs
● usage of resources can be better planned
● names within domains can be independently assigned

How are user names allocated?

A set of attributes has to be assigned to each user name:

country name
administration management domain name
private management domain name
organisation name
organisational units
personal name
other personal attributes
domain-defined attributes

Provided that the national hierarchies between ADMDs and PRMDs are implemented in every country in conformance to X.400 rules (the country name, the ADMD name and the PRMD name being allocated by a central authority), the allocation of user names and the definition of the related attributes may be made independently in each domain (ADMD or PRMD).

Directories of such user names and attributes may be made available in accordance with the CCITT X.500 Recommendations.

X.400 AS A SUPPORTING BASE FOR EDI AND OTHER APPLICATIONS

In the same way the IPM has been seen as a good way to achieve paperless text communications, the concept of electronic data interchange (EDI) is now seen as a tool for improving the efficiency of corporate IT systems. EDI would reduce the need for paper printouts and manual data entry for the communication of documents between different companies.

Are X.400 systems able to support EDI applications?

EDI applications need standard protocols between EDI systems in order that these systems may be able to exchange data without errors. Furthermore, data needs to be coded in standard formats and to be interpreted in a uniform way. The design and the implementation of these standards is up to the organisations which promote EDI applications.

These standards can make use of X.400 systems in order to benefit from the existing base of standards for data communications. EDI systems will, in this case, interface the MHS environment as UAs dedicated to EDI applications.

Nevertheless it is still possible to perform EDI data transfers directly over standard telecommunication networks. However, in this case, EDI systems need to perform a lot of functions of the X.400 systems themselves and are faced with the variety of networks which their corespondents in EDI applications are connected to. The uniformity of the X.400 concept is a key argument here.

The RTT has therefore decided to support the development of EDI applications by providing not only basic data communication networks like DCS, Telex, PSTN and ISDN, but also an X.400 service which can transfer EDI data between EDI UAs.

WHAT IS THE ROLE OF A PUBLIC ENTERPRISE IN PROVIDING SERVICES UNDER COMPETITION RULES?

The Treaty of Rome allows a public enterprise to provide both reserved and competitive services.

Article 90.2 of the Treaty of Rome states that the exclusive or special rights given by member states to public enterprises must be explicitly defined and strictly delimited and that any activity of these enterprises, not included in the scope of these rights, has to be subject to competition.

These activities must respect EC competition rules and in particular Articles 85 and 86 of the Treaty.

To comply with Article 86, public enterprise may not abuse the advantages conferred upon it by its privileged position in services subject to exclusive or special rights, in order to acquire an unduly dominant position in the competitive market or to raise barriers to open competition in this market-place.

Public enterprise has to ensure that the organisation and the accounting of the two types of activities are clearly separated. However, the creation of subsidiaries is not mandatory for this purpose.

Commentaries on the Treaty by lawyers and decisions of the Court of Justice show, however, that a monopoly or a dominant position in one market is not sufficient, by itself, to be qualified as an abuse of this position with respect to another associated market which is open to competition.

The regulation of message handling services in the EEC is not yet stable, because:

- some of these services, or parts thereof, may be considered as included in exclusive or special rights in certain member states, and be open to competition in other member states;
- the scope of exclusive or special rights will be subject to change in the coming years, either by the internal politics of the member states, or as a result of the EEC global strategy regulating telecommunications;
- the X.400 market is still emerging and its current size may not yet allow a significant position to any player.

It may be thought, however, that the parts of message handling services that might still be subject to exclusive or special rights are very few and of limited economic interest. This leads one to the view that X.400 services are virtually open to competition from now on.

THE CO-OPERATIVE RELATIONSHIPS BETWEEN TELECOMMUNICATIONS OPERATORS

Will the co-operative relationships between national public telecommunications operators continue until 1992 and beyond?

Usually, PTT operators of different countries need to establish co-operative relationships in order to provide international telecommunication services for their customers.

Article 85 of the EEC Treaty prohibits the establishment of such relationships where they would inhibit competition in trade between member states.

Where co-operative relationships deal with reserved services (subject to exclusive or special rights) in at least one of the countries, there is no way of avoiding such relationships, be cause the choice of the vendor is not free at one end. It is not very clear what happens at the other end even if there is a free choice of vendor.

However, it would be expected that access to these reserved services will be offered to any potential user and that no obstacles will be placed in the path of developing competitive non-reserved services which are carried over reserved services.

Co-operative relationships dealing with competitive services are permitted when they comply with the EC rules on competition, and in particular with the exceptions listed in Article 85. There are a number of cases where such agreements are possible.

The rules governing these exceptions are based on an analysis of the market for the services concerned. This may be difficult to appreciate in the field of new telecommunications services, because:

- these new services are still emerging: sales figures and market shares are not sufficiently stable;
- international telecommunications generally involve:

(*a*) a country where the full tariff rate is paid by the customer to a service provider;

(*b*) one or more foreign countries where part of the charge is allocated to the operators providing the transport component or some other service.

What figures should be included in the sales statistics of each company? Sales to customers only? Or total revenue from national sales and foreign accounts?

We may therefore conclude that co-operative relationships between telecommunications operators will remain necessary for reserved services. They will be equally applicable to non-reserved services, provided that they conform with competition rules, specifically those instituted by the Treaty of Rome.

Video Communications in an ATM IBCN

B. VOETEN†

INTRODUCTION

Video communications are expected to be one of the major communication services in the future. Though the vast majority of today's video services are still provided to subscribers in a broadcast manner, integrated broadband communications networks (IBCNs) are able to change this as switched video services can be supported. This will clear the way for the introduction of a broad range of new video services. The digital nature of IBCN demands for the application of new coding and transmission methods, which can be totally different from the existing analogue standards. Also the influence on video coding of the asynchronous transfer mode (ATM), which is the technique which will be used for the implementation of IBCN, must be looked at.

VIDEO SERVICES

Video services can be divided into two important groups: distribution and interactive services. Each type has its specific requirements on coding and delivery systems.

Distribution Services

Distribution services are characterised by a point to multi-point structure; a single service provider (transmitter) in the centre point and a large number of subscribers (receivers) in the outer connecting points. Information flow is restricted to the direction from provider to subscriber. Delivery systems only have to consist of unidirectional links between provider and subscriber, and no switching functions are required. For the signal coding system, only one encoder is required but a large number of decoders are needed. Therefore, the main objective is to look for simple and cheap decoders. The main constraint in the selection of the encoder is that the required bandwidth for the signal is minimised.

The most general form of a distribution service is broadcast video on a free access base. Free access means that whoever owns the proper equipment is allowed to access the service. For some services, however, access is restricted by the provider. Conditional access and pay per view services require a subscription that grants access to the service.

Interactive Services

Interactive services can be represented as point-to-point structures of which one or both points can serve as the provider. Examples of interactive services are videophony and video conferencing, services which are propagated by telephone companies as the successors of the existing telephone communications. However, a more dramatic change in our way of life can be expected from a variety of interactive services which can be described as 'video shopping at home'.

The delivery system for interactive services must provide bidirectional connections between both participants. As each subscriber potentially wants to communicate with every other subscriber in the system, a switching mechanism in the delivery system is required to set up all these different connections. For these services, both participants need an encoder and decoder for the video signal. Therefore a trade-off must be found between codec cost and bandwidth cost.

VIDEO CODING

Video Signal

Before discussing video coding and transmission, it will be beneficial to review some of the fundamentals of picture scanning in monochrome and colour televisions. A detailed discussion can be found in standard reference works; for example, Reference 1. In monochrome TV systems a camera analyses an image of a scene in a tube or a CCD element by scanning it in a series of closely spaced lines and transforming the brightness distribution of the incident light into an analogue electrical signal. With the addition of synchronising pulses, these electrical signals are transmitted through a band-limited channel to a TV receiver that reconstructs the image. For colour images, three similar devices are used of which one is sensitive for the red, one for the green and one for the blue light in the image. Therefore each video signal initially consists of three different signals: red, green and blue or R, G, B. In many cases these three signals are transformed into three other signals of which one contains a black and white representation of the image which is compatible with the signal of a monochrome camera and the two others are colour signals. The former is usually called the luminance (L) and the other two the chrominance (Cr and Cb) signals.

Analogue Coding

Analogue coding has been used since the introduction of video transmission. Further distinction is made between composite video (PAL, SECAM, NTSC) and component video (RGB, MAC, HDMAC). The main difference between the composite video formats and the MAC formats lies in the multiplexing of the luminance, the chrominance and the audio signals. Composite formats use frequency multiplexing as MAC uses time multiplexing. Detailed information on these techniques can be found in References 1, 2, and 3. At this moment all video sets have a composite interface because most broadcast services use composite video signals. However with the introduction of direct broadcast satellites (DBS) and the

† Alcatel Bell Telephone, Belgium

increasing demand for higher picture qualities, an evolution towards component video can be observed.

Digital Coding

The important advantage of digital coding and transmission is that higher image qualities can be offered as quality loss during transmission can be minimised. The disadvantage is that digital encoded video signals require higher bandwidths. Different systems to transform the analogue video signals into digital form are under investigation.

A first possibility is to simply digitise the analogue encoded signal (PAL, SECAM, NTSC, MAC, ...). After a digital-to-analogue conversion (DAC) at the receiver, the obtained signal can directly be fed to most existing video sets. This approach has the important advantage that beside the DAC no extra equipment is needed at the receiver. A disadvantage is that the quality is limited to the quality which is offered by the original analogue coding technique (which is low for the composite signals) and that they require very high bandwidths. For instance, digitising a PAL signal with sampling frequency 12 Mhz and 8 bit sample resolution results in a bit rate of 100 Mbit/s.

A second possibility is to use video codecs which start from the full digital video standard CCIR 601[4] input (216 Mbit/s) to reduce the required bandwidth while maintaining high picture qualities. In these codecs data compression techniques are used to reduce this bit rate without significantly influencing picture quality. These techniques are based on the observation that there is a high correlation between neighbouring pixels in an image. Elimination or reduction of this correlation results in a new signal which has the same information contents (this means that the original signal can be exactly reproduced) but needs a lower bit rate for transmission.

In the differential pulse-code modulation (DPCM) technique, for each pixel a prediction is calculated based on some neighbouring pixels (spatial and temporal). The difference of this prediction and the pixel value is used for transmission. Due to the high correlation in the image, these differences will be mostly very small (around zero). In combination with variable length codes (for example, Huffman codes) a high compression ratio can be obtained. Discrete cosine transform (DCT) is an other important decorrelation method used in video coding. In this technique a transformation of the image from the spatial to the DCT domain (frequency domain) is performed. The uncorrelated DCT components are transmitted and at the receiver an inverse transformation regenerates the original picture.

Using these decorrelation techniques, the bit rate for a CCIR 601 signal, for instance, can be reduced to a value between 70 and 100 Mbit/s. Using more complex algorithms, even further reduction of this bit rate to about 40 Mbit/s, can be obtained. However, if the complexity of the techniques increases, implementation cost also increases. Therefore the gain in bandwidth cost must be compared to the extra implementation cost to decide on the applied technique.

For lower quality applications, other techniques (course quantisation, reduction of temporal and spatial resolution) can be included in the codec to even further reduce the bit rate at a cost of image quality. For videophony applications bit rates of 1 Mbit/s or lower can be obtained.

VIDEO DELIVERY OVER ATM IBCN

IBCN Networks

IBCN networks are expected to be the successors of todays telephone networks. Due to their switching capabilities, they can support both interactive and distribution services. The digital transmission will allow for much higher picture qualities.

Video Coding in ATM IBCN

The ATM technique has an important impact on the transmission of video signals over these networks. The asynchronous nature of ATM contrasts to the synchronisation dependent video signals and the packet (cell) oriented nature introduces packetisation defects. However, video coding can benefit from the bandwidth flexibility offered by ATM to offer higher picture qualities at lower bit rates.

Synchronisation

To guarantee a proper display of the video information at the receiver, it is absolutely necessary that the transmitter and receiver clocks are synchronised. In ATM no direct connection between these clocks can be realised. Therefore, at the receiver a stable clock, synchronised to the transmitter clock, has to be derived from the incoming cell stream. Cell delay jitter complicates this synchronisation as a jitter component is superposed on the cell arrivals. In Reference 6 different solutions depending on the selected coding technique, are discussed.

Cell Loss

Cell loss in the network can largely influence picture quality. Especially when highly compressed video signals are involved, each cell will contain information on a large part of the image which will be corrupted in case of cell loss. In the worst case, if synchronisation information is lost, the whole image can be influenced. Because of the high bit rate involved, cell loss occurs rather frequently for video services. For a video service at 40 Mbit/s, a cell length of 48+5 bytes and a cell loss ratio of 10^{-8}, the average time between two lost cells is approximately 15 minutes. This is unacceptable from the quality of service (QOS) point of view.

Therefore, cell loss must be coped with at the receiver. In Reference 5 cell loss handling methods based on layered coding are proposed. The main idea in layered coding is to divide the video information into different parts (layers) which contain information of a given 'importance'. A layer is considered important if it contains information that would largely decrease picture quality in case it was missing (for example, synchronisation information). Cell loss handling then is adapted to the importance of each layer. For the most important layers cell loss correction will be necessary. For less important layers concealment techniques, hiding the cell loss, will suffice.

Variable Bit Rate Coding

An important feature of the ATM technique is the capability to switch variable bit rate traffic. This feature can offer a high efficiency, as network resources can be statistically shared by numerous sources.

For a video source, a variable bit rate can be achieved by adapting the generated bit rate to the local and temporal image complexity, while pursuing a constant subjective image quality. In VBR coding high bit rates are allowed during critical scenes, while low bit rates will be observed during normal scenes. If in the network multiple VBR sources are multiplexed, variations in the total bandwidth will be smoothed out. This principle is referred to as *statistical multiplexing*. In Reference 6 statistical multiplexing of TV and videophone sources is discussed, indicating that even for a limited number of sources a statistical multiplexing gain can be obtained.

CONCLUSION

ATM IBCN networks are very well suited for the transmission of video signals. The use of digital video codecs, which are adapted to ATM, allows for an optimum use of network resources and characteristics. The switching capability of the network allow for the integration of both distribution and interactive video services. The digital nature of IBCN allows for the transmission of both very high picture quality and low quality video services.

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British Telecom's ISDN Implementation

J. F. MARSHALL, and F. WELSBY†

INTRODUCTION

The concepts of integrated services digital networks (ISDNs) have been with us since the 1970s and most telecommunications operators in Europe (including British Telecom) and the United States have implemented pre-ISDN schemes on either a trial or pilot basis. The maturing of standards through the work of the CCITT and, latterly, the European Telecommunications Standards Institute (ETSI), together with the American National Standards Institute (ANSI), has given added impetus to the development of customers' equipment and applications. This, in turn, has led to increased customer awareness of the potential range of advanced applications resulting in the emergence of worldwide consensus amongst suppliers on the value of ISDN and firming of PTT plans for commercial service launches over the next few years. British Telecom has been a major contributor to the standards over this period and, maintaining its position at the forefront of this exciting communications technology, plans to launch its commercial basic-rate ISDN service, ISDN 2, meeting the latest international standards (CCITT Blue Book), during 1990.

THE ISDN CONCEPT

The origins of ISDN lie in the early work of the CCITT which identified digital switching and transmission technology as a means of efficiently integrating traffic carried on the network and, in turn, services interfacing to the customer. The precise CCITT definition of ISDN is:

'A network evolved from the telephony IDN that provides end-to-end digital connectivity to support a wide range of services to which users have access by a limited set of standard multipurpose customer interfaces.'

In more practical terms, British Telecom sees it as a range of enhanced service capabilities brought about by the delivery of a switched digital network to the customers; a releasing of significant investment made in digital and intelligent network capability; and a means to creating the business line of the future.

EARLY ISDN INITIATIVES IN THE UK

During the early-1980s, when the international community began to consider standards for ISDN, British Telecom was already developing equipment for a commercial ISDN and, with the launch of Single-Line IDA in 1985, became the first Telco in the world to offer a commercial basic-rate ISDN service. Although rapidly overtaken by developing standards, the essential characteristics of Single-Line IDA—a signalling channel and two traffic channels for voice and/or data access to the integrated digital network (IDN) over the existing customer loop—made it a valid realisation of ISDN principles.

† British Telecommunications plc, UK

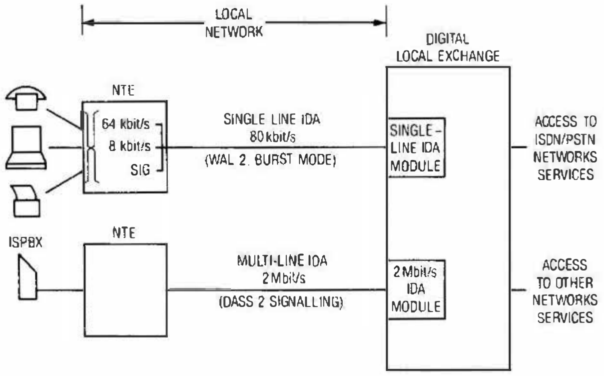

Figure 1—Early ISDN initiatives

The Single-Line IDA service (Figure 1) provides to the customer a 64 kbit/s channel for voice or data and an 8 kbit/s channel for data. Signalling information is carried in another 8 kbit/s channel giving an overall local-loop bit rate of 80 kbit/s. A 256 kbit/s burst-mode transmission system was specially developed to support this service which terminates on System X exchange line cards also developed for this purpose.

At serving sites where appropriate System X terminations are not available, specially developed multiplexers are used which interface with the switch at 2 Mbit/s using British Telecom Digital Access Signalling System No. 2 (DASS2) (Figure 2). This concept has been extended further in British Telecom's current plans outlined later. The service operates over existing copper pairs in the local loop, terminating at the customer end on specially developed network terminating equipment (NTE) which provides both the transmission equipment to complement the line card and the user's X.21 interface. This service was progressively rolled out from mid-1985 and is currently available from some 120 System

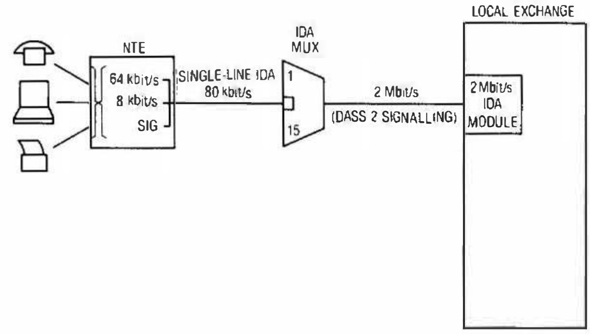

Figure 2—Single line IDA via remote multiplexer

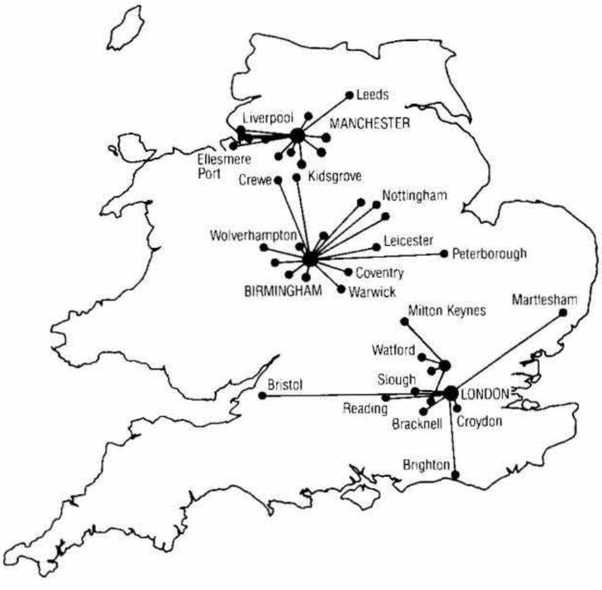

Figure 3—Pilot ISDN coverage in the UK 1986

X exchanges throughout the UK (Figure 3). International service to France, Japan and USA is supported.

In October 1988, a primary-rate (2 Mbit/s) service was launched under the title of *Multi-Line IDA*. This service caters primarily for modern PBXs (ISPBXs) providing a direct 2 Mbit/s interface to the network via DASS2 signalling, thus eliminating for customers the cost of large numbers of 2-wire line cards as well as providing the enhanced facilities inherent in ISDN of high-speed signalling and improved quality of transmission (Figure 1). Multi-Line IDA is currently supported on System X local exchanges and distributed to customers over transverse-screened copper cables. During 1991, this capability is expected to be expanded to include all digital local exchanges in the network including distribution over optical-fibre systems, and will be effectively relaunched under the *ISDN 30* brand name.

BACKGROUND TO CURRENT PLANS

Both Single-Line IDA and Multi-Line IDA were significant British Telecom initiatives implemented in advance of firm international standards being available and much useful experience of the operation of ISDN services in the public network environment has been gained. Consequently, British Telecom is now well placed to launch a commercial basic-rate ISDN service called *ISDN 2* which will be compliant with the latest international standards.

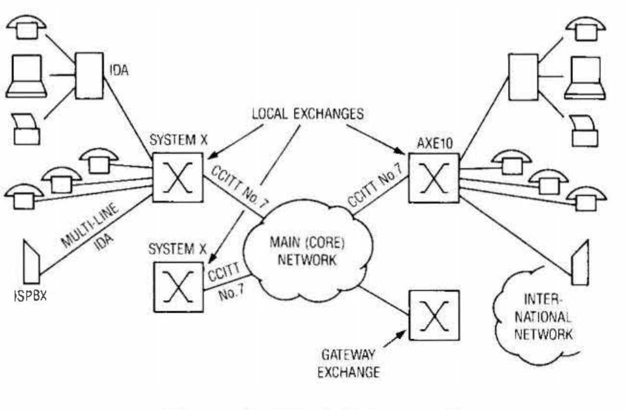

Figure 4—BT digital network

The timing of this launch has been influenced by several important drivers.

- The core of British Telecom's network is now completely digitalised and digital local exchanges are being commissioned at the rate of two per day. The largest proportion of switches are GPT System X units with Ericsson AXE10 units composing most of the remainder. These are interconnected by the most comprehensive and advanced CCITT No. 7 signalling network in the world (Figure 4). This infrastructure offers significant potential for offering advanced facilities and services to customers.
- The standards for the basic-rate ISDN are now sufficiently stable for telecommunications operators and terminal equipment manufacturers to implement interfaces and protocols which are internationally agreed. The basic-rate user interface, defined in CCITT Recommendation I.420, comprises two 64 kbit/s channels for voice or data and a 16 kbit/s signalling channel. This *2B+D* configuration gives a total data bit rate of 144 kbit/s to be carried by the existing copper local loop which currently supports the 3·1 kHz bandwidth necessary for telephony. It is worthy of note that, while the transmission technology to support this bit rate was recognised when British Telecom's Single-Line IDA service was being developed, it is only now becoming possible to implement it economically.
- A European ISDN Memorandum of Understanding (MOU) was signed by 18 telecommunications operators including British Telecom in 1988. This MOU represents a vision for the progressive introduction of compatible ISDN services throughout Europe. It relies heavily on the output of the European Telecommunications Standards Institute (ETSI) as promulgated in its Normes Europeans de Telecommunications (NETs). The NETs, once ratified, form the basis for approvals testing for terminal equipment proposed for connection to public telecommunications networks operated by the signatories of the MOU. Thus terminals approved in any signatory country will be suitable for connection, without further testing, in any other.

The MOU commits the signatories to providing a defined minimum set of bearer and supplementary services compliant with the ETSI specifications by the end of 1992 (Table 1). The MOU also prevents the signatories providing any of the defined services in a non-compliant manner.

TABLE 1

Memorandum of Understanding (MOU)

Minimum Service Compliance (* Services)

- Bearer services
  - —Circuit mode 64 kbit/s unrestricted bearer service
  - —Circuit mode 3·1 kHz audio bearer service
- Supplementary services
  - —Calling line identification presentation (CLIP)
  - —Calling line identification restriction (CLIR)
  - —Direct dialling in (DDI)
  - —Multiple subscriber number (MSN)
  - —Terminal portability (TP)

BASIC-RATE SERVICE: ISDN 2

British Telecom's basic-rate ISDN 2 service will conform closely with the latest (Blue Book) CCITT and ETSI standards evolving to meet the MOU service requirements in 1992.

It will be provided initially via multiplexers which will be located in digital exchanges and will use DASS2 signalling to communicate with both System X and AXE10 at 2 Mbit/s. The ISDN multiplexer (IMUX) implements a proprietary local loop transmission protocol specially developed for this product by STC. It is an echo-cancelling transmission system which uses the SU32 line code, a variant of 3B2T (three binary states converted to two ternary states for transmission) to reduce line bit-rate and thus increase the reach of the system. In this way, the 144 kbit/s user data plus maintenance and supervisory data (bringing the total to 160 kbit/s) are transmitted at a line baud rate of 120 kbaud/s and achieves a specified performance over more than 4·5 km of 0·5 mm copper (Figure 5).

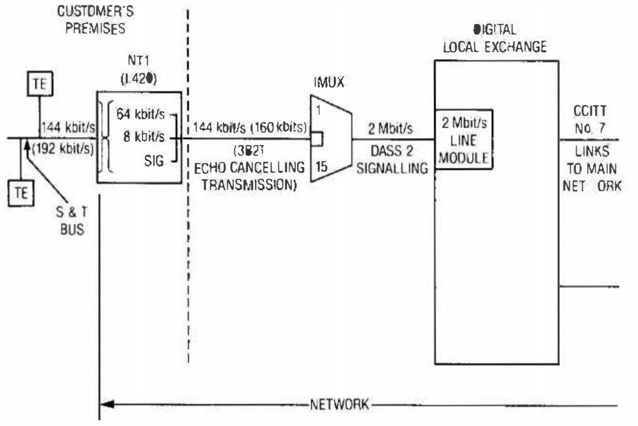

Figure 5—ISDN 2 Service implementation: initial phase (basic service)

At the customer end, the transmission system is terminated on a network terminating unit (NT1) which provides the user–network interface to the latest CCITT I.420 (Blue Book) standards supporting an *S-Bus* which allows the customer to connect up to eight terminals to share the available traffic channels and will support terminals offering ETSI compatible services. The multiplexer effectively maps the I.420 signalling protocols into DASS2 and the switch in turn maps this into CCITT No. 7.

There is currently much debate about the most appropriate position in this link for the formal network boundary. The European view, including British Telecom's, favours the user side of the network terminating equipment (the S/T interface) (Figure 6) while ANSI, in the United States, has opted for 'the 2-wire' ('U' reference point) and is attempting to standardise the transmission system. One advantage of the European view is that likely advances in local-loop transmission technology will not be constrained by the imposition of early standards. The S-Bus offers the customer a long-term standard interface behind which the local-loop transmission can progress to include more efficient line codes, improved distribution methods including optical-fibre and microwave links, and improved supervisory and maintenance mechanisms.

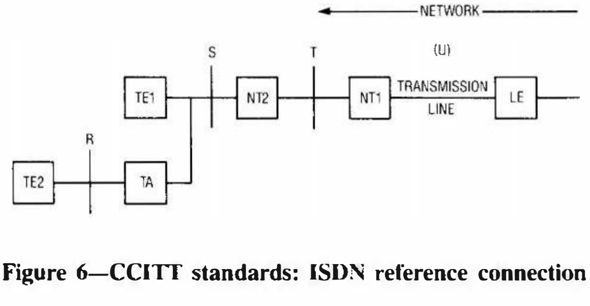

Figure 6—CCITT standards: ISDN reference connection

The multiplexer implementation enables British Telecom to provide I.420 service in advance of exchange line card capability being available. It also provides the opportunity for remote capability at non digital-exchange sites and in broadband/fibre access applications.

IMPLEMENTATION PROGRAMME

British Telecom intends to implement its ISDN 2 service in a phased manner in order that customers will have a basic service offering at the earliest opportunity while evolving capability towards full MOU requirements by 1992. A technical trial phase has already been implemented since the spring of 1990 in order to stimulate applications development. A phase 1 customer service will subsequently take place starting with an initial market development offering to selected areas before the end of 1990 with a view to national service becoming progressively available for January 1991 onwards. Further phases of enhancement will take place thereafter and it is anticipated that this will include upgrading DASS2 to the more comprehensive CCITT Q.931 signalling standard as well as the progressive introduction of an exchange line card, which will interface directly with the NT1. During this period, it is expected that British Telecom's ISDN 30 service will also evolve towards Q.931 becoming fully comformant with the I.421 CCITT standard for primary-rate ISDN (Figure 7).

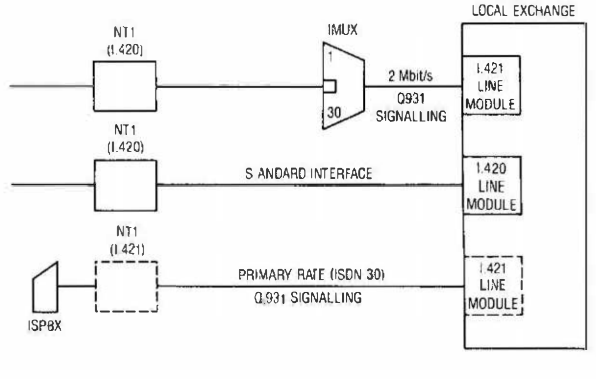

Figure 7—ISDN 2 service implementation: final phase (full MOU service)

NETWORK CO-ORDINATION

ISDN 2 and 30 are public switched network services which by nature have dependencies in key component parts of the network. Many of the service features for example require appropriate capabilities to be in place simultaneously at the multiplexers, switch and the switch operations and management centre (OMC) before end-to-end service can be assured (Figure 8). The current British Telecom implementation of the CCITT No. 7 inter-exchange signalling protocol is capable of meeting BT's main requirements until 1992. However, to provide the added network functionality inherent in the more advanced ISDN services, it will need to be progressively enhanced to support the expanding range of services being offered by the access network. The significant differences between the delivery of digital services compared to the traditional analogue services calls for new installation and maintenance practices and procedures. While, for example, the network termination (NT1) signature may be less discernible by traditional maintenance test access systems than is the case with normal analogue terminations, there is a number of parameters within the digital signal which provide useful indicators of service performance.

Providing the ISDN service has therefore required significant network co-ordination involving the product line, systems engineering and operational departments within the network organisation, together with technology and development support from BT's research department and multiplexer/switch contractors. It is, and continues to be, a major project management exercise dependent on significant team effort for its success.

The technical trial phase of the service is already underway and valuable experience is being gained by British Telecom and application developers in an endeavour to develop the potential market that exists for the service.

CONCLUSION

ISDN is growing in importance in telecommunications worldwide. British Telecom is currently deploying equipment compliant with the latest international standards to assist terminal and applications developers bring their product to the market and in preparation for the launch of its ISDN 2 service. The service will be progressively enhanced in the range of facilities supported and in geographical coverage to provide access throughout the UK to the priority services identified in the European ISDN Memorandum of Understanding by 1992. It has the potential to produce an order of magnitude increase in customer service features from the network over the forthcoming decade.

ACKNOWLEDGEMENTS

Acknowledgement is made to General Manager Network Systems Engineering and Technology for permission to produce this paper. The authors would also like to thank their colleagues in Network, Telephony Services and Research and Technology departments for their support in this project.

The ICEberg Project—A Pilot Broadband Network in Ireland

J. O'SULLIVAN†

INTRODUCTION

In order to maintain pace with the worldwide development of advanced telecommunications, Telecom Ireland plans to develop a pilot broadband network for the support of advanced telecommunications and services in Ireland which will be implemented on a phased basis over a five year timescale. This will be achieved by the implementation of a broadband pilot infrastructure in Ireland to be linked to similar broadband networks both in Europe and the United States as well as the implementation of pilot services and applications using the infrastructure which will be undertaken in parallel.

The pilot broadband network will consist, initially, of two separate infrastructures. A fibre metropolitan area network (MAN) will be established to serve a small number of customers and support business services whereas the second infrastructure will provide TV/entertainment services for the residential market. These two infrastructures will be merged into a single network by the provision of a broadband switch which will enable the establishment of international broadband interconnections.

The project will also involve the development of broadband applications such as a video library and broadband videotex for the pilot residential network as well as expansion of the Dublin MAN as required, MAN interconnect and the support of voice and video on the MAN.

DUBLIN METROPOLITAN AREA NETWORK

Many public telecommunications networks are currently being enhanced to support narrowband ISDN (integrated services digital network) services which will improve the quality and availability of many existing telecommunications services. However, due to the inherent bandwidth limitations and lack of flexibility, narrowband ISDN may be unsuitable to many users who require a switched service greater than 64 kbit/s to support high-speed data and video services. There has also been a large decrease in hardware and software costs for local area network (LAN) systems in recent years which has given rise to a relatively small but rapidly expanding sector of the telecommunications market in Ireland, the LAN user. As a result of this expansion, there is expected to be a large demand for broadband services in Ireland over the next few years. To meet the above demands, Telecom Ireland will establish a MAN in Dublin (Figure 1) which will enable the high-speed interconnection of geographically dispersed local area networks. It will be capable of supporting voice, data and compressed video services and providing compatible interfaces with public networks as well as existing fibre distributed data interface (FDDI) networks.

There are indications that, already, certain major customers of Telecom Ireland could benefit from the added efficiency and reliability offered by a MAN. There are distinct advantages in migrating from their present private network star topologies to a MAN which would support all their private voice and data requirements with efficient use of bandwidth and avoiding the additional costs of network redundancy inherent in star networks. They require a topology which will give a fault tolerant network without the dependence on a central location as is the case at present. Twenty locations have been identified as potential sites for interconnection via the MAN with a total bandwidth requirement of 65 Mbit/s which is expected to increase in the future. To enable full integration of all services to the MAN, the system must be capable of supporting voice as well as data. The central fibre bus will be located in the centre of Dublin which will facilitate the eventual connection of other customers to the MAN as demand arises.

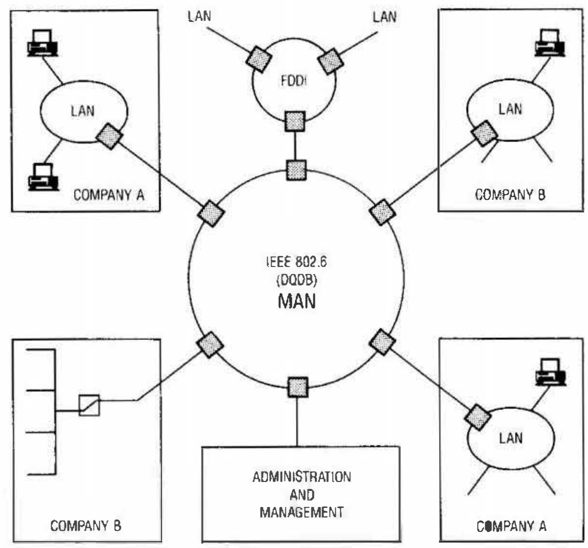

Figure 1—Dublin metropolitan area network

Distributed Queue Dual Bus

The IEEE 802.6 distributed queue dual bus (DQDB) standard will be used to implement the MAN. The DQDB architecture was developed by QPSX Communications Ltd. which was set up as a co-operative venture between Telecom Australia and the University of Western Australia and has been adopted by the IEEE as its metropolitan area network standard. The DQDB MAN provides high-speed connectionless data transfer and is based on two unidirectional buses running in opposite directions that permit full duplex communication between any pair of nodes attached to it. Figure 2 shows a typical configuration of an open-ended DQDB system with three nodes. A node gains access to a bus through a READ tap and a unidirectional WRITE tap. The two buses are media independent but are best suited to optical-fibre cable. Any high-speed standard transmission systems can be used to implement the two unidirectional

† Telecom Ireland, Ireland

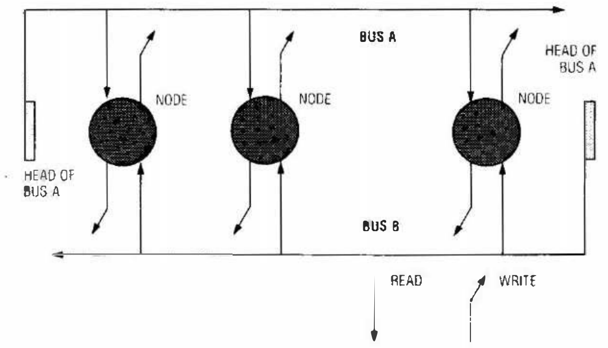

Figure 2—A typical DQDB system

buses; for example, 34 and 140 Mbit/s transmission systems can be used in Europe.

The DQDB MAN uses the asynchronous transfer mode (ATM) multiplexing and switching technique instead of the more common synchronous time-division (STD) techniques which do not provide bandwidth on demand and are inefficient in handling bursty traffic. The standards bodies aligned the IEEE 802.6 and B-ISDN standards in 1989 and agreed on a common header size and information field for ATM which led the IEEE 802.6 committee to adjust the speed of its MAN standard from 140 Mbit/s to 155 Mbit/s. As systems based on the revised DQDB MAN standard are not expected to be available until 1992, Telecom Ireland may decide on early use of a non-standard system, working at 140 Mbit/s, for its trial with subsequent upgrading to work at 155 Mbit/s when the equipment becomes available.

Unlike STD techniques, the ATM technique does not require the dedication of time slots to individual services. Instead the information stream of each service is packetised and placed in short fixed-length cells. Each cell contains a number of 53 octet slots, with each slot containing 5 octets of header and 48 octets of information. To transport connectionless packets between nodes, each packet in the originating node is split up into segments for transport in one of the fixed length cells in the bus. The virtual circuit identifier (VCI), which is situated in the header of the cell, indicates the connection to which a segment belongs and permits the segments to be reassembled into the original packet in the receiving node.

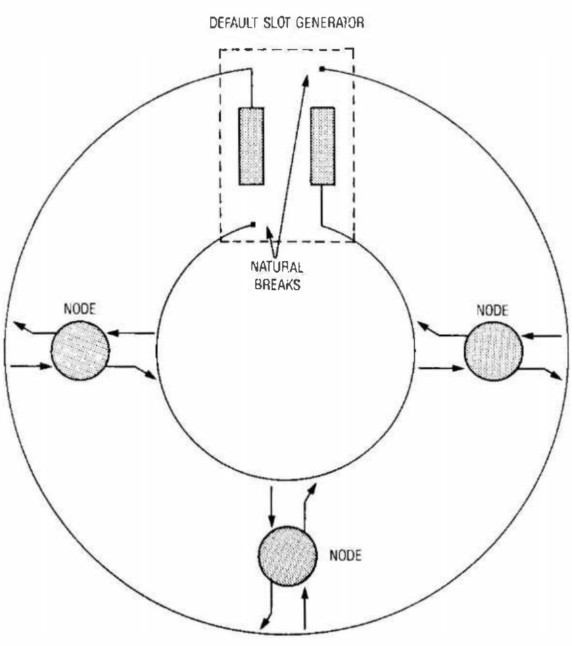

Figure 3—Looped-bus DQDB configuration

The DQDB MAN can also be configured as a looped bus (Figure 3) in which the end points of the buses are co-located. No data flows through the head point of the loop so if a fault or line break occurs, the natural break is repositioned in the loop to the position of the break due to failure. Hence, the network is reconfigured and fully operational in the reconfigured state without the need of redundant transmission as is normally the case with ring networks. Another advantage of using the looped bus configuration is that the framing generator for the two buses is common and hence the PSTN clock can be injected into the network at this point.

RESIDENTIAL NETWORK

Originally, the Dublin collective antenna television (CATV) network was developed to meet the demand for high-quality reception of the UK television channels. Approximately 270 000 premises have been cabled with a customer penetration of 78%, making it one of the largest networks in Europe. All CATV services are supplied in the Dublin urban and suburban areas by Cablelink Ltd. in which Telecom Ireland has obtained a controlling interest.

Existing CATV Network

The existing Dublin CATV network is limited by the distribution network which has many problems associated with it. Most of the distribution network is located above ground which has given rise to piracy and self tapping as well as damaging the cable that is not protected against ultra violet light. The most serious problem is that the Irish Department of Communications has limited the bandwidth of the distribution network to 240 MHz due to radiation and this has restricted the capacity of the distribution network to 11 TV channels which is totally inadequate for modern-day requirements.

About 23 English language channels are available for transmission at present, which exceeds the capacity of the Cablelink distribution system, and this number could grow to 40 by 1992. High-definition television (HDTV) is expected to be introduced over the next few years, resulting in an increased quality and definition. This will give rise to a need for a greatly increased bandwidth per channel as the HDTV standard has twice the number of lines per frame as the existing PAL/SECAM standards. It will also require the duplication of programme transmission until existing PAL TV sets have been completely phased out.

Switched Star Network

In view of the obvious need to upgrade the existing CATV network and the opportunities now offered by existing technology, an all-fibre network will be established to serve the homes in a pilot residential area (Figure 4) supporting both distributive and switched TV channels, high-quality audio channels, and the integration of TV, video and narrow-band telecommunications services. This pilot network will serve as a testbed for study of how best to exploit broadband technology for the integration of telecommunications and entertainment services in the residential market-place.

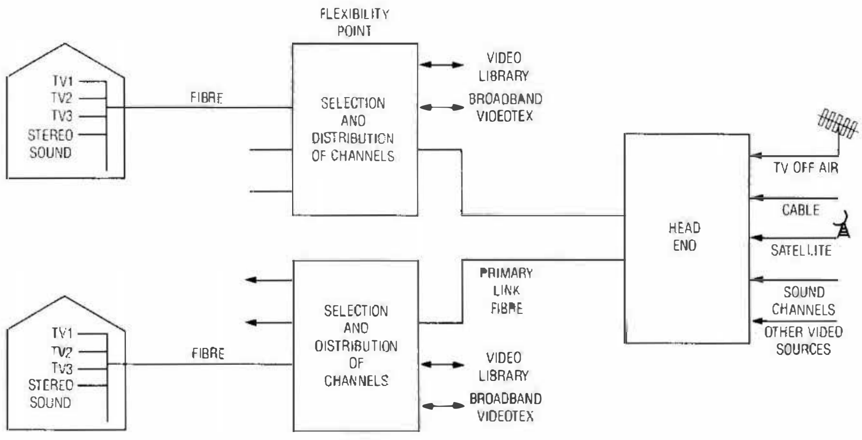

Figure 4—Residential network

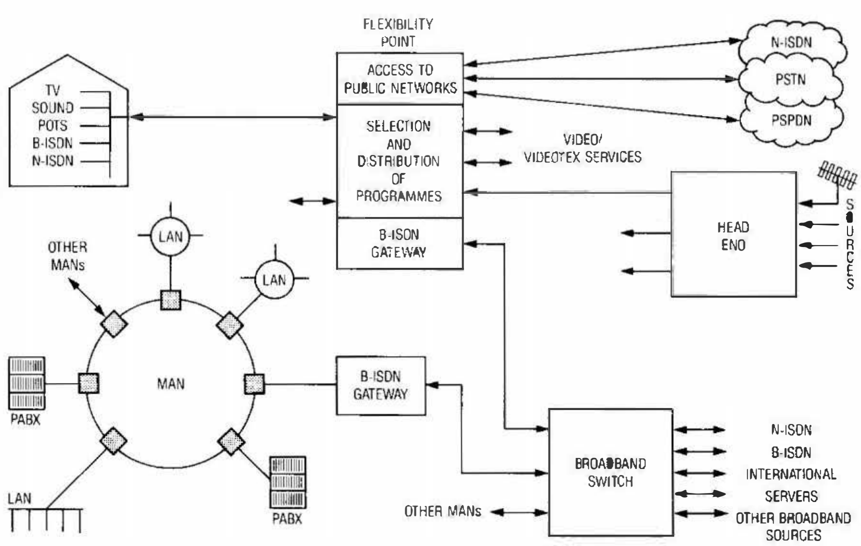

Figure 5—Narrowband and broadband service integration

The existing network uses a tree-and-branch structure where all the programmes are available at the subscribers' premises. The programme selection is made at the users' premises and this limits the number of channels provided and limits the level of interactive services that can be provided. To overcome these problems, a star-type structure will be implemented which will permit a mixture of switched and distributed TV channels. With this type of structure, the programmes will be selected at a flexibility point servicing a number of subscribers and the bandwidth requirements of the final connection to the home will be reduced. Switched-star networks provide good evolutionary capabilities for expanding the number of available TV channels and providing enhanced interactive services. The capabilities of the flexibility point and the total number of channels available at the switch are the only limitations on the number of selections available. Initially, high quality audio channels, multi-channel terrestrial television, satellite television channels, movie television channels, community television and a video library are expected to be offered on the network, but this will be upgraded to include broadband database applications, POTS, packet switched data services and narrowband-ISDN when the television and telecommunications services become integrated.

SINGLE NETWORK

The final major element in the infrastructure development will be the provision of a broadband switch (Figure 5). Access to the switch will be provided by implementing B-ISDN interfaces on the MAN and at the flexibility points of the domestic broadband network. This development will enable international broadband interconnections to be established and will also contribute to the development of broadband applications on an international basis.

CONCLUSION

The ICEberg Project will be very beneficial for Ireland. It will increase employment levels in the telecommunications services industry and enhance the attractiveness of Ireland as an industrial location for foreign investors by providing a high quality advanced telecommunications network. It will also enable Irish engineers to gain hands-on experience in the new technologies and their applications and to use this experience for the expected upgrade of the Dublin CATV network. The ICEberg project will also be beneficial to Telecom Ireland as it will be in a position to take the lead in providing the interconnection of LANs in Ireland which, if done on a private basis, could seriously affect the growth of public network traffic.

A New Acronym for ISDN: It Suits Diversified Needs

D. SAINT-JEAN†

INTRODUCTION

This paper considers the development of ISDN in France and describes France Télécom's strategy: fast geographical coverage, attractive tariffs, international connections and partnerships with users and service providers.

The development of ISDN requires three main actions:

- development of the network,
- development of terminals able to use the inherent capabilities of ISDN, and
- development of applications able to fulfil present and coming users' needs.

This paper considers along each of the three main actions the way France Télécom has managed to promote ISDN, the main results achieved, and the next perspectives of development.

NETWORK EVOLUTION AND STANDARDISATION

Network Development

In the early-1970s, France Télécom started a long-term policy of digitalisation of equipments in switching and transmission. As a result, France Télécom's network is now the most digitalised network of the developed countries.

† France Télécom, France

Later on, France Télécom introduced synchronisation on atomic clocks for all digital switches in operation in the network and implemented CCITT common-channel Signalling System No. 7.

These three components (digitalisation, synchronisation, CCITT No. 7) made the introduction of ISDN as the natural evolution of the telecommunications network and not as an overlay network. The first commercial ISDN was thus opened on 21 December 1987. The commercial name for ISDN in France is *NUMERIS*.

Because of the wide coverage of digital exchanges in France, it is possible to quickly provide ISDN access over the whole territory in a cost-effective way. Connection of ISDN lines only requires the use of a new access card within the subscriber access units. The whole coverage of France will be effective by the end of 1990 (Figure 1)

At the present time, both basic-rate access and primary-rate access are commercially available. ISDN accesses have been open since the end of 1988 in Paris, since the end of 1989 in the whole Parisian area, in Lyon, Marseille, Lille and Rennes, and coverage of the whole territory will be gradually performed during 1990.

International Interworking

When considering ISDN development in different countries, it appears that by 1990–91 most of the countries will provide ISDN services and it is therefore very important to provide international interconnections.

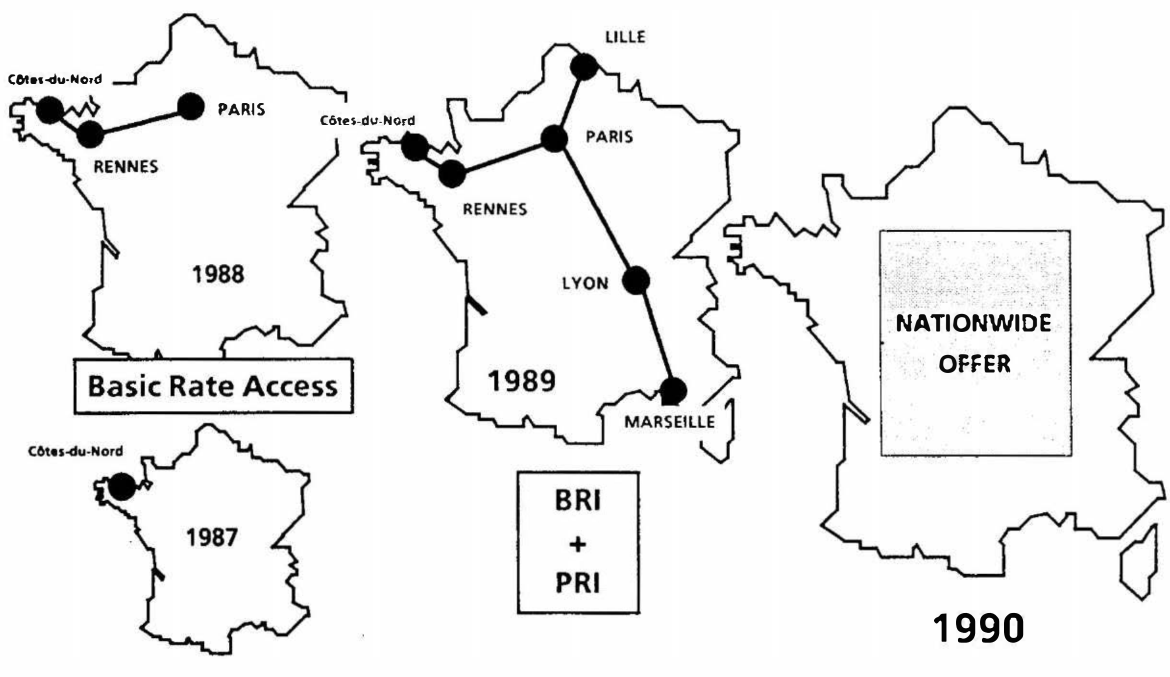

Figure 1—NUMERIS-ISDN: Schedule

France Télécom's policy for ISDN international interconnections can be split in two steps:

(*a*) interworking with pre-ISDN networks (ATT ACCUNET 56 and UK IDA in 1988, Finland DIGINET in 1989); and

(*b*) ISDN-to-ISDN interworking. Commercial openings of ISDN interconnections between France and other countries are already effective or scheduled as follows:

USA: April 1990
Federal Republic of Germany: June 1990
Japan : July 1990

Interconnections are scheduled before the end of 1990 with United Kingdom, Belgium, Denmark and Italy, and then at the beginning of 1991 with Hong Kong and Spain, and later in 1991 with Singapore.

France Télécom could accordingly play a role of international ISDN gateway in Europe.

Standardisation

Standardisation is a basic requirement both for ISDN development and for ISDN interconnections.

Many actions have been launched within Europe since 1984 to contribute to, and to speed up, the standardisation process.

Since the 1984 'Analysis and Forecasting Group' GAP report of the Commission of the European Communities on co-ordinated deployment of ISDN, some key dates can be pointed out.

- 1985, signature of a Memorandum of Understanding by 17 operators of the CEPT on the introduction of a family of telecommunications specifications called *NET*. Several NETs are related to ISDN (NET3 for ISDN basic-rate access, NET5 for ISDN primary-rate access, NET33 for telephone features of ISDN terminal equipment).
- May 1985, quadripartite agreement signed between British Telecom, Deutsche Bundespost, ASST/SIP and France Télécom in order to speed up specification works and to plan their ISDN interconnections.
- 1986, European Council of Ministers recommendation No. 86/659/EEC on co-ordinated deployment of ISDN in the European Economic Community.
- April 1989, signature by 23 operators representing 18 European countries of a 'Memorandum of Understanding on the implementation of European ISDN service by 1992'.

The interconnections will be based on the agreed standards such as Signalling System No. 7 TUP + (Telephone User Part Plus) and ISUP for international connections, NET3 and NET5 for terminal aspects.

- 1989, set up of ETSI (European Telecommunications Standards Institute).

More recently, as far as supplementary services are concerned, extensive work has been done to define and standardise them in order to ensure their availability in the different countries.

TERMINAL ASPECTS

Adapters and Individual Terminals

More than one year before the ISDN first commercial offering, France Télécom opened a pre-ISDN switched 64 kbit/s digital service called *TRANSCOM*, for which several equipments using CCITT X.21 or V.35 interface have been developed.

To allow the use of these equipments on NUMERIS as well as the use of equipments connected to leased lines or to packet switching networks, France Télécom has also developed a wide range of adaptors: X.21, V.35, V.24, X.25 and analogue adaptors.

The large field of supplementary services available on NUMERIS is enhancing the efficiency of communications. A full range of ISDN telephones provided by several manufacturers—Alcatel Telic, Matra Communications, SAT is now available.

When considering users applications on NUMERIS it appears that most of them use PC-compatible terminals. In fact a PC with add-on boards for audio coding or for image processing, and an S interface card can be considered as the multi-purpose terminal required in most applications. To facilitate the use of those equipments and to enlarge their scope of applications, France Télécom has set up an active policy to promote standards in different fields such as file transfer, image compression and coding.

PABXs

Over the last few years, private exchanges (PABXs) have evolved to become digital. The evolution to ISDN is a natural evolution for them. ISDN extends PABX services to the outside. The PABX becomes a genuine corporate teleport: all their features, services applications are accessible by the other locations of the company and even by partner corporations. Thanks to the S interface, which already has a unifying role for digital telephony, all terminals may have 64 kbit/s connections, and the benefit of all the network supplementary services (calling line identification, user-to-user signalling).

For all PABX manufacturers (Alcatel Telic and Alcatel Opus, Matracom, Jeumont-Schneider, Saltelcom), large capacity PABXs, already digital and multiservices, are, or will soon be, enhanced to NUMERIS by a simple software release. In 1990–1991, the remaining part of the PABX range will be upgraded, from very low capacity (5 extensions) to medium capacities (300–500 extensions), with costs equivalent to those of analogue technology.

Computers

Large computer manufacturers (IBM, DEC, BULL, HP) have realised the contribution of ISDN to their offer in communicating networks and systems. After a wait-and-see period, where ISDN was just a part of external speeches, the first pieces of equipment are appearing: add-on boards for PC, PS/2 and Mac, S2 network controllers (SNA, Decnet, Datanet), PABX front-end processors (BULL and Jeumont-Scheider). Now most manufacturers have claimed the support of ISDN by all their equipment with native interfaces before 1992. IBM, DEC, HP, Data General, ICL, APPLE have chosen France for their worldwide ISDN development activities and will or did sign partnership agreements with France Télécom.

How will the data processing landscape be modified by ISDN? Contributions are numerous: speed and costs of course, but also quality (very low bit error rate, fast call set-up), security (the network guarantees the calling terminal line identification and digital transmission allows password exchange, encryption, and closed user-groups) and reliability (line monitoring). NUMERIS is a new reliable data network with flexibility and costs of telephony.

Present Situation

As a global demonstration of the results achieved so far for terminal aspects, it can be mentioned that in November 1989, at the second NUMERIS congress in Paris, 50 exhibitors were already proposing terminals.

SERVICE ASPECTS

The results of the different market studies made on ISDN have shown two main results.

First, there is not a single ISDN market but several ISDN markets according to the size of the companies involved.

Second, there are many application fields where users have urgent needs and are looking for quick solutions.

Partnership

Seven years ago, France Télécom decided to promote videotex services and started the development of Minitel services in partnership with service providers. Such a strategy led to the gigantic development of more than 10 000 videotex services for more than five million Minitels.

Now France Télécom considers that NUMERIS brings a new opportunity to develop services. Therefore a partnership policy has been set up with customers, service providers, manufacturers and installers. Most of the partnership ventures are signed between a user, a service provider and France Télécom. The user defines his needs, the service provider brings its competences and develops the application, France Télécom facilitates the development of the whole application and may finance a part of the developments (Figure 2).

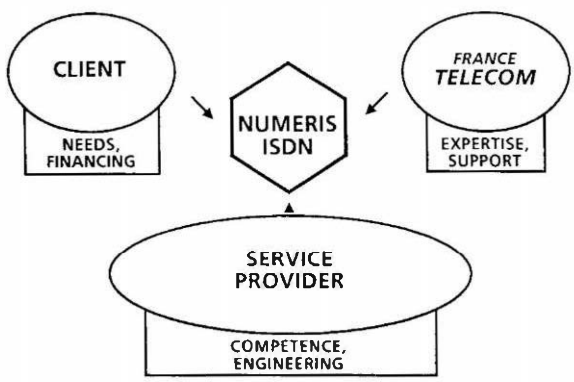

Figure 2—NUMERIS-ISDN: Partnership—A springboard for new applications

Up to now, 47 partnership contracts have been signed with customers coming from many different activity sectors (Figure 3).

The objectives of this policy are the following :

- to identify solutions able to answer customer needs,
- to promote ISDN by developing its notoriety and its knowledge, and
- to generate new connections and traffic to develop the network.

To be accepted by France Télécom, the project must fulfil three criteria:

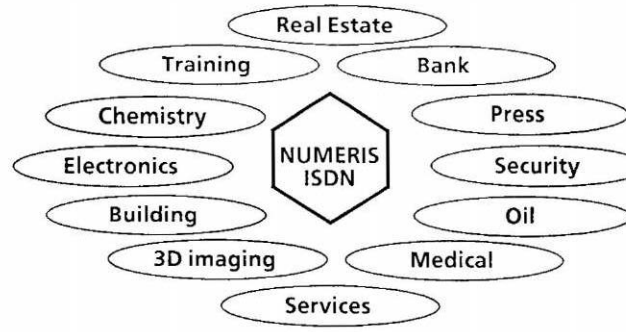

Figure 3—NUMERIS-ISDN: Partnership—involved market segments

- It should be innovative and able to exploit ISDN capabilities (high bit rate, use of supplementary services, use of two simultaneous calls...).
- It should be commercially realistic. A complete business plan should be elaborated and should show the return on investment and the benefits of the use of NUMERIS instead of alternative solutions.
- It should be generalisable. By simple environment changes, it must be usable in other activity sectors. The product should be commercialised by the service provider involved in the contract.

It is now possible to draw the main lessons of this policy because most of those partnership contracts are now operational:

- First, the importance of image and document transfer has to be noticed. Such information transfer was impossible before ISDN because of the lack of cost-effective switched 64 kbit/s transmission means.
- Second, the large diversity of activity sectors involved in ISDN has to be considered, going from real estate agencies to medical, from banking and insurance to tour operators, from the press sector to computer-aided design, from pharmaceutical companies to oil companies. The use of ISDN enhances the communication efficiency of the companies involved in those applications and therefore optimises their position towards their competitors.
- Third, the main role of the personal computer, which is used in all the different projects. Add-on boards for ISDN-S interface, for image processing, for high layer software are now available at affordable prices to build multimedia terminals.
- Last but not least, it has to be noticed that ISDN does answer existing needs. The main reason for such a quick development of applications in various activity sectors is that those applications were potential projects but were not in a position to be implemented because of inadequate or too expensive telecommunication means before ISDN was available on a large coverage.

In addition to all those actions, France Télécom is actively promoting international use of ISDN, both towards ISDN users and towards other telecommunication operators. It has to be noticed that France Télécom and German DBP Telekom are working together on this scheme to develop applications between the two countries.

First Results

After 18 months of partnership, 47 contracts had been signed. Now all of them are fully operational.

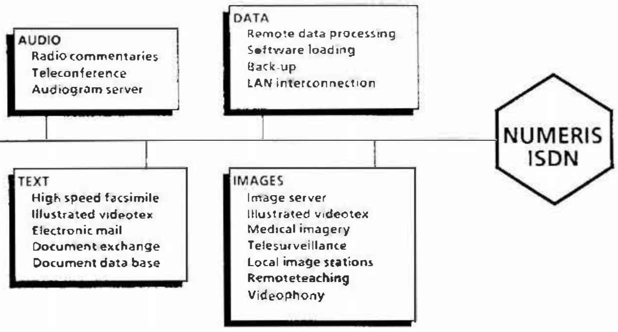

Figure 4—NUMERIS-ISDN Partnership—a variety of applications

The first analysis of those applications shows four main categories (Figure 4).

Image Applications

One third of the applications fall in this category.

In all these applications, an image database is used, either integrated in an existing videotex database or connected to this last one. The terminals used in users' premises are PCs with S interface board plus an image board.

According to the application characteristics, different levels of image definition may be used: medium definition for real estate photographs or video telesurveillance, high definition for news image transfer, and very high definition for medical images sent from a remote hospital to a central hospital.

It has to be noted that if at the beginning various *de facto* standards, such as VGA, were used, now applications are selecting the new ISO ADCT standards which will facilitate the spreading of those applications because of compatibility.

Document Applications

This category covers 25% of the applications and gathers many different document transfers going from pharmaceutical documentation to oil documentation, from document transmission between state libraries to order management for computer equipments.

Most of those applications have been defined to enhance the efficiency of document searching. The benefit of those applications is rather obvious:

In the case of pharmaceutical documentation for example, ISDN replaces the old system which required approximately one month from the moment when a doctor inquires of the pharmaceutical company up to the moment he receives the document by post after a lengthy search of information. Now as soon as the employees of the pharmaceutical company have received the doctor's questions, they instantaneously access the relevant document in the database and automatically send it by post to the doctor, who then receives the information in less than two days.

In the case of the state libraries system, ISDN replaces the old system whereby each time a student asked for a given document in a remote library a postal request had to be transmitted to a central library which was supposed to store the document. It was then necessary to wait several days before the document was sent to the remote library.

Now with NUMERIS, when the remote library clerk has received the student request, he automatically accesses the database of the central library and selects the requested document. The document is then transmitted automatically by group 4 fax to the remote library and can therefore be given to the student in a few minutes instead of several days.

Similar examples may be considered in all the other sectors.

Data Applications

20% of the applications fall within this category. This includes point-of-sales applications as well as accounting applications, software loading as well as CAD files transfer for printed circuit boards.

In these applications, ISDN provides the large 64 kbit/s transfer capability which allows information transmission which was unforeseen even a few years ago, in a cost effective way. In addition, it provides enhanced security which is a fundamental prerequisite for applications related to funds transfer.

Multimedia Applications

This category includes 20% of applications, going from remote teaching to audio-visual advertising in department stores, from audio-visual training of employees to horse betting.

In those applications ISDN provides the capability of simultaneous connections on the basic-rate access.

This last category can be considered as the emerging part of new applications that up to now were limited to potentiality but which become reality thanks to ISDN.

These applications facilitate the development of new communication means and open new perspectives for people-to-people or people-to-machine communication.

The Successive Steps in ISDN Usage

We have seen that ISDN has provided a wide range of services. Let us consider how those potentialities are set in use by business users. Three main steps might then be considered for ISDN usage in the case of large companies:

In the first step, those companies start to use ISDN for specific applications. The main characteristics of such a project are the following: first the existence of immediate needs, second the capability to define a limited, cost-effective and easy-to-implement project. Such a project should not question the existing corporate network communication but, on the contrary, should be quickly operational.

Examples of such applications are image videotex when several videotex services have already been used within a company. The information flows being well managed, it is easy to enhance an existing videotex service by high definition images coming from an image database connected to the existing videotex database. Such events occur in many activity sectors.

The second step is related to voice and data integration. Large companies are used to voice and data integration on leased lines to develop a digital private network between their main locations. ISDN provides them with the opportunity to enlarge this integration to the other locations involved because of the large capabilities of the public switched network.

It has to be noticed that many factors are now available to facilitate such an integration:

- availability of single workstations integrating telephony and computer,

- ISDN cabling standards compatible with existing cabling systems, and
- availability of existing standards between the computer world and the PABX (ECMA standards).

At the time of PABX renewal, such an opportunity is often caught, all the more that all PABX manufacturers have, or will have in the near future, ISDN compatible products.

In the third step, ISDN is fully merged within the architecture of the corporate network. The various needs carried by a corporate network are split amongst the three main bearer networks which are digital leased lines, packet switched network and ISDN. The planning for the definition of this architecture requires 2 or 3 years before it starts to be available.

The architecture of the corporate network is thus defined to optimise the use of each different telecommunication means:

- digital leased lines for the high-traffic links between the main locations,
- packet switched network for long transaction oriented applications, and
- ISDN for fast file transfer and all the applications between the locations which are not accessed by leased lines, because of insufficient capacity, or by packet switched network. In addition ISDN is used for all the relationships with customers, subcontractors, dealers etc. At a time when most of the companies intend to develop their commercial networks, NUMERIS provides a unique opportunity to build a powerful and flexible communication means between the different partners.

Besides this step-by-step evolution of large companies for ISDN usage, ISDN also fulfils needs of medium-size and small-size companies.

In the case of medium-size companies, ISDN provides a means to enhance and develop their applications at better costs. Those companies have presently small switching systems and several dedicated accesses to specialised network such as TRANSFIX digital leased lines, TRANSPAC packet switching network, Telex network, etc. NUMERIS facilitates the rationalisation of their networks and offers an opportunity for cost saving.

Besides, it provides them with all the supplementary services and thus facilitates their integration in networks gathering them with other companies.

An important number of small companies and professionals is now used to dealing with digital information, because of the large development of PCs on the one hand and of Minitel on the other hand. Up to now, they used non-automatic means to transmit their information: mail, private carrier, etc. Now, NUMERIS brings them new and powerful solutions which are fully integrated within their usual way of work.

When considering the reasons for migration towards NUMERIS, those different-sized companies list several key elements:

- the cost effectiveness of the solution provided by NUMERIS, compared to other solutions;
- the absence of geographical constraints, because of the very quick ISDN coverage in France;
- the capability to use existing equipments via terminal adapters; and
- PABX.

CONCLUSION

The capabilities brought by a new telecommunication means require several years before being fully utilised. From the very beginning of ISDN development in France, France Télécom has led several actions in parallel:

- on the network side:

  (*a*) fast development of the network in less than three years from 1987 to 1990, and

  (*b*) development of international interconnections with other ISDNs to fulfil requirements of business users;

- on the service side:

  (*a*) definition, well in advance, of attractive tariffs, and

  (*b*) development of partnership with users and service providers to promote new applications.

As indicated in this paper, the first results are now available. They all show that ISDN provides a very significant opportunity for business communications, both for the enhancement of existing applications such as telephony services and data services with the whole set of supplementary services, and for the development of the new services such as those promoted by partnership.

At a time where users are more and more considering networking aspects, ISDN provides a unique opportunity to globally consider all the service aspects of business users.

Taking into account the important results already achieved in the development of NUMERIS, France Télécom knows for certain that:

'ISDN: It Suits Diversified Needs'

Network Management in a Multi-Supplier Environment

J. DUNOGUÉ, and J.-M. CORNILLE†

INTRODUCTION

A rapid survey of state-of-the-art public networking shows that network technology and services have advanced faster than network management capacities. We have probably reached a turning point where we need to aim at service-oriented management solutions rather than pursue the traditional equipment-oriented approach. Moreover, service-oriented solutions can either be limited to operator needs alone, or take into account new facilities enabling subscriber involvement.

Using a *one-of-a-kind command* system, it is possible to answer to the operations, administration and maintenance (OA&M) needs of both service providers and users, from basic telephony to intelligent network services as complex as the mobile radio application.

The following discussion covers the main issues underlying the debate of how far a one-of-a-kind system can be used to resolve the general needs of public networks. The terminology used is based on the *Telecommunication Management Network* model (TMN), under study at CCITT. Its basic components are recalled in Figure 1.

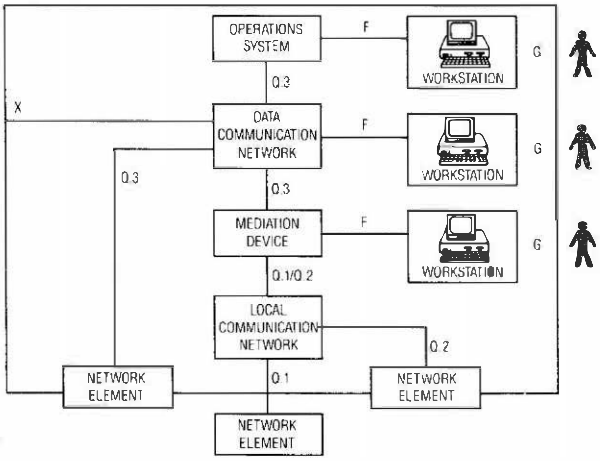

Figure 1—CCITT TMN model

EQUIPMENT INTERCONNECTION

Telecommunications Equipment

In an existing network, most of the SPC digital transmission and switching systems—whoever the manufacturer—will become network elements (NEs). Where will the mediation with TMN take place? And what kind of mediation is required?

Mediation will occur in the system that today hosts the operator terminals. A switch operated locally will be upgraded into NE status. On the other hand, an operation and maintenance centre (OMC) for several switches will become an NE (but not its controlled exchanges). Similarly, transmission systems—such as SONET and cross-connect—are distributed in nature; use internal service channels; and have their own OMC equivalent which hosts the transmitter operator terminals that will mediate. Alcatel applies these principles to both its switching and transmission equipment.

Mediation will include the Q.3 communication protocol and *object orientation* of the messages. Complements to protocol adaptation seem necessary, namely:

- mediation shall cope with OSs and DCN temporary breakdowns; and
- at mediation level,

  (*a*) some preprocessing could be delegated by the OSs, and

  (*b*) the workload on the NE induced by OS requests should be regulated.

A number of evolved systems, such as Alcatel E10, are capable of gradually incorporating mediation. For others, an external mediation will be more suitable.

Future equipment will offer built-in mediation capabilities at installation.

Operations Systems

Present support systems—whoever the manufacturer—will be connected to TMN. Consequently, upgrading (mediation specific to OSs) is needed. This comprises Q.3 dialogues with NEs. It also has specificities, for example bound to:

- security, since the OSs will (or should) no longer be physically confined to certain equipment, terminals, and operators; and
- availability of OS functions, which can be increased assuming that TMN surveys the OSs and finds a 'spare' OS for operators when the 'normal' one fails.

TMN also paves the way to new network-oriented and service-oriented OSs (see 'TMN applications' below).

Data Communication Network

The DCN supports the OSI layers 1, 2, and 3. It is based on the X.25 packet-switching protocol, or possibly on CCITT Signalling System No. 7. Links may be either leased lines or reuse of resources in a switched network. Such choices depend directly on the network of each operating company. Important criteria are naturally the safety, security and integrity the network is capable of guaranteeing.

Other factors such as the operator's OA&M organisation should also be considered.

† Alcatel CIT, France

Size and Performance

In the requirements we have met, a TMN addresses typically a sub-network (for example, SONET, transit switching centres, PLMN, IN) with the following orders of magnitude:

- 100 000 to 1 million subscribers;
- 10 to 100 NEs; and
- several hundred terminals (in any case less terminals for more functions than today).

A key point for the TMN success is the response time to operator requests. This depends largely on the TMN implementation. One can say anyway that a simple man–machine command could be slower via the TMN, while elaborated results will be achieved much faster.

TMN APPLICATIONS

Management of PSTN

Centralised OA&M has been applied for decades on transmission or switching equipment. The totally new feature offered by the TMN is the OSI and Q.3 capabilities; for example,

- true multi-vendor NEs, OSs and workstations; and
- common view on 'objects',

(*a*) reducing the gap toward a common presentation to the operator, and
(*b*) easing the introduction of new OSs.

Due to networking—and assuming it is managed—the TMN can also make the organisation and the evolution of OA&M facilities more flexible. OSs and WSs may be distributed—and relocated in case of failure or extension—as best adapted, on host machines anywhere around the DCN.

The TMN offers other new opportunities. It can dialogue, in near real time, with all NEs and can access and store their data on a controlled basis. This makes introducing new applications easier, for instance:

- network-oriented OSs encompassing both transmission and switching: alarm supervision (example in Figure 2) and traffic management;
- service-oriented OSs: direct reading (by the operating company or even the subscriber) of charging data, retransmission of alarms on leased lines to privileged service providers.

Management of New Services

Compared to POTS, management of new services such as intelligent or mobile-network services raises specific constraints. For instance, in the IN, several service providers may manage their own services independently from the operator of the PSTN, but share the PSTN infrastructure and associated management tools. This multi-user environment leads naturally to a TMN approach, as detailed now for Alcatel solutions.

The basic IN architecture is shown in Figure 3. The *service management system* (SMS) is devoted to the technical management of the IN nodes as well as the service (including its customisation) management. As such, the SMS mainly ensures the following functions:

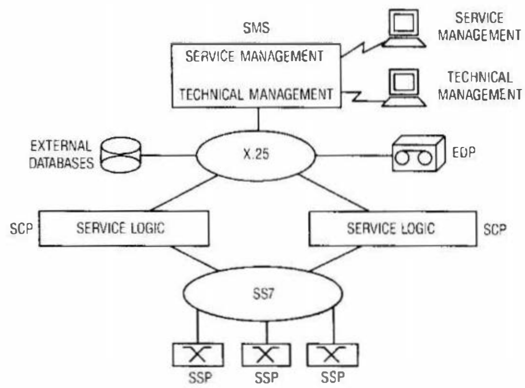

Figure 3—Basic IN architecture

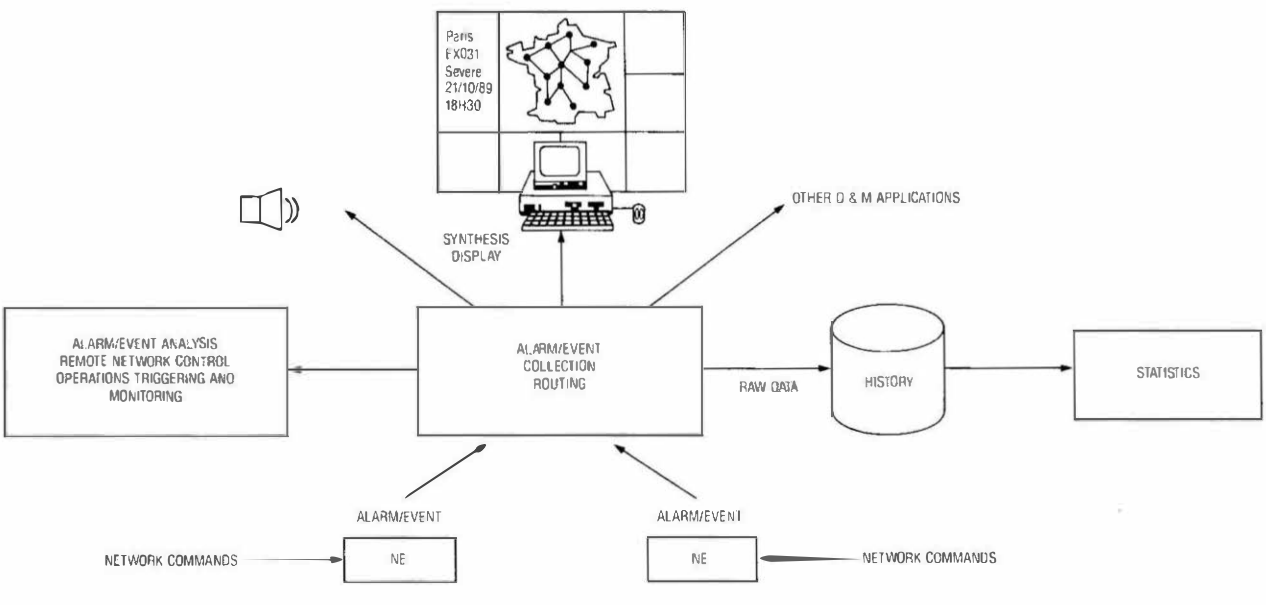

Figure 2—Alarm management

- subscriber database management,
- downloading of files and software to *service control points* (SCPs),
- software release and update management,
- alarm reporting,
- network supervision and management,
- configuration management, and
- remote or local man–machine interface.

The physical layout of an Alcatel ECR 900 PLMN is shown in Figure 4. The operation and maintenance centre (OMC) ensures the centralised management functions, in particular:

- charging,
- log management,
- observations,
- alarm management,
- maintenance,
- configuration management, and
- access to local OA&M.

It appears that SMS and OMC share basic centralised management functions to which each system adds some specificities; in particular for IN, service aspects are more developed. These commonalities are provided by the TMN platform (see below).

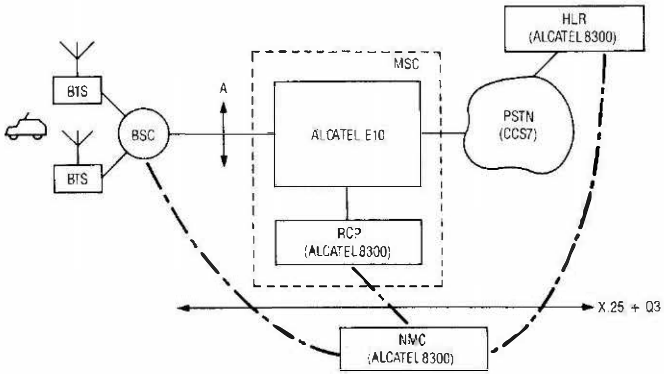

Figure 4—ECR900 architecture

WHAT IS A TMN PLATFORM?

A TMN platform allows mastering multi-system OA&M in a TMN-like network, while decreasing the customisation required to fit specific user's needs. It is a network-wide support environment providing OSs and OA&M applications with the TMN dimension, making them possible to work and inter-operate.

By *TMN dimension* we mean first integrating in one global system the OSs and applications distributed around the DCN. Operators and applications may access network services and data located in each sub-system under security constraints (access rights, data encryption, etc.), from any access point in the TMN. Operators may benefit from a common working environment with a single top-level man–machine interface and help functions such as electronic mail.

Two other important aspects of TMN are addressed by the platform:

Openness This of course is provided first by the Q.3 communication protocol. A complementary practical means is the applications development environment allowing customers to master their own developments.

Flexibility TMN distributed architecture as well as modularity and configurability of OSs enable a fit to an operating company's organisation. However, it is not sufficient (and has to be completed with facilities) to introduce and manage evolutions in the OA&M organisation and in the telecommunications network including downloading of releases, TMN configuration management, access rights management etc.

These objectives correspond to the rationale behind Alcatel's 'TMN platform'; that is, provision of a single network-wide environment allowing any type of OA&M application to be developed and installed in a TMN-like network. Current application areas are intelligent network (SMS), mobile radio network (OMC-RADIO), PSTN (switching and transmission).

Alcatel's TMN platform is defined by:

- the TMN model network architecture,
- a basic hardware and software,
- a TMN-oriented software package, called *TMN-Kernel*, and
- a software factory to develop applications intended to run in a UNIX™ environment.

Compared with CCITT's basic architecture, a specific OS is added (see Figure 5)—the network management centre (NMC). Besides supporting applications like any other network management unit (NMU), the NMC ensures TMN management.

Basic hardware/software is a combination of ALCATEL8300 and UNIX-workstations. This enables bridging the NE's world, dealing with specific telecommunication quality standards, with the computer world, and its permanent and fast evolution.

ALCATEL8300 is the basic computer of new Alcatel telecommunication products (for example, IN, PLMN, ATM, etc.). In TMN it provides the necessary telecommunication features, such as, fault-tolerance, real-time, various and numerous couplers, and protocols. It hosts the general TMN network services—NE coupling, infrastructure and administration functions, etc—and acts as a network data/applications server.

UNIX-workstations are included for the data processing part of applications; for example, advanced graphics and man–machine interface, peculiar devices, standard development tools. Moreover, they are viewed as interchangeable front-ends following the computer market offering, and are the privileged location for new software technology such as expert systems (see next paragraph).

TMN-Kernel completes the basic software with:

- Infrastructure network services such as distributed process and access management, security management, data collection and centralisation (alarms, observations, charging data, etc.), man–machine command management, etc.
- The TMN management application, including TMN hardware/software configuration management, TMN supervision and maintenance, TMN defence, and reconfiguration of applications.
- Help functions for operators; for example, activity management, mailbox, desktop tools.

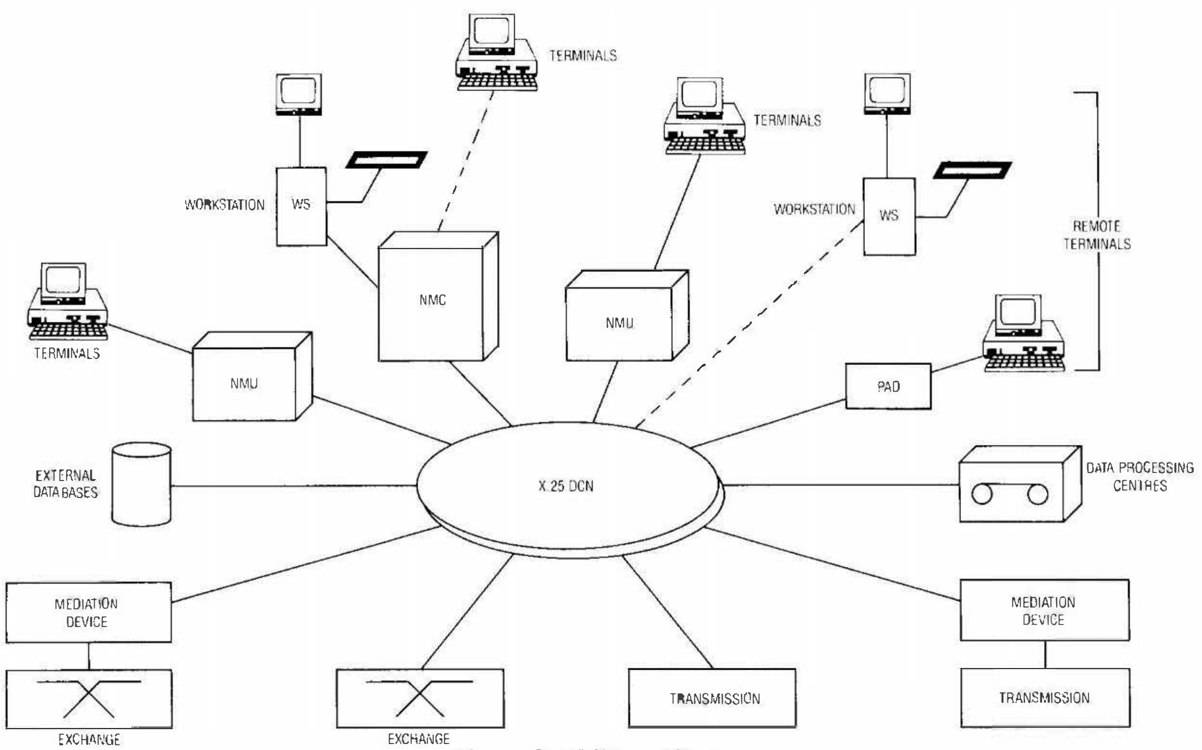

Figure 5—TMN architecture

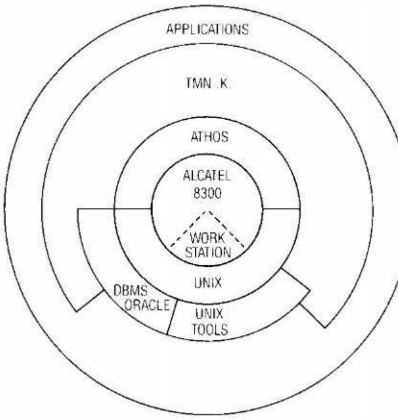

Figure 6—Software organisation

Figure 6 shows the software organisation of applications running on Alcatel's TMN platform.

INTRODUCTION OF NEW SOFTWARE TECHNOLOGY

New software techniques such as *expert systems* (ESs) and *artificial intelligence* (AI) are now mature enough for certain classes of problems, such as, knowledge-based diagnosis and planning. In network management they enable operators to deal with complex applications, such as, alarms correlation and network level fault diagnosis, and network command/control for traffic optimisation.

These new techniques will not replace existing ones, but will provide complementary features to more conventional applications (for example, alarms correlation enhances a network-supervision application). Integration in one unique system means therefore the creation of hybrid architectures and the co-operation of new and conventional techniques. This is now possible with recent ES/AI development environments on UNIX-workstations, which offer the right interfaces with DBMSs (for example, ORACLE™), communication systems (for example, OSI) and presentation systems (for example, X-WINDOW).

In the ES/AI domain, Alcatel has led important research programmes both fundamental and applied. Main fruitful results are in-service expert systems (for example, for equipment fault diagnosis) as well as a complete commercial development environment, named *SPOKE*™. SPOKE™ includes an object-oriented environment and peculiar tools for AI, such as, an inference engine, and a truth maintenance system etc. It runs on UNIX computers (for example, workstations) and is totally integrated in standard UNIX environments.

In network management, first Alcatel applications are related to fault management. As an example, a second generation expert system provides the following features:

- filtering and synthesis of fault data (messages from NEs),
- diagnosis of faulty network systems, and
- explanation of elaborated results.

It uses a knowledge base including a structural/functional model of the network and heuristics for symptoms interpretation.

CONCLUSION

In a completely new context of telecommunication networking capabilities and with the gradual spread of deregulation, better adapted management approaches are being examined to satisfy complex network OA&M requirements. Key issues are the interworking of systems in multi-vendor environments and the development of new applications that are more network/service oriented rather than confined to equipment.

A common umbrella, the Telecommunication Management Network, under study in CCITT, is convenient for addressing the entire field, from any point of view (operator, service provider or equipment manufacturer).

To answer OA&M requirements for a wide variety of network types, be they PSTNs, INs, or PLMNs, Alcatel proposes a one-of-a-kind system relying on a basic TMN platform. This platform provides a network-wide environment offering the TMN dimension to OA&M applications. It establishes the necessary bridge between the telecommunication and computer worlds, enabling advantage to be taken of fast technology evolutions such as expert systems.

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Network Node NK2000—A Controllable Multiplexing and Distribution Facility for Transmission Networks

E. M. KÜGLER†

INTRODUCTION

For the operation of efficient and obsolescence-proof transmission networks, intelligent and remotely-controllable transmission equipment is required which, under the control of a superordinate network management system, can perform the following tasks:

- supervision of digital links,
- react quickly and flexibly to the need for changes in the transmission network,
- perform fully automatic network protection switching in the event of disturbance of digital line sections,
- ensure optimum use of high bit-rate transmission paths, and
- provide subscribers with dedicated circuits at short notice.

The network node NK2000 fully meets the specified requirements for transmission networks. It contains electronic cross-connects, which replace the earlier mechanical distribution frames. The digital interfaces of the network nodes comply with the relevant CCITT Recommendations for plesiochronous digital signals and for synchronous STM-1 signals. The network node NK2000 is thus suitable for connection to transmission equipment of the plesiochronous digital hierarchy and of the synchronous digital hierarchy (SDH). The SDH multiplexing structure is shown in Figure 1.

SYSTEM STRUCTURE

The network node NK2000 contains various switching facilities—cross-connects (CC) and cross-connect multiplex (CCM) facilities—and controls. Figure 2 shows a functional diagram.

Switching Facility CCM64K

Switching facility CCM64K is a cross-connect multiplex facility with a switching network for blockage-free jumpering of 64 kbit/s signals and with interfaces for 2 Mbit/s signals. The 2 Mbit/s signals are fed in via plesiochronous ports (interface modules) with integrated multiplexers. Depending on the version of the switching facility, up to 512 ports are possible.

Switching Facility CCM2

Switching facility CCM2 is a cross-connect multiplex facility, which contains a multi-stage, synchronous switching network. It permits blockage-free jumpering at different switching levels of the SDH, which are the switching level VC12 for 2 Mbit/s signals, and the switching level VC3 for 34 Mbit/s signals. Switching facility CCM2 can be equipped with different interface modules containing the required supervision circuits, and multiplexers and mappers for the individual switching levels. Furthermore for digital signals of the 1·5 Mbit/s hierarchy with the bit rates 1·5 Mbit/s and 6 Mbit/s, corresponding ports are optionally available.

When equipped for full capacity, the switching facility CCM2 contains 65 536 ports for 2 Mbit/s signals. This capacity is reached in stages by adding different multi-stage switching network facilities. In the final capacity stage, instead of 2 Mbit/s ports it is possible to set up to 4096 ports for 34 Mbit/s signals or up to 1024 ports for STM-1 signals (155 Mbit/s). A mixed configuration with the different ports is freely selectable according to requirements.

† Siemens AG, Federal Republic of Germany

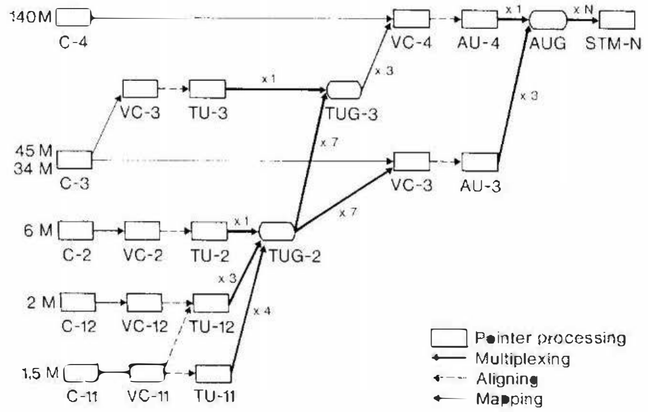


Figure 1—SDH multiplexing structure

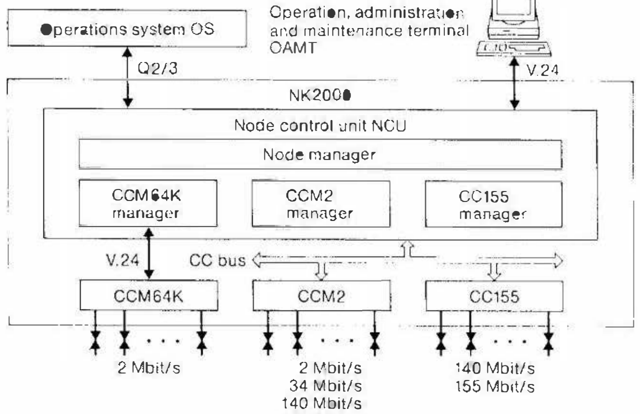


Figure 2—Network node NK2000

For the 2 Mbit/s ports protection switching facilities are provided in the ratio 7:1.

Switching Facility CC155

Switching facility CC155 is a cross-connect facility with a synchronous switching network for blockage-free jumpering of 140 Mbit/s signals and STM-1 signals (155 Mbit/s) at switching level VC4. The interface modules for the 140 Mbit/s signals and for the STM-1 signals can be combined in any desired manner. The maximum capacity stage is for 1024 ports.

Network Node Control Unit

Network node control unit (NCU) is a powerful control processor, which controls and supervises all the switching facilities in the network node. It is doubly connected via double control busses with the switching facilities CCM2 and CC155. The switching facility CCM64K is connected via a double V.24 interface to the network NCU. All functions of the NCU can be either remotely controlled by a superordinate network management system *operations system* (OS), or initiated locally via the *operation administration and maintenance terminal* (OAMT). For the connection of a network management system a Q2/3 interface is provided in duplicate. For local or remote operation up to four OAMTs can be connected.

The software of the network NCU comprises the basic software and the application software. It is of modular structure; that is, the different managers can be implemented independently of the configuration of the network node.

Operation, Administration and Maintenance Terminal

The OAMT permits local or remote control of the network node. In the latter case, one OAMT can be used to control several network nodes. It is an interactive input/output terminal (PC) with keyboard, high-definition 19 inch colour screen, mouse and printer. It offers operators an easily-learnt, menu-oriented, graphics-aided, user interface. Entries are made with the aid of dialog masks. They are checked for formal correctness and executability. For all operator functions, help information is available at various depths.

Commands can also be entered in man–machine language (MML). On the screen, graphic and textual information can be displayed simultaneously in several windows. The OAMT is additionally equipped with a graphics printer, via which all screen activities can be logged if desired. Figure 3 shows the example of a network section with associated graphic representation of quality data in accordance with G.821.

FUNCTION

Switching and Multiplexing

The network node NK2000 permits, in its switching levels 64 kbit/s, VC12, VC2, VC3 and VC4, the blockage-free jumpering of digital signals. Point-to-point connections can be set up in both bidirectional or unidirectional forms, as well as unidirectional point-to-multipoint connections (for

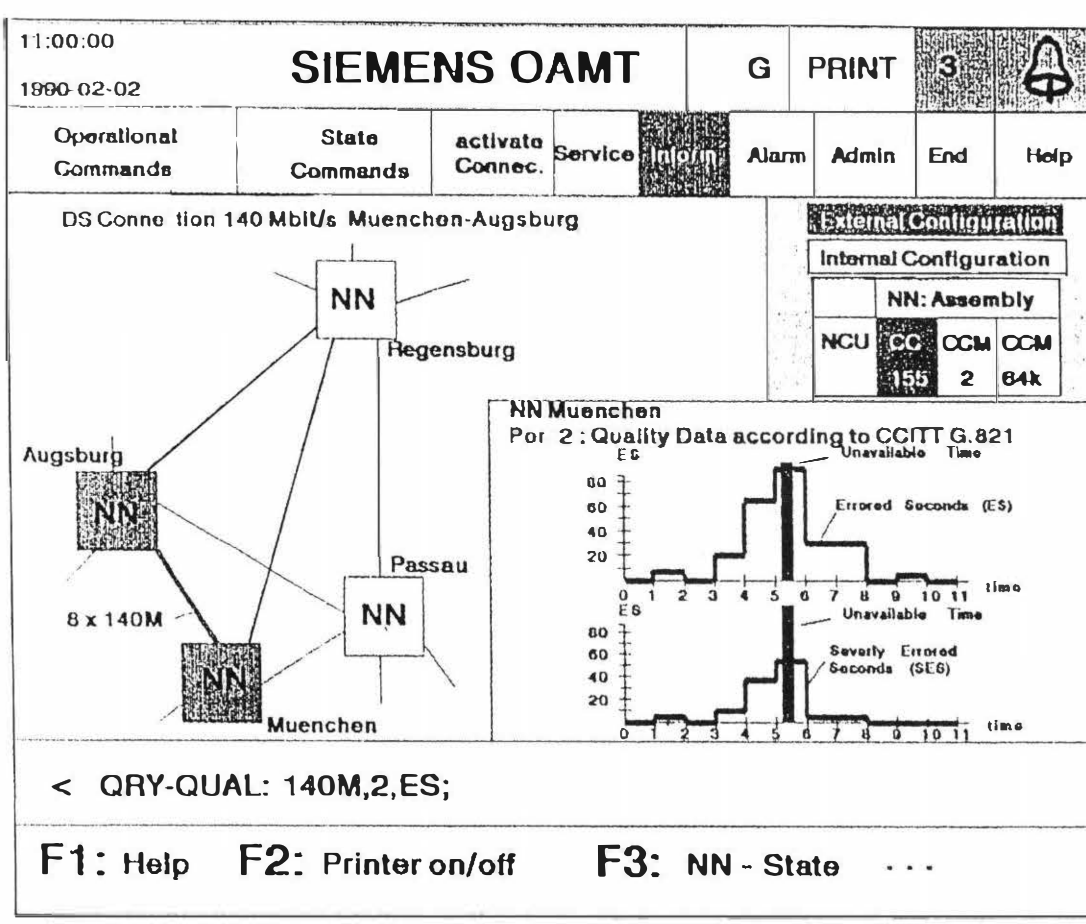


Figure 3—Graphics screen NK2000, example

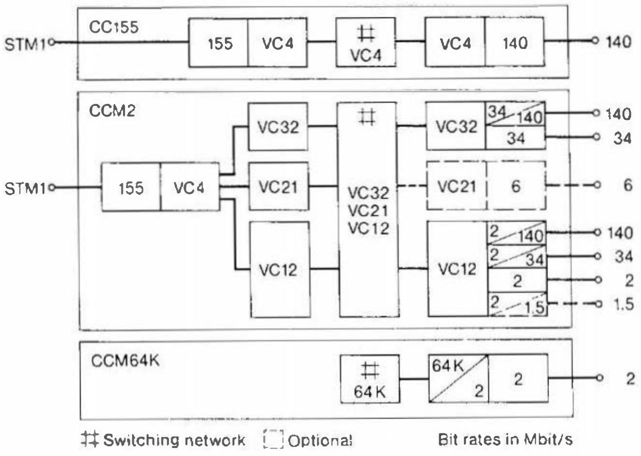


Figure 4—Structure of the switching facilities NK2000

example, broadcast and TV branching). In switching facilities CCM2 and CC155, all plesiochronous digital signals are inserted via mappers in the corresponding containers of the SDH. For signals with 34 Mbit/s and 140 Mbit/s, structured in accordance with G.751, plesiochronous multiplexers can be prefixed.

The STM-1 signals are either fed direct to the VC4 switching network of the switching facility CC155 or, depending on their signal structure, split up in assemblers of the switching facility CCM2 into the corresponding containers (see Figure 4).

Supervision and Alarm Signalling

All digital signal inputs of the network node are supervised for loss of the digital signals (KDS), for AIS and for special signals. Terminating digital links can additionally be supervised for SYN and for bit error rate (BER) $> 10^{-n}$ (with n adjustable) and subjected to quality measurement in accordance with G.821.

For checking the correct routing of digital links in the network node area, telegrams are injected to the digital signals 140 Mbit/s and STM-1, which accompany the information signals as source-destination identification. This code is prescribed by the network management system and in the appropriate network node it is either injected, checked or extracted. In addition, the network node supervises the internal digital signal through-connections for error-free correct through-connection.

In the event of disturbance of a digital signal at the input of a port or in the digital signal path of the network node, an alarm signal is sent after a prescribed guard time via the network NCU to the OAMT or to the network management system. At the output of the associated port, AIS or a special signal is injected as a consequence.

Control

Before commencing operation and control of the network node, registration is necessary for the user and for the network management system. This consists of a user ID code and the associated password. The user is thus granted access authorisation to a predefined delimited task sector.

To support the operations in the network node, further functions are implemented, such as automatic configuring, administration of operating and component states, and the keeping of a diary. All stored information concerning the digital signals, the digital signal links, system parameters, equipment pool data, diary information, etc can be interrogated by the network management system or the OAMT and be outputted on a printer.

SYSTEM FEATURES

Modularity

The switching facilities can be freely selected and combined, depending on the requirements for a network node. Likewise, the equipment of the switching facilities with ports and switching networks is freely selectable and combinable. The network NCU, too, is of modular design. Depending on the choice of switching facilities and their capacities, various hardware configurations and software packages are available.

Extension to the wiring of the network node can be performed in stages up to the planned final capacity, without interruption or disturbance of the already connected digital links.

Protection Concept

In-operation test routines are run to supervise the correct functioning of hardware and software of the network node. Protocols are transmitted safely via the internal control interfaces. Internal network node faults generally lead, after evaluation, to switch-over to duplicated or redundant facilities.

All central functional units (such as the switching networks, the central power supplies, and the entire control system) are duplicated, including the network NCU and the control bus. In this way, all failures of common functional units can be intercepted without interrupting operation. For maintenance work, seized switching network slide-in units can be released. In the event of loss of control, the through-connected digital connections in the switching facilities are retained.

Both the system software, and the system and setting data, reside in non-volatile memory so that, for example, a fast restart is possible after failure of the entire power supply.

The CCM2 slide-in units and the CC155 slide-in units are equipped with their own decentralised power supply modules, which can be powered by the power supply system of the telecommunications centre (for example, 60 V) via double leads. The decentralised power supply results in a high degree of isolation between the feed and the operating voltages, so that extraction and insertion of slide-in units causes no bit errors in adjacent slide-in units.

MECHANICAL DESIGN

Construction

The network NCU, the switching facility CCM64K in version PN64, and the switching facilities CCM2 and CC155 are accommodated in racks with the dimensions: height 2200 mm, width 600 mm and depth 450 mm. In these racks, one-row or two-row insets are installed, which are equipped with slide-in units with double Euroboard format (see Figure 5). In the operations rooms the racks are mounted on ventilating bases, so that no additional ventilators are required.

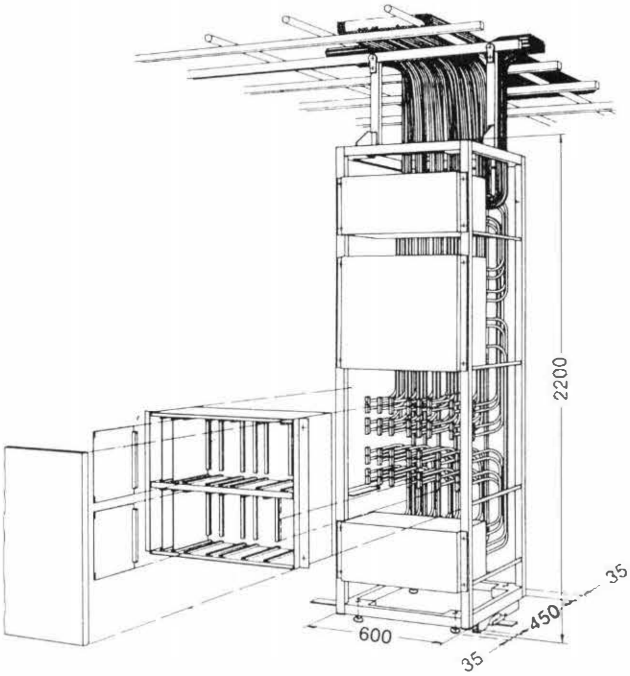


Figure 5—Rack structure NK2000

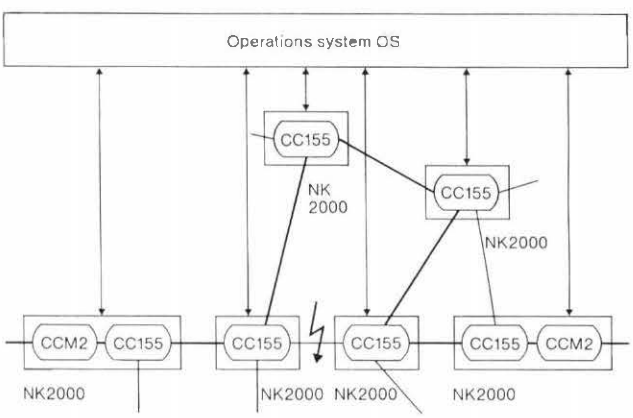


Figure 6—Example of STM-1 protection switching

The switching facility CCM64K in the Deutsche Bundespost version DACSII is mounted in racks that are $n \times 120$ mm wide. With $n = 6$, 12 and 18 the rack widths 720 mm, 1440 mm and 2160 mm are obtained.

Capacity Stages

Table 1 shows the expansion limits and the associated number of ports. Ports can be continuously retrofitted up to the planned final capacity.

INTRODUCTION STRATEGY AND NETWORK APPLICATIONS

The high flexibility of the systems with respect to size and use of partial functions permits practically continuous introduction into existing transmission networks, depending on the desired application. For example, if it is desired to create, as the first step, primarily free switching options of STM-1 transmission paths in the long-haul network, both for operation and for the event of disturbances, then network nodes with the switching facility CC155 should be installed. Figure 6 shows the example of network protection switching at the STM-1 level.

The transition from the long-haul to the local inter-office network is created by introducing the switching facility CCM2 with its multiplexer and assembler functions. Installation of the switching facility CCM2 permits, moreover, the setup of a controllable 2 Mbit/s dedicated circuit network in the local and long-distance areas. With the switching facility CCM2, the functions of a terminal multiplexer 2/155 and those of an ADD/DROP multiplexer can also be performed.

The network node NK2000 with the switching facility CCM64K offers the possibility, for example, of setting up a controllable dedicated circuit network with controllable multiplexers close to the subscriber.

TABLE 1

Switching facility		Maximum number of ports (smallest capacity stage)		
	Bit rate of the ports	Ports	Port racks	Insets
CCM64k	2 Mbit/s	128	1	
CCM2	2 Mbit/s	128	1	1
	34 Mbit/s	8	1	1
	140 Mbit/s	2	1	2
	155 Mbit/s	2	1	2
CC155	140 Mbit/s or 155 Mbit/s	16	1	1
Switching facility		**Maximum number of ports (largest capacity stage)**		
	Bit rate of the ports	Ports	Port racks	Switching network racks
CCM64k		512	2	1
CCM2	2 Mbit/s	1024	2	-
		2048	4	1
		16384	32	8
		65536	128	32
CCM2	34 Mbit/s	64	2	-
		128	4	1
		1024	32	8
		4096	128	32
CCM2	140 Mbit/s	8	2	-
		16	4	1
		128	32	8
		512	128	32
CCM2	155 Mbit/s	16	2	-
		32	4	1
		256	32	8
		1024	128	32
CC155	140 Mbit/s or	64	2	-
	155 Mbit/s	1024	26	4

The Operation, Administration and Maintenance of Advanced Services Networks

K. BURTON, and K. BLAKESLEE†

THE COMPETITIVE ENVIRONMENT

Recent years have seen radical changes in the telecommunications industry. Until recently, each country's PTT enjoyed a virtual monopoly on business within its own national borders. Now however, PTTs must plan for a more liberalised regulatory environment and more competition for customers. British Telecom, for example, now has to compete both with other public operators such as Mercury, and with commercial companies setting up private networks. In addition, there is an as-yet unquantifiable challenge from mobile services and the new, emerging value-added networks. Although still undefined, these will nevertheless present significant competitive pressure all across Europe.

To respond to these new pressures and to protect their core business, PTTs are becoming more business orientated with a sharper focus on profit, on business performance and on customer service.

In this paper, we shall concentrate on the protection and expansion of network services and call traffic, on the opportunities that are emerging for the PTTs—such as the provision of new services—in catering for the needs of the medium and large business customer, and on the resultant administrative and operational problems and opportunities.

THE NEW OPPORTUNITY: NETWORK MANAGEMENT SERVICES

It is within the context of offering these new services to the medium and large customer that the phenomenon of the hybrid (public/private) network begins to offer possibilities as a new growth area for the PTTs. These are the very customers who are likely to already have a partially or fully built private network, interfacing with a public one. The efficient and cost-effective management of such a private network provides a challenge to such companies, whose core business would most probably be in an area other than telecommunications. These businesses find themselves owning a network which is a strategically important asset, but also one which they feel they must manage directly in order to control costs and to ensure that it is flexible and responsive when their business needs change.

Typically, the private network in place consists of PBXs, various data networks, leased lines, etc., to suit their own particular needs. Their network is costly, both in terms of the network itself and in terms of the administration and operational costs.

These hybrid networks present new challenges to the PTTs in the areas of administration and control.

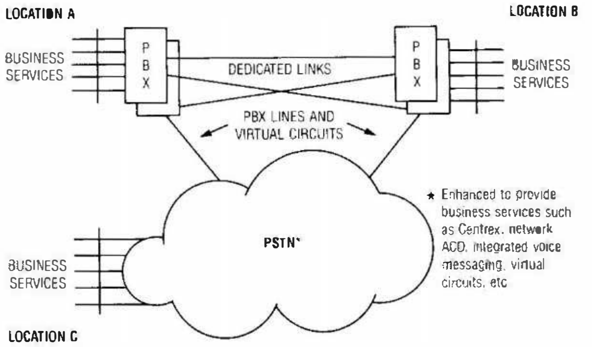
So, how can the PTTs and their medium and large business customers move their businesses forward?

HYBRID NETWORKS

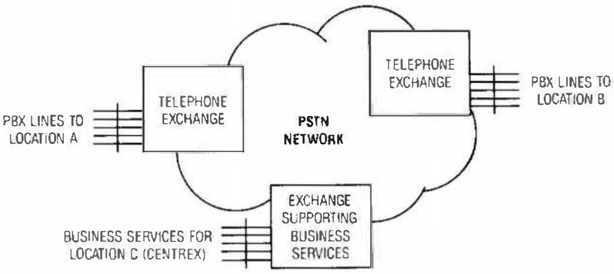
National networks are developing to a point where they are able to offer services and products which complement the private network, such as 'virtual' private networks, 'virtual' leased lines, ISDN and broadband data and enhanced voice services such as centrex, ACD and voice messaging. The ideal hybrid network would combine the public and private facilities with the additional services for the customer's benefit, in terms of both service and economy. The management of a hybrid network in such a way that it provides these benefits to the customer presents a challenge in network administration, but also an opportunity for the PTTs.

In order to appreciate the difference between public, private and hybrid networks, we must look at the different perceptions of what the network is. The customer's view of his unique network would include things such as:

- each building location, including the types of service, the number of lines, and the volume of traffic;
- the connectivity both between locations and to public networks;
- the public and private numbering plan; and
- network management points.



The network provider's view, however, will be oriented more toward the network realisation of the customer's needs. The physical mapping of these corporate requirements onto the actual exchange and transmission systems of the business network and/or PSTN will often result in the network provider having a completely different view—one dominated more by the network infrastructure rather than each customer's unique requirements and physical locations.



By providing business exchanges capable of supporting virtual facilities, it is feasible to aggregate all corporate requirements in the most effective way to make optimum use of shared exchange/transmission systems. A 'corporate network view' must be partitioned and maintained to give

† Northern Telecom Europe Limited, UK

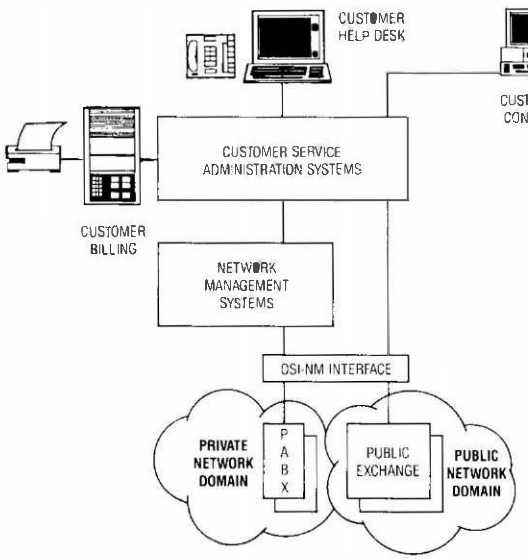
each individual customer the services and visibility related to 'his' network.

The hybrid network presents the PTT with an opportunity for market growth, by providing products and services which enhance and complement those used by the private network. They might, for example, provide business exchanges capable of supporting 'virtual' capabilities, or find new business in the managing of hybrid networks on the customer's behalf.

The management of a typical hybrid network is itself a complex affair, which may be further complicated by other factors, such as, for example, if the network crosses international boundaries.

MANAGING CORPORATE NETWORKS

The diagram, below, provides a suggested operations infrastructure for organising and managing such a hybrid network.



The solution proposes a separation of management of the network provider's network from administration of the customer's corporate network. These are presented as two layers, as indicated in the above diagram. By connecting both public exchanges supporting virtual facilities and customer-owned PBXs to a common customer administration layer, it will be possible for the network provider to offer network management services across each unique corporate network.

The functionality between the customer-owned/public owned facilities, and the customer's administration system will include:

- service provisioning, and moves and changes, taking into account the corporate numbering plan;
- customer network configuration including network connectivity and network provided services; and
- management reports detailing the use of the network and its performance. This will normally include billing information.

The interface between the public network exchange, which will in general be supporting many customers, will require customer data partitioning, relating performance and usage information to a particular customer. Today's interfaces will continue to be vendor-specific character string interfaces. However, object-oriented interfaces are being defined within the standards forums, and early implementations and trials of the interfaces are currently being planned either as part of network management forums, or between vendors and network operators.

Once the network is organised in this way, it may be managed by the customer himself, or the PTT can provide a service to manage the network for him. But in either case the hybrid network must be managed as the corporate resource of the customer, and be unique to each customer.

RECOMMENDATIONS

The PTTs should view the customer's hybrid network, both its private facilities and its shared network resources, as that customer's own corporate asset. In terms of products, this focus means designing and producing new services which enhance and complement the running of the network, and when designing the service taking into account the operations and maintenance issues. This could mean managing the customer's network for him, or, if the customer prefers, to manage his network himself, providing him with the necessary tools to give him greater control of his own operations.

In order to provide and manage these end-user-oriented services, which will be used by large businesses, new administration systems will need to be incorporated*. Large businesses have very different needs from the individual domestic customers and an administration management infrastructure will be required which will allow the PTTs to deal with these large customers and business entities separately.

The drive toward industry standardisation in the area of network administration must be continued using an object orientation approach, meaning that the key terms used to define services or common processes are generic rather than specific to one network component or product. All new products, of course, should comply with OSI-NMF standards, for the obvious commercial and implementation benefits this would offer.

CONCLUSIONS

This paper has offered an analysis of the introduction of advanced network services, the management of hybrid networks, and the opportunities which these enable in the new commercial environment facing the PTTs.

The phenomenon of the hybrid network offers new opportunities for business growth, both for the PTTs themselves and for their customers.

A full understanding of the management of hybrid networks is necessary for the public network operator to penetrate the private network market with public network based services. The rewards will be increased revenues from the new services, and a consolidation and enhancement of existing call traffic.

* Further details and recommendations on the subject of administering new services are given in a separate paper, 'An approach to Providing Exchange Operations Support Systems' by Tony Long, Crispin Williams, Ken Burton and Ken Blakeslee, which was presented at the International Switching Symposium in Stockholm in May 1990. This paper proposes an operations, administration and maintenance hierarchy based on remote operations standards and the development of object-oriented systems and protocols, for use in the evolution of high-quality, low-cost, high-functionality networks.

The Introduction of a Service Switching and Control Point in the Telecom Ireland Network

R. R. WALSH†

INTRODUCTION

Telecom Ireland introduced an automatic Freephone service in April 1990. The service is provided from an AXE 211 exchange. This exchange was specifically commissioned for the provision of special services. At the moment it supports the Freephone and Part-Paid services and it is planned to introduce information services later this year.

At the moment an extended number translation capability enables the exchange to meet most of the Freephone service objectives. The exchange software will be augmented in September 1990 by the introduction of a new platform for defining a range of services. This platform, the *service script interpreter* (SSI), will provide the exchange with the functionality of a service switching and control point (SSCP) and will be the first step towards an intelligent network.

This article outlines the Freephone service requirements and how they are being met within the constraints of the existing network. The rationale behind Telecom Ireland's decision to adopt this evolutionary approach to intelligent network development is explained.

Special Services Exchange (SSE)

The Freephone service requirements were specified in 1988. The service would be based on a new exchange located in Dublin. As well as a Freephone service, a Part-Paid service and information services were also to be provided from this exchange. In order to accelerate the introduction of the services the specification attempted to minimise the amount of work required to interface the PSTN with the new exchange. The exchange would have to use the main PSTN signalling system R2D and produce CDRs containing tariff information in the form of charge units.

Main Features Specified

Translation of the Freephone number to a destination number depending on:

(*a*) The origin of the call. The specification only required the analysis of the first significant CLI digit.
(*b*) Time of day.
(*c*) Day of the week.
(*d*) Date.
(*e*) Day type.
(*f*) Specified distribution requirements.
(*g*) Retranslation to alternative destination on busy.

In addition to the translation requirements other features that were specified were:

- Definable limits to the number of simultaneous calls to particular destinations.
- Tones and announcements available to callers and service providers.
- Collection of additional digit information from callers.
- Limited service providers control of translations using DTMF signalling.
- Service providers access to service data and statistical information.

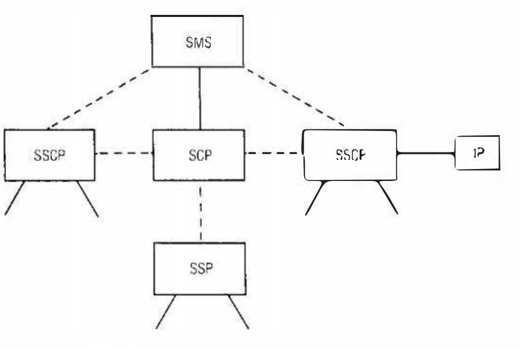
A variety of proposals were received ranging from implementation on a standard switch to intelligent network (IN) solutions. The development was carried out against a background of discussions on technical solutions to IN architecture and implementation. Our main objective however was to provide a flexible system able to meet our customers' requirements. The main objective of IN, that is, rapid service introduction, matched our requirements but the time scale and cost of introducing several IN components into a network the size of Telecom Ireland's would be prohibitive.

The solution offered by Ericsson, quick implementation of the Freephone service with early upgrading of the exchange to SSCP functionally, was very attractive. As well as enabling us to solve our immediate problem, providing the Freephone service, it also would give us the opportunity to gain from work being done on service development for the IN.

IN ARCHITECTURE

The main components of IN architecture are:

Service Switching Point (SSP) This provides access for telephone users to the services. Call processing is carried out in the SSP which consists of a traditional switch with special software. The SSP can access the SCP using the CCITT No. 7 signalling network. It can request instructions required for call handling. See Figure 1.



SMS: Service management system
SCP: Service control point
SSP: Service switching point
SSCP: Service switching and control point
IP: Intelligent peripheral

Figure 1—IN architecture with SSCPs

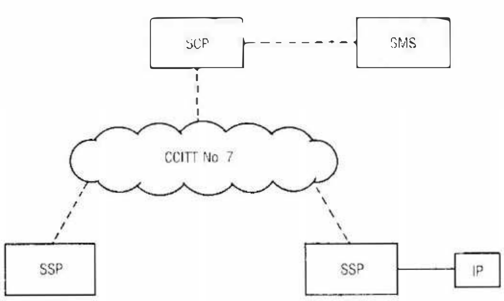
† Telecom Ireland, Ireland

Service Control Point (SCP) The service logic and data reside in the SCP. The SCP will instruct the SSP on call handling when requested. The service control function can be executed by a commercial computer or by a modified switch, using the processing capabilities rather than the switching capabilities. The SCP must be able to rapidly access large amounts of data. In addition to databases within the SCP, external databases can be accessed.

Service Management System (SMS) This system could be used to provide a service creation environment and to maintain the services databases. SCP/SSP operations and maintenance could also be located in the SMS. The SMS could also provide an access point for service providers to allow control over their individual services.

Intelligent Peripheral (IP) The IPs provide an interactive environment between service users and the service logic. This equipment could consist of voice response, DTMF receivers etc.

Service Switching and Control Point (SSCP) The SSCP consists of an IN node where the SCP and SSP functions are integrated. The SSCP is realised in a switch. The SSCP can perform the functions of an SSP, it can access other SSCPs or SCPs to obtain call handling information. It can also perform the functions of an SCP and provide call handling information to SSPs. See Figure 2.



SSP: Service switching point
SCP: Service control point
SMS: Service management system
IP: Intelligent peripheral

Figure 2—IN architecture

CHANGES IN THE PSTN FOR INTRODUCTION OF THE SSE

The PSTN hierarchy consists of two tertiary centre exchanges located in Dublin. These exchanges are also the international access points. All the secondary exchanges are digital AXE or E10B. About 50% of Telecom Ireland customers are located in Dublin. It was estimated that more than 50% of Freephone customers would also be located in Dublin. Because of the method chosen to provide the Freephone service the changes required in the network were minimal.

Numbering

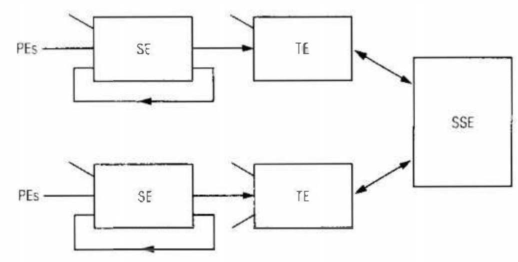
A significant amount of work was carried out at analogue exchanges to open access codes for the new services. As well as Freephone and Part-Paid codes, other access codes were opened for possible future use at the SSE. The codes are given below:

1800	Free
1850	Part-paid
1510	
1520	
1590	

The 15xx codes were associated with all available charging rates.

Routing

All special services traffic was routed to its secondary centre on existing routes. No new routes were required. From the secondary centre to the tertiary centre existing routes were also used. Because of the danger of bursts of traffic causing disturbances to the network, loop routes were provided at the secondary centres. See Figure 3.



SSE: Special services exchange
TE: Tertiary exchange
SE: Secondary exchange
PE: Primary exchange

Figure 3—Simplified routing diagram

Signalling

The signalling system being used is R2D; however, in order to allow the service provider to control the call, the signalling implementation is not standard from the SSE outgoing to the network.

Call Origin

'A' number transfer is being used to forward origin information. At the moment only two digits are required. The ability to send 'A' number information is limited in the network because the crossbar exchanges are not equipped with this facility. By using the implied 'A' number capability of the digital exchanges sufficient origin information is made available. In addition to the above changes in the network, the billing and service order system preparations were completed in March 1990.

SPECIAL SERVICES EXCHANGE

The special services exchange opened in April 1990 providing two services, '1800' Freephone and '1850' Part-Paid. The '1850' service offers the same features as Freephone but callers are charged one unit per call. International Freephone and Country Direct services will be introduced in late-1990.

The features available are controlled from the extended number translations facility in the exchange. Calls are 'routed' to this facility from the normal exchange analysis, no switching is involved until the destination number is received back into the normal analysis. The features that are in use at the moment are:

Origin dependent routing
Time dependent routing (day, date, day of week)
Call distribution
Freephone tone
Verbal announcements to callers
Call gapping

The call gapping feature allows the call intensity to be limited in any branch of the service number analysis. The parameters associated with call gapping can be varied for each application. Call gapping is required because of bursts in traffic. It can be used to stop new calls to a destination for a specified time if a specified call intensity limit is exceeded, for example:

Call gap = 30 seconds
Call intensity limit = 20 calls in 10 seconds

If there are more than 20 calls in 10 seconds then for the next 30 seconds new calls will be routed to an alternative destination. Data associated with service numbers is input to the exchange using a PC connected as an exchange I/O device. This PC provides a service creation environment (SCE). The SP's required service is graphically designed on the PC. The system then checks the logic of the design and highlights any errors or omissions. The PC then generates the MML commands and inputs them to the exchange.

SERVICE SWITCHING AND CONTROL POINT (SSCP)

Service switching and control point functionally will be introduced into the SSE in September 1990. It will be based on the *service script interpreter* (SSI). The implementation of SSI in the SSE will be the first application of this Ericsson product. The SSI uses *service scripts* for processing calls. A service script is built up from modules each of which performs a task the outcome of which may determine the next module to be invoked.

Service Script

The service script is triggered by the 'B' number dialled. In the case of Freephone, '1800' will cause a query to be sent to the SSI. The signalling between the SSI and the traffic control subsystem (TCS) will take the form:

Query
Collect digits
Digits response
Termination

Service script is the link between service logic and service data. In combination they describe the service performance for an individual service number. The service logic may be shared by a number of service numbers, but the data will be unique. See Figure 4.

Functional Modules

The service script is built up from modules to form a branching mechanism. The modules that will be available in September are listed below:

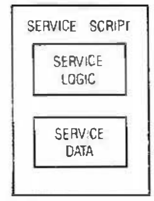


Figure 4—Service description

Date
Time of day
Additional digits
Subscriber's class
'A' number (branch on up to three digits)
Route origin
Limit on simultaneous calls
Call intensity limit
Call distribution
Modify number
Compare number to list
Go to another script
Destination number
Branch on additional digit

A number of these modules will be combined to allow the Freephone service progress towards our original objectives. One of the features will allow service providers limited control over their traffic flow. This will be achieved by the collection of additional digits, comparing digits to a list and branching on additional digits.

Statistical Information

Statistical counters may be placed on any of the branches in the service script. These can be simple counters or counters with call result information such as 'B' answer, 'B' busy etc. Reports produced will be available to service providers.

OTHER SERVICES

In addition to improvements to the existing services the SSI platform will allow the development of several new services:

- alternative billing service,
- personal numbers, and
- virtual private networks.

It should be possible to introduce these services rapidly and economically once SSI is available.

The opportunity will be available with the widespread introduction of CCITT No. 7 to decentralise the SSP down to the secondary exchanges, or alternatively the SSCPs could be de-centralised within different services provided at different levels. Only experience gained by providing network services will enable the design of the network to be optimised.

CCITT Signalling System No. 7—A Test Equipment Manufacturer's Perspective

R. URQUHART†

INTRODUCTION

From the user and telephone company viewpoint, CCITT Signalling System No. 7 is completely changing the way the telephone network is controlled, and provides the foundation for many new services currently being offered and planned.

As a test equipment manufacturer, Hewlett-Packard must be keenly aware of these new developments in order to be able to supply the tools needed to develop, install and maintain the intelligent network in all its guises worldwide.

Whereas the physical specification of a new transmission system gives a framework for testing, Signalling System No. 7 specifications give little hard guidance.

Opinions from those who work in switching vary from 'we needed sophisticated test equipment two years ago' to 'there's so much redundancy and built in self test that the No. 7 network won't ever need any test'.

To develop new test equipment we must first be convinced that a real need exists. Then a careful study of application areas and potential users must be made.

THE NEED FOR MEASUREMENT

The need for some kind of measuring and analysis equipment is underlined by the complexity of the protocol, by the complexity of the messages needed to set up various types of call, and above all by the enormous complexity of the overall No. 7 network. In every country, it will be the most complex datacom network by far.

In many countries several different telephone networks, operated by different organisations, will be interconnected. In all countries there will be international gateways carrying traffic and signalling abroad.

Most European countries are currently working towards a new digital mobile radio system known as *GSM*, which will begin to enter service in 1991. GSM will offer customers a better service standardised throughout Europe.

GSM depends on a specialised version of CCITT No. 7 signalling. This manages the setting up of calls, while minimising radio channel occupancy, and the speedy transfer of information from the user's home database to the region where he is currently located. It also sends accurate billing information to the appropriate service providers and to the user. Setting up a call from a mobile to the fixed network can involve around 40 signalling messages—messages which must continue during the call if the mobile is actually moving.

Several countries have already licensed more than one GSM network operator, each of which must be interconnected to the fixed network.

In each country the No. 7 network is, or will be, the most complex datacom network in existence. It is inconceivable that such large, complex, interlinked systems will operate and evolve without problems. Fortunately many of these problems will be minor, resulting in lost calls, re-dialling or mis-billing. However there have been major failures. The most widely publicised of these was the recent AT&T 'Nine Hour Disaster'. This was such a major network-wide failure that is worth examining in some detail.

THE AT&T DISASTER

Early in the afternoon of the 15 January 1990, switch number 51 in Lower Manhattan, a 4ESS switch manufactured by AT&T, detected a problem on one of the trunks feeding it. It signalled a second switch to stop sending it traffic, a routine procedure which normally meant that it would not process calls for a few seconds. During that time it reallocated traffic to the trunks which were operating correctly. It then sent a No. 7 signal to the second switch to indicate that it was ready to accept traffic again.

Previous revisions of the software required positive acknowledgement of the restart message by the second switch. However, the latest revision attempted to speed up the process by using the first call set up message from the out of service switch to indicate that it was back in service. Switch two had correctly received the first call set up message and was in the process of resetting its status tables when it received a second call set up message from the out of service switch.

This eventuality had not been foreseen by the software designers. The second switch then decided that it had a processor fault and went out of service, in turn informing switches connected to it of its action. Within 20 minutes all 114 4ESS switches in AT&T's long haul network were out of service and the remainder of the network was in chaos.

Nine hours later, at 11.30 in the evening, when traffic demand had subsided, the network was finally restarted with modified software.

It is interesting to read the comments from the industry spokesman following this event, particularly from AT&T's rivals in the long haul business.

> 'We don't believe it could happen to us. We can't say never because as soon as we do lightning strikes.'
>
> —MCI spokesman

> 'Nothing is impossible when you're dealing with the level of sophistication that you have in today's network software—we'd be fools to say it can't happen to us'.
>
> —US Sprint spokesman

Finally from an AT&T spokesman:

'If it can happen to us it can happen to anyone'.

† Hewlett-Packard Ltd., UK

NETWORK EVOLUTION

The above example is a consequence of one of the major strengths of the modern intelligent network. Because the network is defined by the software in its switches and computers, it can evolve to provide new and better services. New revisions of network software are constantly being created, tested and introduced. No large piece of software is perfect, all have defects. In fact AT&T themselves estimate that software has a defect rate of one per thousand lines of code. Thus new revisions of software correcting old defects and introducing new features inevitably carry with them new defects with consequences which cannot be known in advance.

Few software defects result in failures as dramatic at AT&T's. Many however will result in loss of revenue and will be much more difficult to track down. They will require instruments which can record, sift and analyse the many thousands of messages present on signalling links.

BUILT-IN REDUNDANCY AND SELF TEST

Like all parts of all telephone networks the signalling network has built-in redundancy. A No. 7 link connecting two signalling points will always consist of at least two separate paths each able to carry all the traffic. In many cases, where the connection is highly critical, there will be as many as four or six separate paths. This redundancy demands a certain amount of self monitoring. In order to know when to switch signalling traffic to another link, error rates must be monitored. In order to know when to switch to an alternate 800 number database some continuous measure of health is needed.

The No.7 protocol already has parts devoted to this task both on a link and network wide basis. It is an area which is currently being studied by the various standards bodies involved. However, although self test is necessary there are strong arguments for the co-existence of independent means of test and monitoring.

THE CASE FOR INDEPENDENT TESTING

All parts of the signalling network are designed to operate at significantly less than full rate, even during busy hours, so that all failures can be accommodated by reallocation of resources. When failures do occur, signalling points still in operation will be too busy to run monitor and self test routines—at the very time they are most needed. Independent test equipment solves the problem.

The software industry recognises the need for independent software checking. As an example, the most highly reliable software being written today is for fly-by-wire aircraft. Here the technique adopted is for three or more independent teams each to write software for the same task using different processors and different high level languages. In use, all machines are run simultaneously and, in the case of a discrepancy, a vote is taken. Writing test software as part of the operational software cannot achieve independence; external test equipment and test systems can.

CONFIGURATION: 1	TYPE OF TEST: VAT and CPT	TYPE OF SP: SP
EXPECTED MESSAGE SEQUENCE:		
SP A		SP B
IAM	- - - - - - - - - - - - - - - - - - - >	
	< - - - - - - - - - - - - - - - - - - -	ACM
	--	Ringing tone
	< - - - - - - - - - - - - - - - - - - -	ANC
Speech	———————————	
CLF	- - - - - - - - - - - - - - - - - - - >	
	< - - - - - - - - - - - - - - - - - - -	RLG

TUP LEVEL 4 TEST SPECIFICATION

TEST NUMBER: 2.1.2
REFERENCE: Q.724 § 1
TITLE: Bothway circuit selection

```
PROCESS TUP_2_1_2
> IAM
< ACM
< ANC
> CLF
< RLG
```

Figure 1—Program input for instrument emulating signalling point A (SP A)

Finally, the long test period required by new revisions of operational software make it difficult to introduce modifications to the testing software if the two are part of the same program. Again independent testing equipment solves this problem.

CLASSIFICATION OF MEASUREMENT NEEDS

There is a clear opportunity for a test equipment manufacturer to make a contribution. This is underlined by the fact that most networks are not yet carrying full traffic loads and are not fully interconnected. At this stage the difficulty is in defining exactly what is required.

The three main areas are: the design and testing of new hardware and software; the installation and bringing into service of new equipment; and the monitoring and maintenance of the operational network.

NEW DESIGN TESTING

New revisions of software require testing in two respects. Obviously the new features which have been added must be exercised. In addition it is necessary to test existing functions to make sure they have not been affected by the changes. Such testing can be done by interconnecting a number of signalling points in a laboratory, and running the new software while monitoring progress.

Although this process may be necessary in some cases, it is expensive. More important, it does not represent independent testing. Replacing part of the trial network with an instrument which can be programmed to emulate network elements by sending and receiving messages on several links simultaneously is cheaper and independent. With an appropriate programming method it is also possible to send erroneous or out of sequence messages to stress the item under test.

Since the essence of emulation is to send, receive and respond to No. 7 messages, it should be possible to program the test equipment for this task as simply and directly as possible. An example of this is shown in Figure 1 where a test from CCITT Blue Book Telephone User Part (TUP) is shown together with the input needed to program the HP37900B/C Signalling Test Set.

In addition to feature testing it is usually necessary to load-test switches. The quality measured is the number of busy hour call attempts (BHCAs) the switch can handle. For the mobile switching centres (MSCs) which provide the switching in GSM networks, loading is a much more complex task. A realistic load comprises a number of users switching on, a number switching off, a number roaming and so on. Typically these processes involve many messages on several links necessitating the use of several test sets controlled by a work station. This requirement dictates that test sets are capable of remote control.

INSTALLATION

The installation of a large telephone exchange takes several steps. After the equipment is physically put in place and powered up, a range of emulation tests is carried out. These must assure the network operator that the exchange is functional but are much simpler than the tests required at the design acceptance stage. Installation equipment must be able to run preprogrammed tests and record the results.

HP37900 Signalling Test Set

Message Date Stamp : 20.10.88

	1000 0101	ISUP message, National network
	0000 0011	24 Bit Destination Point Code (DPC)
	0000 0001	
	1111 1111	
	0000 0001	24 Bit Originating Point Code (OPC)
	0000 0001	
	1111 1111	
	000 00001	5 Bit Signalling Link Selection (SLS)
	0000 0001	14 bit Circuit Identification Code (CIC)
	00 000001	14 bit Circuit Identification Code (CIC);2bits spare
F	0000 0110	MT = Address Complete Message (ACM)
F	1101 1000	Backward Call Indicators Parameter Field, bits H..A
F	0000 0000	Backward Call Indicators Parameter Field, bits P..I
V	0000 0001	Pointer to start of optional part
O	0000 1100	Redirection Number Parameter
O	0000 1010	LI of Redirection Number Parameter
O	0 0000010	Odd/Even indicator, Nature of Address indicator
O	0010 0010	Numbering Plan, Address Presentation Restricted indicator
O	0001 0000	Address signal
O	0011 0010	Address signal
O	0101 0100	Address signal
O	0111 0110	Address signal
O	1001 1000	Address signal

Figure 2

During the bringing into service stage the network operator must enter all the necessary information into the switch memory. At the simplest level this consists of the routing table data needed to handle the transmission, reception and routing of signalling messages. At the highest level it may require many months of effort to load up a large credit card information database. Initially test requirements are to run emulation scripts, but as work progresses the need to capture, monitor and interpret long sequences of messages grows.

Most telephone networks are planned to grow over a period of years. It is unusual to install a complete network at one time. Yet this is exactly the prospect which currently faces GSM service providers.

MAINTENANCE

Maintenance of a No. 7 signalling system, unlike the earlier stages, does not require emulation. The power of the protocol means that it is much too dangerous for test equipment to send messages into the working network. It is all too easy to send, inadvertently, a message which shuts down a vital signalling point.

Maintenance equipment, therefore, makes its contribution in capturing and interpreting signalling messages. As networks carry more traffic, more problems will appear. Problems range from calls which fail to complete, to 800 numbers which do not operate from certain locations, to mis-billing, and to the AT&T disaster described.

The main contribution a tester can make is to 'simplify' the No. 7 protocol. Figure 2 shows part of a message used to initiate an ISDN call set up. Such messages can be up to 273 octets (bytes) long. They cannot be decoded merely by looking up the meaning of a particular octet since blocks of information vary in length. Consequently the position of a particular block of information, for instance the calling party number, is not fixed.

An obvious, though difficult, contribution for a tester is the decoding of messages to show them in the words and diagrams of their original specification. This frees the maintenance engineer from the drudgery of constant and time consuming reference to volumes of No. 7 standards.

Figure 2 also shows an example of the kind of decode needed.

A typical monitoring session will result in the capture of many thousands of individual messages. Without powerful searching tools, which enable the desired messages to be found, this is a pointless exercise. The tester must provide these tools.

With decoding and searching techniques it is possible to provide even higher level functions. For instance capturing and displaying all the messages relating to a particular telephone number—call trace—has obvious use.

The kind of tester described can have a wider application than trouble shooting. The gathering of signalling traffic statistics provides information useful in network design. Deciding whether or not a new service is viable means estimating how much of the various network resources it uses and which other services it impacts. Gathering particular messages over a period can provide this kind of information.

CONCLUSION

The CCITT No. 7 signalling network is the most complex datacom network ever created. Although growing in complexity as new services are implemented, it is still in its infancy. Its software, like all software, has defects: some will be found soon; some may lie dormant for years; some may never be found; all are potentially dangerous.

As a test equipment manufacturer we believe there is a need for specialised signalling test equipment. It is with such instruments that we can make our contribution to the intelligent network.

GECAV—A Computer System for the Maintenance of Submarine Cables

R. RICCA, and G. MUZI†

THE ITALIAN SUBMARINE NETWORK

The submarine medium is becoming more and more an essential component of modern telecommunication networks due to its high quality of transmission and to its high reliability.

Because of its geographical situation in the mediterranean area, Italy adopted submarine cables for telecommunications as soon as they appeared on the market. They were soon used both for domestic connections, between the mainland and the islands, and for international connections between Italy and other mediterranean countries.

These cables, making up the Italian submarine network, were laid between the early-1950s and the late-1980s, at different times, and therefore differ from one another in capacity and transmission systems, depending on their age, due to the constant development of technology that has occurred during the last decades.

Some of them have copper conductors and are equipped with FDM analogue systems while others, recently laid, use optical fibre and TDM digital systems.

Lately, a new and interesting connection has been implemented between several Italian coastal towns on the mainland. It consists of optical-fibre cable links no longer than 200 km so that submerged repeaters are not required.

This technique, called *festoni*, is applied in a large system of new connections which is planned to be implemented between today and 1992. Part of the system has already been laid, covering the distance between Pomezia and Messina for about 750 km at a maximum sea depth of 1300 m.

The Italian submarine network now includes 15 cables, 8 international and 7 domestic, plus a 'festone' made up of 6 sections.

Here follows a list of:

(*a*) *International Links*

Malta–Italy	Cu	101 km	1 FDM system	48 Ch.
Spain–Italy 1	Cu	792 km	1 FDM system	480 Ch.
Albania–Italy	Cu	160 km	1 FDM system	3 Ch.
Egypt–Italy	Cu	709 km	1 FDM system	480 Ch.
Algeria–Italy	Cu	1107 km	1 FDM system	480 Ch.
Spain–Italy 2	Cu	961 km	1 FDM system	1380 Ch.
Turkey–Italy	Cu	2005 km	1 FDM system	480 Ch.
Spain–Italy 3	Cu	727 km	1 FDM system	4140 Ch.

(*b*) *Domestic Links*

Civitav.–G.Aranci	Cu	271 km	1 FDM system	480 Ch.
Roma–Cagliari	Cu	557 km	1 FDM system	1380 Ch.
Roma–Palermo	Cu	466 km	1 FDM system	3600 Ch.
Genova–Sassari	Cu	510 km	1 FDM system	3600 Ch.
Palermo–Cagliari	Cu	460 km	1 FDM system	3600 Ch.
Roma–G.Aranci	OF	266 km	6 TDM systems	140 Mbit/s
Palermo–G.Aranci	OF	480 km	6 TDM systems	140 Mbit/s

(*c*) *Festoni*

Pomezia–Formia	OF	141 km	6 TDM systems	140 Mbit/s
Formia–Napoli	OF	61 km	6 TDM systems	140 Mbit/s
Napoli–Salerno	OF	139 km	6 TDM systems	140 Mbit/s
Salerno–Scalea	OF	162 km	6 TDM systems	140 Mbit/s
Scalea–Lamezia	OF	130 km	6 TDM systems	140 Mbit/s
Lamezia–Messina	OF	108 km	6 TDM systems	140 Mbit/s

(*d*) In addition to the above quoted systems, ASST shares the property, in terms of channels, of the following international submerged links:

France–Italy 1 (MARPAL)	687 km	1380/2580 Ch.
France–Italy 2 (SEA-ME-WE)	940 km	240/2580 Ch.
Egypt–Italy 2 (SEA-ME-WE)	1920 km	185/2580 Ch.

The total length of active cables owned either totally or partially by ASST, amounts to about 15 000 km, the capacity being 21 956 channels on analogue systems and 48 blocks of 140 Mbit/s on digital systems.

Figure 1 shows the present size of the Italian submarine network.

The plans in course of implementation are bound to produce a large expansion of the network.

At the end of the year 1990, the western festoni system will be completed. The Genova–Pisa–Grosseto–Civitavecchia–Pomezia and the Messina–Santagata–Palermo chains will be added to the Pomezia–Messina chain. The new Genova–Golfo Aranci, Sardinia–Corsica and EMOS 1 cables will also be put into service within this period.

In 1991 and 1992, international links MAT 2, TAT 9, Italy–Tunisia, Italy–Malta and Italy–Libya will be laid as well as the eastern festoni system along the Adriatic coast. Then the Italian submarine network will appear as shown in Figure 2.

The total capacity of analogue cables will not change while the number of digital blocks will increase from 48 to 156 at the end of 1992.

MAINTENANCE ISSUES

Organisation of maintenance branches into two kinds of activities.

- preventive maintenance, and
- corrective maintenance.

Preventive Maintenance

Preventive maintenance consists of all sorts of actions meant to prevent, as much as possible, failures of the systems and consequently loss of service and any action aimed to stop the service quality fading.

Actions of preventive maintenance include:

† Azienda di Stato per i Servizi Telefonici (ASST), Italy

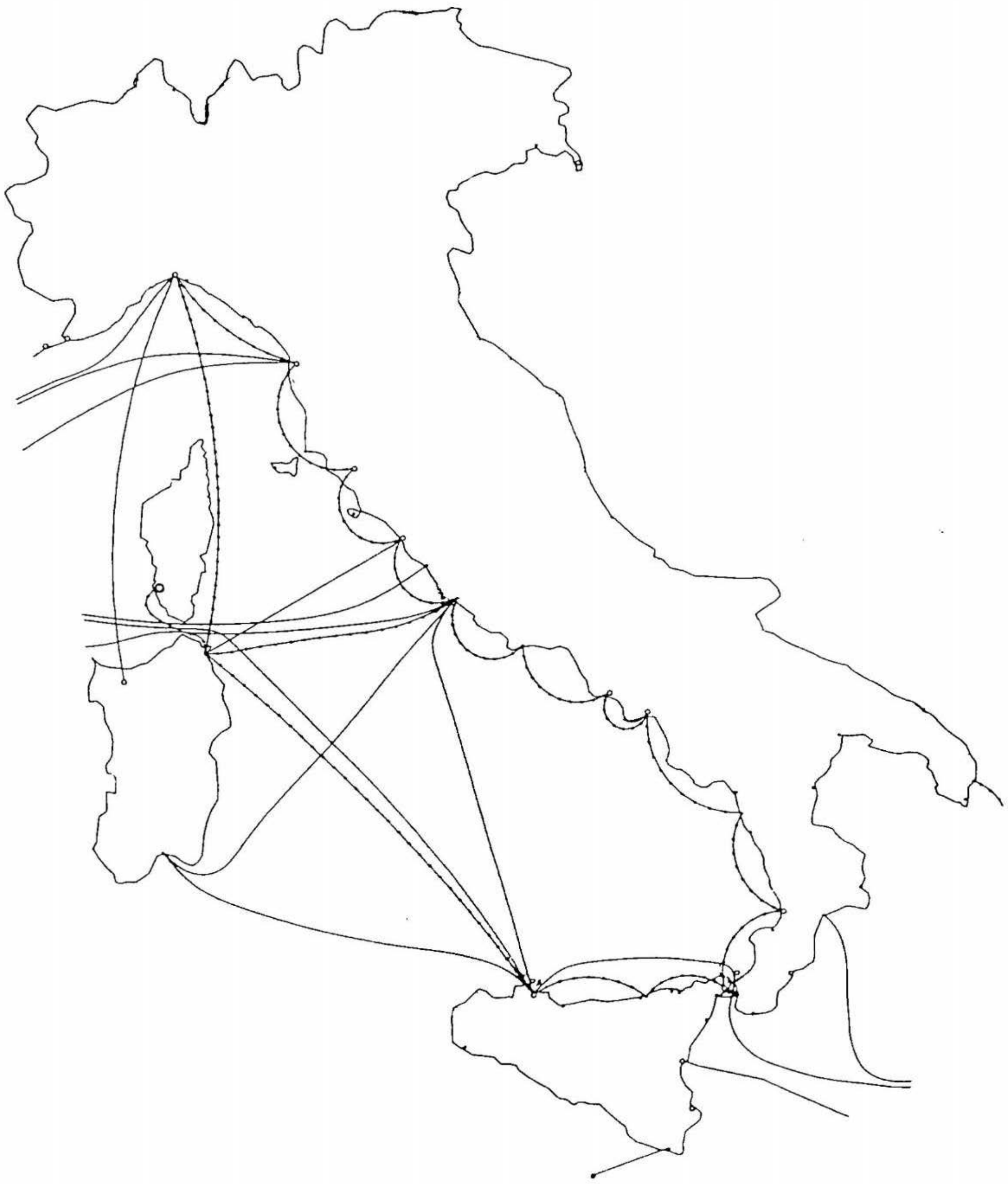


Figure 1—Italian submarine cable network, 1990

Monitoring of Electrical Parameters

These actions are concerned essentially with the constant monitoring of terminal equipments to keep transmission pilots, power supply alarms, supervision signals related to gain of repeaters, etc., under control.

Periodical Inspection of Landing Sites

These actions are aimed at preventing damage to the mechanical protection of cables on the land stretches between beach-joints and repeater stations that is usually caused by incautious and often unauthorised excavations.

Periodical Tests on Spare Parts

Periodical tests on spare parts are concerned with spare equipments such as repeaters, equalisers (for coaxial cables), cables and any other device that, in case of a repair at sea, are needed to be inserted on the line or to make joints.

Repeaters and equalisers are kept in *ad hoc* depots located on coastal sites. A climatisation system keeps the air at constant temperature and humidity, free from saline components.

Spare equipment is periodically tested. Measures carried out on repeaters are aimed to keep the gain-frequency distortion under control.

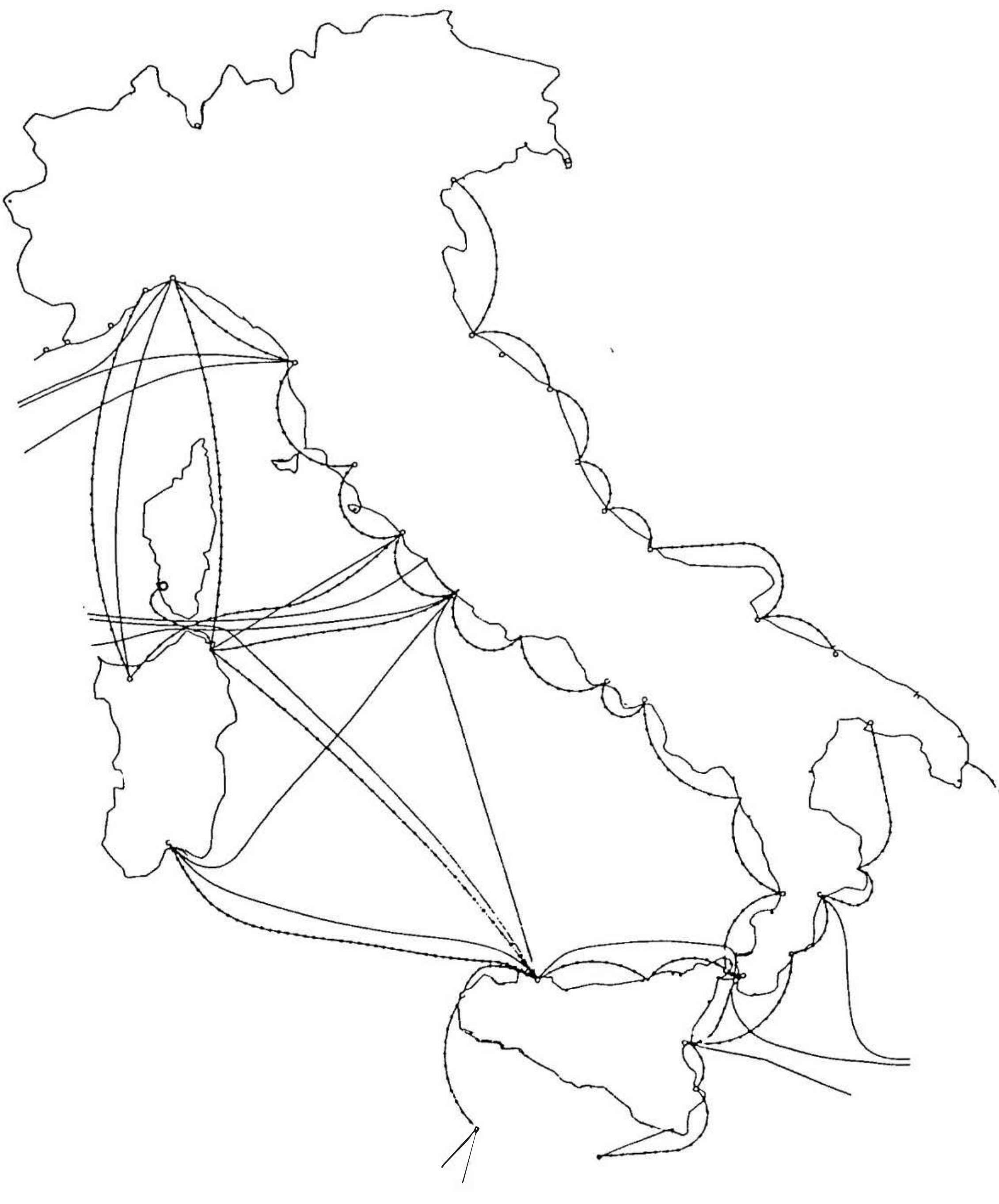


Figure 2—Italian submarine cable network, 1992

Spare cables are kept in suitable tanks. Cables provided with a metal protective layer are kept separated from non-protected cables, and are dipped in water in order to prevent corrosion of the iron layers.

Cables without a protective layer require protection from light that can cause crystallisation of the external polythene sheath. This protection comes from a cover made of dark material.

Protection Against Interferences

These actions are aimed at preventing damage caused on cables by operations carried out on the sea bottom such as fishing, anchorage and surveys.

Unfortunately drag fishing and anchoring on top of submarine cables are very difficult to prevent because these operations are not subject to previous authorisation. Therefore they are usually the main concern for telecommunication administrations and for other bodies dealing with maintenance of submerged lines (electric power cables, oil pipelines, water ducts, etc.).

Even surveys or exploitations of the sea bottom very often interfere with telecommunication cables although these operations can be controlled more easily through the exchange of information with the competent authorities.

According to regulations in the Italian region this authorisation for operating on the sea bottom is issued by Ispettorato delle Telecomunicazioni, which is a government body, part of the Italian Ministry of PT, where all applications, fully accompanied by all necessary information like the type of vessel, the co-ordinates of zone, sea depth, description of operations, etc., have to be addressed. The Ispettorato delle Telecomunicazioni will grant the authorisation after consulting all the concerned authorities, telecommunications (ASST), fishing, environment, coastal guard, etc., and will either fully authorise or apply limitations.

On the Italian part ASST is usually concerned with the highest number of interferences at sea, being in charge of the largest system, by far, of submerged lines.

General information about the submarine network layout is issued through naval maps, to inform all operators at sea as much as possible in order to prevent accidental faults. Nevertheless the need to spread this information conflicts with the fact that the same information should be kept confidential to a certain extent for security reasons.

When an interference is detected, ASST will put limitations to the authorisation, issuing the diagram only of the section of the concerned cable(s).

When in spite of all measures taken, a failure occurs, the corrective maintenance procedure starts.

Corrective Maintenance

Actions for corrective maintenance include:

- fault location, and
- repair operation.

The location of a fault and the detection of its nature are the first actions to be taken.

On land sections ASST follows the same procedure as for land cables. The repair work is then carried out by their own engineers with the co-operation of a contractor company.

On sea sections the fault location (repeater or section of cable between repeaters) is obtained with the use of the supervision systems and echometers.

If the fault is located at sea a cableship comes into action. She is first sent to the appropriate depot to collect the spares and then she proceeds to carry out the actual repair work.

To share the high cost of cableships, ASST is a member of an international pool in charge of the maintenance of almost all mediterranean cables.

At the end of a repair session at sea a report with the new diagram of the altered section is produced in order to update the link's data.

In the period between 1979 and 1989, the total number of faults at sea on an average length of about 10 000 km of submarine network was 45; that is, 2·25 faults per year.

THE GECAV SYSTEM

All activities connected with the operation and maintenance of a submarine network require a full collection of data and an easy access to it.

In particular, protection against interferences and corrective maintenance actions require an easy and fast consultation of data in order to be able to take prompt decisions.

GECAV is a computer-based system that meets these requirements.

The information in GECAV is kept in three forms:

(*a*) graphical,
(*b*) description files, and
(*c*) documents.

The outputs can combine the three different forms of information.

The configuration consists of:

Hardware (see Figure 3)

Olivetti M380/XPI personal computer:

microprocessor Intel 80386, 32 bits, 20 MHz
8 Mbyte RAM
135 Mbyte hard disc (seek time 20 ms)
1·2 Mbyte 5·25 in and 1·44 Mbyte 3·5 in floppy disc

High resolution Olivetti graphical kit:

Intel 80387, 20 Mhz math. coprocessor
Matrox PG 121, 1280 × 1024, 1·5Mbyte graph. card
Olivetti 19 in, 1280 × 1024 colour monitor

Hardcopy colour printer:

Seiko CH-53112
A3, A4
Thermal printing
7 colours
8 dots/mm (2048 × 2944)
RGB (7·5 Mhz–130 Mhz) video interface
Paper and ink for 600 copies

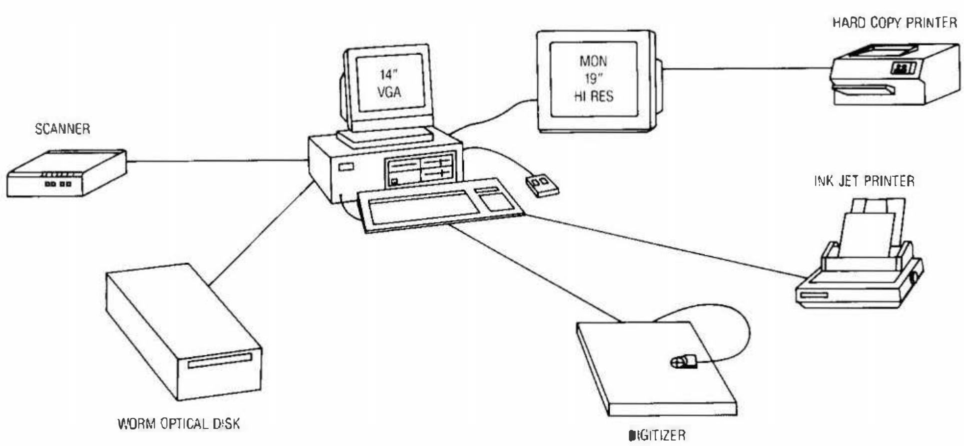


Figure 3—GEVAC system

Graphtech 4600 digitizer:

A3
RS232

Microtek MSF 3002 scanner:

A3 300 dots/inch
24 bits colour

WORM 800 Mbyte optical disk:

Cartridges 400 Mbyte per side

Honeywell printer:

136 col., 200 cps

Software

The operating system is MS-DOS 4.01. The implementation is based on Microsoft BASIC 7.0 and Professional Development System that allows the generation of sophisticated programs in MS-DOS environment.

The main features of the software are:

- BASIC 7.0 professional developer system language.
- ISAM (index sequential access method). Effective method for handling complex data files.
- User interface toolbox. This tool allows effective handling of windows by using special BASIC procedures.
- Far spring support, program overlay and other utilities implemented by Microsoft to optimise space and speed of programs.

THE DATABASE

The three aspects of the database have the following characteristics:

Graphical Aspect

A geographical scenery of the submarine network is given on graphical maps containing fixed information.

Maps have three levels of definition according to the represented zone and they are hierarchically tied to each other as follows:

(*a*) The main map contains coast to coast the whole Mediterranean Basin at a scale of 1:1 000 000 with a definition of 20 000 dots. This map does not require up-dating.

(*b*) Zonal maps (sub-divisions of the Mediterranean Basin) at a scale of 1:25 000 (1000 dots)

(*c*) Cable landing point maps at a scale of 1:1000 (1000 dots).

Maps can be shown in three different projections: Lambert, Mercator, Table projection.

All auxiliary information normally used in nautical maps (such as rivers, cities, political borders, etc.) can be shown on the maps as an overlay enabled by the operators. The display of the maps can be obtained both on the video-screen and on the associated printer (hardcopy). An *ad hoc* program, fully guided to help operators, allows the addition of zonal and cable landing point maps due to the modification and growth of the submarine network.

The system interface is friendly enough. Some significant functions are:

- Sub-division of the graphical video display in four work-areas in order to allow the use of four windows at the same time.
- Use of the alphanumerical video display to have auxiliary information on the geographical display.
- Access to essential functions by mouse or keyboard.
- Overlapping (if required) of the geographical reticule choosing grade of resolution.
- Automatic conversion of co-ordinates (nautical miles into kilometres, vice versa, etc.).
- Finding the distance between two points.
- Selection of objects.
- Filling closed areas.
- Help on line.

Through a graphical editor it is possible to edit the basic objects (lines, circles, labels, symbols, etc.) on any map; they can be moved, magnified, made smaller, deleted, modified, stored, by means of a mouse.

The graphical editor also allows the production of maps. Pictures can include additional information appearing in two bands placed at the top and the bottom of the picture under the form of short texts and symbols, taken from a library.

Descriptive Aspect

The descriptive database is divided into the following sections:

- Cables file
- Spare parts
- Tables
- Security

Cables File Section

The most important file is the cables file as it contains all information concerned with all the Italian submarine links.

Each cable is described as a polygonal line and information is divided in three sections:

(*a*) Information of the cable as a whole:

Station, town, country of Terminal 1
Station, town, country of Terminal 2
Type of cable
Sequential number
Length
Total capacity
System 1 (pairs, capacity, utilisation)
System 2 (pairs, capacity, utilisation)
System ...etc.
Date of activation
Date of disactivation

(*b*) Information of vertices of the polygonal line: (repeaters, equalisers, joints, beach units, etc.):

Sequential number
Latitude
Longitude
Depth
Type of equipment (repeater, equaliser, joint, branching unit, etc.)
Service (whether in or out)
Pointer to spare parts file

(*c*) Information of the segments of the polygonal line:

Numbers of adjacent vertices
Type of cable
Length
Service (whether in or out)
Pointer to spare parts file

The cables file is up-dated when a new cable comes into service and when an alteration of the layout is introduced as a consequence of a repair work; in fact repairs at sea often require the introduction of new segments replacing part of the original layout so that the number of vertices and segments of the new layout differs from the original one.

Removed vertices and segments are not deleted from the file, they are kept with an 'abandoned' label.

Of course information of the new characteristics of the introduced section, if there are any, will be digited together with the rest of the data.

The total length of the cable resulting after the repair is automatically up-dated.

Data can be extracted from the cables file in three ways:

(*a*) listings,
(*b*) diagrams, and
(*c*) graphical forms.

The *listing* is the traditional inquiry of data either displayed on the video or printed on paper.

The *diagrams* are straight lines also displayed on the video or plotted on paper where all significant points (vertices, repeaters, equalisers, joints) appear under appropriate symbols. Other data like depth, type of cable, length of section, etc., will appear in alphanumerical form.

As the diagram of a cable is usually very long it will appear synthetically in its total length on the top half of the screen while on the bottom half a scrolling and zoomed image of it will show all the details along the link. In the meantime a coloured segment on the top image spots the relative position of the observed section. The diagrams can also be bidimensional and give the vertical profile of the link having the length of polygonal segments as abscissae and the depth of vertices as ordinates.

The *graphical form* consists in plotting the cables on the maps the number of details varying according to the scale of the map.

Cables appearing on the maps can be selected. All or only some of them can appear by means of parameters.

Measure units relevant to the link's data can be selected amongst decimals and non-decimals. The conversion of units is provided automatically.

Names and sentences associated with graphical maps can be written either in Italian or English, on request.

Spare Parts Section

The spare parts file is a necessary complement of the cables file.

The description of spare parts is grouped per single submarine system. Besides all possible technical data of the single spares, compatibility data amongst different type and models are recorded in order to make a correct use of them. Storage data are also recorded so that they can be immediately located.

An example of data relevant to spare parts is given below:

(*a*) CABLES

type of employ (sea bottom or land tails)
conductor (copper or optical fibre)
shield (simple, double)
diameter (internal diameter of external conductor)
capacity (number and type of optical fibre)
compatibility (interchangeability with other cables)
storage (depot where cable is kept)

(*b*) REPEATERS

code (identification of model)
brand
features (supply, gain, etc.)
compatibility (interchangeability with other repeaters)
storage (depot where repeater is kept)

(*c*) EQUALISERS

(*d*) JOINTS

(*e*) CONVERSION KITS

(*f*) PROTECTOR KITS

(*g*) OTHER DEVICES

Items (*c*) to (*g*) have records structures similar to those of items (*a*) and (*b*).

The spare parts file is up-dated (decreased) after a repair and (increased) after purchasing new equipment.

Records of all devices include free notes to grant flexibility of information.

Access keys normally used for information retrieval help to identify wanted spares and depots where they are stored.

Table Section

Tables are auxiliary files where all codes used in cables files and spare parts files are stored.

The main tables are relevant to

- sites (city names, acronyms, country, country code),
- cable (code, main characteristics, compatibility), and
- device (code, main characteristics, compatibility, symbols used in diagrams).

Data in the tables are given in Italian and in English.

Technical characteristics of the items appear synthetically in all tables although their detailed description is contained in the documental file.

Security Section

The security of the GECAV system was designed to prevent either intentional or accidental loss of information.

To prevent intentional loss of information, operators must enter passwords hierarchically to have access to:

- information retrieval only
- information retrieval and up-dating
- assignation of passwords and capabilities.

To prevent accidental loss of information the GECAV system can count on hardware and software redundancy; the database does not need frequent up-dating, or heavy log and recovery procedures; periodical copies are enough to protect data against accidental loss.

Documental Aspect

In the documental file, documents are stored as images in optical discs under a suitable index in order to be easily retrieved.

The documents are relevant to:

Maintenance rules
Maintenance contracts clauses
International committees recommendations
International agreements
Utilities for names and addresses
Data sheets of equipment and cables
Miscellaneous

ADVANTAGES

The GECAV system helps to have immediately all sorts of correct information in order to improve all maintenance activities.

Perhaps the greatest help is found in the detection of interferences with operations at sea.

ASST receives about 180 requests per year to which an immediate answer is usually vital to meet the industrial interests.

On reception of applications concerned with protection against interferences, ASST engineers are able almost immediately to draw up permits and limitations due to intersections with, or to proximity to, cables.

Applications are usually concerned with core boring, dredging and composed operations in certain polygonal areas.

In case of core boring the co-ordinates of the boring points are introduced in GECAV. Then a length of a radius representing the security distance is entered. In case cables are in the circle area, GECAV will give in output the distance between the boring point and the nearest section of each cable.

In case of dredging the co-ordinates of dredging segments are introduced in GECAV that will give the co-ordinates of intersections between dredging segments and cables or the smallest distance between dredging segments and cables.

Composed operations applications refer to a polygonal area in which case the GECAV procedure applies as an extension of the dredging procedure. GECAV will give the co-ordinates of intersections between the polygon sides and the cable sections, if any, or the smallest distance between the polygon sides and the cable section.

In all cases, input of co-ordinates can be done by mouse or keyboard.

A security band of a variable width along the cable can also be entered in GECAV. In this case, each cable will appear in the middle of a security area shown by two parallel lines.

This procedure is usually needed when layouts of cables are not accurate, especially for the older ones which were laid without the modern dynamic positioning techniques of cableships.

It is also needed when data relevant to operational zone and positioning of the operating ship are doubtful.

Personal Communications in the Intelligent Network

R. DE SÁDABA†

INTRODUCTION

Nowadays a new generation of advanced telecommunication services is being brought into being. These new services may be characterised because they impose high requirements on network signalling capabilities, so far as large volumes of service-related information have to be managed. These requirements exist not only during the call set-up and clearing- down phases, but also during the active phase of a call and, in some cases, without any call in progress.

Personalised services, which may be defined as those oriented to the user rather than to the network termination, are the best representative of this new generation. To provide personalised services, a network should be capable of supporting *personal communications*. Personal communications are based on some new concepts, such as *logical addressing* and *user-location tracking*. All of them may be summarised by the term *personal mobility*, which results from a set of new network capabilities. To support such capabilities an advanced infrastructure, called *personal communications system*, is being defined.

PERSONAL MOBILITY

Personal mobility may be defined as the ability (for a particular user) to move around freely by any means, keeping in touch by telecommunications. Access to telecommunication services is available to customers, without any concern for whereabouts, giving them the ability to place and receive calls as if they were at home once their identities are recognised.

Personal mobility is the final step in the way opened by terminal mobility, currently supported by mobile networks (for example, GMS). As opposed to calls in fixed networks, which have to address a *network termination point* (NTP), calls in mobile networks have to address a terminal whose location may vary with time. Therefore, the basic aim of the later networks is to provide telecommunication facilities to moving subscribers who, due to their need of mobility, must access the networks via radio links.

Personal mobility is a much wider concept than terminal mobility and, as such, it may be implemented either on mobile or fixed networks. That means that terminal mobility is not always required to provide personal mobility.

New network capabilities need to be available to support personal mobility. Among them, a very important one is the ability to address an individual rather than an NTP. Lets look for a while at the evolution of network addressing capabilities.

EVOLUTION OF NETWORK ADDRESSING CAPABILITIES

The possibilities for addressing for different networks are shown in the following table.

†Telefónica de España SA, Spain

TABLE 1

Network	Addressing capabilities
PSTN	NTP (improvements with personalised ringing)
ISDN	NTP or terminal (SAD, DDI)
Mobile Networks	Terminal
Personal Communications Systems	Individual

On the PSTN, the calling party addresses an NTP, but if distinctive 'personalised' ringing tones are used (depending, for instance, on the number dialled) some degree of improvement may be introduced as a NTP could have two different network numbers producing two different ringing tones, and corresponding to two subscribers.

On the ISDN it is possible to address a particular terminal connected to a passive bus, by using *sub-addressing* (SAD) or *direct dialling in* (DDI) facilities. Furthermore, D-channel protocol capabilities allow going beyond plain NTP addressing, as *high-layer compatibility* (HLC) and *low-layer compatibility* (LLC) fields identify the service and, consequently, the class of terminals.

With mobile networks, which are characterised by terminal mobility, the called-end addressing refers always to a terminal which normally is on the move. The network has to keep track of terminal location, mapping a logical address (by which the calling user identifies the desired called terminal) to the real network address determined by the actual terminal situation.

Finally, with personal communications systems the calling party really addresses an individual, and the network is responsible for managing his correspondence to either a terminal or a NTP, depending on the kind of personalisation utilised.

PERSONALISED SERVICES

Currently, in a fixed network a subscriber is associated with the network termination point to which his terminal is attached. Whenever a call is set up to him, the call is sent to such an NTP. There is a static relationship between subscribers and NTPs.

In mobile networks a subscriber is associated with his terminal. Calls are in fact addressed to the terminal, and the static relationship is established now between subscribers and terminals. However, there is now a dynamic relationship between terminals and NTPs.

To provide personal mobility, the relationship between subscribers and NTPs, as well as that between subscribers and terminals, have to be decoupled. The static relationships are then turned to dynamic ones, being NTPs and terminals—the access points to fixed and mobile networks, respectively.

In a personalised service, communications are associated always to customers, who are identified by a *personal number.* Such a number is later mapped in the network to the actual address at which the subscriber is located, in order to deliver to him incoming calls.

According to the CCITT, at least the following functions are needed for personalised services:

(*a*) authentication,
(*b*) location management,
(*c*) call handling,
(*d*) charging, and
(*e*) accounting.

The *authentication* function verifies subscriber identity, which is required to perform the remaining functions.

The *location management* function has to keep the correspondence between a personal number and a network address updated in real time.

The *call handling* function is in charge of the establishment and routing of calls.

The *charging* function applies the right tariff depending on the kind of call.

The *accounting* function registers the corresponding charge to the subscriber's account.

Possibilities of Personalisation

There are several possibilities of personalisation, depending on the application of the concept to outgoing calls, incoming calls, or both.

Outgoing Personalisation This refers to a subscriber originating a call. To personalise outgoing communications, functions (*a*), (*c*), (*d*) and (*e*) are required; but not function (*b*).

Incoming Personalisation In this case personalisation refers to the subscriber to whom a communication is addressed. To personalise incoming calls functions (*a*), (*b*) and (*c*) are needed, at least. Notice that for an incoming freephone call, functions (*d*) and (*e*) would also be needed.

Overall Personalisation Both incoming and outgoing communications are personalised.

The intensity of personalisation may vary in relation to the method used to personalise a communication. That mainly refers to the accuracy of the authentication function. Two methods may be considered here:

Algorismic Personalisation Subscriber identity is checked based on a personal number (PN) and a *personal identification number* (PIN).

Biometric Personalisation Subscriber identity is checked against several biologic parameters which are specific and different for everyone; for example, voice verification. This is a long-term method that will provide a very high level of accuracy on the identification of individuals.

Implementation Methods

For outgoing personalisation the authentication function is of paramount importance. In an algorismic approach, the calling subscriber has to provide his PN and PIN, whose correctness is checked before allowing him to do anything. To introduce such numbers, several solutions are possible.

DTMF Signalling The subscriber introduces his PN and PIN from a DTMF keypad or acoustic coupler.

Voice Recognition Natural language is used provided that a voice-recognition device with high-accuracy performance is available.

User-to-User Signalling In the ISDN, user-to-user signalling is used to support the communication between the subscriber and the computer which checks the PN and PIN.

Smart Card The authentication function is based on a smart card which is read by the terminal.

In a biometric approach some biologic data must be introduced by the subscriber, as finger-prints—a few spoken key-words—to be validated by the computer. Biometric methods may replace algorismic ones, or they may be complementary so adding a further level of security.

So far as incoming personalisation is concerned the most important function is *location management*, which is the management of the dynamic relationship between a PN and a network address varying with time. To implement such a function different solutions are possible, from lower to higher degrees of refinement.

Follow Me The subscriber notifies the network of his location whenever it changes, and the network updates the correspondence between the PN and the appropriate network address.

Call Hunting The subscriber only notifies his location once he knows, via radio paging, that a call is trying to reach him.

Personalisable Terminal By means of a smart card, the subscriber personalises a terminal in the vicinity of his location. The terminal notifies the subscriber's position to the network.

Personal Terminal A hand-portable terminal is assigned to every subscriber and is identified in the network by a personal number. Such a terminal is accessible irrespective of its location.

Notice that mobile terminals may also be personalisable. In that case, the location management function should be split into two: terminal location and individual location.

Personal Communications Systems

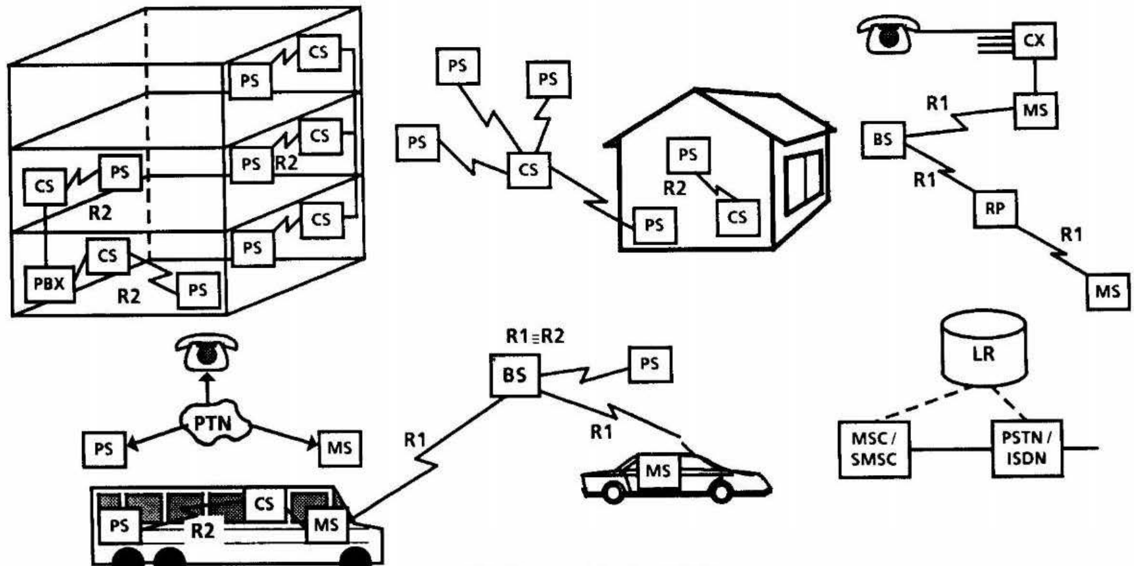
CCITT, CCIR and ETSI have already begun to study *personal communications systems* (PCS). In a broad sense a PCS may be defined as a logical network by means of which it is possible to address any subscriber by using a PN. The PCS may be accessed from any network, either existing or to be implemented in the future.

By means of a PCS the addressing capabilities should be independent of the service, the access networks, the terminals, and the subscriber location. Therefore, personal mobility will be fully achieved in a PCS which adopts the evolution of the personalisation concept as its medium-term target.

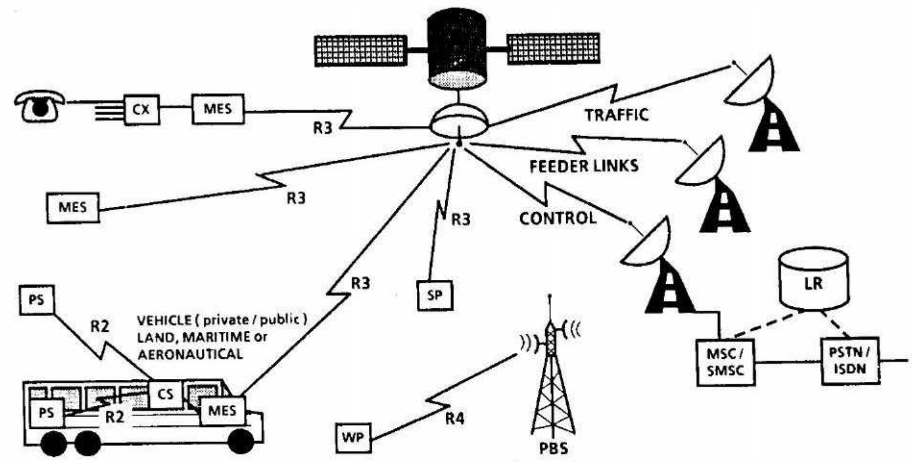
A PCS includes all the functions described in the previous Section. In Figure 1 the envisaged structure for a PCS is shown. Notice that terrestrial and satellite components are used to serve different needs.

Looking further into the future, one may think about the possibility of eliminating any numbering scheme and addressing individuals by their proper identity; that is, by name.

This, perhaps, will be possible during the next century, but only when biometric approaches to support the authentication function are ready, and algorismic ones are no longer necessary. Replacing the usual dialling process by the introduction of a subscriber identity would require very



(*a*) Terrestrial component



PS: Personal station
CX: Small rural exchange, etc.
BS: Base station (for MSs)
MSC: Mobile services switching centre
SP: Satellite pager
LR: Location register
MS: Mobile station
PTN: Personal telecommunications number service
MES: Mobile earth station
WP: Wide area pager
CS: Personal base station (cell site for PSs)
RP: Repeater
SMSC: Satellite mobile services switching centre
PBS: Paging base station

Source: CCIR WP 8/13

(*b*) Satellite component

Figure 1—Personal communications system

powerful voice-recognition systems and a lot of computing power to map names to real network addresses.

SUPPORTING INFRASTRUCTURE

To support personalised services, it is necessary to provide capabilities to collect, transfer and process a lot of information. Every call needs a particular treatment which may involve different entities. The call-handling function becomes more and more complicated, as sometimes pieces of information needed to process a call may reside in different points in the network.

A network supporting such capabilities should comply with the following two conditions:

- The functional entity which manages the processes and deals with the assignment of resources, signalling, switching, etc (that is, the control) should be able to access remotely-stored information, located either in a database or a network node, and
- All network nodes may be controlled remotely or, in other words, their control should be open and flexible.

To fulfil these two conditions an information transport mechanism is also required to support the interchange of information between the entities concerned in a particular call. A powerful network signalling system, such as CCITT No. 7, can well fit these requirements.

A network having all these capabilities is clearly an *intelligent network*. Therefore, this concept should be considered along with the personalisation one.

Intelligent Network

The concept of intelligent network is widely used nowadays and a lot of work is in progress in the international standardisation bodies to standardise and define all matters related to it. Here, avoiding any deep description of such a concept, let us consider some important aspects which have implications on personalised services.

In an intelligent network, all calls have a singular and intelligent treatment which depends on several parameters and variables. Several entities are involved in the control of a call, with the switching functions clearly separated from the control ones. The main consequence of this is that an intelligent network provides for flexibility. This flexibility applies to several aspects, for example:

- numbering,
- charging,
- routing,
- subscriber location,
- network management,
- service creation, etc.

Subscriber location flexibility provides a good support for personal mobility. This means that within an intelligent network there is no longer a one-to-one relationship between an individual and a network termination point. Consequently, the personalisation concept can well be implemented on such a network.

In Figure 2 the concept of intelligent network is represented.

Subscriber Access

The starting point, so far as personalised services is concerned, is the PSTN. In such kind of access, user–network signalling capabilities are very limited as, in many-cases, DTMF is not provided for and individuals should carry an acoustic coupler, which is in some way a nuisance. Moreover, only voice-based services may be provided to PSTN subscribers.

The introduction of ISDN and the provision of an integrated subscriber access allows the set of services a subscriber can access, as well as the user–network signalling capabilities, to expand. This is the first step to implement non-voice-based personalised services. But it is not enough. The supporting infrastructure should, in addition, be able to deal with any media information and consequently with communications which present very different requirements. The capabilities of the intelligent network as the supporting infrastructure should then be increased a lot. Such an evolution drives us to the concept of *universal information network* (UIN), also named *information network architecture*.

Universal Information Network

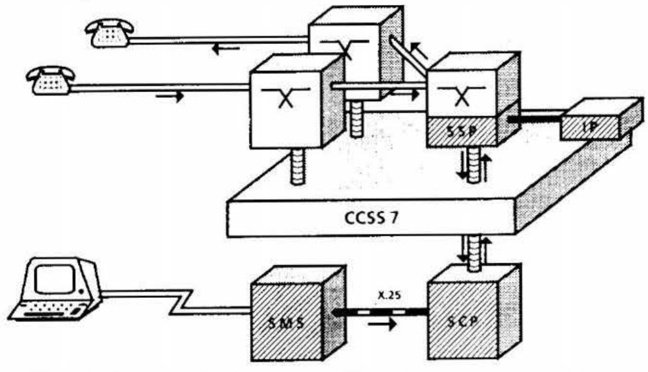
The shift from voice communications to other media-based communications will produce the evolution from the first releases of the intelligent network to the UIN. UIN will be a fully integrated structure which will allow the rapid implementation of information networking services, accessible from an universal adaptative user interface. Operations and network systems will be integrated in UIN and functions such as dynamic bandwidth allocation, customer network management, network automatic call distribution, etc, will be available.

If the personalisation concept is to be applied to any type of service, the user will have personalised access to information of any kind, anywhere and at any moment. To comply with that, two functional architectures will be needed:

- a service control architecture, and
- a service access architecture.

The *service control architecture* should have the capability to support any type of service, either narrowband or broadband. Therefore, B-ISDN entities will be components of such an architecture.

The *service access architecture* should provide the users with universal and adaptable access to services and will keep some degree of independency from the service control architecture. The service access architecture will contain the user–network interface and should support a very powerful user-network signalling system.



SCP: Service control point SSP: Service switching point
IP: Intelligent peripheral SMS: Service management system
CCSS: Common-channel signalling system

Figure 2—The intelligent network concept

As those two architectures are intended to be integrated in UIN, such a network may be identified as the long-term supporting network for universal personalised services. Therefore, all the previous realisations including personal communication systems will migrate, in the long term, to UIN.

CONCLUSIONS

In this article, the concept of personalised service has been reviewed, considering its evolution from a 'follow-me' based implementation to personal communications systems. Personalisation classes and methods to implement them have also been described, and the network infrastructures which can support personalised services have been introduced.

The importance of the personalisation concept will increase progressively as time goes by. In fact, as we are already in the information era, one may not be wrong to think that the capability of accessing information irrespective of location and time will be of paramount importance for the information age man.

Personalised services are beginning to be implemented nowadays. Firstly, they reside in fixed networks which take advantage of the capabilities of intelligent networks. Subsequently, personal communication systems will provide a more elaborate realisation of the concept. Finally, UIN will build the network basis to support universal personalisation which means, personalised access to any kind of information whenever the user wants and wherever he is.

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Mobile Communication—Channel Modelling

P. CONSTANTINOU†

DEFINITION OF A MOBILE CHANNEL MODEL

A mobile channel model is a set of mathematical expressions into which channel characteristics obtained from field measurements can be inserted in order to predict the performance of a proposed mobile communication system.

The basis for a model may be either theoretical or empirical, or a combination of these two. Theoretical propagation models allow a recognition of the fundamental relationships that apply over a broad range of circumstances. They also allow definition of relationships that exist among any combination of input parameters. Empirical models are derived from measurements and observation, and offer a major advantage in that all environmental influences are implicit in the result regardless of whether or not they can be separately recognised and theoretically studied. Empirical models offer the opportunity to provide probabilistic descriptions of the propagation phenomena. The validity of empirical models is limited only by the accuracy with which individual measurements are made, and by the extent to which the environment of the measurements adequately represents the physical environment in which the model is to be applied.

UMTS—A NEW SYSTEM

The Universal Mobile Telecommunication Service (UMTS) will provide a personal communication service and will be composed of several different types of subnetworks; for example, cellular networks, microcellular networks, wireless PABXs etc. The UMTS terminals will have the capability to access any of these subnetworks. The system will provide a universal coverage, utilising different types of cell sizes, for indoor and outdoor communication, and it is proposed to operate in the 1·7 GHz band. The traffic will include both analogue and digital transmission with a bit rate of up to 2 Mbit/s. For the microcell structure the system will use base antennas of a low height installed on the top of lamp-posts, and will cover areas of less than 200 m. For the proposed UMTS, as in any new system, it is desirable that the radio propagation channels to be used in the 1·7 GHz band are fully characterised.

PROPAGATION ASPECTS

In a mobile channel the transmitted waves are scattered, diffracted and attenuated. The various scattered components interfere, building up an irregular field distribution. The signal at the receiver is therefore attenuated and distorted. The severity of this disturbance depends on the specific physical properties of the scattering environment. The propagation of electromagnetic waves near the ground or inside a building due to diffraction, scattering, reflection and absorption of the incoming signal is broken into several components which are attenuated and delayed differently. The signal at the receive antenna is thus composed of a direct component and a delayed, scattered component. The direct path can be obstructed, depending on the antenna location and shadowing conditions. The degree of shadowing varies very strongly with the movement of the mobile antenna, leading to equivalent time fluctuations of the received power of the direct and delayed components. From the above it can be seen that the mobile radio channels are randomly dispersive in both time and frequency. Therefore for digital transmission when the duration of a transmitted symbol is anywhere near the fading correlation time for the channel, an increase in the probability of error will result due to time selective fading caused by Doppler effects as a result of vehicular motion.

Similarly, if the bandwidth of the transmitted symbol is close to the coherence bandwidth of the channel, an increase in the probability of error results from frequency selective fading due to multipath propagation. On such channels therefore, there exists an optimum combination of digital symbol rate and symbol shape that can be chosen to minimise the probability of error. Even if the time-bandwidth product of transmitted symbols is chosen so as to make the channel non-selective, flat fading causes an effective signal-to-noise (S/N) degradation which must be accounted for in the system design.

It is clear that accurate characterisation and modelling of the UMTS 1·7 GHz mobile channel is a necessity. The required information for this characterisation includes knowledge of the statistics for signal fading, of the dispersive nature of the medium, and of the additive noise that can be expected in a mobile radio environment.

WHY MODELLING

To characterise the UMTS mobile channels requires a complete knowledge of the propagation parameters described above for all environments where the system will operate. Conducting measurements to obtain all propagation parameters for all possible environments is an impossible task and for a limited number of environments is a time consuming exercise. In addition, testing a new system requires repetition of the measurements with the same propagation medium; that is, a stable propagation environment. Therefore a propagation model is required which provides all the parameters which characterise the mobile channel.

Complete channel characterisation is required by the equipment and mobile radio systems design engineer. Propagation models that apply to a wide variety of locations, but in a limited frequency band and for limited distances, are needed for general system design, such as when systems that will operate in many locations are being developed. When a given performance objective is to be met in a known location, the specific system design requires a propagation

† National Technical University of Athens, Greece

model that accounts for relevant environmental and topographical information.

Allowance for such phenomena can only be made if a model is available which accurately describes the expected probability distribution of the envelope of signals received over a mobile radio link, and the amount of dispersion that can be expected.

WHO WANTS A MODEL AND WHY

In a mobile communication system, as in any communication system, we can identify three major parts: the transmitter, the channel and the receiver. In the transmit site the signal must be conditioned in such a manner that distortions introduced by the channel are overcome. This task involves coding, pulse shaping and modulation. Therefore prior information about the channel is a necessity. The receiver task is to extract the information signal from the received signal by implementing all the available techniques such as equalisation, demodulation, error correction, error detection and decoding. These tasks require complete knowledge of the mobile channel.

In a mobile system while the receiver is moving it will receive the signal(s) from a channel which continuously changes. This channel variability is a function of time and location of the mobile in each environment, and demands, from the design point of view, certain problems of handover to be resolved. Handover study can be completed assuming knowledge on signal level as a function of the environment, co-channel interference, statistical distribution and spatial correlation of the fast and slow fading signals; that is, a description of the channel(s) where the handover process will take place is required. The distinctive challenges of designing an equaliser for fading channels are:

(*a*) the necessity for continual and rapid updating of the equaliser coefficients to track the changes in the channel.

(*b*) a need to compensate for multiple paths with nearly equal strengths and for deep nulls within the bandwidth of interest.

To meet the challenge of designing an equaliser, information on tap weight values, type of fadings experienced and probability distribution of delay spread must be available to the design engineer so that he can determine for what percentage of locations an equaliser, of whatever dimension, has an effect.

Error control requires information on CNR and CIR, time dispersion, random FM, error frequency and distribution.

The type of antennas to be used and power requirements demand information on signal level, interference environment and noise environment.

A knowledge of channel characteristics is necessary so that frequency allocation, channel bandwidths, and channel spacings can be set down in optimal fashion. Without such knowledge, channelling schemes currently being used in the lower frequency bands, will most likely be applied in the UMTS allocated band, resulting in possible inefficient use of the available spectrum.

UMTS MODEL DEVELOPMENT

The process of developing the channel models for UMTS involves a literature review of existing propagation models, mathematical analysis of an idealised channel, measurements in different type of propagation environments for the collection of data required for the characterisation of the channel and modelling of the fading and dispersive properties of the 1·7 GHz mobile radio environment. The models, selected as appropriate, are used to predict the performance of the proposed 1·7 GHz UMTS.

PROPAGATION GROUP ACTIVITIES

The parameters of the mobile channel which are required for the development of the propagation models are the following:

Signal attenuation—Path loss.
Signal fading (fast and slow fading)
Fading depth and rate of occurrence
Impulse response:
  Mean delay
  Delay spread
  Delay interval
  Delay window
  Channel tap setting and weight values
Noise environment
Interference environment

To provide all the above parameters to the different Core Tasks in the UMTS the Propagation Group is involved with the following Work Packages:

Dr. Neher Lab.	'Outdoor Wideband Propagation Measurements. Time delay Characteristics.'
British Telecom	'Measurements of wideband channel in cells less than 0·2 km.'
Ericsson	'Shadowing measurements for microcells.'
Televerket	'Propagation measurements.'
Finnish PTT	'Use of satellite maps to predict propagation.'
Norwegian PTT	'Wideband Propagation Measurements in Urban and Rural Terrain.'
OTE-NTUA	'Channel Modelling.'

PROPAGATION GROUP ACCOMPLISHMENTS

At the end of the second year of the RACE project the Radio Propagation Group has accomplished the following tasks:

Indoor measurements of wide band channel characteristics in cells of area less than 0·2 km^2 Ref. RMTP/RB/E094

Outdoor wide band measurements (IR) for suburban environment. Ref. RMTP/RB/H404.

Measurements on Micro Diversity Performance in Indoor Microcells in the 1700 MHz Band. Ref. RMTP/RB/J041

Measurements on Penetration Loss by Buildings at 1·7 GHz. Ref. RMTP/RB/G005.

RMTP Propagation Models (Issue 2). Ref. RMTP/RB/S303.

A document on propagation models to be used by the Members of the RMTP has been issued (Issue 2: Draft). The document presents indoor and outdoor propagation models. For each case path loss (narrow band) and impulse response (wide band) are modelled. The models are based on measurements conducted by the RACE MOBILE Propagation Group and from data available in the literature. The final document on 'UMTP Propagation Models' will be available at the end of 1990.

Prospects for Personal Communications in France During the 1990s

A. G. TEXIER†

WHAT ARE PERSONAL COMMUNICATIONS?

It is generally meant that a *personal telecommunications* service enables users that have subscribed to this service to send and receive calls and/or messages, irrespective of their geographic situation, from any user-network access.

Therefore, personal telecommunications are to be distinguished from mobile radiocommunications, although in many cases it will use it. Mobile radiocommunications includes service calls (dispatching, ...) which are not devoted to persons but to employees, and most of the time presently mobile radio calls are established from and towards terminals; that is, it takes the role of the line in fixed networks.

Personal communications can also be a feature of the fixed network: when he is at home or in his office, why would the subscriber use systematically a radiotelephone, more expensive and presently of less quality than the POTS?

Nevertheless, it is sure that mobile communications have many advantages: in modern life people are moving more and more and need more and more to communicate. Moreover, personal communications is more efficient than line communication since you are sure if a call is answered then you reach the people you need (and not his or her secretary). In certain cases also, privacy could be an interesting feature.

Presently, four axes of development are followed by France Telecom: development of mobile radiocommunications, development of electronic mail, development of call transfer and development of mobile access to the network.

DEVELOPMENT OF MOBILE RADIOCOMMUNICATIONS

As discussed above, personal communications is more than radio, but radio will be the main vector of it. France, a well developed country in telecommunications, is presently under-developed in the radiocommunication field; by the end of the year 1989, there were only 200 000 cellular subscribers compared with nearly one million in the UK.

Nevertheless, an ambitious catching-up plan is under development and is based on the introduction of the GSM pan-European cellular system by the end of 1991/early 1992 as regards the commercial service, and of a telepoint service named *POINTEL* in 1991.

By the year 2000, it is felt that the market could be about 10 up to 15 million mobile telephones, provided that adequate frequency allocation is made available at WARC 92. It is too early to know how this feature would be distributed between these two systems. It is foreseen that wrist-watch pagers or equivalent would be available in the second period of the decade.

† France Télécom, France

DEVELOPMENT OF VOICE AND ELECTRONIC MAIL

Voice mail is used more and more, either in business or for private needs. The recent introduction of remote control voice recorders allows the distant pick-up and erasing of voice messages. Therefore, such recorders can be a basic component of personal communications.

Electronic mail is traditionally used for business in private corporate systems. However, the development of electronic mail is slowed down due to the fact that these systems are only opened within closed user groups.

A true open electronic mail service, named *MINICOM*, has been opened this year by France Telecom. The basic feature of MINICOM is that any telephone subscriber—that is, everybody—can participate to this mailbox service by use of a Minitel: there are presently more than 5 million Minitels in France.

Specific efforts have been made as regards to the economics of the service and its tariff is presently fixed only on a consultation charge of less than 1 FF/minute on peak hours (exactly 0·98 FF). To keep this service simple and cheap the charge is applied to the calling line in real time. So MINICOM is not completely a personal communication service, but, however, its universality gives it good advantages to be used in a personal communication environment.

It is already technically proved that access to the service, which is presently ensured by the user's keying a telephone number and personal keyword, could be done by means of a smart card. This smart card could be identified by a specialised centre, which would transfer the call to the message centre and could also ensure afterwards the billing and accounting of the service, by use of intelligent network techniques. Transition is only a question of cost and would make a step further into the field of personal communications.

CALL TRANSFER

Call transfer is a commercial service, both in the telephone network and in the Transpac packet switched network.

In the telephone network, the service is a transfer of calls from one telephone line to another, on a national basis. Cost of this service is less than 10 FF per month and service is available to all subscribers connected to an electronic switch; the price of the re-routed call is charged to the called party. This service allows subscribers a 'follow me' function which is only controlled from the subscriber's line.

Therefore, the next step from a service's point of view would be a dynamically reconfigurable function that would allow the re-routing to be controlled from anywhere by the user. The main problem to be solved is the security of access by the user. The use of a smart card for security checks seems to be the most adequate technique.

In the Transpac packet switched network re-routing of a call from a Transpac line towards another can be carried out on a predetermined basis only.

DEVELOPMENT OF MOBILE ACCESS

The basic problem as far as mobile access is concerned is the problem of payment. On the fixed network, either the payment of the overall service should be very low, as is the case with MINICOM (such a feature allows the subscriber of a telephone line to make it available to others) or there is no taxation of the telephone line's subscriber, but taxation of the user of the overall service. Such a procedure needs a secure, and personalised user identification procedure. Up to now this type of procedure has been used only in specific cases: hotels and public telephones.

The history of public telephones is quite interesting on these respects: during the last decade in France, we have past from the classical, not very convenient coin payphone to the user ID smart card with the intermediate, and quite satisfactory, stage of a prepaid card.

The next step is to make telecommunications services available on a personal basis from private terminations on a network and not only from public telephones. The current prepaid card technology cannot be used, both for technical and security reasons. Therefore, France Telecom notwithstanding a possible agreement with the banking community as regards the use of credit cards is now introducing a specific personal telecommunications card called the *Pastel* card. This allows the user to place an automatic call either from public or for private locations and the user to be billed later.

It is foreseen that the usage of such a card can be extended to public transportation such as trains, planes, and so on. As regards usual mobile services like GSM and POINTEL, the basic assumption is that they would be used only by specific subscribers. Nevertheless, the GSM's SIM technology allows a difference to be made between the user and the terminal, which would be new in the mobile field. The first example of such a practice will probably be rented cars.

CONCLUSION

As a conclusion, it can be said that several existing independently services can be joined to develop personal communications.

In the years to come, personal communications are not only the dream of a small cheap pocket telephone used by everybody: this situation, if it will appear, will take decades. Personal communications is radio combined with intelligence in the network and in the terminals, as regards transfer of calls, storing of messages and remote control. Personal communications will be available in the years to come by the operators who have the will to do it, and the marketing expertise to sell it, notwithstanding the fact that they are PCN licensees or not.

Personal Communications Services and the Intelligent Network

A. BATTEN†

INTRODUCTION

Telephone companies throughout Europe, indeed the world, are introducing or planning the introduction of *intelligent network* (IN) technology into their public network architecture. The strategic justification for this development is straightforward: it allows the telephone company to serve their customers more directly by offering advanced telecommunications services that meet customers' needs.

IN gives the telephone company direct control over the development of new services by introducing service logic into the network which is held externally to the exchanges' call processing environment. The building blocks of services can be re-used to create different services without the need to change the exchange software. Competitive differentiation between telephone companies is possible because service development occurs within the telephone company's domain, not that of the supplier.

From the perspective of the customer—and note IN is a network-wide initiative and applies to all customers (residential and business)—the benefits of IN are most evident as a multitude of new services. For the first time in the history of telephony, the technology exists for individual customers to mix and match a number of standard features, and even to create new, individually tailored telecommunication services.

IN OVERVIEW

The major thrust of INs is to speed up the provision of new services. It is planned that this will be achieved by restructuring the existing public network, especially with regard to the way call-control functions are implemented. Specifically, call-control functions will be distributed between the exchange—shown as the *service switching point* (SSP) in Figure 1—and a new element in the network architecture called the *service control point* (SCP). The advantages of this arrangement can be exploited if an open interface to call-control functions is available to the telephone company. This would allow services to be created, developed and partially tested, off-line, in an environment called the *service creation environment*, and then downloaded into the SCP via a suitable management process in the *service management system*. All this activity would fall within the telephone company's domain. Further, if standardisation of interfaces occurs, the service logic can be used by all the telephone company's digital exchanges, not just those of one manufacturer. The final element in the generic IN architecture is an *intelligent peripheral*. This is a general class of network elements which enables the rapid introduction of new services that require collection of digits, playing or synthesising announcements, speech recognition and speaker recognition.

† British Telecommunications plc, UK

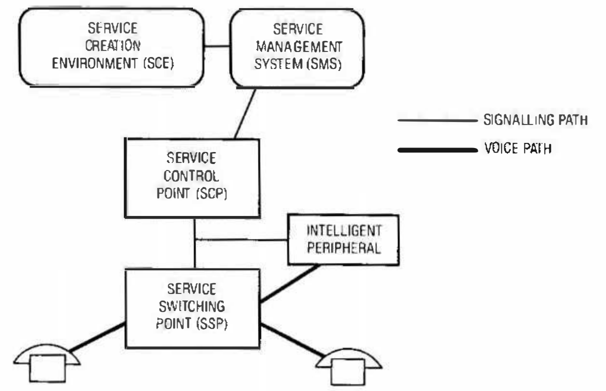

Figure 1—Basic intelligent network architecture

The distribution of functional call-processing entities is shown more clearly in Figure 2. Call processing within the SSP has virtual connection to service logic programs in the SCP. Messages between the SSP and SCP are invoked by certain events, known as *triggers*. Call processing in the SSP determines, using trigger tables, the need to activate a particular service logic program as it progresses through the various states in the call.

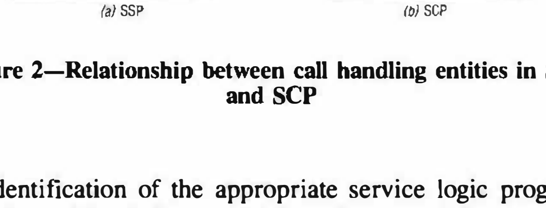

Figure 2—Relationship between call handling entities in SSP and SCP

Identification of the appropriate service logic program will be achieved by embedding the potential triggering points within a representational structure of call processing known as the *call model.* Figure 3 shows an example of a call model with embedded trigger check points between all call states. As a call progresses from one state to the next, the trigger check point interrogates a trigger table to determine the need to trigger a message to the SCP.

To illustrate this, a 'hotline' service would trigger a message to the SCP following the transition from ON-HOOK to OFF-HOOK. The SCP would return an instruction, like *route call* to a predefined directory number which the SSP

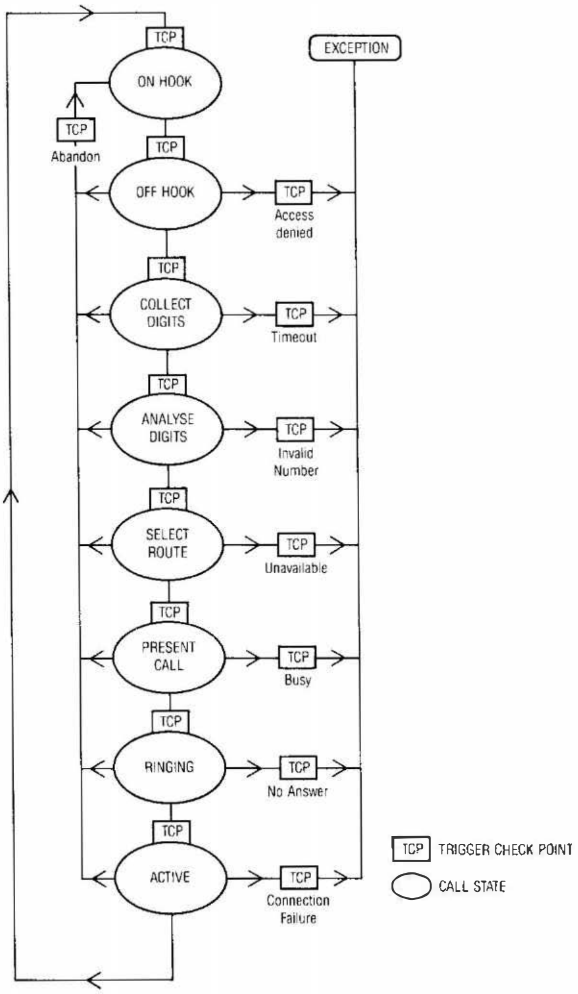

Figure 3—Typical call model

would use to route the call in lieu of digits collected from the telephone. A selective outgoing call-barring service would trigger following the COLLECT DIGITS state. Calls to premium rate services, such as '0898' would trigger following the ANALYSE DIGITS state, as would calls to 'personal numbers'.

PERSONAL COMMUNICATIONS SERVICES

It follows from the introduction that there is no single personal communications service as such, because the intention is that customers define their own personalised services. There are, however, a number of features which can all contribute to the fundamental objectives of personal communications services. The principal objective, which is making communications easier, can be broken down into three specific objectives:

- to increase the success rate of call attempts to 100%,
- to increase customer control over how incoming and outgoing calls are treated, and
- to integrate an ever-growing number of network services.

To meet these objectives, a wide range of intelligent features can be envisaged. The nature of these features, and their encapsulation into a unifying framework are discussed below.

PERSONAL NUMBERING

A framework for establishing personal communications can be built by extending the numbering plan to embrace personal numbering. The intelligent network could allow a unique personal number to be allocated to each individual. Upon dialling a personal number, the intelligent network would select a directory number determined by information held in the SCP and route the call accordingly. A simple case would be that calls to a personal number during working hours would be routed to the individual's office, and outside these times be routed to the individual's home.

Personal numbering has a number of immediate effects:

- callers only have to remember one number for each person,
- callers face better prospects of successful call completion, and
- personal number users are responsible for the accuracy with which calls are completed.

The name given to this information is a *profile*. Each personal-number customer has a profile, which is stored in the SCP. In the first instance, a customer's profile includes various directory numbers and time-of-day routing information. Additional information concerning various IN features is also stored in the profile.

Manipulation of information in the profile is potentially complex, especially for entering time-of-day routing information. Using an MF telephone, customers access a profile management centre which offers a voice-guided menu of update options. The design of the voice guidance system can take advantage of the intelligent peripheral's rich functionality by, for example, synthesising digits that a user has just entered to help verify the transaction.

In summary, it is clear that personal numbering significantly contributes to the achievement of integration. Call completion rates may also be improved. Customers gain some control over how their calls are treated by the network. Hence, all three of the objectives expressed above are met to some extent by personal numbering. IN service features supplement this framework in further pursuit of these objectives.

INTELLIGENT FEATURES

Intelligent features fall into two categories those contributing towards 100% call completion, and those which give the user increased control over calls.

Quest for 100% Call Completion

At present, it appears that up to half of all call attempts fail because the called party is not present at the attempted number or is engaged on another call (a small fraction fail due to network congestion, corresponding to the selected grade of service). Four conditions emerge from this.

The called telephone is not answered

In this case, a *no answer* exception message (see Figure 3) would cause a triggered invocation of the SCP. The SCP would select an alternative number from the profile of the called party and re-route the call.

The called telephone is answered but the intended party is not present

This condition presents more of a challenge to the personal-numbering concept. In this situation, there would be no point in re-dialling the personal number. From the perspective of the caller, the ideal solution is for the network to automatically recognise that the call needs to be re-routed. Solutions to this are likely to demand an enhancement to the switch-call model shown in Figure 3. For example, Figure 4 shows a DISCONNECT state which would follow the ACTIVE state; an exception trigger caused by the called party replacing the handset and the caller 'hanging-on' would be interpreted by the SCP as an instruction to re-route the call using information in the called party's profile. Another solution may use a mid-call trigger; the caller would enter a code, probably using the recall facility in addition to MF codes, which explicitly issues a command to the SCP to re-route the call.

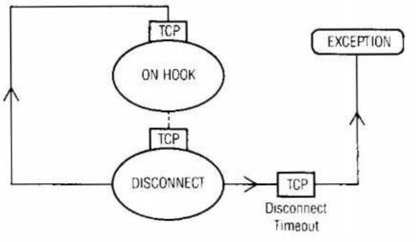

Figure 4—Exception trigger

The called party is engaged on a call

A number of solutions are applicable to this condition. Call waiting, executive intrusion, and automatic callback will be familiar to users of modern PABXs. Call waiting is, in fact, already available to customers of BT's star services. All of these features can establish a call to a party who is initially engaged. Alternatively, a customer may wish incoming calls to be forwarded if engaged, perhaps to a voice-messaging service. For this, the busy trigger in the call model would be set, which would invoke a re-route call request to the SCP.

The telephone is engaged by someone other than the intended party (and the caller believes that it is the intended party who is engaged)

This final condition requires a method of verifying who is using the called line and touches on a wider issue of personal numbering. Presently, it is assumed the user of a telephone is the subscriber for that telephone line and call charges are attributed directly to this subscriber. Personal numbering would decouple this arrangement to some extent, and allow customers to use any phone so long as they identify themselves at the outset. It can be envisaged that as personal numbering penetrates the network, so information will be available that effectively maps current physical connections back to personal numbers. Architecturally, this requirement is not trivial and the optimum solution has yet to be determined.

It should be emphasised that these multiple attempts at connecting calls could employ any network service, including PSTN, cellular, voice messaging and paging, and the order in which these are tried is defined by the customer. The only requirement is for a suitable directory number for the service to be held in the individual's profile.

Achieving Customer Control

A consequence of increased call completion is that individuals are, potentially, going to receive more calls, especially when away from the normal place of work. For many people, this is undesirable and the telephone company must answer to these needs by offering features that allow the customer to achieve control over how incoming calls are treated. Reasons for not wanting to receive calls are numerous, but it seems that in addition to the time-of-day routing described above there is a need to provide *call screening* according to the identity of the caller. Call screening allows individuals to prioritise incoming call attempts, and to route them according to the level of priority. For example, an individual may wish to route calls from business colleagues or members of a family to a currently used phone, but all other calls to a voice-messaging facility. It is even conceivable that this feature could be combined with time-of-day information for callers with different priorities at various times of the day.

The obvious method of screening incoming calls is to use the *calling line identity* (CLI) field of call-setup messages, and to compare this against a database of entries for the called number. As a result of this comparison, certain calls may be diverted to another number or may cause the phone to ring in a special way. The reliability of this service is dependent on the availability of the CLI. Circumstances where CLI is not available include calls using older exchanges, which are rapidly being replaced in the UK. Also PABXs, which would need to use advanced signalling such as DASS2 to communicate CLI along their trunks. In addition to the absence of CLI, there is the problem of misleading or uninformative CLIs such as calls from other personal-number users, from shared phones or from payphones. A longer-term solution may use personal numbers as the basis of screening, which would overcome some of these problems.

In addition to control over incoming calls, a number of features achieve the same for outgoing calls. Call barring will prevent calls to specified numbers, perhaps according to time-of-day, day-of-week, identity of caller or the caller's account status. Features such as short-code dialling and automatic call-back contribute to the principal objective by making outgoing calls easier.

SERVICE CREATION ENVIRONMENT

Offering intelligent call and control features to customers as individual options has only limited use, because introducing these inherently useful facilities will undoubtedly stimulate demand for combinations and enhancements to suggested services. Therefore, a means of expressing this logic and converting it into a form that can be used in the network is required. The name given to this facility is the *service creation environment* (SCE), and it exists to offer personalised service logic by giving the customer some control over the service definition.

The natural users of the SCE are the telephone company's marketing personnel, who are responsible for ensuring that customers needs are met by the services portfolio of the company. IN gives them direct power to quickly create services as described by a customer. As long as the service uses existing service logic building blocks, there is no need to consider critical mass, segment size or any of the usual constraints: each customer effectively becomes a niche market.

CONCLUSIONS

Using intelligent networks, many new service opportunities exist, for example calls can be made conditional on time-of-day, identity of caller, location or availability.

Basic telephony can use a logical routing plan rather than the present geographic routing plan. This use of personal numbering addresses the need for mobility in the first instance, but also serves as a framework for unifying customers' network services and features.

Services can be provisioned against individual customers rather than lines. This allows customised services to be considered and, because access to user data and service logic is not confined to a single switch, customers can roam across the fixed network and between networks.

By standardising the interface to call-processing environments of all exchanges, a uniform design of personal communications services is feasible.

Personal communications services will be designed and created by a collaboration of the customer and the telephone company's marketing personnel, ensuring a close match between customer requirements and services offered.

The intelligent network extends the scope of personal communications services by integrating a number of network services and enriching these with features that allow 100% call completion and customer control of how individual calls are treated. It therefore ranks as one of the most significant developments in the history of telephony.

Acknowledgement

Acknowledgement is made to the Director of Research and Technology, BT, for permission to publish this paper.

Vehicle Location in the Netherlands Trunking Network

P. J. K. LANGENDAM, and D. J. H. KORENHOF†

INTRODUCTION

In June 1989, PTT Telecom, Tele Atlas Nederland and Pijnenburg Microelectronics and Software entered into an agreement in principle concerning the possible establishment of a joint venture entitled *Vehicle Locating Systems*. A feasibility study was subsequently carried out. At a later date, Nokia and Bell Atlantic joined the project.

Vehicle Locating Systems will be engaged in operating the 'Vehicle Locating System', which is a platform for transport company fleet management. The system is based on a digital map of the Netherlands (developed by Tele Atlas), an advanced autonavigation system and PTT mobile radio telephone network, which is currently being developed. The product is expected to be available in its final form in 1992.

VLS will supply the complete product consisting of hardware and software and connection to the trunking network. See Figure 1.

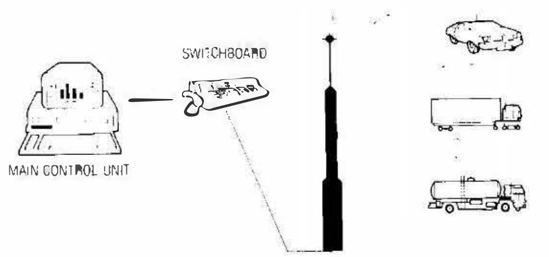

Figure 1—Vehicle locating system

MARKET DEVELOPMENTS WITHIN THE TRANSPORT SECTOR

Increasing restrictions imposed on the free transport of goods by traffic overload, toll collection and security are resulting into moves to make traffic flow management much tighter. There is also evidence within the transport sector of important developments, such as internationalisation and scaling up, which will further optimise logistics. The lorry is in all respects becoming a controllable extension of the company. These developments call for better and more decisive management. Such management in turn requires up-to-date and reliable information. Telecommunications and computers are vital components in the management systems.

These developments have led to a growing need to achieve greater efficiency and improve services. In order to limit the risks resulting from these changes, the transport and transhipment companies have responded with the following measures:

(*a*) reduction in stocks and delivery periods,
(*b*) greater production flexibility,
(*c*) integration of transport and distribution activities throughout the entire logistical chain.

Logistical pressures in turn increase in direct proportion to the prevalence of the following features:

(*a*) just-in-time deliveries,
(*b*) tight time schedule between receiving a contract and carrying it out,
(*c*) deliveries and/or pick-ups at many different locations,
(*d*) quantities only learnt at pick-up or delivery location,
(*e*) non-regular customers,
(*f*) goods with a high economic value or hazardous substances,
(*g*) the availability of multi-purpose vehicles,
(*h*) transportation of mixed cargoes.

What we see is a slow computerisation of the transport process.

INFORMATION REQUIREMENTS

Developments similar to those described have been noticeable in all sectors and the transport industry is no exception. Indeed, by comparison with other areas, the needs have been felt more strongly. A general feature of the transport sector is its dependency on other areas of economic activity. The demand for transport services is determined largely by a complex set of external factors, such as the level and physical distribution of (and the changes in) production and consumption. It is also a service industry; its quality is determined not by its intrinsic value but by the care, price and speed with which the service is provided.

Decisions are based not only on information about external processes (market trends, consumer behaviour, etc.). They are also based on information about internal company procedures. Many firms have introduced various kinds of management information systems (MIS) for adjusting their procedures effectively and at the right time.

Another specific feature of management information in the transport sector is the relatively complex nature of communication. This is because production and management are by definition at different locations. During transportation, driver, vehicle and cargo are beyond the direct reach of the transport company and the consigner.

A fully integrated 'transport control centre' with several applications will not be operational in the near future. Only concrete tools will make it possible to penetrate the transport sector with mobile datacommunication services (Figure 2.)

THE VEHICLE LOCATING SYSTEM (VLS)

The VLS is based on a digital map of the Netherlands (developed by Tele Atlas), an advanced autonavigation

† PTT Telecom, Netherlands

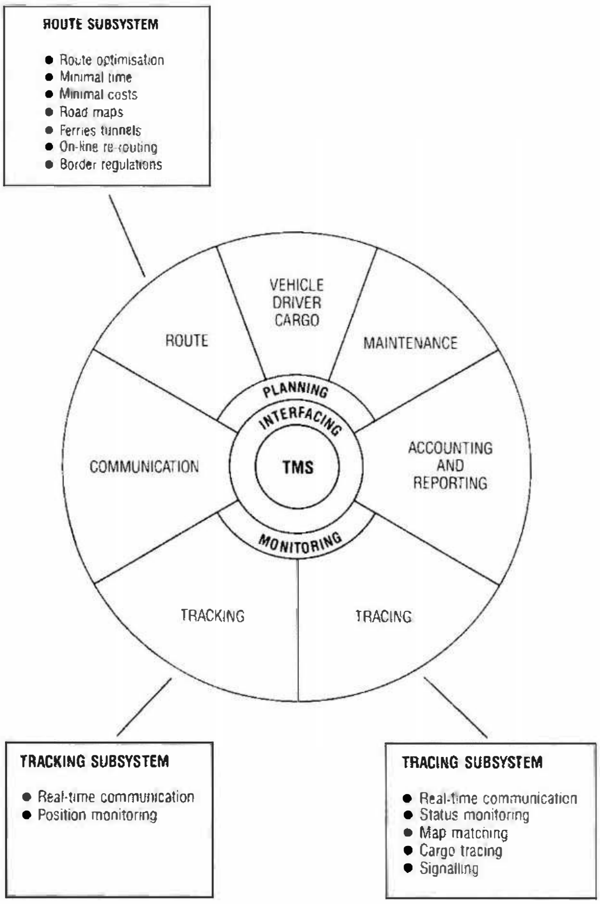

Figure 2—Information support of VLS

system (Pijnenburg) and the mobile radio telephone trunking network now being developed by PTT Telecom. VLS is essentially based on map-matching (within the range of location and navigation technologies). Sensors on the wheels of a vehicle (two) register all movements. These movements are 'matched' with a digital map. The digital map (scale 1:10 000) is on CD-ROM in the vehicle. So you can continuously see the vehicle 'driving' on a screen, in the car but also on the home-base. For the connection with the home-base you need some kind of mobile datacommunication. The technologies are compared in Figure 3.

The communication technology used by VLS (trunking network) is land mobile radio. This network will be operational for the national range and in the future on a European scale. For a short period cellular telephone (ATF 2) will be used.

The VLS consists of the following hardware and software:

(*a*) 'box' and screen (travel pilot),
(*b*) a digital map (of the Netherlands) on CD-ROM,
(*c*) an orientation and communication system,
(*d*) system software,
(*e*) basic application software,
(*f*) link-up service (initially ATF2, later national mobile radiotelephone trunking network and satellite),
(*g*) base station.

Modules (application software) can be added to the VLS to extend its range of application. Besides tracking and tracing, it can record arrival times, distances covered and distances to be travelled and can easily be integrated with existing information systems (thereby making them more effective). The basic VLS model provides companies with mobile data communication to enable them to notify a central operations room of a vehicle's current location. Accuracy is such that vehicles can be located to within a few dozen metres.

Tele Atlas is already anticipating the internationalisation of VLS by developing maps of other European countries and will supply regular updates of the map of the Netherlands.

Figure 3—Technologies by range

—URBAN AREAS———————— ——NATIONAL——————— ———INTERNATIONAL ——————

Location and navigation technologies

——Proximity beacons——————
———Deadreckoning————————
——————————Map Matching———————————————
———————————————————Loran C————————————————
————————————————————— Omega————————————————————
—————————————————————Radio Determination Satellite Service ————————
—————————————————————————GPS Navstar ————————————

Communication technologies

————Proximity Beacons ————— (infrastructure dependent)
—————Land Mobile Radio —————— (infrastructure dependent)
———————Paging ————————————————————————————(infrastructure dependent)
——————ATF 3 ———— Cellular Telephone —————————— ———————(ATF 4)————————
————————————Cellular Telephone ATF 2 ———————————————(infrastructure dependent)
————————————————Satellite/Voice & Data ——————————————————
————————————————Satellite /Data Only ———————————————————

A TOOL FOR FLEET MANAGEMENT

The term *fleet management system* (FMS) is one with which the transport industry is now familiar. Various forms of FMS are used, albeit on a limited scale at present and almost exclusively by large companies. FMS is a collective term and refers to a system which combines equipment on board a vehicle for transmitting information between the vehicle and its home base and information processing at the home base.

• transport of cash and securities	safety
• transport of perishable goods	speed
• transport of hazardous substances	safety
• courier amd express services	speed, return freight
• taxi services	return passengers/freight
• maintenance companies	speed, optimum routing

VLS SYSTEMS COMPARED WITH OTHER MOBILE SERVICES

The intention is to provide the service via the ATF-2 network during the trial period, switching over to the trunking network when it is completed (at the end of 1991).

The mobile radio telephone trunking network plays an important role: it is significantly cheaper than a national mobile radio telephone network, car telephones and satellite communications.

Obviously, there is already a wide variety of mobile communication and information transfer products, such as the 'semaphone' (paging system), the mobile radio telephone and the carphone. In addition, a number of new products are being developed, particularly in the field of satellite communications. However, no two products are identical. The place of the VLS will be determined by its specific product features and the pricing.

Optimum use of transmission frequencies means that it works out considerably cheaper than a national radio telephone network.

By comparison with systems which use a satellite link (for example, LOCSTAR, Prodat, Standard-C), the VLS locates vehicles with greater accuracy. However, this advantage is not relevant to all forms of transport. The VLS also scores over satellite communication as regards stage of development. The way things look at the moment, the VLS will be operational before most of the satellite-oriented systems. It is also appreciably cheaper for domestic use and more accurate than a satellite communication system.

WHY PTT TELECOM?

The threshold for non-transport linked investments in the transport sector appears to be high. VLS is a concrete step that marks the entry of PTT Telecom into 'the market for fleet management systems'. Depending on market trends, the same company may be used by PTT Telecom for carrying out any related activities in the transport sector.

The connection with the mobile telephone trunking network is equally important, since it will speed up full development and market introduction. VLS is an application that uses mobile telephony services. Each form of additional data communication means additional returns. Unlike current mobile telephony services, which are almost exclusively speech-based, VLS performs a complementary role; it does not duplicate existing features.

PTT Telecom will be better able to impose its standards on the market for fleet management systems, which is now being developed. This is characterised by a total lack of suppliers with sufficient know-how, means and ready products.

In short, for PTT Telecom, this venture means penetrating a new (communications) market.

The New Telecommunications Network: Architecture and Development Criteria

F. PARENTE, and A. PALAMIDESSI†

INTRODUCTION

The evolution of the telecommunications network has been traditionally driven by technological improvements, and the architecture of the network, together with the development criteria, was a direct consequence of technical-economic considerations coming from the telecommunications operators.

The general requirements of cost reduction and quality of service, essentially for telephone traffic, have recently become part of a more complex optimisation process in which a number of new aspects have to be taken into account.

THE BASIC NEEDS

Three main aspects may be listed that need to be carefully studied.

Technical-Economic Aspects

Digital transmission on optical fibre became a quite stable technology during the 1980s, consolidating its economic competitiveness in terms of both investments and operational costs.

This has led telecommunications operators to consider optical-cable systems as the basic infrastructure for the trunk network and, more recently, for the access network.

The above perspective of substantially homogeneous technology requires a unitary approach as far as the network architecture is concerned.

Furthermore, the network architecture should be compatible with the introduction of new systems, particularly the systems of the synchronous digital hierarchy (SDH).

The above consideration on optical systems, together with the massive introduction of digital switches and automatic cross-connection nodes, drives the telecommunications network in the direction of reducing the number of service distribution nodes, mainly for cost reasons, interconnecting them by transmission links at increasing rates.

The widespread trend to have several new and integrated services will make the nodes more complex and huge, and the technological possibility to easily transmit on optical fibre several gigabit/s will emphasise the above trend.

New Users' Needs

It is a widespread opinion that the evolution of network and systems will be driven by the market as much as by the technology.

The recent and forthcoming deregulations, together with saturation forecast for a number of traditional services, increase this predominant position of the user, being now able to choose among a number of alternatives.

In the above scenario, public network operators must produce the maximum effort to provide the customer with two key features: flexibility and quality.

As far as the impact on the telecommunications network is concerned, consequent to users' demand for new services and generalised quality, the following considerations may apply:

- The need to comply simultaneously with the requirements of several new services, in a very wide range of bit rates and distances, implies the modification of both the access network and the trunk network.

  The access network, in particular, shall be able to collect the various types of services, concentrate and transport them towards the distribution nodes, whose centralisation will be even more highlighted by the traffic moving from local to international.
- The need to provide the end user with a better quality of service, in terms of time for provision, availability of service and transmission quality, requires that the access network must have an architecture and transmission systems having intrinsic characteristics of quality and self-protection, as much independent as possible from the type of service.

Management Aspects

As far as telecommunications network management is concerned, the most important result to achieve for network operators will be a management system that is simple and powerful.

This should be accomplished by introducing a certain degree of 'autonomous operation' in the network itself (that is, for protection purposes), in order to reduce the load of the control centre; further improvement could come from the efficient modelling and layering of the network such that the 'virtualised network' seen from the operation system appears the most simple and manageable as possible.

From the architectural point of view, the priority target is therefore to simplify the network topology greatly, based on the following considerations:

- A more complex network configuration, even if it is proven to give some benefit in terms of investments, is very likely to imply higher operation costs and could severely affect further upgradings.
- When introducing high flexibility in the network, it is expected that a simple topology could make the advantages achievable by integrated operations systems (OS) greater and more quickly achievable.

† Società Italiana per l'Esercizio delle Telecomunicazioni p.a. (SIP), Italy

NEW TELECOMMUNICATIONS NETWORK ARCHITECTURE

Prior to giving details of the telecommunications network architecture, it is necessary to describe the basic layers (see Figure 1) in which the network should be organised:

Access network	From the end user to the service distribution nodes
Inter-service node network	Among the service distribution nodes and from these nodes to the transit ones
Inter-transit node network	Among transit nodes

As previously outlined, the development of the network will lead to (*a*) many services converging to a single user, (*b*) demand for better quality of services and (*c*) reduction of service distribution nodes.

These three points have consequences in the access network in terms of (*a1*) extensive use of optical fibre, (*b1*) network structures offering intrinsic and autonomously operated protection (ring-type) and (*c1*) introduction of 'distributed access points' in order to aggregate the various service accesses and convey them towards the nodes (Figure 2(*a*)).

A reasonable assumption for the future situation could be that a service distribution node will serve tens of thousands of users (50 000 – 60 000 as an average), then the number of nodes in most cases could reduce to 1/20 of the present figure.

As a consequence of this reduction, the user–service node distance could increase, in worst cases, up to 20 times the present distance for POTS.

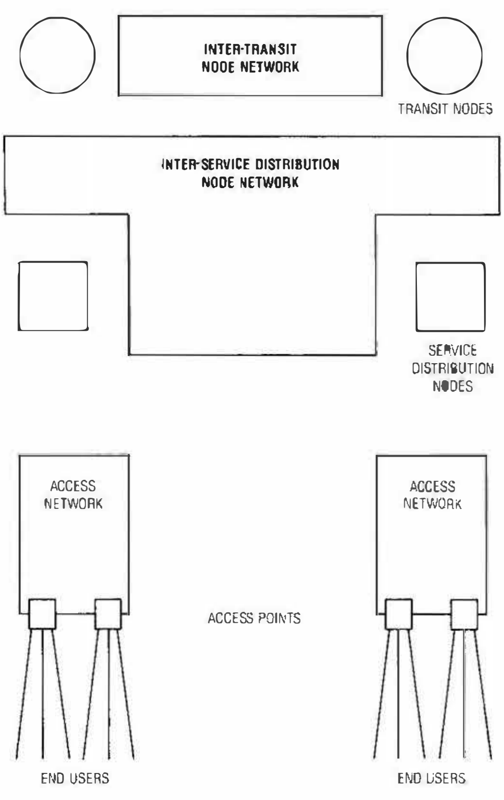

Figure 1—Telecommunications network layering

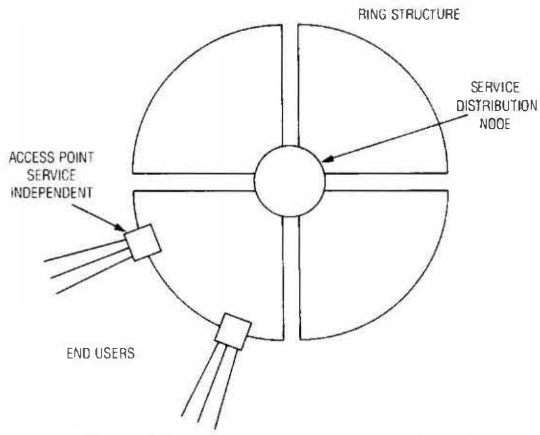

Figure 2(*a*)—Access network structure

This figure can be reduced to 10–15 times (15–20 km) considering the concentration of subscribers.

In this scenario, and assuming a short-term need of 2 × 64 kbit/s transmission capability per user, two 100-fibre cables would be sufficient to support, with 155 Mbit/s STM-1 rings, the traffic to each node, including redundancy for better availability.

In the long-term perspective that users' transmission capability will increase up to 155 Mbit/s as a result of growth in broadcasting services, each pair of fibres in the above mentioned 100-fibre cables should operate at approximately 155 Gbit/s.

Even if such a high rate could be not unrealistic, it can be reasonably assumed that each pair will transport some 256 times 155 Mbit/s, approximately 40 Gbit/s.

Assuming a ring-based structure for the access network, it seems reasonable for a typical services distribution node to handle four rings each one with 100-fibre cables having also taken into account network resources for automatic protection.

As far as the inter-service node network is concerned, the basic feature to be assured by this intermediate layer is the highest possible flexibility in terms of connectivity both between access points and between access points and services.

To achieve this goal, the network structure will be a 'logical' full mesh even if the physical structure will consist of a loose mesh together with a number of connections performed by the transit node of the upper layer (see Figure 2(*b*)).

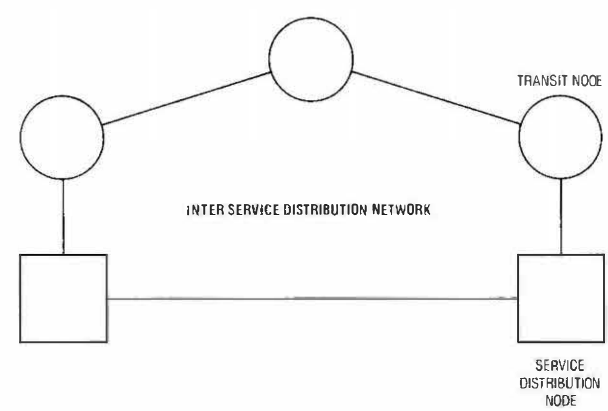

Figure 2(*b*)—Inter-service distribution node network

The requirements for this layer are:

(*a*) at least two routes shall be available between any two service nodes;

(*b*) the routing of services shall be operated by the service distribution node only (service rate cross-connect);

(*c*) the links among service distribution nodes, being logical direct-connections, shall be provided through transport-rate cross-connect equipment; and

(*d*) the transport-rate cross-connect shall provide re-routing for protection within this intermediate layer.

Based on the short-term assumptions for the user's transmission capability, a total trunk capability of 9–12 Gbit/s has been calculated for each node, including re-routing redundancy; this would reflect on the need for just a few small-size optical cables if 2·4 Gbit/s systems were used.

Considering the long-term assumptions, the trunk capability of the node would become approximately 10 Tbit/s; this would mean, using 40 Gbit/s line systems, a total need of about 250 fibres subdivided among 50- and 100-fibre cables.

The inter-transit node network is essentially a transport network whose basic function is to provide a very high degree of availability.

This will be accomplished with the introduction of a full-mesh physical structure (see Figure 2(*c*)) and with 1 + 1 (or $N + M$) link protection.

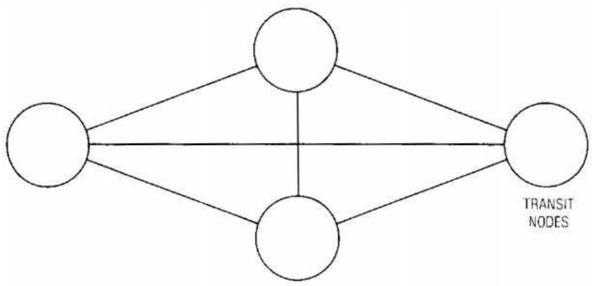

Figure 2(*c*)—Inter-transit node network

The higher costs of 1 + 1 protection, when compared with distributed protection and centralised control, have to be weighted with respect to the global costs of protection for the two upper layers.

The estimated extra cost is about 20% of the cost for a fully distributed protection and nearly 5% of the network costs for the two upper layers.

On the other hand, the advantages offered by this solution are:

- The network is self-managed; that is, no external control system is required.
- The coverage of the protection network is implicit in the growth of the network itself.
- The response time of protection is much faster than other solutions. This is furthermore a mandatory requirement with respect to the lower layers.
- No deadlock situation can occur when managing resources for protection (blocking factor).
- The network can be quickly deployed, based on the available infrastructure and without any need for co-ordination with the protection system of the intermediate layer.

Considering the short-term situation, about 10–40 (depends on the choice of protection) 2·4 Gbit/s links seem to be sufficient for each transit node to be connected to the others, including protection.

The above figure is not expected to grow significantly in the long term because wideband broadcasting services will impact only on the lower layers (no transit node mesh is required for these services).

MOVING TO THE NEW NETWORK

Based on optimisation studies carried out accounting for cost profiles, modularities, and performances of digital systems, a new target structure has been planned for the PSTN and the transition phase is currently implemented.

The characteristics of the new SDH systems, which are to be introduced, fit well into the above network structure.

The deployment strategy for SDH is tightly correlated to the achievements of a number of advantages offered by this new technology, with respect in particular to two application goals:

(*a*) promote the early availability of a transport infrastructure, more suitable for wideband services applications; and

(*b*) introduce a generalised approach for network protection against failures and catastrophic events, and through ADM-based ring structures extend the security up to the local and peripheral portions of the network.

According to these statements, priority will be given to the deployment of SDH systems within large metropolitan areas, both at loop plant and urban junction levels, adopting the following criteria:

- In connection with the already stated deployment of optical cables on the most important feeder routes towards the largest business customers, STM I connections can provide to these users an integrated access for new wideband services besides all existing private and public facilities %PABX and dedicated lines*.
- The extensive use of DXC 4/3/1 in the main nodes of the metropolitan network together with a SDH interconnection layer (at STM-1 or STM-4 level) among these nodes allows business customers to be offered a managed flexible network for wideband services ranging from 2 Mbit/s to 34/45 and 140 Mbit/s, thus extending the present narrowband flexible network based on DXC 1/0: this evolution is seen as an important step at transport level toward the ultimate B-ISDN.
- With the availability of an optical feeder loop infrastructure a massive introduction is foreseen of optical loop carrier (OLC) for POTS and ISDN accesses through the copper terminal distribution network; the linking of several OLCs on synchronous ADM-based rings allows more economical and reliable loop structures.

As mentioned before, the introduction of SDH systems will play a decisive role in the implementation of a highly reliable and fully protected transmission network.

As far as the backbone inter-city transmission network is concerned, the 140/155 Mbit/s multiplexing level is the most appropriate for the implementation of a protection policy based on re-routing through a stand-by transmission network; as a consequence, the deployment of DXC 4/4 is foreseen allowing re-routing protection under a centralised quasi real-time control.

These DXC 4/4 devices equipped with both plesiochronous 140 Mbit/s and synchronous 155 Mbit/s interfaces also guarantee the necessary interconnections between the existing and the future SDH network during the transient period.

In the final scenario, the above DXC 4/4 will become part of the service distribution layer, providing extended service connectivity.

NEW RULES FOR THE NEW NETWORK

A number of aspects, such as network planning, design rules and equipment-related considerations will need to be modified as a consequence of the new approach.

The network planning process will be greatly simplified, because just two basic parameters will have to be taken into account:

- the traffic relationship between any two nodes, and
- the total transmission capability of each node.

As far as the network design is concerned, given the intrinsic flexibility coming from both the network structure and the equipment features, the design becomes virtually independent from the services nature and geographical distribution.

Finally, new criteria need to be adopted for sizing the equipment:

- In order to maximise the diffusion of access equipment, the common parts of the equipment themselves should be negligible in terms of cost, with respect to the tributary units, which are specialised by service.
- The nodal equipment, on the contrary, will have a significantly complex common part, and the criteria for their sizing will follow rules similar to those already defined for digital exchanges.

CONCLUSION

The paper gave an outline of the new telecommunications network, whose deployment is foreseen in the near future.

The first part listed the driving forces pushing towards a development of new network architectures.

Then a proposal was formulated for a new network architecture.

An evolutionary path has been illustrated from the present network to the new one, with some consideration of the impact on network planning and design.

Fibre in the Local Loop

M. D. BARNETT†

INTRODUCTION

The success of fibre optics technology is unquestionable. Over 4 million kilometres have been installed worldwide in long-haul telecommunications networks.

The cost of systems has reduced at approximately 20% per doubling of installed volume. This has resulted in fibre systems being justified economically for shorter and shorter routes and for lower bandwidths. In 1982, fibre was cost effective for distances of 10 km or more and for more than 120 voice channels. Today, fibre is the optimum for distances above 2 km and for more than 30 voice channels.

However, with current point-to-point fibre systems, it is not possible to envisage fibre ever being cost effective for telephony alone.

Without this deployment, however, the PTTs will not be able to benefit from the revenues attributable to tomorrow's services such as video telephones and high-definition television (HDTV) distribution.

Thus, the challenges for the telecommunications industry are two-fold, namely:

(*a*) To justify the installation of fibre in the loop for telephony alone assuming service providers and the regulatory environment will allow the use of the network for broadband services later on.

(*b*) To make systems using fibre in the local loop as practical, cost effective and flexible as the current copper network.

NETWORK ARCHITECTURES

The chosen optical architecture has to be competitive. It must be easy to install and maintain and it must be upgradable to provide the foreseeable services. The two most likely solutions, are *passive optical* networks and *double star* networks.

Passive Optical Networks

These networks are attractive as they enable the PTTs to share the cost of optical devices and electronics over many subscribers. Furthermore, they can be accommodated in the current duct network, requiring no more street furniture than current copper networks. Until recently, there were some reservations regarding the upgradability of these networks for broadband application. With the advent of optical amplifiers this concern is diminishing.

Double Star Type Networks

These networks in effect replicate the current PTT copper network and as such will use lots of fibre. This will result in a network that is initially expensive to install but which will be cheap to maintain and easy to upgrade.

† BICC Cables Limited, UK

THE CHALLENGE TO THE CABLE SYSTEM HOUSE

The cable industry cannot predict which network topology will dominate in coming years. However, it can influence the decision by developing cost-effective fibres, cables, splicing systems, cable management hardware, and cable measurement instruments.

In this section, I will describe progress made to date in this area and future trends. Much of BICC's experience has been gained from participation in field trials in the UK and Italy, so it is appropriate to thank BT and SIP for their support.

Fibre

Progress in this area has been spectacular and whilst improvements will be effected they will be less startling than to date.

For instance, fibre attenuation is now very closely maintained as can be seen in the distribution shown in Figure 1.

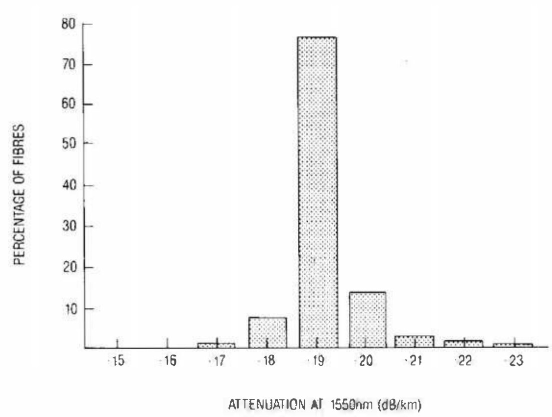

Figure 1—Distribution of attenuation at 1550 nm

Similarly, dimensional controls have improved so that splicing is much easier today than it was in the past.

Future trends in fibre manufacture will result in reductions in price, increased control on dimensions and make fibre more resistant to micro and macro bending and to strain.

The price trend is dependent upon the volume used by the PTTs. If 100M fibre kilometres were used in the loop, it is possible to forecast a further 60% reduction in fibre price.

Cable

In order to understand trends in cable making, it is necessary to understand the network topologies.

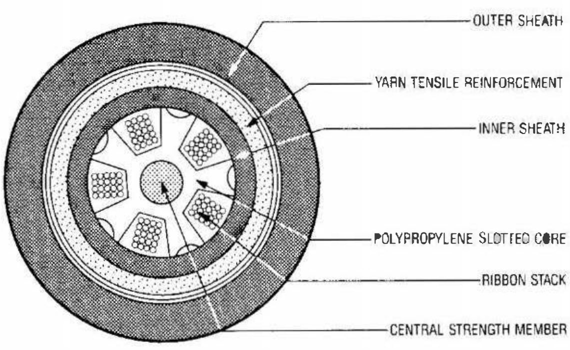

Figure 2—100-fibre slotted core ribbon cable

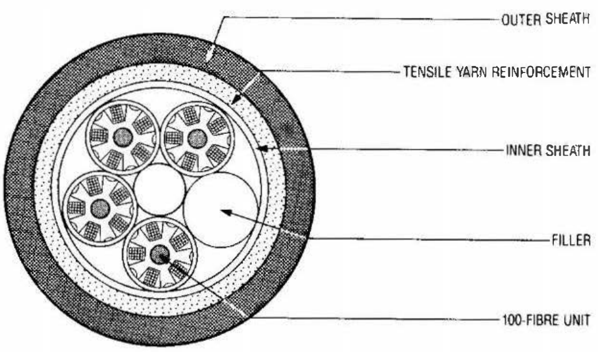

Figure 3—400-fibre slotted core ribbon cable

Whilst these are not known in detail, it can be assumed that there will be a requirement for cables from 600 − 1000 fibre down to single fibre external drop cables, together with high-density internal wiring and connectorised leads.

The common requirements for these cables are:

(*a*) They must be cost effective.
(*b*) They must preserve the fibre attenuation across the operating window; that is, at least to 1575 nm.
(*c*) They must be easy to install and maintain.
(*d*) They must be easy to splice or connectorise.
(*e*) They must have a minimum 20 year life.

Obviously, the design concept for each cable size will be quite different.

100–1000 Fibre

The favoured design for high fibre count, that is, greater than 100, is likely to be ribbon in slot, which is shown diagrammatically in Figures 2 and 3.

The benefits of ribbon in this application are that it provides a very high packing density (*circa* 0·8 mm^2 per fibre versus 3 mm^2 per fibre for loose tube). It also offers the possibility of mass splicing and connectorisation and testing. As the latter is a very high cost both in the cable factory and the outside plant, this is a very significant advantage.

Typical attenuation results of an early 100-fibre cable manufactured by BICC's Italian subsidiary (CEAT CAVI) are given in Figure 4.

It is important to standardise on the dimensions of arrays as early as possible. This may require a change in fibre coating thickness.

4–100 Fibre

Currently, the preferred design for these applications is multifibre in-tube, as this offers an extremely benign environment for fibre. However, as indicated earlier, this is not terribly space efficient, particularly at low fibre counts.

Indeed, the need for rapid cable preparation and mass splicing might result in the use of ribbon solutions for low fibre counts as well as high, or, paradoxically, a move to single fibre in loose-tube cables.

For instance, in the Bishop's Stortford local loop optical-fibre trial, there was a need to test a range of clip-on

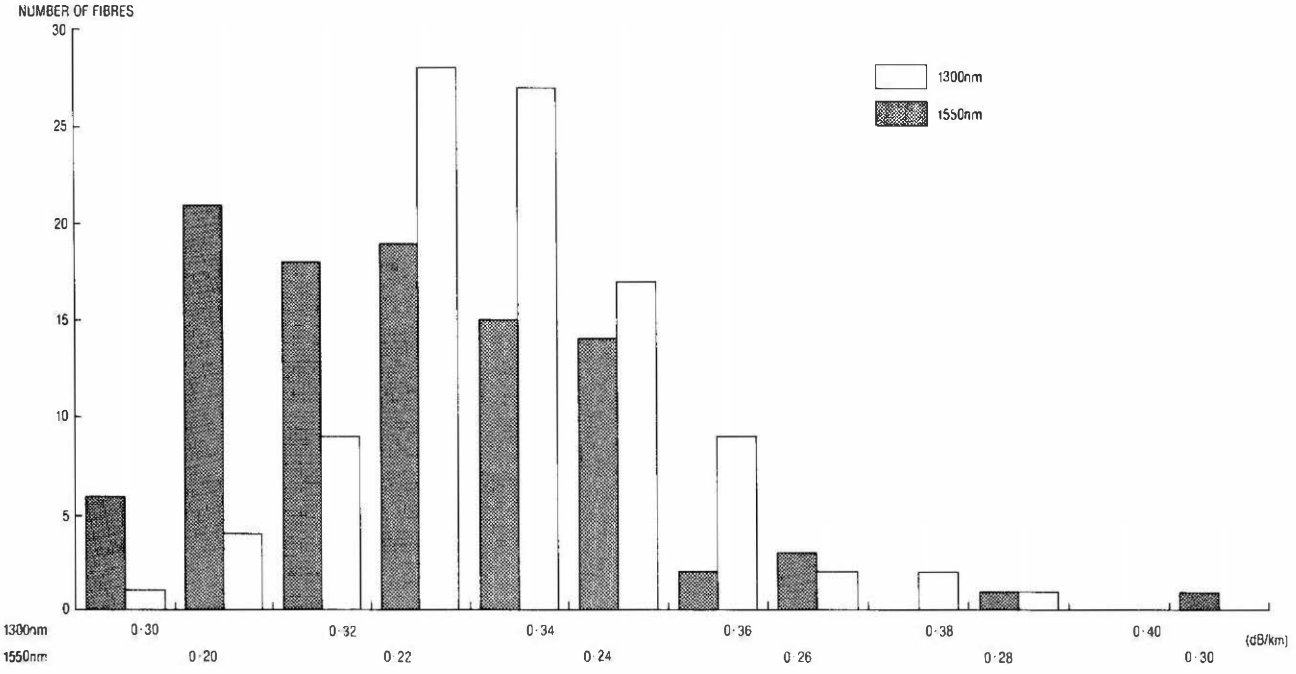

Figure 4—Attenuation distribution in 100-fibre ribbon cable

power meters as part of the maintenance and installation philosophy. This, in turn, required uncoloured fibre and hence single fibre in tube designs.

Of course, ribbon solutions also permit the use of uncoloured fibre without compromising the ability to identify individual fibres.

Drop Cable—Low Fibre Count Cable

The major design challenge for fibre in the local loop and the field trial in Bishop's Stortford was the design of the overhead drop cable.

A key requirement placed by the trial was that the cable contains both optical fibre and copper pairs which were required as a back-up to the optical system.

A dual lobe cable was designed to meet this requirement as this had a number of benefits. Firstly, it allowed the copper pairs and optical fibres which are incorporated in separate tubes to be separately terminated and it also allowed the isolation of the fibres from clamping forces imposed by the grips as the strength is incorporated in the tube not containing the fibre. This cable is shown in Figure 5.

However, in order to reduce the cost of the strength members in the drop cable, BICC incorporated strain-resistant fibre whose lifetime is not deleteriously affected by the application of permanent strain.

A second option tried in the trial and which has potential for both low fibre count underground and overhead cable is the use of *blown fibre*. In this technique, empty tubes are installed and individual fibres or units are installed later. This technique allows fibres to be installed when customers need service.

Single Techniques

There has been much discussion over the years over the merits of fusion versus mechanical splicing. With the advent of passive optical networks, return loss has become critical so it is essential that splices are fused or mechanical connections have angled polishing. Fusion splicing is currently favoured as it gives excellent reliability in service.

Angle polished connectors give excellent return loss in cases when demountable performance is needed.

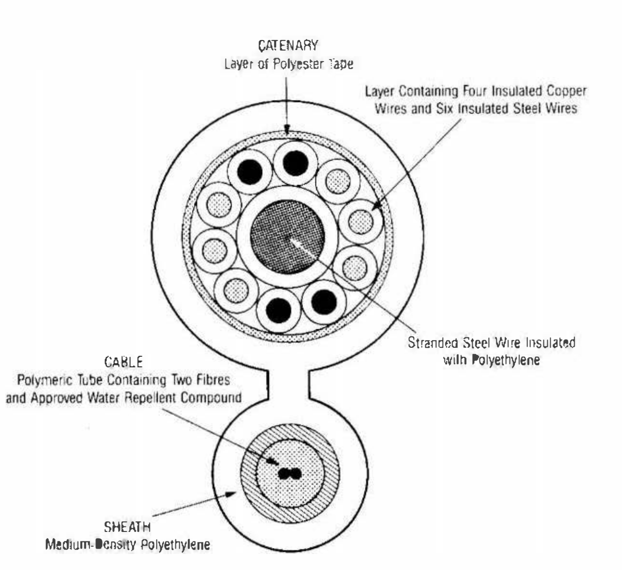

Figure 5—Construction of a fibre overhead feed cable

Whilst there has been significant improvement over the years in splicing fibres first with local light injection then with profile alignment systems, fusion splicing is still relatively expensive and time consuming.

New developments are, however, significantly changing this position. It is likely that large fibre count cables will be spliced using mass splicing techniques and machines are currently available from Japan and starting to emerge in Europe.

Low fibre count cables will be spliced using hand-held cheap devices (certainly less than £1000 each) and will enable connections within homes and offices. These devices will rely upon the improved geometry of the fibre to effect a low-loss splice.

Similarly, fibre cleavers have to be made low cost, more robust and more easy to use.

Street Furniture

Current designs of street furniture, cassettes, distribution points and termination cabinets are expensive and bulky. For local loop applications, it is necessary to make all components smaller and more practical. This, in turn, demands a less bend-sensitive fibre or ribbon.

Great care has to be taken in the design of street furniture for use with passive optical networks as these require special access points for testing and fault diagnosis.

Connectors

Currently connectorised leads cost in the order of £20–£25. To make fibre in the loop cost effective, it is necessary to reduce this by an order of magnitude. This can best be effected by means of precision moulded mass or singleway connectors.

Japanese examples indicate the potential of this technique. Current attenuations of such devices are given in Figures 6 and 7 (singleway and array respectively).

As the use of passive networks and optical amplifiers increases, it is necessary to angle polish connectors to improve return loss. BICC has achieved return losses better than −50 dB using this technique on array connectors.

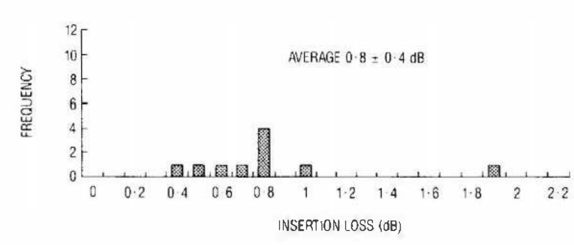

Figure 6—Insertion loss measurements for flat polished MT-1 connectors

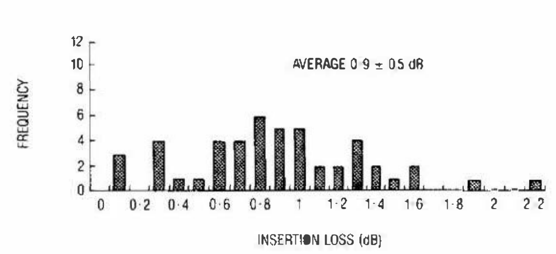

Figure 7—Insertion loss measurements for flat polished MT-4 connectors

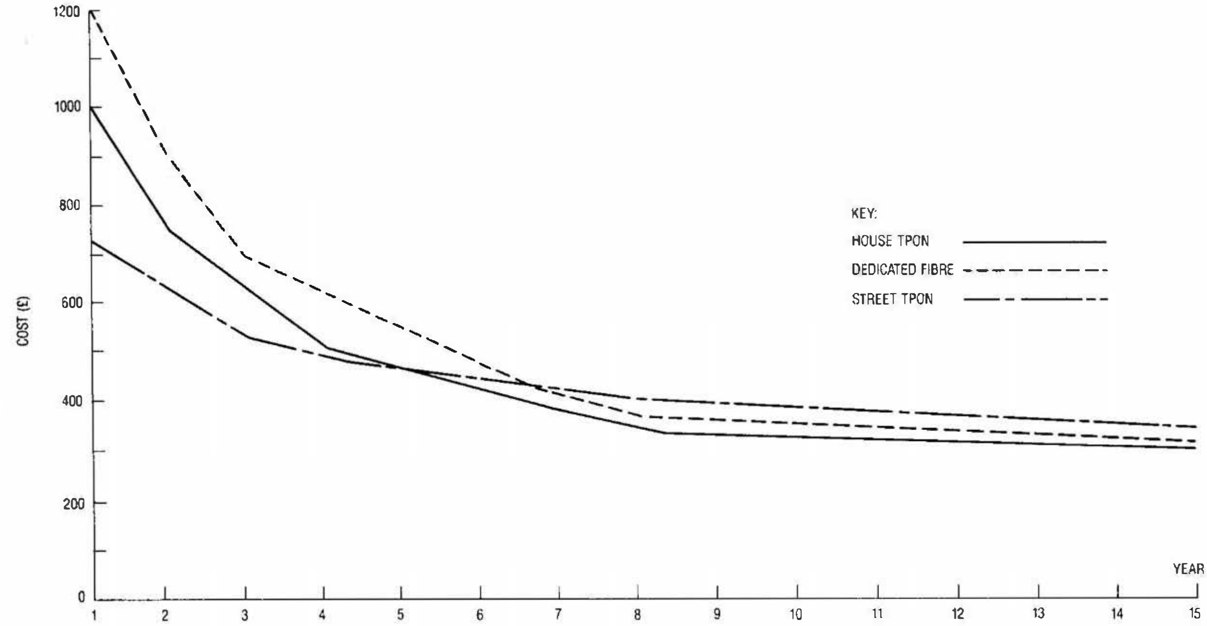

Figure 8—Fibre in the local network—cost per customer

Testing

As has been mentioned previously, the testing element is now a significant element of cable and installation costs.

Moreover, it is likely that the PTTs will demand that cable be better characterised in the third window. Ideally, cable makers should not change the fibre performance at all; that is, preserve the window to 1650 nm. Therefore, there is a need for factory and field spectral measurement as well as OTDR characterisation.

There will also be a requirement for test equipment specifically designed for maintenance or fault finding. The 'clip-on' technology developed by BT is intended for this purpose. The device will be used to monitor signal levels throughout the network. The device can be non-instrusive; that is, it traps and measures a small percentage of the light in the fibre, ensuring that if the fibre is carrying live traffic this is not affected.

SYSTEM COSTS

Calculating even installed first costs is not simple. Figure 8 shows our estimate of relative costs of hardware only for three different network types. It is based on new build and some specific topographic details which are shown.

Although the passively split network has significantly less fibre, this is offset by today's cost of passive splitters. Figure 8 is based on a 32-way split; increasing the split to 64-ways would bring the costs of the passive network to parity with the dedicated fibre networks. The double active star is of course significantly cheaper as it has less fibre and no passive splitters; remember this is plant only, no electronics costs are included. Of course, this means that the passive network is overall cheaper in hardware cost as there is significant saving in exchange electronics largely because of the reduced opto-electronics cost which offsets the greater complexity of the electronics itself both in the exchange and in the customer's premises equipment.

I must emphasise these are today's costs for the outside plant only. It is, however, possible to project these costs using a classic learning curve analysis.

When this is done, then an analysis would indicate that on a full-scale roll-out, and this is based on 25M customers connected by year 15, then most options begin to look as if they cost the same within a reasonable margin. Here we are dealing with total installed first costs of electronics and outside plant. The issue therefore seems to revolve around the early costs and the costs of evolving each network type as service provision is upgraded. Although the dedicated fibre approach has the highest early costs, it also has the least upgrade cost, since the outside plant, which is the most expensive to install, is unchanged.

We are currently carrying out a more detailed analysis of these costs with the aim of understanding these upgrade issues and determining cost sensitivities and drivers for future component developments.

CONCLUSION

The future for fibre in the local loop is exciting for the PTTs and the manufacturers.

Our experience to-date with the Bishop's Stortford trial has shown that fibre in the loop is realisable providing we all pay attention to detail and plan and design for every eventuality. The systems will not be reliable until we have improved every piece in the system to make it simple, more cost effective and practical.

We at BICC are committed to this task.

Broadband and Wideband Network Service Provisioning in the 1990s

M. WARD, and J. ARNOLD†

INTRODUCTION

While a great deal of work has been done in Europe in the RACE programme on the development of broadband switches, as yet there is insufficient knowledge of ways in which the cost and risks of introducing a broadband network service, initially unfamiliar to the paying customers, may be minimised. A purpose of this paper is to suggest ways by which the costs and risks may be minimised in a network evolving by modest steps according to demand, providing full broadband service to those who need it, but principally providing a service on multi-slot circuit switched connections in the evolving narrowband ISDN network. In this paper, this service is referred to as *wideband* to distinguish it from the narrowband 64 kbit/s service and direct-access broadband service.

An argument in favour of investment in the wideband service by European PTTs is the likely erosion of the core POTS business revenues by the introduction of personal communication networks (PCNs), in which the PTTs may be prevented from being major players by regulatory conditions. Wideband service could not reasonably be provided over PCNs because of lack of bandwidth thus, by promoting this service, customers will wish to retain existing communication links and with it the other ISDN services including voice.

EVOLUTION OF THE BROADBAND NETWORK

For the purpose of this paper, broadband service is defined as primarily a point-to-point service and does not include distributive services such as TV.

The strategy must take into account the following factors:

Risks to the equipment manufacturing company of not recovering the high cost of developing equipment for broadband services for which there is no established market. This risk may be minimised by using broadband to enable substantial enhancement of existing services using ISDN-based wideband access into the broadband network.

Risks to the operator from investing in new technology for services for which there is no established demand, balanced against the risk of losing new revenues by being late in the market. Wideband enhanced services provide for low-risk entry.

Growth rate Apart from a few predictable applications for direct-access broadband services, such as high-speed LAN interconnect, new services will not arise overnight; growth in traffic and revenues will therefore be over a lengthy period. Modest enhancements to the narrowband network to enable wideband service will provide traffic and revenues to justify expenditure in the early years of growth.

Customer access The largest component of investment in the provision of direct access broadband service is likely to be in the customer access connection (CAC). Such investment will only be made where it is justified by revenues; thus the service will start with a few large business sites, expand down the scale and may never be economically justifiable for domestic subscribers. Wideband service, carried over the broadband network and accessed via the ISDN narrowband network, provides a high-class service at affordable cost for domestic users and an adequate service for small and most medium business sites, at least through the 1990s.

Three implications drawn from the above are that development costs must be minimised for the equipment company, equipment and installation costs must be minimised for the operating company, and that wideband service is an essential feature of the new network.

Asynchronous transfer mode (ATM) is now widely recognised as the technology for the implementation of broadband networks. There are two compatible switching technologies for ATM and these are MANs (DQDB/IEEE802.6 or FDVDI) and ATM star-switches. A low-risk start to the broadband network is achieved with the introduction of MANs linked by simple bridges, providing a service from nodes on dedicted optical CACs to large business sites. Further, by offering at this stage only a connectionless datagram service, much of the complexity of network integration is avoided. This is the approach already adopted by AT&T, Bellcore and some of the BOCs with the Switched Multi-megabit Data Service (SMDS).

As the popularity of the service grows, both in geographic and traffic terms, the number of MANs which must be interconnected increases. Where there are more than four fully interconnected MANs, the bridges should be replaced by routers and the switch in the router would be a small ATM star-switch. At this stage, connection-mode services should be added to the datagram service. With further growth, the direct interconnection of routers improves efficiency and represents a major step towards the ultimate target broadband network using large ATM star-switches and, possibly, MANs as local 'concentrators'. A circuit-switched network with 64kbit/s granularity will, however, continue to provide the core services for the majority of users for the forseeable future.

The growth of the broadband network is illustrated in Figures 1 to 5.

BROADBAND AND WIDEBAND ACCESS

Some large business sites will gain access to the broadband network on direct optical lines using SDH STM-1 links. Initial studies suggest that, assuming monomode fibre in all public network applications, there is no cost advantage in providing a physical path at less than the 155/150 Mbit/s rate. Other possibilities, serving a group of customers, include SDH add/drop multiplexers providing a contracted portion of the STM-1 bandwidth for narrowband and broadband services to each customer, or a MAN providing

† GEC Plessey Telecommunications Ltd., UK

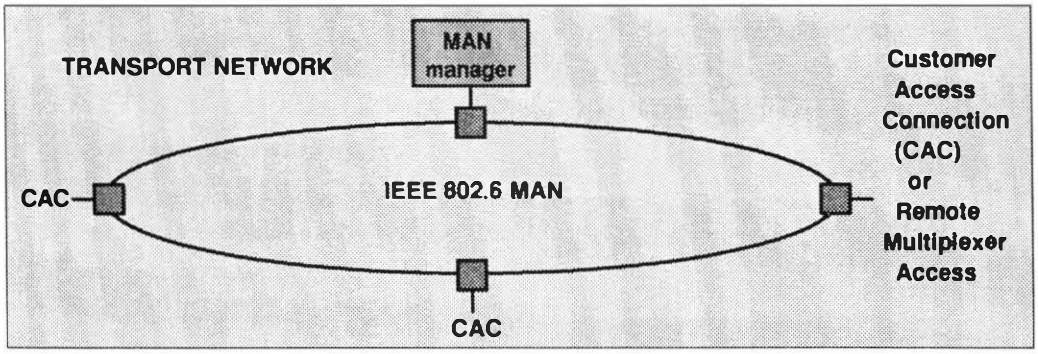

Figure 1: Stage 1
A single MAN is 'embedded' in the transport network. A datagram service is provided to a few large business sites on dedicated optical customer access circuits. Ports are directly addressed. Port address memories are maintained by a *manager*

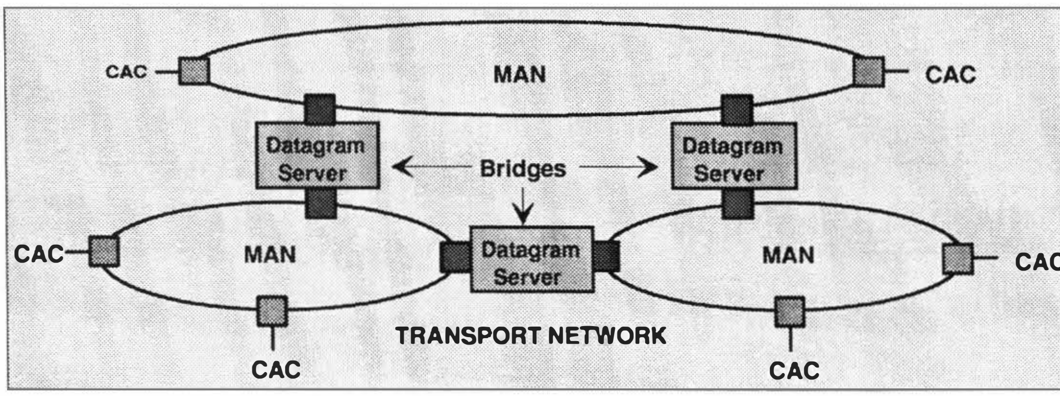

Figure 2: Stage 2
Further MANs are added to the network linked by point-to-point bridges incorporating datagram servers. The limit is about four MANs before the structure becomes unwieldy

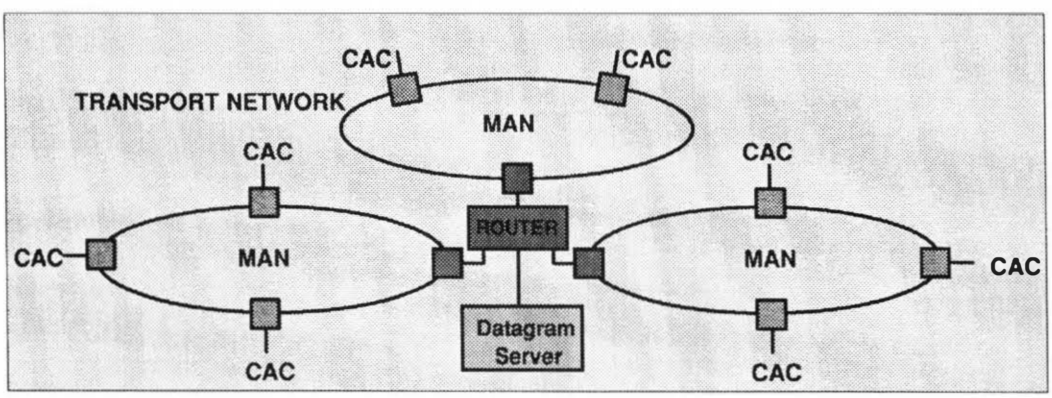

Figure 3: Stage 3
Groups of bridges are replaced by routers which will use small ATM switches, typically with 16 or 32 ports, providing full rate connectivity between MANs and to a datagram server. The majority of the traffic will be on virtual circuits

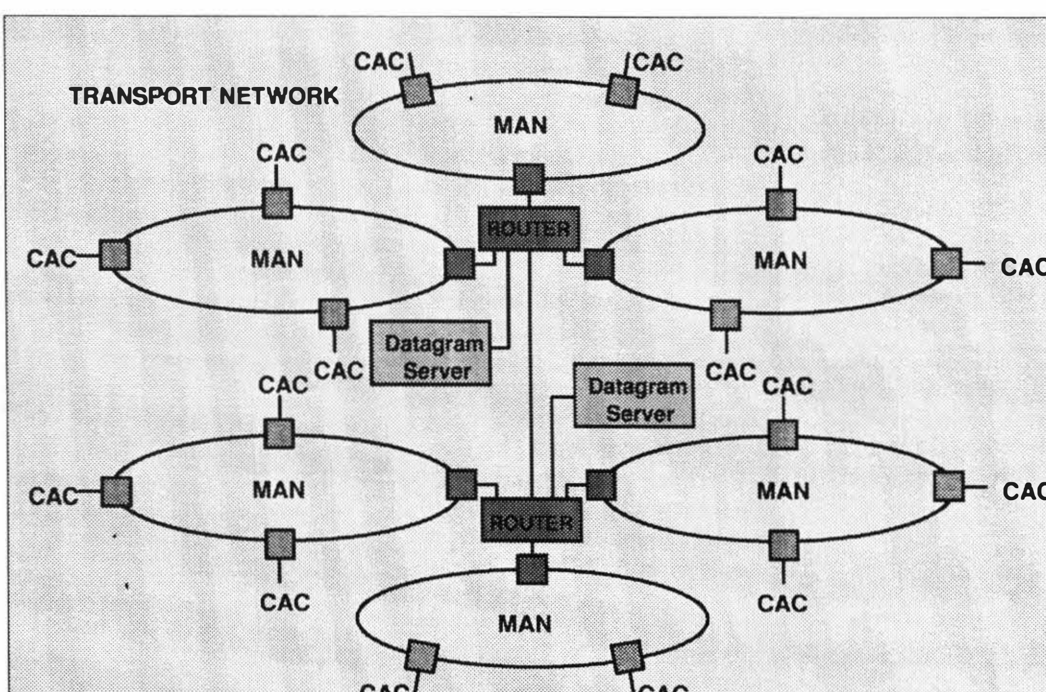

Figure 4: Stage 4
Isolated routers are now interconnected by direct links, removing the need to route transit traffic through intermediate MANs, simplifying the structure of the network and 'fertilising the embryo' of the target network architecture

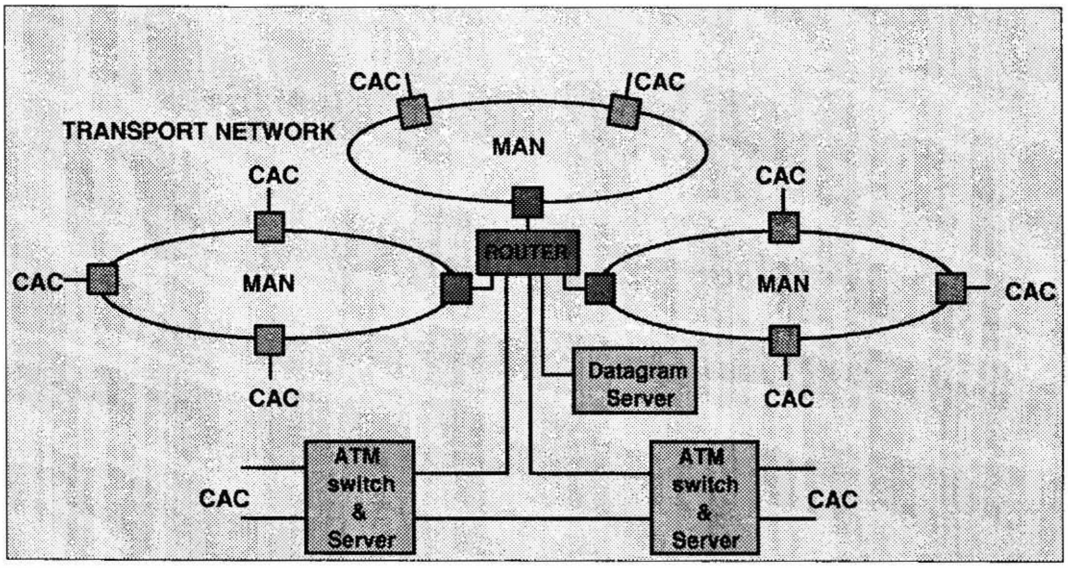

Figure 5: Stage 5
The routers are now linked to large ATM star-switches with directly connected subscribers. The ATM network will continue to grow and the MANs will be relegated to the status of local concentrators

ATM-mode and isochronous-mode service over a single fault-tolerant medium.

Operating companies in Europe and North America are now investing heavily in an ISDN infrastructure. ISDN primary-rate access can provide a 1920 kbit/s bearer channel in Europe or 1472 kbit/s in North America and this is 200 or 150 times better than a 9·6 kbit/s modem. This service is described as *wideband* in this paper. In order to achieve superior performance for a packet-mode service, the ratio between the upstream bearer rate and the peak user bandwidth should preferably be greater than 8:1 to give good statistical smoothing. With a 2 Mbit/s source, the implied upstream bearer rate should be greater than 16 Mbit/s which the broadband network, with 150 Mbit/s bearers, is well able to provide.

New network requirements such as intelligent networks, PCNs and distributed control will put severe demands on the signalling network such that the present 64 kbit/s network will be inadequate. All signalling is therefore expected to migrate to broadband in time, thus D-channel signalling will be adapted to ATM near to the local access. The packet switched public data network (PSPDN) is expected to be replaced eventually by ATM-mode wideband packet services enabled by the broadband network.

A typical local network architecture providing for access to wideband services is shown in Figure 6.

ATM switches simply relay data while the PSPDN provides frame-switching with the Layer 2 protocol, providing the error-free guarantee, terminated in each switch. The PSPDN standards were evolved when the network was largely analogue with relatively high error rates. We can assume a low error rate for the all-digital network (say 1 in 10^{10} average BER over the complete path); thus requests for repeats will be very rare even over the much longer end-to-end path, and the resultant delay can be neglected. Also, by providing a protocol independent interface, services such as packetised-voice are easily provided. Figure 7 shows a typical wideband service network connection and the stage-by-stage delays under heavy load with 53 octet ATM cells. The heavy outline in the figure shows the queueing delay in rate-adaption at the last stage, with more than half of the path delay; thus it can be concluded that terminating the Layer 2 protocol at intermediate points, as in the PSPDN, would give very little advantage.

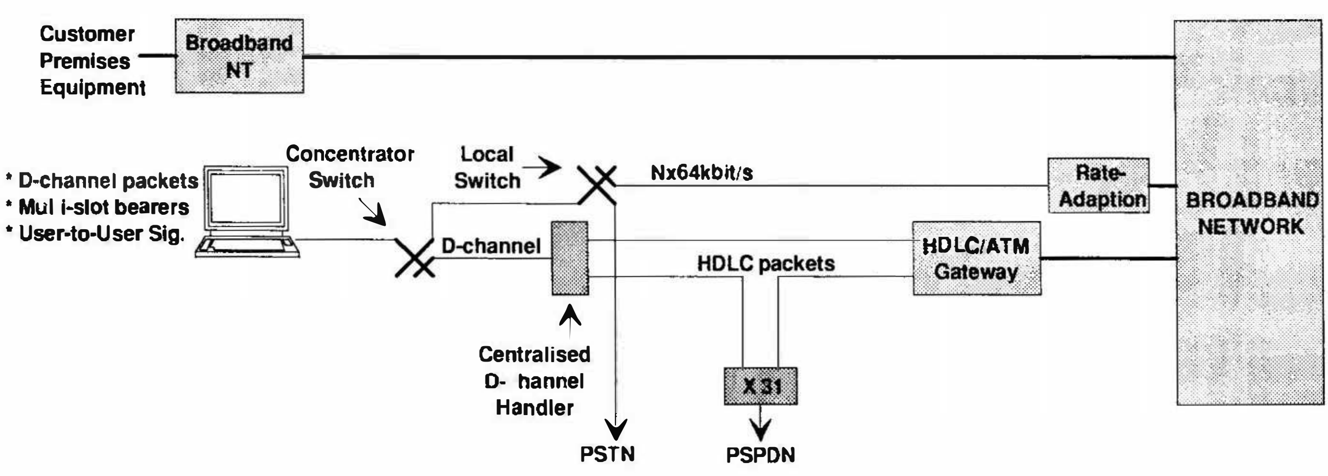

Figure 6—Typical local network architecture showing direct access and wideband access to the broadband network

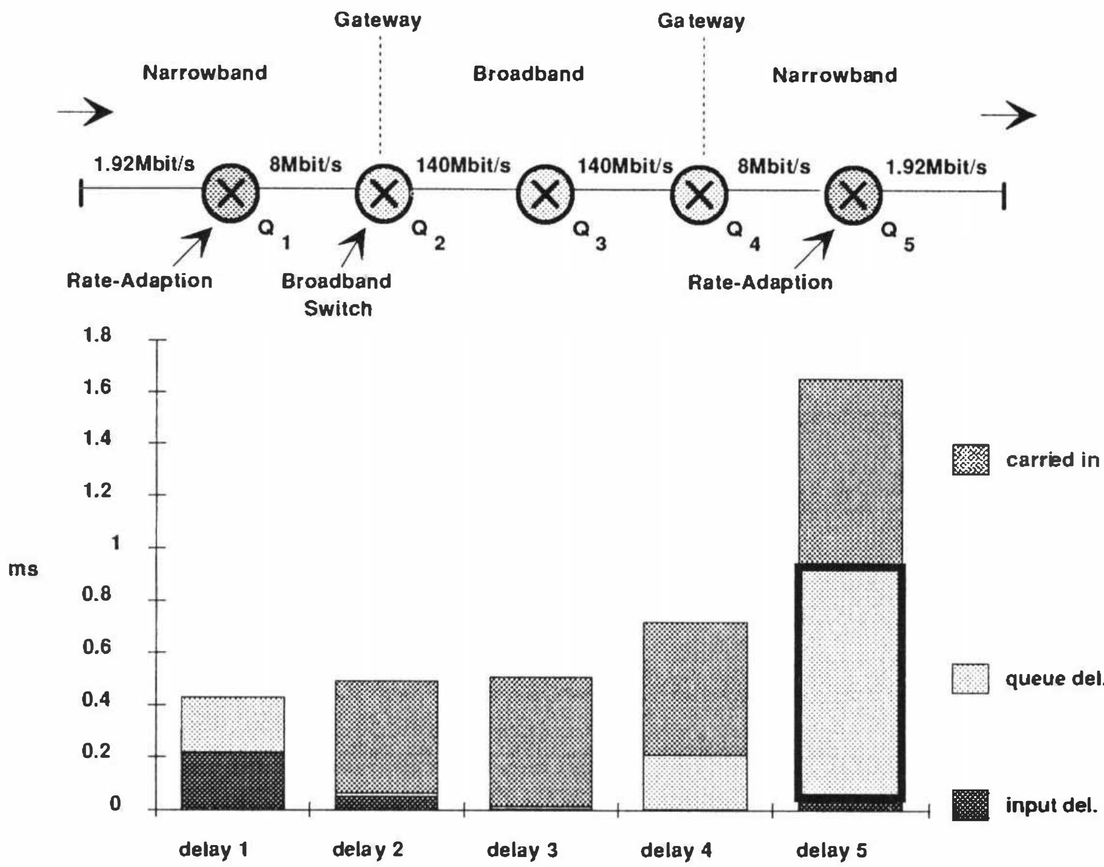

Figure 7

If the loop delay in the path is equal to, or less than, the product of the transmit time of one packet and the window size (window size equals the number of packets/acknowledgements which may be in transit), then the maximum transfer rate may be achieved. Half the difference between the loop delay and the product of transmit time and window size is therefore equal to the maximum transmission delay which may be tolerated before the peak throughput starts to be reduced by path delay. Figure 8 shows the overall distance, calculated at 3·5 μs/km, against window size for three load conditions (average queue sizes of 1, 4, 8 respectively). It will be seen from this figure that a window size of 32 is desirable.

ISDN CUSTOMER ACCESS FOR PACKET-MODE SERVICES

The most common means of access to the PSPDN at the present time is to a PAD (*PA*cketiser/*D*epacketiser) via an

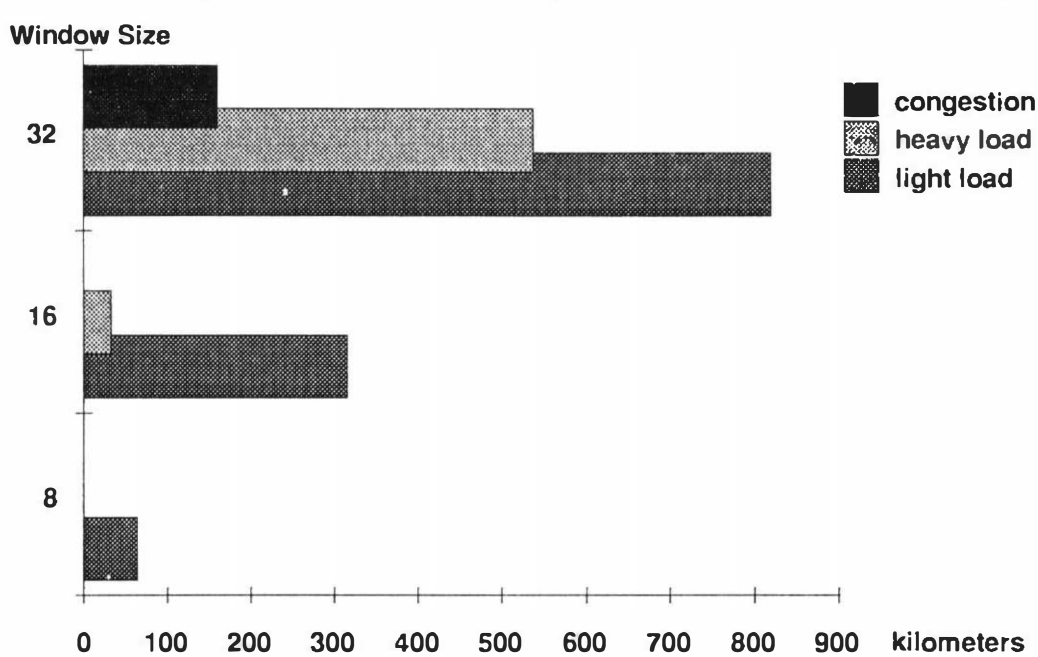

Figure 8

RS232 interface and a modem operating at rates from 300 bit/s to 9·6 kbit/s. The PAD may be in customer premises equipment or, more usually, in the network. The modem link is the slowest and most error prone link in the connection but is usually unchecked and hence is a major cause of user complaint for apparently poor network performance. The proposed hybrid network assumes ISDN access which, being digital, will be far less error prone. Nevertheless, an unchecked link is considered to be unacceptable for a new packet-mode service. While the Layer 2 protocol may be applied end-to-end, this will require relatively complex protocol handlers which will need to operate with bearer rates up to 2 Mbit/s. Four access alternatives are suggested below:

(*a*) *Transparent access* (Figure 9.) This full-duplex access mode may be used by sophisticated customers via a PAD in the customer premises equipment and transparent access to the broadband network via single or multi-slot circuit connections in the local network. Other applications are packetised voice for pair-gain in private networks and packetised Group-3 FAX. In all cases, multiple destinations may be set up on the one bearer channel (that is, not limited by circuit access restrictions).

(*b*) *Normal access* (Figures 10 and 11.) This access mode is full duplex and may be used for any packet-mode service on the D-channel, or on dial-up B-channel and multi-slot connections to a protocol extender in the local network. Statistical multiplexers may be used in the customer premises equipment if required.

A very basic I.441 (X.25 based) protocol is used to communicate with the protocol extender unit. Only I and S format message frames are supported and the window size is one. Examples of the peak (information) throughput with a 10 km CAC and 128+6 octet packets are as follows:

16 kbit/s	D-channel	14 kbit/s
64 kbit/s	B-channel	57 kbit/s
128 kbit/s	2 × B	114 kbit/s
1920 kbit/s	30 × B	1548 kbit/s

(*c*) *'Dumb' terminal access* (Figure 12.) This access mode is half-duplex and may only be used for text carried on a B-channel in a direct dial-up connection to a PAD in the local network.

Simple character echoing is used with checking at the terminal and a backspace delete on errored characters. Characters are carried in bytes delineated by the transmission frame. A non-printing character such as all-ones is used in empty slots. A second non-printing character such as 00001101 (13) is used to request/confirm a reversal of direction. Note that 11111111 and 00001101 are reserved in the IBM extended character set. Standard HDLC packets are formed on the upstream side of the PAD and, at *packet*

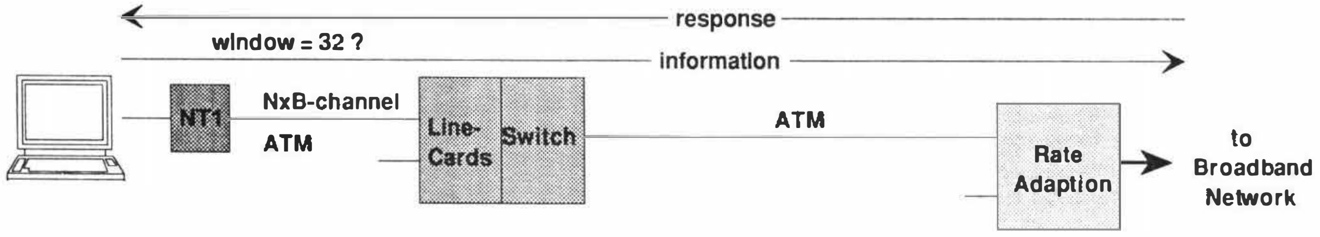

Figure 9

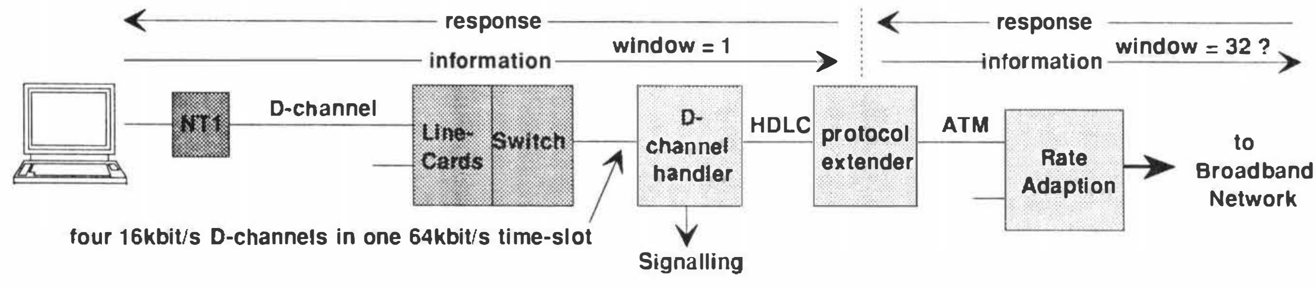

Figure 10

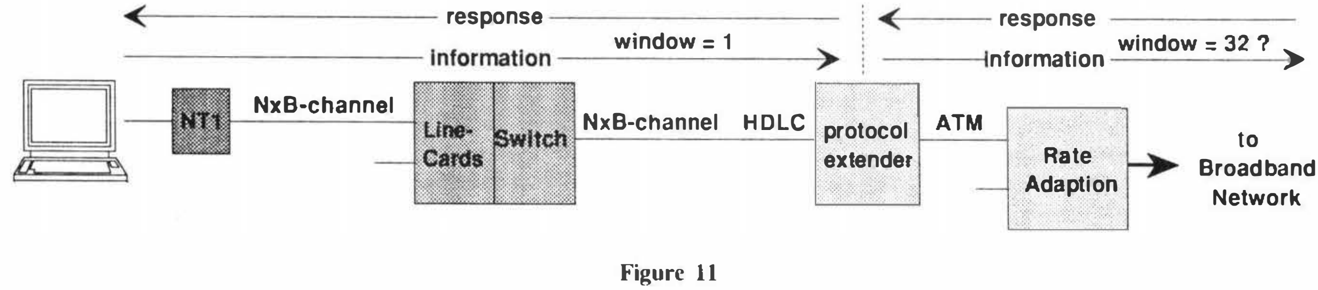

Figure 11

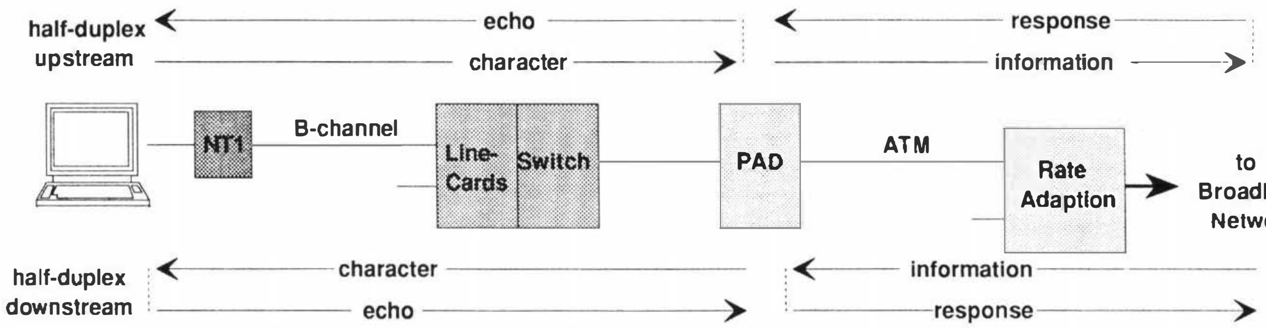

Figure 12

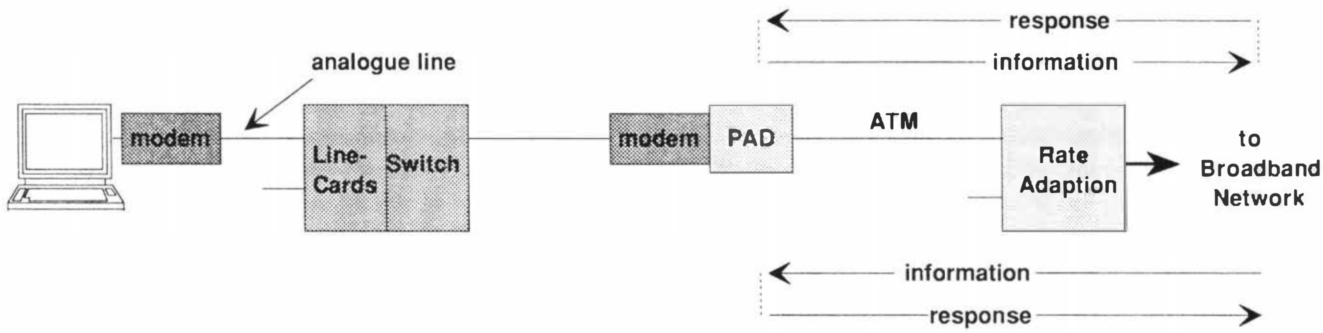

Figure 13

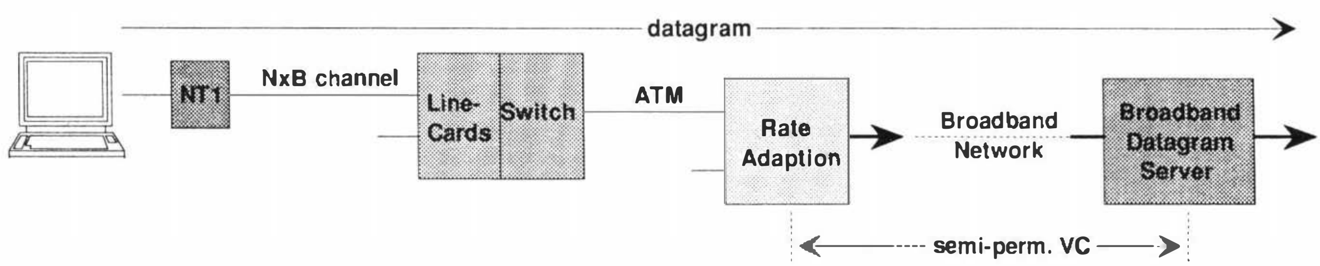

Figure 14

full (after the last character plus one in case the last character was errored) or after a *time-out* (for example, 8 s), are segmented and transmitted as ATM cells. With a 10 km CAC, the peak throughput is equivalent to about 25 kbit/s.

(*d*) *Analogue access* (Figure 13.) For existing PSPDN users, the same form of access that they are used to will be provided; that is, a modem providing an unchecked link to a PAD in the network.

DATAGRAMS VIA THE WIDEBAND NETWORK

A datagram service may well be considered to be useful by users. The datagram service is provided for by servers usually located on each MAN or at each star-switch. The calling subscriber and successive servers in the path are linked by reserved virtual paths. Each server will receive the complete datagram, examine the destination address held in the information field of the first ATM cell, and route to the next server in the relevant direction or to the destination subscriber. For the network configuration of Figure 1, with a single MAN and providing only datagram service, each MAN node may provide address translation, kept up-to-date by a MAN manager. For Figure 2, the servers are provided in the bridges. For Figure 3, connection-mode service is assumed for the majority of the traffic and a limited number of servers connected on router ports provide adequate capacity; similarly, for the configurations of Figures 4 and 5.

Figure 14 shows a typical local access arrangement. The rate adaption unit would have a permanently assigned VP to the nearest datagram server in the broadband network. Access to the service could also be via the D-channel and an HDLC/ATM adaption unit; in this case, a circuit connection is not needed and a semi-permanently assigned VP can be rented to the subscriber to give instant access. This value-added service could be particularly attractive to domestic customers where a datagram may replace a letter in many instances.

CONCLUSION

This article has attempted to show that provision of an ATM-based broadband overlay network may be economically justified by enabling enhanced services accessed over the narrowband ISDN network. At the same time, direct access broadband services may be provided to the relatively few large business users for which the higher access costs are viable.

Deployment Strategy for Transmission Networks Based on the Synchronous Digital Hierarchy

T. C. WRIGHT†

INTRODUCTION

Transmission networks based on the synchronous digital hierarchy (SDH) offer a number of significant advantages over existing networks particularly in terms of the ability to manage the capacity. This manageability is of prime importance since it will enable faster provision and rearrangement of services and much more rapid restoration in the event of facility failure. The deployment of SDH-based facilities, however, requires a careful re-examination of the fundamental way in which transmission networks are planned, installed and operated. Although the basic transmission functions of grooming, consolidation and routing are still required, synchronous multiplexing offers new ways in which these functions can be carried out compared with plesiochronous multiplexing. Fundamental to this re-examination is an understanding of the client networks which the SDH transmission server network will be required to support since this will significantly influence the initial deployment approach and the evolution towards widespread SDH-based networks.

This article reviews the server/client nature of transport networks and then examines two candidate deployment strategies which seek to optimise the support of client networks. The possible evolution of asynchronous transfer mode (ATM) based client networks is also reviewed.

THE SERVER/CLIENT RELATIONSHIP

There is now wide acceptance of the concept of the layered nature of transport networks with a server/client relationship between layers; this concept is not only useful in aiding understanding of the way one network layer supports another, but is also proving very useful in simplifying the management standards. To illustrate the concept, consider the 2 Mbit/s based plesiochronous digital hierarchy (PDH): the 34 Mbit/s server network supports the 8 Mbit/s client network and the 8 Mbit/s server network supports the 2 Mbit/s client network. In general, the signal structure of the server network comprises a payload (into which one or more signals from the client network are multiplexed) and a server network overhead. This overhead ensures the integrity of the server network. It is thus possible to distinguish between the bit rates of the server network and those of the client network. An example is that of the plesiochronously multiplexed hierarchical bit rate, 34 368 kbit/s; the server network bit rate is 34 368 kbit/s, but the client bit rate is 16 × 2048 kbit/s (that is, 32 768 kbit/s).

† British Telecommunications plc, UK

SDH-based networks likewise exhibit a server/client relationship between their layers. For example, higher-order virtual container (VC) networks serve to support lower-order VC client networks. Moreover, these VC networks can serve to support client signals from the existing PDH. Recent agreements in the CCITT have resulted in a significant simplification of the SDH multiplexing structure (to be reflected in the 1990 revision of Recommendation G.709[1]) which offers the potential of widespread networks based on a common set of VCs. Thus, any SDH deployment strategy should recognise the emergence of VC networks in the longer term and the eventual demise of existing PDH bit rates. Although the multiplexing structure described in Recommendation G.709 provides for the support of most PDH bit rates including simultaneous mixes of different bit rates, there are likely to be advantages, both in terms of simplicity of management and of evolutionary potential, by limiting the range of PDH bit rates to be supported. The strategy, therefore, should be optimised for the support of the most important client networks of the PDH whilst taking into account the likely requirements of future client networks such as ATM or digitally encoded TV. It is thus necessary to identify the most important client networks. Table 1 indicates the broad service categories which either exist or are expected to emerge in the future and the corresponding network requirements in terms of bit rates.

What emerges is that, at present, 2 Mbit/s is a key bit rate and will undoubtedly remain so. 140 Mbit/s is also an important rate with rather modest quantity requirements at present but with the likelihood of significant increase,

TABLE 1
Service Categories and Network Requirements

Service Categories	Network Requirement
Voice	2 Mbit/s paths
Low-speed data	2 Mbit/s paths
High-speed data	$n \times 2$ Mbit/s paths (for example, 4, 6, 8, 10, 12 up to 30/40 Mbit/s)
Multi-service (very-high-speed data or video)	≈140 Mbit/s paths (probably using ATM)
Broadcast TV	Presently 140 Mbit/s through moving to lower bit rates (for example, ≈ 34 or 45 Mbit/s)
High definition television (HDTV)	Presently ≈ 600 Mbit/s though moving to lower rates (maybe ≈140 Mbit/s)

especially with the advent of ATM. It is also the PDH server network layer at which protection switching is commonly provided. In between 2 and 140 Mbit/s, commercially important services are expected to emerge with requirements which will not necessarily be related to existing PDH bit rates. For example, the local area network (LAN) interconnect and metropolitan area network (MAN) requirements with bit rates of perhaps 10 – 100 Mbit/s.

The most important client networks, therefore, are presently at 2 and 140 Mbit/s and it is considered that introductory deployment strategies should be optimised around these rates. However, such a strategy should not jeopardise the emergence of other client networks.

INTRODUCTORY DEPLOYMENT STRATEGIES

The support of signals at around 140 Mbit/s can very readily be provided by SDH-based networks since the signals can be mapped directly into the VC-4[1] and all SDH-based networks will offer VC-4 networking. It is the support of lower bit rate signals which requires more detailed consideration. In the following discussion, two different approaches are described; denoted *approach A* and *approach B*.

Approach A

This approach recognises the importance of the 2 Mbit/s client network. The SDH network, therefore, is primarily organised to offer management of the paths of the 2 Mbit/s network and the interfaces to the SDH island are at 2 Mbit/s. The early introduction of SDH-based facilities can thus be illustrated as shown in Figure 1 in which the 2 Mbit/s signals are mapped into VC-12s and routed across the SDH island. A slight variant of this approach, illustrated in Figure 2, is where the interface to the SDH island combines plesiochronous multiplexing and SDH tributary mapping functions in a back-to-back arrangement, sometimes referred to as *transmultiplexing*. As in the case shown in Figure 1, the 2 Mbit/s signals are supported in VC-12s in the SDH island. This approach could prove a cost-effective solution noting that plesiochronous skip multiplexing can be realised with a fairly modest chip set and that physical interfaces at 2 Mbit/s are not required. It should be noted that, in this latter case, the SDH island could be simply a cross-connect equipment at a single site where the desired initial benefit is the automated management of the site rather than the management of the network as a whole.

Approach A has a high degree of future-proofing; as plesiochronous islands diminish and the SDH islands increase in size, the same routing principles in the SDH island can be used thus offering a smooth evolution to all-VC-based SDH transport networks. With time, more and more network elements will have SDH-based transmission interfaces (such as the PSTN/ISDN switches illustrated in Figure 3). However geographically small or widespread the SDH island, from the outset it is important to regard the SDH island as providing VC networking rather than networking of PDH bit rates.

Approach B

An alternative approach is for the SDH island to support plesiochronously multiplexed server network layers (that is, 8, 34 and 140 Mbit/s) as well as 2 Mbit/s in the case of the 2 Mbit/s based hierarchy as shown in Figure 4. With this approach, elements of existing transmission networks are replaced (or added to) by SDH-based facilities on a functionally like-for-like basis but with the potential for management. It should be noted that plesiochronous multiplexing/demultiplexing, by definition, cannot occur in the SDH island. This approach has the advantage that the

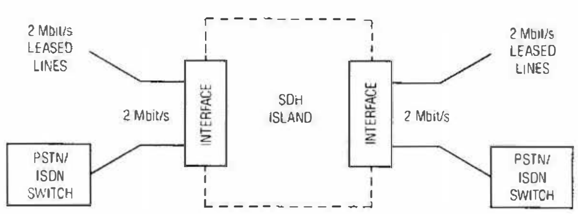

Figure 1—Early introduction stage optimised on key rate

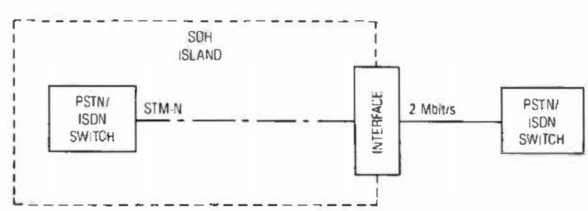

Figure 3—Emergence of SDH-based switch ports

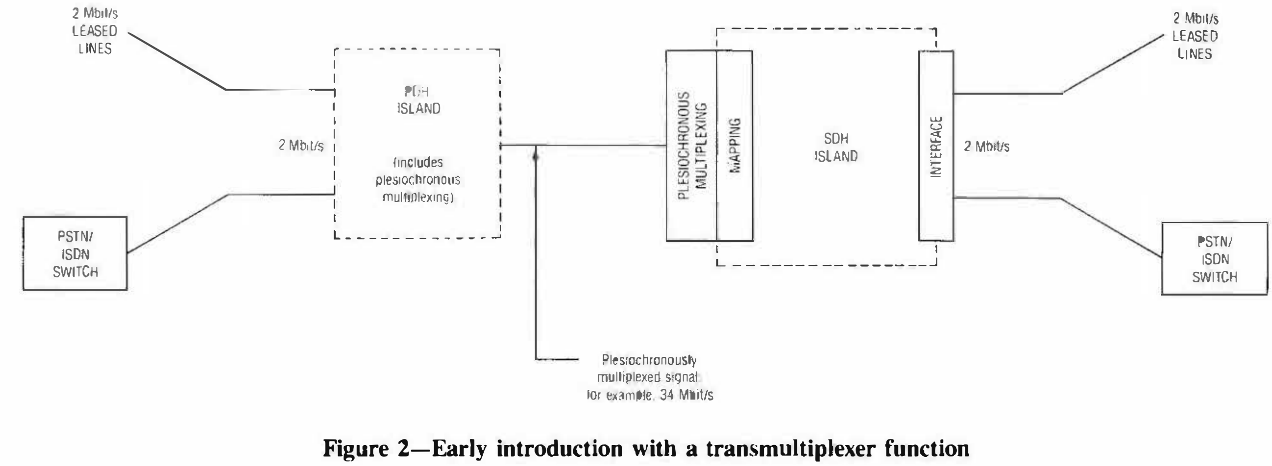

Figure 2—Early introduction with a transmultiplexer function

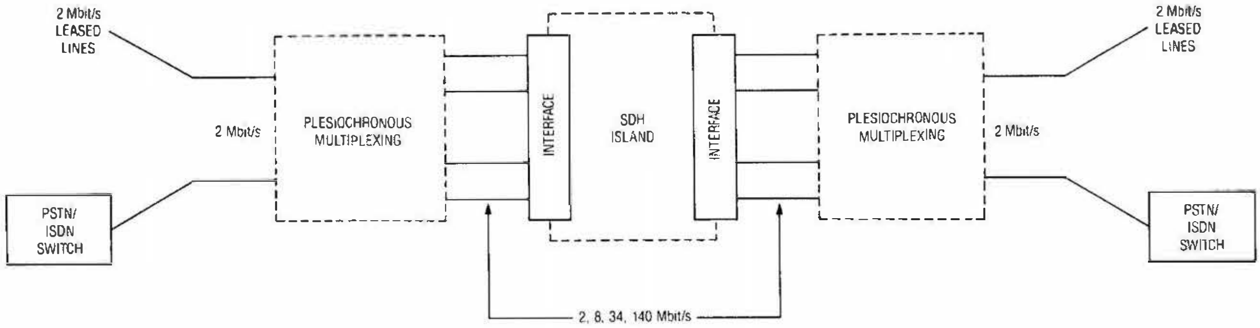

Figure 4—Early introduction supporting all plesiochronously multiplexed rates

planning and routing arrangements developed for the existing network can be used in the SDH-based arrangements. However, there are a number of drawbacks:

- Since the 8, 34 and 140 Mbit/s signals are server network layers containing plesiochronously multiplexed 2 Mbit/s tributaries, plesiochronous multiplexers (outside the SDH island) will continue to be required (Figure 4).
- Migration to an all-SDH-based network will require new routing arrangements to be implemented to take into account the change from routing VC-2s and VC-3s to routing VC-12s.

It is important to distinguish between cases where a PDH network layer is a server network, as discussed under approach B above, and those where it is a client network only. There are occasions when PDH network layers, such as 8 and 34 Mbit/s, are client networks only (such is the case when these rates are offered as service rates) and they will therefore be required to be supported transparently in the SDH island. In such cases, the client PDH rate will be mapped into an appropriately sized server VC.

Comparison of Approaches

Although approach A demands a more rigorous examination of client network requirements prior to deployment, it is considered that it has a greater degree of future proofing than approach B. For this reason, network operators in Europe envisage adopting the principles of approach A. Moreover, these principles are reflected in an emerging CCITT draft Recommendation on SDH network aspects[2].

EVOLUTION OF CLIENT NETWORKS

In the long term, ATM should enable the decoupling of service bit rates from transport rates and thereby offer the flexibility to meet the uncertain service needs of the future. Within transmission networks, ATM signals will be mapped into the various transport rates that are available. For example, with SDH, ATM signals will generally be mapped into the VC-4 for transmission between ATM switches and terminals. However, in the pre-ATM environment, it will be possible for SDH-based networks to support a range of intermediate rates, for example, television encoded into 34 or 45 Mbit/s, using VC-3s or concatenated VC-2s. Moreover, with agreement in the CCITT on the standards of the ATM cell and the broadband ISDN user/network interface (to be reflected in 1990 CCITT Recommendations I.361 and I.432[3]), there exists the possibility of an early introduction of a LAN interconnect service, using the user/network interface as the customer interface, with full cells mapped into concatenated lower-order VCs. This concept offers a smooth migration to broadband ISDN for business users, initially with a point-to-point LAN interconnect service, and subsequently, as ATM switches emerge in the network, with full broadband ISDN services. It is considered that this concept could prove an attractive national and, importantly, international service.

CONCLUSIONS

This article has shown that an introductory deployment strategy optimised for the most important existing client networks (that is, 2 and 140 Mbit/s) not only safeguards existing service categories but it also provides a high degree of future-proofing for the uncertain demands of future service categories and offers a migratory route to broadband ISDN capability.

ACKNOWLEDGEMENTS

The author wishes to thank the Director Network, BTUK, British Telecommunications plc for permission to publish this article.

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Remote Rural Modernisation in the UK

F. R. C. HAMILTON, A. J. MACDONALD, J. S. DIXON, and S. A. MOHAMED†

INTRODUCTION

Rural Perspective

As a general rule, rural communication advances follow behind those of provincial and urban areas. This is not because of any wilful discrimination by administrations against rural communities, but purely because they wish to utilise the available resources in areas of greatest benefits. This is true in all areas of communications (for example, road and rail).

By their very nature, rural communities are remote from urban/provincial areas, and have developed out of primary industries. Often these industries can no longer support the community and poor communications deter other industries from moving in. The consequence is high levels of unemployment which forces a rural population drift towards the cities.

The introduction of modern telecommunications defeats the distance barriers, particularly those experienced by remote rural areas, and give immediate access to worldwide markets. Expectations are rising within these areas for advanced telecommunications, which may encourage tele-cottage industries to sprout and reverse the rural decline.

British Telecom (BT) Initiatives

BT, on its own, and in partnership with developent agencies has initiated a number of programmes to place modern advanced communication facilities in the rural community. These include the Highlands and Islands Initiative[1] in Scotland, STAR[2] project of Northern Ireland, radio transmission trials in Cornwall and a trial modernisation of a complete geographical area in rural North East England (Hexham cell).

Whilst these projects provide some extremely useful indications of quality improvements achieved through exchange and transmission modernisation, such methods are rarely cost effective and could not be justified for the BT rural network as a whole. A small local exchange (SLE) strategic study was set up to find the best way forward.

This article addresses the issues:

(*a*) BT's search for a cost-effective SLE replacement. At the time of writing this article, BT is assessing the cost implications of the SLE solutions so no firm indications as to the way forward can be provided. However, indications as to what solutions are practical, problems associated in developing these to meet BT's requirements and integrating the solutions in to the BT network are detailed.

(*b*) An investigation of the opportunities for radio in the rural access network.

(*c*) The possibility of amalgamating these so that further cost savings and quality gains may be realised.

† British Telecommunications plc, UK

SMALL LOCAL EXCHANGE MODERNISATION

BT's Modernisation Progress

In discharging its mission[3], BT aims to provide its UK customers with a world class, high functionality, cost competitive, quality telecommunications network.

Compared to existing analogue exchanges, modern digital exchanges are physically smaller, have a greater capacity, exhibit a much lower running cost and provide superior service standards. Telecommunications operators can realise significant benefits by replacing several large analogue exchanges by a single digital exchange. The use of remote concentrators often provides cost justification for modernising the larger rural exchanges generally located in key rural centres. The smaller exchanges, mainly because of modularity effects but also their poor revenue generating potential, are uneconomic to replace for modernisation purposes alone.

BT's investment in the UK network has risen steadily since 1982 averaging £1·9 billion per year at today's prices (see Figure 1). This trend is continuing; 89/90 saw £2·3 billion, increasing further this financial year. This investment has realised a backbone of digital transmission links to enable BT to provide the world's largest wholly digital switched trunk network. During 89/90, BT brought into service 4·6 million digital local exchange lines (more than any other single administration over a 12 month period). BT now has more than 19 million connections installed on modern local exchanges capable of providing high levels of quality and functionality. Exchange modernisation is, in general, targeted at areas of greatest benefit, thus the SLEs will be the last to be modernised.

The SLE Study

By March 1991 there will be approximately 1 million lines connected to low-functionality SLEs of less than 1000 connections. This represents some 2·7% of connections at

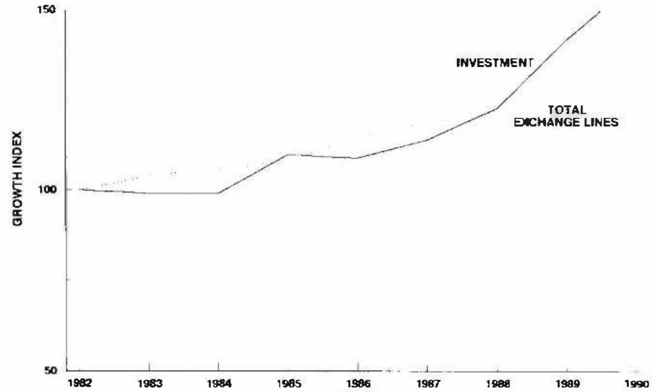


Figure 1—BTUK network growth

27% of BT's telephone exchange sites. Invariably these exchanges are in rural areas with the majority in the remote regions of Scotland and Wales. In most cases, the existing local exchange at the group switching centre (GSC)[4] will have been replaced using remote concentrators parented upon a consolidated[5] processor exchange.

Replacing SLEs with the existing ranges of remote concentrator units is not cost effective. BT instigated the SLE study to search for a method of economically connecting these customers to the new digital network.

The SLE study objectives are to:

● Identify systems throughout the world which fulfil BT's requirements and that could be deployed within the BT network without major alterations from 1992 onward.
● Formulate the national strategy for replacing SLEs.

The Approach

Having decided upon the course of action (see Figure 2) we advertised our intention in the *Official Journal of the European Community* (*OJEC*) and invited prospective suppliers to show an interest. Eighteen suppliers responded including our main exchange equipment suppliers. We provided these with sufficient information to decide if their products were capable of meeting the BT requirements (see Figure 3).

1. Advertise in OJEC	Jul/Aug 1989
2. Issue scope document to suppliers who registered an interest	22 Sept 1989
3. Receive submissions from suppliers	15 Jan 1990
4. Evaluate responses	Jan-Jun 1990
5. Redevelop strategy	Jun-Sept 1990
6. If strategy approved, publish tenders/SORs to suppliers	End 1990
7. Tendering responses/Evaluation	March 1991
8. Pilot system trial	Mid-End 1991
9. Commence roll out of SLE solutions	Start 1992

Figure 2—Small local exchange: BT schedule for project

Once satisfied that a solution could be offered, detailed information of the network and forecasts were provided to enable the implementation costs to be evaluated. Nine suppliers were asked to provide a response detailing their proposal with sufficient information so that BT could assess the whole life costs and relative merits of each solution.

The Solutions

The solutions fall into four basic categories:

Switching (all small exchanges of < 2000 connections capacity),
Multiplexing,
Remote concentration, and
Point-to-multipoint radio.

Some suppliers offered a single solution covering the whole range of exchange sizes, whilst others offered a combination of these.

Analysis

Each solution was slightly different offering varying levels of support, reliability, management and customer services.

TECHNICAL REQUIREMENTS

- Integration with Future/Existing Network
  - Management and operations
  - Support existing access lines
  - Signalling and interworking
  - Delay standards
  - Power
  - Numbering
  - Charge groups
  - Call charging
  - Tones and announcements
- Environmental
  - Safety
  - Accommodation
- Reliability/Performance
  - MSF minor/major failures
  - During upgrade/extensions
  - Fault diagnostics
- Support
  - Training
  - Operational backup
  - Repair
  - Upgrades
  - Documentation
  - Guarantees
- Provisioning

SERVICE REQUIREMENTS

- Itemised billing for all customers
- Customer dual signalling (MF4 and loop disconnect)
- 50 Hz SPM
- Star services
- Range of verbal guidance
- SLIDA (I.420) capability
- Fast call set-up

COMMERCIAL REQUIREMENTS

- Budgeting prices
- Delivery and installation capabilities
- Cost of ownership details
- Quality assurance

Figure 3—BT requirements

Each system imposed differing requirements on the existing network elements such as transmission and parent exchange requirements (Figure 4).

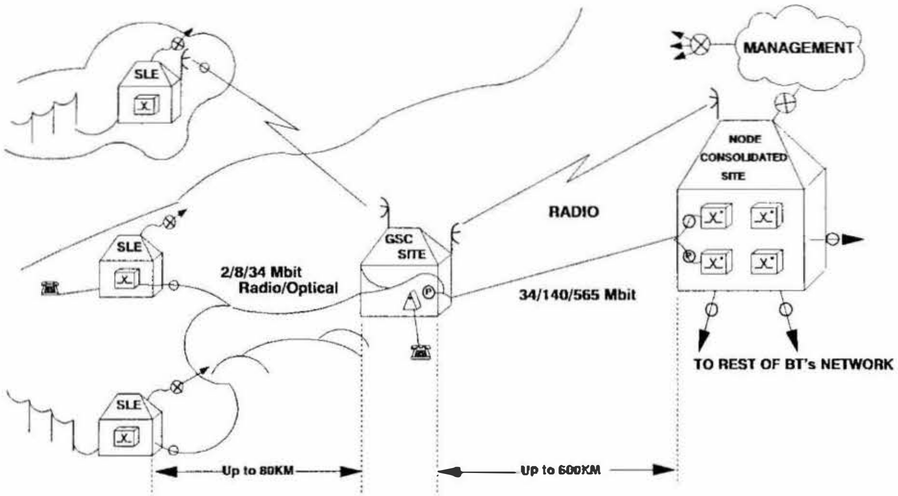
All responses needed some form of modification to meet BT's requirements. The following is a synopsis of the major areas where adaptive engineering is required by the different types:

Switching and concentration solutions:

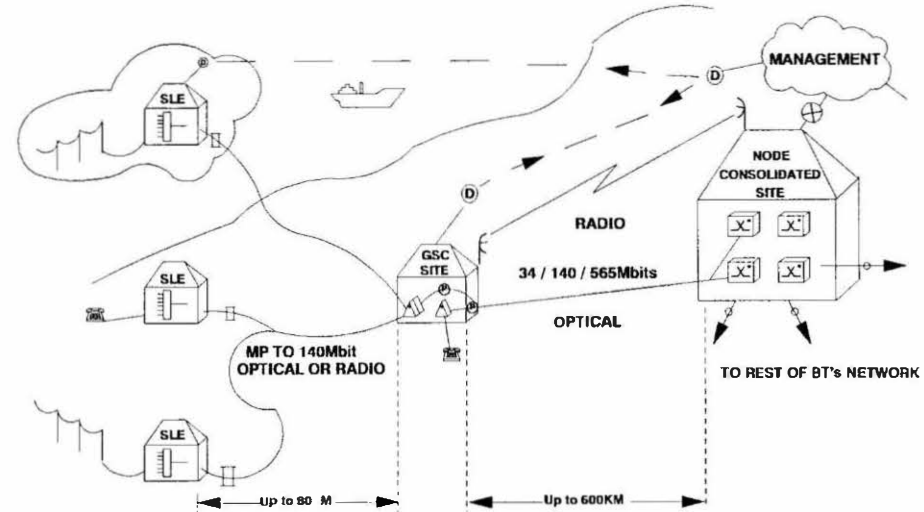
● Signalling System No. 7 (BT version),
● Charging and billing requirements,
● Line card capabilities, and
● Remote line test capability.

Multiplexing solutions:

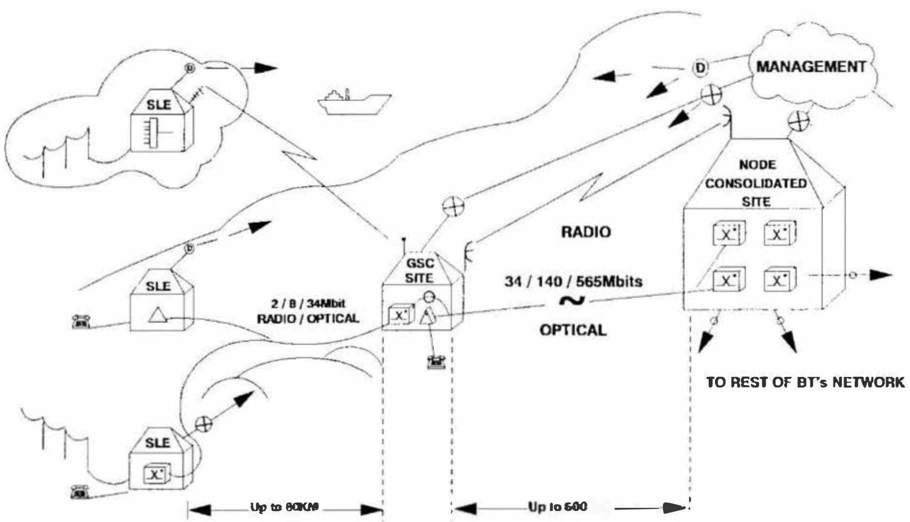
● Tones to indicate to a customer that the handset is off (the howler).
● Resilience of the equipment in the event of a component failure.
● Line card capabilities.



(a) Switching solution



(b) Transmission Solution



(c) Combined Solution

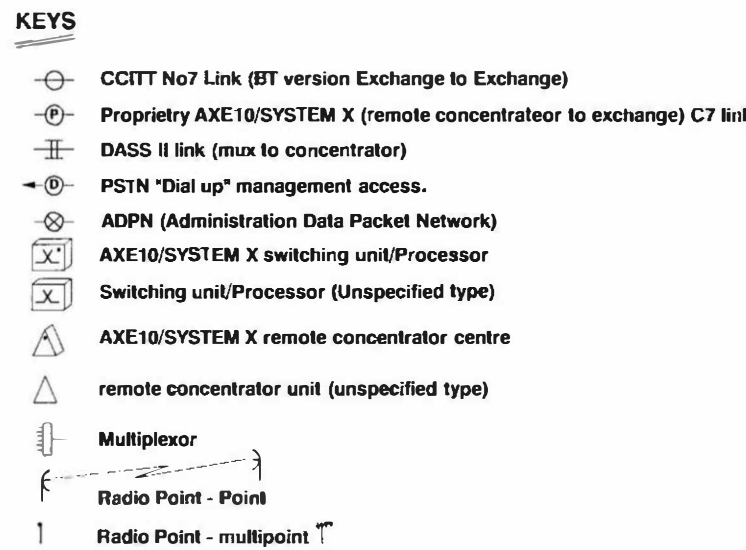


Figure 4—Alternative solutions

Radio solutions:

• Transmission delays in excess of the national network delay limits of 1 ms exchange-to-NTP limit.

Solutions which use exchange-dependent proprietary multiplexers or concentrators to serve the smaller exchange sites needed to be considered carefully. A host exchange has to be provided before, or at the same time as, the dependent proprietary equipment. The host must also be within the same geographical area (usually the GSC area). This could force advanced modernisation at 'larger' SLEs to make provision for exhaustion of the smaller dependent exchanges. This is particularly important when considering slower rates of modernisation.

We aimed to:

• assess all responses in a fair, unbiased and consistent way,
• identify the solution/s that best fit BT's needs from which the strategy would be devised.

Our method was to split the analysis into four independently manageable parts (whole life costs, technical, commercial and customers' services analysis). Each part was given to a separate team to appraise all the responses on the same basis. Weightings of the relative importance of the requirements were agreed and an assessment as to how close the responses came to the requirement made by the teams.

Position To-Date

The assessment of all solutions is, at the time of writing, still being performed. Reductions in the whole life costs will be achieved through the SLE initiative. What is not finalised at this time are the systems to be used and the strategy to be followed. Suppliers offering point-to-multipoint radio in their response have failed to convince BT that the 1 ms delay limit is achievable in the 1992–95 time frame. Point-to-multipoint radio has been excluded from the SLE analysis but we believe there is an opportunity for selective use of radio in particularly remote rural locations to make whole life cost savings.

OPPORTUNITIES FOR RADIO IN THE REMOTE RURAL LOCAL ACCESS NETWORK

The Current Rural Access Network

The local access network encompasses all of the transmission plant between the local exchange and the customer. In rural areas, the installation of long lengths of cable (sometimes overhead) are often required, to serve a few (or even individual) customers. Such plant is expensive to install and maintain, both in terms of materials and labour. In some cases, the cost of maintenance may be excessive due to the inclement weather suffered by such areas of isolated or exposed terrain. The high cost of maintenance is further exacerbated by the long distances, and the time taken by the linesmen to locate and repair the fault. Underground cables are less vulnerable to poor weather; however, the installation cost can be prohibitive in areas of hard rock, and may not even be feasible.

Demands on the Access Network

Premises remote from the existing telephony network, being inhabited by business people eager to escape from the environment of the city, are creating unforeseen demand. Furthermore, demands are increasing on the existing network (for example, for fax machines and modems). The former creates its own demands with the need to provide new paths; however, both are now creating shortages of capacity in the existing cables linking back to the exchange. Sometimes an expedient temporary solution is required, since the time taken to install a new cable can lead to an excessive service provision time. Such a temporary solution would also prove to be useful for diverting call traffic during any routine cable/duct replacement or repair. The demand for services to remote premises is now being positively encouraged by development agencies in rural areas. A prime example of this is the Highlands and Islands Initiative[1].

Specific Examples from the North of Scotland District

A recent study of transmission problems in the North of Scotland by BT Research Laboratories, has confirmed all of the above problems, and others:

• Customers can be very isolated.
• The environment is harsh.
• Customers sometimes do not have any mains electricity, which makes difficult the reliable use of active systems such as radio (the use of renewable energy sources is being studied).
• Often, the best (or only) access to customers is across waterways, which utilises expensive submarine cables.
• The rugged mountainous terrain makes transmission paths difficult.
• Cables may be difficult and expensive to install, and direct radio paths may not always be available.
• Environmental preservation can be a key issue in such rural areas (that is, ensuring that any installations are unobtrusive, and may include avoiding disturbance of the ground in sensitive areas).

The above can be exemplified by two sharply contrasting cases arising from a recent study of transmission problems in BT's North of Scotland District.

Example 1 (Figure 5)

This lies in a mountainous region in the central Highlands, where telephony is already provided to numerous points across a mountain, mainly for the benefit of serving a skiing area there. A cable was laid for providing the initial service; however, such is the environmental sensitivity of the area, that further ground disturbance for cable laying is not acceptable. Therefore an alternative method for providing transmission is required—the obvious being the use of radio. The use of radio would be eased here, since power is already available across the area, for the skiing facilities.

Example 2 (Figure 6)

On the west coast of Scotland, lies a group of communities circling a sea loch which extends inland for nearly 15 km. The 73 customers in the area are well distributed around the loch. Serving most of those that lie on the southern side of the loch does not present any great problems, since there is a reasonable road along there. The one exception to that is an old buried cable, which lies in boggy ground, and suffers from frequent corrosion. However, on the northern side of the loch, are two communities which currently have transmission problems. The first is inaccessible by road,

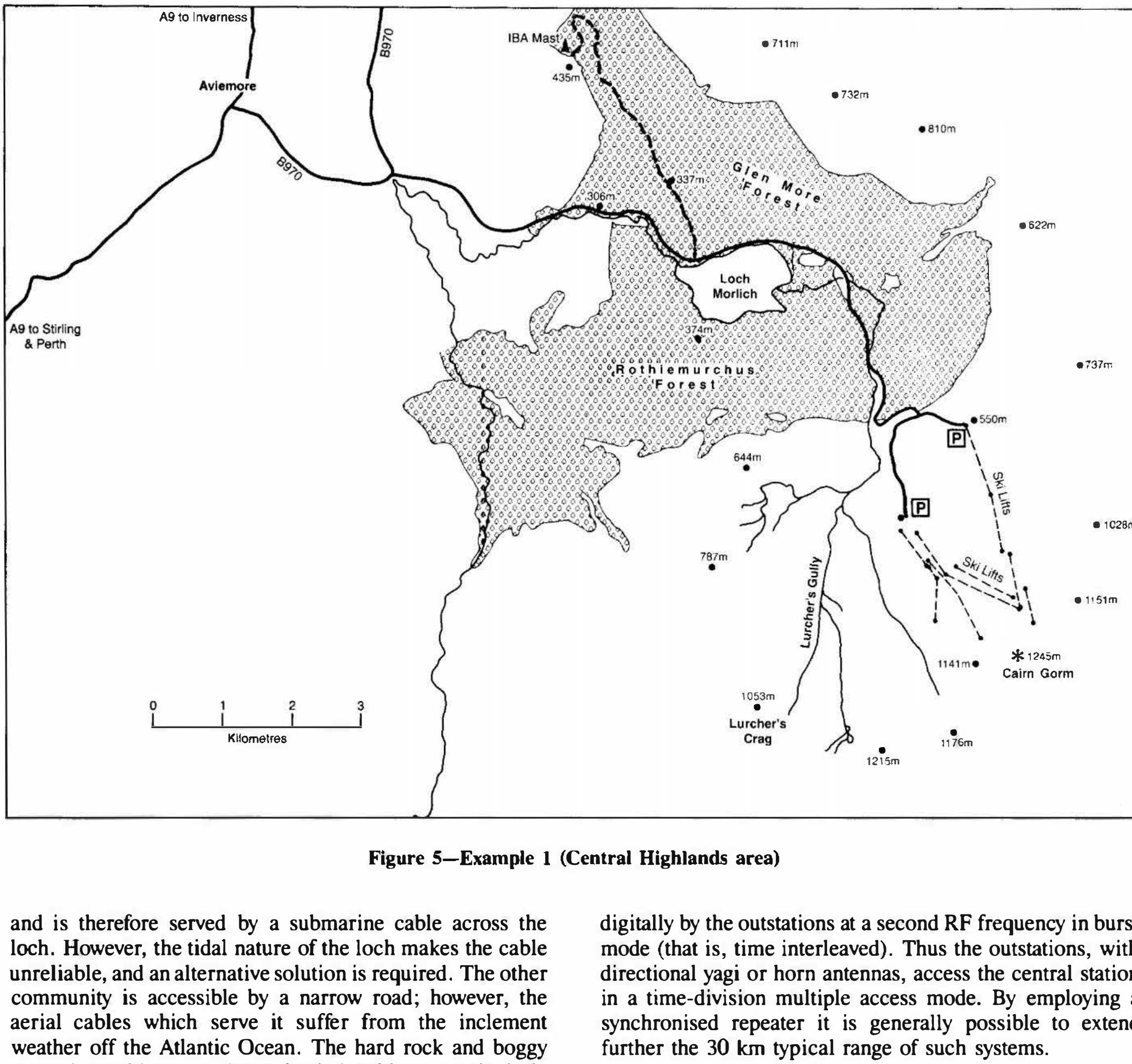


Figure 5—Example 1 (Central Highlands area)

and is therefore served by a submarine cable across the loch. However, the tidal nature of the loch makes the cable unreliable, and an alternative solution is required. The other community is accessible by a narrow road; however, the aerial cables which serve it suffer from the inclement weather off the Atlantic Ocean. The hard rock and boggy ground would not make a buried cable a particularly attractive alternative for such a small number of customers. To further complicate the problems, neither of the communities on the northern side of the loch have mains electricity. Despite that, radio is still being considered as the best alternative to the current cables.

Radio Options for the Access Network

Point-to-multipoint and point-to-point single-channel radio solutions have been considered in other parts of the UK where some of the problems discussed above are similar. A point-to-multipoint radio system comprises a central station (which is generally located at or near a telephone exchange), and a number of geographically dispersed subscriber outstations which have line-of-sight paths to the central station (see Figure 7). The customers are then linked to the outstations via overhead or buried cables. Telephony signals from the exchange are generally encoded digitally and modulated to RF, before broadcasting from the central station using an omni-directional antenna. In the up-link direction, the subscriber telephony signals are transmitted digitally by the outstations at a second RF frequency in burst mode (that is, time interleaved). Thus the outstations, with directional yagi or horn antennas, access the central station in a time-division multiple access mode. By employing a synchronised repeater it is generally possible to extend further the 30 km typical range of such systems.

Multipoint Radio

A multipoint radio system has been trialled successfully by Westward District, initially at Plymouth[6], and currently at Camelford in the rural environment of Bodmin Moor. This particular system has 15 trunks which can support up to 94 subscribers on a demand assignment basis. Each outstation is designed to serve a small number (typically 1–6) of subscribers, which also matches the subscriber distribution encountered in a rural environment. A higher capacity system with 60 trunks, which can be shared by over 500 subscribers, has also been recently trialled in Cumbria[7]. This system also offers the potential of replacing very small exchanges by large capacity outstations. The two trials of multipoint systems have led to the following conclusions:

- An overlay network of multipoint systems offers the best option in providing quick service to subscribers distributed over a wide geographical area. Furthermore, this scenario does not preclude the use of an outstation or central station to replace a small local exchange where multipoint systems with relatively high capacity are used.

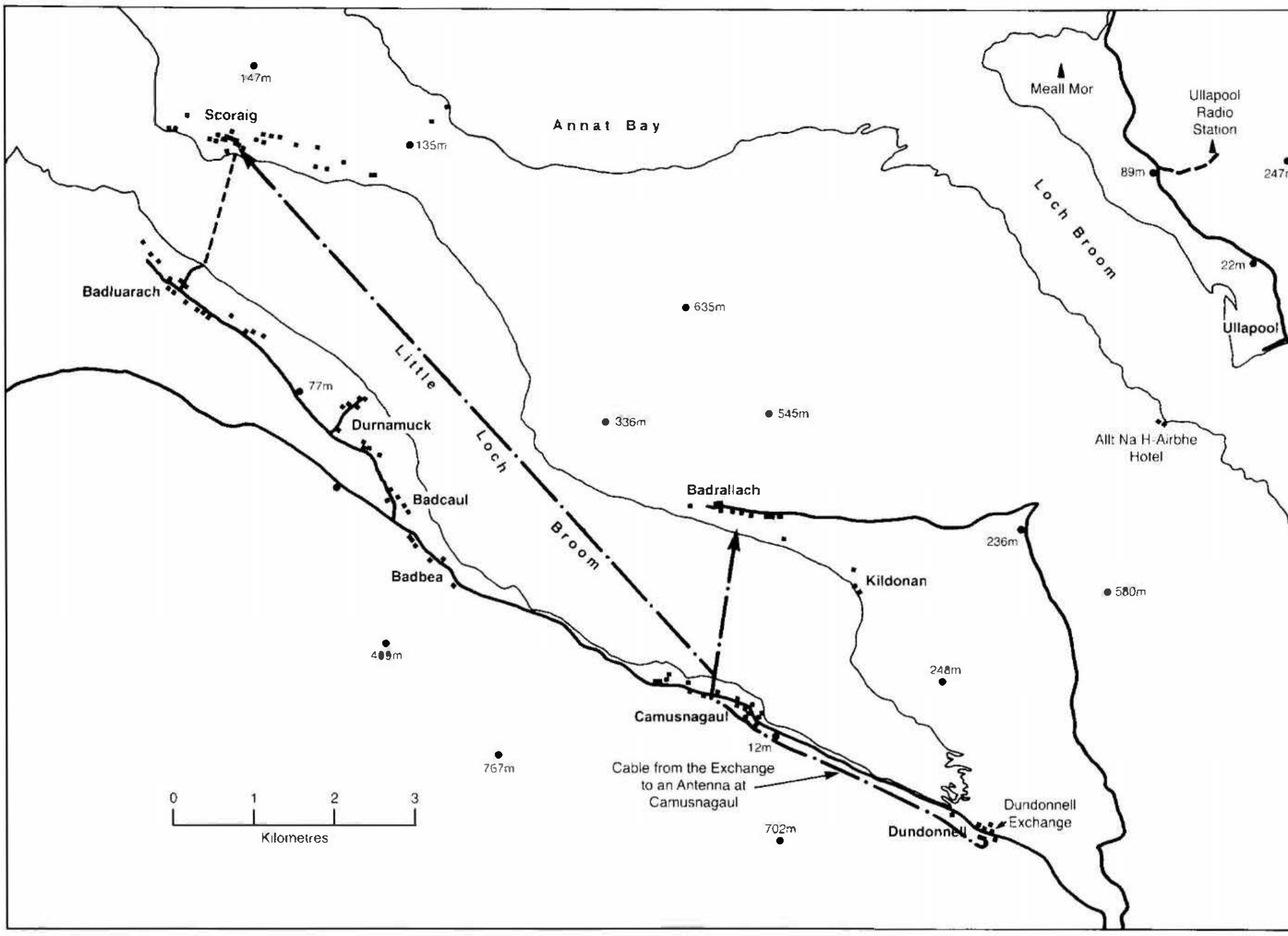


Figure 6—Example 2 (West Coast of Scotland)

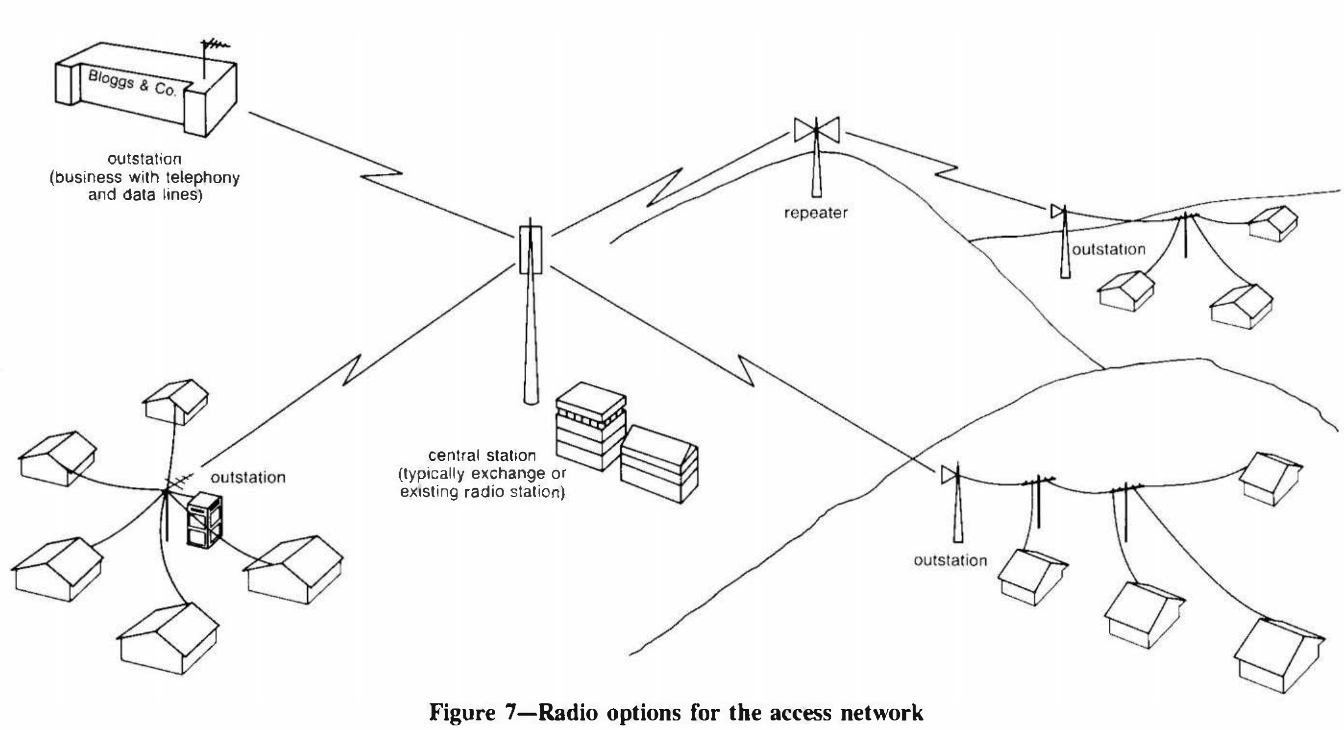


Figure 7—Radio options for the access network

- The transmission delay of the packetised multipoint system (plus any additional processing delay) must be less than 1 msec, so as not to exceed the national network delay limits. Also, use should not be made of echo control devices (except at the international switching centre).
- The cost per circuit should be low, particularly for serving

a single subscriber. This factor will determine the extent to which the system will be used in the network in future.

- The system reliability and suitability for operation with alternative power sources are important factors.
- The system should be upgradable, for example ISDN access.
- The system should offer adequate remote testing/monitoring facilities.

For the first example discussed earlier (Figure 5), any vantage point with visibility to the area to be covered, plus access and power, would be suitable for siting a multipoint radio central station. Figure 7 shows one of a number of possible multipoint radio solutions to the second example.

Point-to-Point Radio

Multipoint radio does not eliminate fault-prone overhead cable entirely, except where designs exist for a single subscriber outstation. A single-channel point-to-point radio system offers an alternative attractive solution without the high up-front cost of a central station. Trials of a proprietary VHF point-to-point single-channel radio system with terminal equipment at customers' premises have shown the suitability and acceptability of this type of system. However, since the subscribers with transmission/plant maintenance problems are generally located far from an exchange, the achievement of a line-of-sight radio path from subscriber premises to a nearby convenient point in the network (preferably the local exchange) can be difficult. This strongly suggests the desirability of using lower frequencies which permit signal diffraction. Most current, low cost, single channel radio equipment also operates at frequencies below 1 GHz. However, in view of the current regulatory thinking, which favours the use of these frequencies for mobile applications, a comparison of coverage obtained at microwave and VHF is currently under investigation.

THE INTEGRATED MODERNISATION SCENARIO

In the first part of the article, the problem of replacing SLEs in a cost-effective way was considered. In the second part, we have considered opportunities for using radio transmission in the rural environment. We shall now briefly look at the opportunities that can be provided by considering an integrated approach to rural network modernisation.

The original locations of the exchanges were largely dictated by the limitations of the copper network, and a large number of small exchanges, resulting in relatively short line lengths from the exchange centre. With fibre and radio systems the coverage area can be considerably greater than that possible with copper.

Combinations of radio systems, multiplexers, copper lines and emerging passive optical-fibre networks offer a number of possibilities in replacing SLEs, junction and parts of the local access plant in an integrated manner. For instance, for the remoter customers, point-to-point or point-to-multipoint radio systems offer good performance connections over a wide geographical area. It would be possible to bypass small local exchanges totally using multiplexers placed in the local access network and served by point-to-multipoint radio from a larger centrally located concentrator site. This could lead to savings from better utilisation of the concentrator and give line plant savings in the access network. It would also make it possible to respond quickly to sporadic demand over a wide geographical area which could in turn reduce the requirement for spare plant in the access network. These, and other network scenarios will need to be carefully studied with particular regard to whole life costs, the problems of obtaining line-of-sight paths for radio and those of powering remotely located equipment where no mains power is available. The ability to serve customers over longer distances also poses the potential problem of crossing charge group boundaries.

CONCLUSIONS

In this article we have addressed the issues of replacing SLEs in a cost-effective manner and the opportunities for radio systems in a rural environment. The existing ranges of remote concentrator units do not provide a cost-effective solution to replacing SLEs. A study initiated by BT has resulted in a number of suppliers proposing different solutions which fall into four categories: (*a*) switching, (*b*) multiplexing, (*c*) remote concentration, and (*d*) radio point-to-multipoint. The detailed analysis of each proposed solution is currently under consideration before a deployment strategy and financial justification are made.

The opportunities for radio in the rural environment have been examined and illustrated with examples from Scotland. Successful trials of proprietary VHF point-to-point radio systems with terminal equipment at customers' premises have shown the versatility of these systems. Trials of point-to-multipoint systems have shown conclusively that such systems must introduce minimal transmission delay and should preferably have suitable designs of single and multiple customer outstations which generally match the customer distributions encountered in the rural environment.

A combination of all transmission media and multiplexers may allow an integrated approach to rural network modernisation, without the constraints imposed by the existing network which is largely copper-based.

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1 Partnership between the Highlands and Islands (H & I) Development Board and British Telecom which together are investing £16 million to provide a modern digital infrastructure which replaces some 43 exchanges in key areas throughout the H & I by 1992. This is aimed at ensuring businesses in the area are not disadvantaged from a telecommunications aspect, compared with their national and European competitors. ('The Highlands and Island Initiative' *Br. Telecommun. Eng.*, July 1989, p. 107.)

2 STAR project has received grants from the EEC to bring advanced digital telecommunications to the Northern Ireland region.

3 British Telecom Report and Accounts, 1989.

4 A group switching centre is usually located at major population centres within a geographical area and is a natural hub for telephony links. The GSC is used in the BT analogue network and performs three separate functions. It is a local exchange, a junction switching exchange and a trunk switching exchange for all the local exchanges in its group.

5 A node consolidation exercises has been performed within the UK network. This has moved parent exchange processors together at a central location to achieve a more effective use of exchange systems within the network.

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Satellite Communications Using Very Small Aperture Terminals (VSATs)

J.-D. BÜCHS†

INTRODUCTION

European plurality, amiable with respect to language and culture, is undesirable in telecommunications. The assimilation of the networks in the European countries will be tedious and time-consuming. It is, however, possible to overcome the existing barriers quickly, namely by means of satellites, which by nature are not boundary limited. In the past, this potential of satellite communications was only usable with restrictions since the traffic had to be routed through one or a few large earth stations per country.

Thanks to the steady improvements of satellite performance, the minimum ground station size has decreased drastically (Figure 1). In the 14/11/12 GHz range (Ku band) antenna sizes as low as 1·8 m ± 0·6 m have become usable. With these *very small aperture terminals* (VSATs), installed at the end users' premises, it is now technically possible to interconnect arbitrary points within countries or regions. Thus, extremely competitive regional satellite networks have become feasible which are promising solutions for the improvement of communications in Europe and in third-world rural areas[1,2].

SYSTEM CONCEPT, SERVICES AND USERS

How is it possible to exchange information with good quality between two earth stations over a distance of more than 72 000 km? We make a theoretical experiment with two ground stations in assuming that the size of one station is increased and the size of the other one is kept constant. If we then analyse the quality in terms of energy per bit (E_B) divided by noise power density (kT), the following is observed:

- When station 1 transmits, E_B/kT at station 2 will always become sufficient.
- When station 2 transmits, E_B/kT at station 1 will approach a limit which depends on the parameters of station 2. If station 1 is chosen large, the latter direction determines the information rate. Approximately 100 kbit/s are achievable with typical satellite data and a size and transmit power at station 2 of 1·8 m and 2 W, respectively.

The answer is that high quality can indeed be achieved, if a topology is chosen where small stations (VSATs) are linked to a large *hub* station, with a size of 7 to 8 m at Ku band (Figure 2). With this star topology, one-way-services (information distribution in outbound direction or information collection in inbound direction) and two-way-services (information exchange) can be implemented. In doing a single hop through the satellite, signals are delayed by roughly one quarter of a second. Meshed communication between VSATs is possible as well (namely by through-connection in the hub station) if the delay of approximately half a second associated with the double hop of the signal is acceptable.

A highly competitive solution is a configuration with a hub station controlling several small VSAT networks (*shared hub* solution).

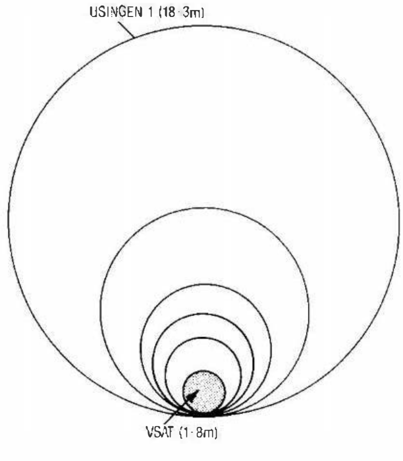
Star-type VSAT networks are attractive for large organisations with a branch structure like press agencies, banks, department store and hotel chains, insurance companies, travel agencies etc. Services like data exchange, Telex, facsimile, still picture transmission and telephony are possible. Functions supported hereby are, for example, instructing, reporting, updating, booking, checking, telecommanding, telemetering etc. Typical information rates are between 1·2 and 64 kbit/s.

BASIC SYSTEM FUNCTIONS

In applications as discussed here, the satellite channel is divided into frequency portions which means that basically frequency-division multiple access (FDMA) is applied. A single frequency portion can be used by a ground station

- in certain frequency slots which are occupied permanently and exclusively (FDMA);
- as above, but for only one baseband channel per slot (single channel per carrier (SCPC)),
- in certain time slots and exclusively (time-division multiple access (TDMA)),
- permanently together with others, the signal being immunised against collisions by coding and spreading (code-division multiple access (CDMA));
- in a certain percentage of time, collectively and with repeated transmission in the case of collisions (ALOHA); or

† ANT Bosch Telecom, Federal Republic of Germany



Usingen 1 is a station of Deutsche Bundespost located north of Frankfurt/Main

Figure 1—Development of ground station sizes at Ku band

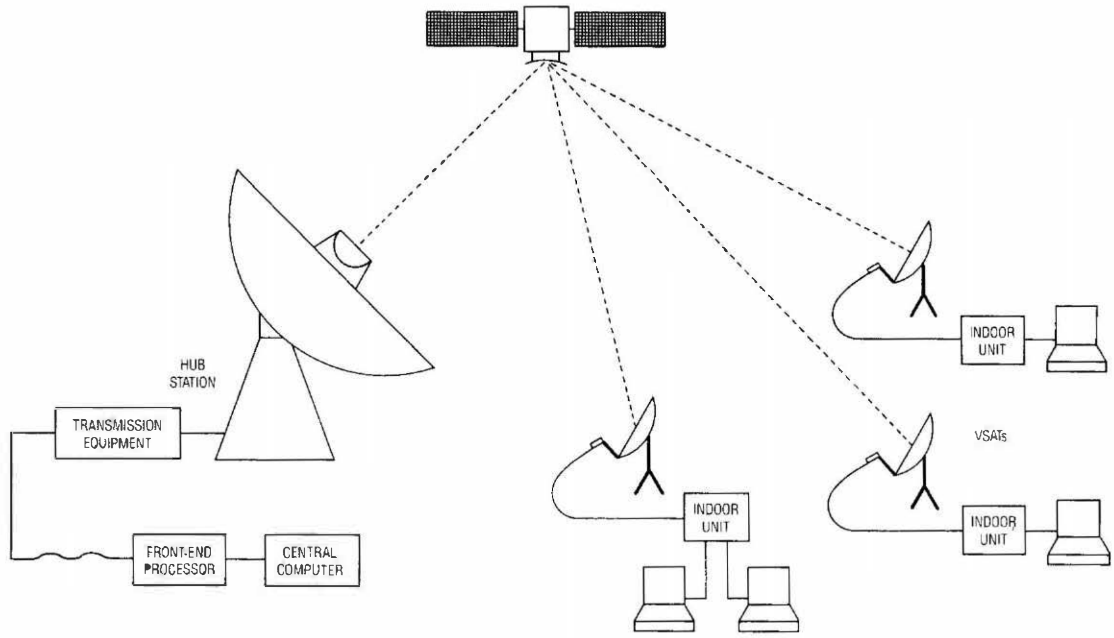


Figure 2—VSAT network

- in certain time slots, collectively and with repeated transmission in the case of collisions (slotted ALOHA (S-ALOHA)).

A repeated transmission is initiated either by not acknowledging the proper reception of a packet or by requesting to repeat a faulty information part.

Usually, the hub station distributes its outbound information by means of a time-division multiplex (TDM) signal in one frequency portion of the satellite channel. The VSATs apply CDMA, but only in rare cases. Mostly, they use sequences of ALOHA and TDMA. The choice between these two access modes is controlled by the satellite protocol such that the throughput is maximised. Slotted ALOHA, though more complex than pure ALOHA, is preferred due to its higher throughput.

A SYSTEM EXAMPLE—ARCHITECTURE

For illustration, a Ku band VSAT system of ANT Nachrichtentechnik GmbH, part of Bosch Telecom, is described in the following (Figure 3). The information rate of the outbound TDM carrier from the hub station to the VSAT groups equals multiples of 64 kbit/s, typical and maximum values being 512 kbit/s and 1·5 Mbit/s, respectively. The information rate of a carrier from a VSAT group to the hub station is 96, 128 or 256 kbit/s. The modulation used in both directions is binary phase shift keying (BPSK).

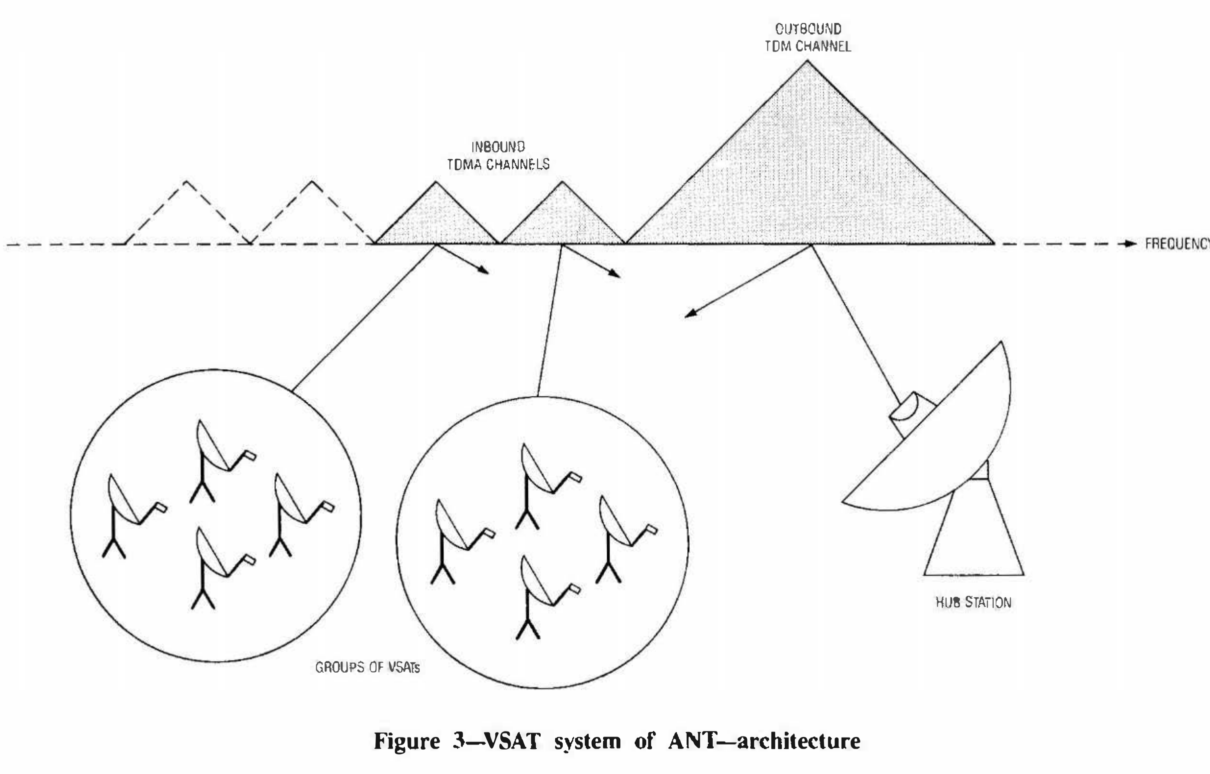


Figure 3—VSAT system of ANT—architecture

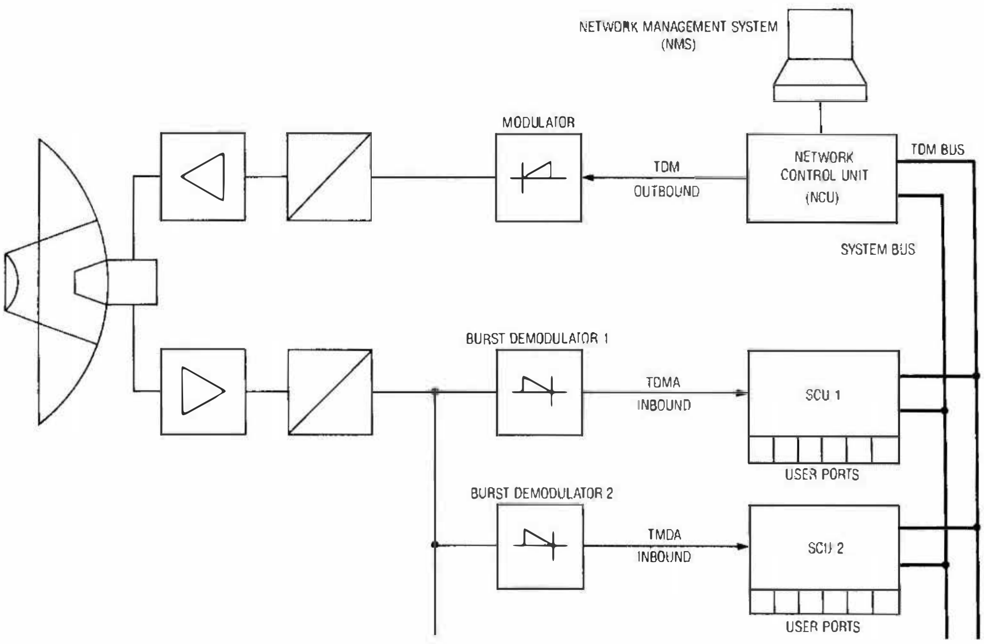


Figure 4—VSAT system of ANT—Hub station block diagram

The transmission rate on the channel is twice the information rate, since rate 1/2 forward error correction (FEC) in combination with Viterbi decoding is applied. The link budgets have to be such that the bit error rate under good weather conditions and including FEC is 10^{-7}. Thanks to the multiple access scheme which is implemented in the satellite protocol, the real error rate is much lower because checks for transmission errors are made regularly.

A SYSTEM EXAMPLE—HUB STATION AND VSATs

For the hub station size, a standard value of 5·6 m has been chosen (Figure 4). Additional building blocks are the receive and transmit subsystem and the network management system. The signals received in the 12 GHz range are preamplified and converted to 140 MHz. Each of the received carriers is fed to a burst demodulator which is followed by the Viterbi decoder. The baseband signal is then handled in so-called *subnetwork control units* (SCUs). Here, after evaluation of the addresses, the packets are delivered to one of the user ports.

In the reverse direction, after having received their addresses in the SCUs, the packets enter the TDM bus and travel to the so-called *network control unit* (NCU) where they are multiplexed into the TDM signal. After encoding and modulation, upconversion to 14 GHz, amplification and transmission are performed.

Arriving packets bound to another VSAT are routed by the SCU directly to the NCU.

The system is operated by means of the network management system which comprises a dedicated computer, a high-resolution colour screen, a keyboard and a mouse.

The VSATs are equipped with offset antennas having sizes of 1·2, 1·8 or 2·4 m; 1·8 m antennas are the standard solution. In order to minimise the losses, the receive and transmit chains are accommodated in an outdoor unit which is close to the feed horn (Figure 5). The Ku band amplifiers are equipped with field-effect transistors. Demodulator, modulator, baseband processor and power supply are contained in an indoor unit. One indoor unit comprises 4, 10 or 16 user ports.

A SYSTEM EXAMPLE—MULTIPLE ACCESS

The signals which the system is designed for are data consisting of packets or of short, medium or long blocks, real-time telephone signals which are represented by pieces of continuous data streams when the speaker is active and other signals.

In order to cope with this vast variety of source statistics, the traffic of all VSATs is monitored and one out of four access modes is applied by the hub station; these modes are:

- *TDMA* In this mode which is defined for an individual VSAT a time slot is assigned for exclusive use. It is mandatory for telephony.
- *TDMA with dynamic capacity assignment* In this mode which is a variant of the previous one additional time slot length is assigned as long as required.
- *S-ALOHA* This mode refers to a group of VSATs; the group is assigned one or several time slots. A VSAT transmits as soon as a packet has been prepared; if a collision occurs the transmission is repeated.
- *S-ALOHA with dynamic capacity assignment* In this mode, which is a variant of the previous one, a VSAT is separated from the group and treated as a TDMA user as long as its traffic exceeds a threshold.

With this spectrum of access modes the hub station is able to cope with different signals and to secure high throughputs.

A SYSTEM EXAMPLE—APPLICATIONS

The performance of the ANT VSAT system was tested successfully in several field trials[3].

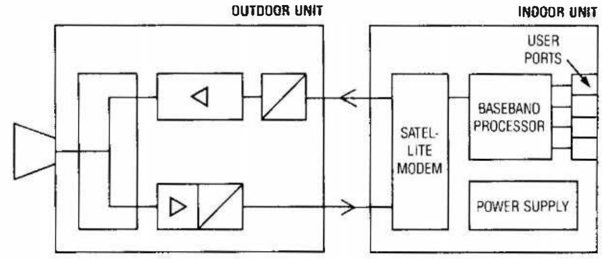


Figure 5—VSAT system of ANT—VSAT block diagram

In a network with a hub station in Backnang, transmissions were made to Deutsche Nachrichten GmbH in Frankfurt, the signals being

(*a*) weather map facsimile from Deutscher Wetterdienst in Offenbach,
(*b*) press reports from Deutsche Nachrichtenagentur, and
(*c*) high-resolution still pictures taken in Backnang.

In another configuration, with a hub station at the premises of Fernmeldetechnisches Zentralamt, the system was tested—in co-operation with Deutsche Bundespost—within the sales organisation of Bosch. The connection between the control computer in Stuttgart and the hub station in Darmstadt was realised in two ways: by means of a 64 kbit/s terrestrial line and, alternatively, by establishing an additional VSAT hop thus giving single and double hop conditions. The VSATs were installed close to three Bosch sales offices which are equipped with multiplexers and terminals: the locations were Hannover, Cologne and Munich.

FUTURE DEVELOPMENTS

VSAT networks are spreading rapidly in North America due to advantages such as: cost effectiveness, reliability and transparency, reconfigurability and expandability, short implementation times and—above all—independence from outside service suppliers. A similar development can be expected in Europe provided that a liberalised environment is created. It goes without saying that VSAT networks lend themselves ideally to serving as telecommunications infrastructures in rural areas of third-world countries.

When looking on the VSAT networks of the middle- and late-1990s, a need for VSAT-to-VSAT communication including telephony is identified; this means that meshed networks have to be realised. In the far future, broadband capabilities will be desirable.

The easiest way to provide full connectivity between the VSATs is by application of SCPC. The improvements required for meshed networks can be achieved by the elimination of the uplink noise; that is, by signal regeneration on board which entails a need for demodulation after reception and remodulation before transmission.

The challenge of demodulating and remodulating SCPC signals with low-cost, low-mass and low-power equipment has been solved recently with the development of multicarrier modems. According to a development by ANT, a multicarrier demodulator can be partitioned into a demultiplexer which separates the carriers from each other and demodulators. A favourable demultiplexing principle is the hierarchical multistage method (HMM), whereas the best solution for a demodulator is the application of a signal processor. In a future integrated version, a power of only 100 mW per channel will be needed[4].

With multicarrier demodulators and remodulators, simple payloads with improved performance can be designed which are suited for meshed VSAT networks.

A more advanced innovation connected with higher payload complexity, is to replace the broad beam covering all of the service area by many narrow beams (multiple beam coverage). This leads to higher satellite antenna gains and to an improvement of the link performance. In multiple beam payloads, the uplink signals have to be routed to the downlink spot beam to which the information is addressed.

This routing is simple to implement if the number of spot beams is limited and SCPC is applied. Certain carrier frequencies are assigned to certain beams. In case TDMA is applied on the uplink, the bursts arriving at the satellite can be routed in an intermediate frequency matrix which is controlled by a processor; this principle will be used in the American Advanced Communications Technology Satellite (ACTS) (Figure 6)[1].

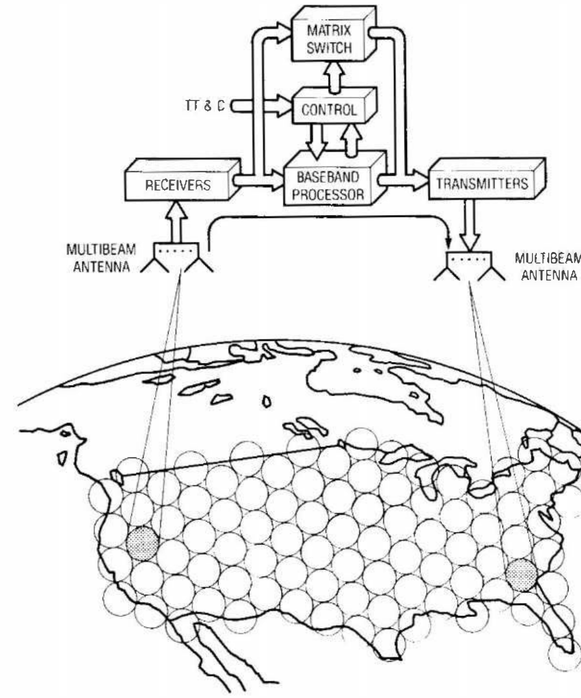


Figure 6—Advanced Communications Technology Satellite (ACTS)

The highest degree of improvement is achieved if regeneration on board and multiple beam coverage are combined. Again, SCPC and TDMA are conceivable as access modes. In the case of SCPC, multicarrier demodulators and remodulators are advantageous and the routing can be realised at baseband. In the case of TDMA, the switching function is best realised by means of a dynamic baseband switch matrix which is controlled by a processor; ACTS will demonstrate this principle as well[1].

CONCLUSION

VSATs are on the verge of playing an important part in North America, in a liberalised Europe and in rural areas of the Third World. The improvement potential of future satellites will enable the step from star to mesh configurations to be taken and will increase the information rates significantly.

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SIMNET Simulation System

I. B. LAGATHINOS†

INTRODUCTION

Simulating large computer networks imposes a heavy load both on memory requirements and on computer time. These requirements are approximately proportional to N^2, where N is the number of nodes of the network. SIMNET has been developed by the Electrical Engineer I. B. Lagathinos of Hellenic Telecommunications Organisation (OTE). This is perhaps the most appropriate time period to introduce SIMNET as a tool of study in the Greek network since the digitalisation process is by this time at its starting point. The system is mainly intended to serve the needs of an effective network management especially in the field of digital telephony.

GENERAL INFORMATION

The target of SIMNET is to offer the user a detailed global view of the performance of large networks consisting of 200 or more nodes.

Due to this fact:

(*a*) The design of the system is mainly oriented to fast execution times. This implies significant main memory requirements for the creation of fast data structures.

(*b*) The principle of circuit limited operation is adopted under which no internal congestion of the nodes is considered. This principle yields sufficient accuracy under normal traffic operating conditions. When congestion begins to spread out, the situation can be approximately modelled by either introducing internal congestion in the nodes, or state dependent congestion in the links connecting the nodes.

SIMNET is not tailored to meet the needs of a particular network structure; on the contrary it is designed to model the utmost generalised situation whenever the user wishes to study.

This means that no restriction applies on the hierarchical or whatsoever routing principles of the network to be simulated. Besides SIMNET is apt to simulate only one exchange at a time; for example, an international digital exchange.

Great effort has been focused on random number generation. An extremely good and relatively fast generator has been built based on the central idea of the Marsaglia/Mclaren shuffling generator. This idea has been to a large degree extended by the author of this text, whilst the drawbacks of the original generator referred to by Knuth have been eliminated. Each source of randomness uses a different random number generator. Degeneracy phenomena due to drainage of a single generator are therefore avoided.

INPUT DATA

At first, the user has to determine the topology of the network (nodes and links). The number of the traffic cases is determined next. Each traffic case might be characterised by the source/destination exchanges of the originating call. The number of traffic cases is not necessarily restricted to N^2 or $N(N-1)$. In fact it could be any number inside or outside the $(N(N-1), N^2)$ interval.

Great flexibility is thus given to the user to simulate different traffic classes (for example, business and residential subscribers) or networks comprising nodes not giving birth to traffic (for example, tandem exchanges). The user has subsequently to determine the routes to be used during the call establishment procedure by each traffic case.

The above information is given under the form of non-binary routing trees in pre-ordered traversal. We suggest the pre-ordered traversal is the most convenient way to map the alternative paths of routing trees. No restrictions exist regarding to the shape or the number of branches of each routing tree. Due to this generalised data structure form any routing principle scheme can be modeled by SIMNET.

Depending on the condition for a call attempt to fail, SIMNET simulates either the common-channel signalling (CCS) case or non-CCS case. In the case of the non-CCS case, the call fails only if no path through the entire routing tree is available from source to destination. In the non-CCS case, the call fails if it has been routed to a congested branch (link) and this branch has no brother in the direction of a pre-ordered traversal to be hunted for a free line. Two branches are said to have a *brotherhood relationship*, if they stem from a common root. The traffic demand corresponding to each particular traffic case is described by the interarrival time probability density functions (PDFs) and service (holding) time PDFs. At the present stage of SIMNET, samples can be drawn from the following distributions: negative exponential, n-Erlang, gamma, beta, lognorma, Weibul, normal, uniform, constant, and user-defined. Thanks to a specific structure of SIMNET the user has the following options:

- To select one kind of distribution for interarrival times and one kind of distribution for holding times for all traffic cases.
- To select one kind of distribution for interarrival times and one kind of distribution for holding times for each particular traffic case.

Finally the user has to specify the parameters for each of the above mentioned distributions. The number of parameters required to uniquely specify one distribution depends on the kind of that particular distribution.

OUTPUT RESULTS

The output data of SIMNET can be classified into 37 categories of functionals which describe in detail the performance of the simulated system.

This is perhaps an extravagant amount of information about the system and it is the user's responsibility to make use out of it.

† Hellenic Telecommunications Organisation SA (OTE), Greece

It is quite noticeable that SIMNET produces this tremendous flow of information without a serious impact in the total execution time. This is due to the fact that during the main simulation time the minimum number of measurements necessary for the production of results is performed by SIMNET.

The main volume of results is produced during the statistics-making period which represents only a small proportion of the total run time. The functionals estimated by SIMNET can be further classified into three main categories: functionals per real branch, per logical branch and per tree.

The notion of real branch, logical branch and tree comes directly from the above mentioned routing trees structures of SIMNET. Let us further elaborate:

Real branch stands for a specific link in conjunction with the total traffic through it.

Logical branch stands for a specific link in conjunction with some traffic flowing through it, which belongs to a particular traffic case.

Tree stands for all links constituting the routing tree of a particular traffic case.

The above may be clarified by the following example:

Carried traffic through real branch 27 means the total carried traffic through link 27. This traffic is the merge of constituent traffics belonging to the traffic cases which make use of this link in their routing procedure.

Carried traffic through logical branch 1418 means carried traffic through link 56 belonging to traffic case 23.

Carried traffic through tree 23 means end-to-end carried traffic of traffic case 23.

Now onwards BL will stand for the expression 'on a logical branch basis', BR for 'on a real branch basis', TR for 'on an end-to-end basis' and S for 'on a system basis'. The functionals estimated by SIMNET can thus be summarised in the following space effective mode:

(1) OFFERED TRAFFIC (BL, BR, TR, S)
(2) CARRIED TRAFFIC (BL, BR, TR, S)
(3) BID OVERFLOW (REJECTION) (BL, TR, S)
(4) TRAFFIC OVERFLOW (REJECTION) (BL, TR, S)
(5) MEAN HOLDING TIME PER ANSWER (BL, BR, TR)
(6) MEAN HOLDING TIME PER BID (BL, BR, TR, TR)
(7) MEAN HOLDING TIME PER SEIZURE (BL, BR)
(8) ANSWER/BID RATIO (BL, BR)
(9) ANSWER/SEIZURE RATIO (BL, BR)
(10) CARRIED/OFFERED TRAFFIC RATIO (BL, BR)
(11) OCCUPANCY PER CIRCUIT PER HOUR (BL, BR)
(12) BIDS PER CIRCUIT PER HOUR (BL, BR)
(13) SEIZURES PER CIRCUIT PER HOUR (BL, BR)
(14) ANSWERS PER CIRCUIT PER HOUR (BL, BR)

If for example the network to be simulated consists of only 4 nodes, 6 arcs and 6 branches per routing tree, then the total number of functionals estimated by SIMNET is 1168.

Indeed there is no recess of the network which is not illuminated.

HIGHLIGHTS

One of the most time-consuming activities of similar programs is searching the current event list for the most imminent event to occur. This is dramatically improved by using the binary trees search technique. For example, if the number of traffic cases rises to 1600, the event list structure consists of 1600 nodes. The inhalt of each node is the number of the corresponding traffic case where the key of the structure is the arrival time. The arrival times of the traffic cases are registered into a separate array. The leftmost node of the tree contains the number of the most imminent traffic case. This leftmost node is stored in a variable; therefore only the operations 'add/remove a node' are performed.

A similar method is followed to implement the hunting procedure; that is, the process by which a trunk group is searched for a free outgoing line.

For each trunk group a separate tree structure is created. Each node contains the number of the line and the corresponding release times (event-to-event simulation) are kept in a multi-array/pointers structure.The most imminent lines to be released of each trunk group are stored in a separate array. Each time a hunt is to occur on a trunk group the most imminent line of this group is seized in case the line has a release time less or equal to the current time (clock time) of the simulation. If this condition is not fulfilled then the hunting on the particular trunk group does fail. Another topic of general interest in simulation is the control of the simulation's duration. Regarding this, two options are provided: simulation time is either externally determined by the user or internally decided by SIMNET.

In the latter case, simulation continues until some convergence conditions set up by the user are met. In order to eliminate initial conditions bias error, SIMNET makes use of a 'warm-up period', during which no measurement is made.

At its present stage SIMNET consists of 8000 FORTRAN lines. As the case must be with voluminous software, modularity is the most salient feature. New possibilities can be included, for example time-varying arrival processes or repeated attempts, without having extensive modifications all over the program to be made.

CONCLUSION

In this article an attempt is made to convey some information to people involved in simulation activities.

These people are not only concerned on how to create simulation models but mainly on how to implement them in the most efficient way. Knowing by experience that even a minor idea may render a major evolution in this field any relevant proposal is mostly welcomed.

Network Management of Broadband Networks

B. AMBROSE†

INTRODUCTION

This paper describes the work of the Netman project, one of about 90 projects that make up the RACE (Research into Advanced Communications for Europe) programme. The aim of the RACE programme is to facilitate the smooth introduction of integrated broadband communications (IBC) into Europe from 1995 onwards.

IBC involves the provision of low to very high bandwidth services that interwork with existing services, to customers over an optic fibre cable network. An integrated broadband communications network (IBCN) that covers all of Europe is the eventual goal of RACE.

The Netman project aims to develop standards for network management of the IBCN and is a key project in the RACE programme. The Netman project will produce functional specifications for network management of the IBCN.

These specifications will state what the network management system for the IBCN should be capable of doing, without being in any way restrictive about how the network management system will eventually be built.

TRENDS IN NETWORK MANAGEMENT

Future network management systems are expected to offer more control of the network for the operator as well as less need for operating personnel. High performance workstations are becoming more and more a part of network management systems. The possibilities of integrated network management are opening up, which would allow a single network management centre to manage in an integrated way equipment from a number of vendors, that provide a number of services and which support a number of networks.

Technologies developed in the EC ESPRIT programme are being tested by three RACE projects for applicability in network management systems. This ESPRIT technology includes knowledge-based systems (KBS), advanced man–machine interfaces (MMIs) and distributed database technology.

DEFINITION OF NETWORK MANAGEMENT

For the purpose of the Netman project the following provisional definition has been used to outline the scope of network management:

Network management is the set of human and automated decision making processes which result in changes being made to the IBC networks and equipment with the objectives of optimising user perceived QOS, performance, network resources or to cater for growth.

MANAGED ENTITIES

The IBCN will be pan-European, made up of a large number of exchanges, linked by fibre optic transmission systems spanning hundreds of kilometres. Connection to individual subscribers might be by fixed fibre optic cable, terrestrial radio systems or satellite with different network management requirements for each. The network will use a new mode of information transfer, asynchronous transfer mode (ATM), as opposed to the circuit switched synchronous transfer mode (STM) used in ISDN. The advantage of ATM is that it makes more efficient use of bandwidth. However it has the disadvantage that load control and charging are made more difficult. With ATM it may be possible to dynamically trade quality of service against traffic load, and this would have major network management implications.

The fact that the IBCN will have gateways to other networks and that hybrid networks using both ATM and STM will exist for a number of years will add to the problems of network management. When mobile terminals are developed for the IBCN, problems will occur in keeping track of customers and charging correctly for usage. Security and integrity of the IBCN will have to be managed also.

STANDARDS ACTIVITY

The international standards body CCITT has begun work on developing standards for network management of telephony networks. In particular CCITT Recommendation M.30 (Blue Book) gives principles for the design of a network management system called the *Telecommunications Management Network* (TMN). It is important that Netman specifications developed for network management align with these principles.

In Europe, ETSI Subgroup NA4 is specifying *application services*, which are the services provided to operators to run the network. It has produced a list of over 20 application services. More could be produced in the future. Application services are broken down into application functions that the network management system has to supply. A lot of ETSI work has been devoted to development of the procedure for developing these application services.

From the computers communications side of things, ISO has been very active in the open systems management arena for the past few years. A common management information services (CMIS) protocol has been developed by ISO for the communication of management information. More management services are to be defined under the headings of Fault Management, Configuration Management, Accounting Management, Performance Management and Security Management.

NETMAN WORKPLAN

Figure 1 shows the Netman workflow. It is aimed at producing a stable and long lasting set of functional specifications for network management.

As in all specification projects, the aim is

(*a*) to carry out requirements capture whereby the requirements that are to be imposed on the system are gathered from the relevant sources;

† Broadcom Éireann Research Ltd., Ireland

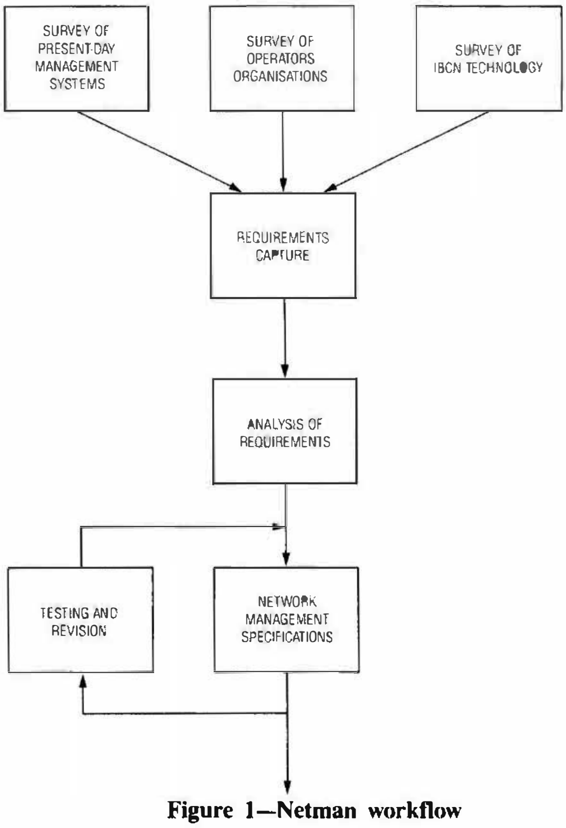

Figure 1—Netman workflow

(*b*) to carry out analysis of requirements, where the requirements are analysed to show up gaps or inconsistencies or non-feasibility; and

(*c*) to produce functional specifications, which detail in a non-ambiguous way the functions that the system is to perform. Given the long time frame of the IBC, implementation-independent specifications are essential.

Since the Netman project started it has been engaged in requirement capture work in order to assess what demands would be made of a network management system. This has involved:

- analysing the functionality of present network management systems,
- analysing present network operators requirements; and
- using results from other RACE projects about what will have to be managed in the IBCN.

Only functional requirements which refer to system behaviour are of interest to Netman. The actions that the system will carry out are described. Interactions with the user of the system and the consequences of these interactions are described.

Examples of non-functional requirements from this perspective are data throughput and other performance characteristics. These will not be specified by Netman.

From time to time, detailed case studies are carried out by Netman to check the specification method that is being used and the specifications that are being produced.

NETMAN CUBE MODEL

When Netman analysed the requirements that it had captured, it was found that a model of network management was needed to classify the functions that had been collected. The Netman model of network management is shown in Figure 2. It was found that three independent axes were needed to scope the area. This prompted the creation of a 'cube' model.

One side of the Cube Model stresses the generic decision making processes involved in network management. These are:

(*a*) *Awareness Creation* that a decision has to be made. Awareness Creation triggers the decision maker into the realisation that a decision has to be made. It can take the form of alarms in the case of failure, or a customer request in the case of customer administration or a message from another TMN.

(*b*) *Decision Making and Support* are carried out by humans and software and involve gathering of information required to make a decision and the choosing of which change(s) to make, if any.

(*c*) *Decision Implementation* then involves the carrying out of the decision. It is worth noting that decision implementation can involve a number of activities performed by humans or machines to ensure that implementation is performed properly.

The second side of the Cube Model stresses the various layers of network management. Working definition of the layers of the Responsibility Model have been developed. These layers are defined to be:

Business Management

The Business Management (BM) Layer manages the interaction between the network and its environment (except for the customer), and includes functions and information necessary for the implementation of policies and strategies within the organisation which owns and operates the services and/or the network.

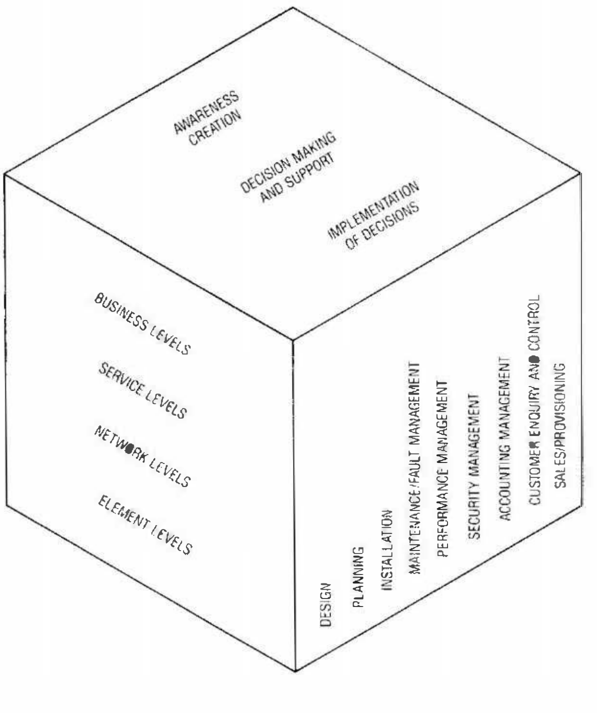

Figure 2—Netman Cube Model

Service Management

The second layer is the Service Management (SM) Layer. Here are allocated all functions and information needed to manage a particular service. The service may be implemented across several networks, each network performing many services. It is at this level that customer-related functions and information are to be found, including subscription information and service profiles, access rights, usage records and accounts as well as functions and information related to establishing and maintaining the facilities required by the service itself, over and above the networking facilities.

Network Management

The third layer is the Network Management (NM) Layer. Here are allocated functions and information addressing the management of the particular network as a whole. Configuration of the network as a whole would be performed at this level, as would network control, performance analysis and statistics.

Element Management Layer

The fourth layer is the Element Management (EM) Layer. Here are allocated functions and information related to the management of a number of individual network elements (NEs). Specific information on the individual NEs is required. The Element Management Layer will not independently take any account of network configuration aspects and will have only limited visibility of other parts of the network.

The third side of the Cube Model is a life cycle model of network management, moving from design, planning and installation and on to the in-service network management functions. This reflects the Netman split of network management into nine functional areas.

NETWORK MANAGEMENT SPECIFICATIONS

Netman has already produced draft specifications for nine network management functional areas: Design, Planning, Installation, Sales/Provisioning, Accounting Management, Maintenance/Fault Management, Performance Management, Security Management and Customer Query and Control. For example, the specification for Maintenance/Fault Management covers preventative maintenance, corrective maintenance and surveillance-based (controlled) maintenance.

Maintenance activities are further classified into:

Maintenance Planning
Trouble Detection
System Protection
System Recovery
Trouble Notification/Reporting
Trouble Verification
Trouble Diagnosis and Localisation
Putting a System Resource Out-of-Service
Repair Supervision
Repair
Repair Verification
Return to Service

A description is given of each of these activities in the specification.

At present the specifications are structured using a template. This template helps the specifier to ensure that all specifications are consistent. The template includes: function name, function definition, interaction with other functional areas, an overview of the specifications and an in-depth specification of the subfunctions that comprise the function.

As part of the template, the detailed specifications are structured using the Cube Model mentioned above. This aids checking for completeness, correctness and consistency bearing in mind the fact that the requirements were derived from a number of different sources.

INFORMATION MODELLING

Functions act on information and the storing and retrieving of information from common databases is one of the major headaches in the design of network management systems. Too often the 'spaghetti syndrome' evolves, with various network management systems using copies of network management data in different ways, resulting in inefficiency and higher costs.

Information modelling is a necessary step to overcome these problems. Various techniques are available for information modelling ranging from entity relationship models, to dataflow models to object-oriented models.

Netman selected an object-oriented approach to modelling of the information stored in the network and network elements. Object-oriented models offer advantages in modelling telecommunications networks as one can define classes of objects (such as switches) and ensure that subclasses of objects inherit the attributes and operations of their superclasses. This allows the specifications to be future proof in that it is relatively easy to define new subclasses and still have interworking with systems in which only the superclass exists. Object orientation can reduce the specification work considerably over the system life-cycle.

FUTURE WORK

By the end of 1992, Netman will have placed 35 person-years of effort over 5 years into the specifications of the functions needed in a network management system. The Netman approach is designed to produce a very structured set of specifications, which will ensure less difficulty for the designer of the network management system to verify that the specifications are met. Drafts of the specifications have been released for consensus building.

Future work of Netman will involve refining and testing these specifications by means of case studies and feedback from other RACE projects. Eventually in 1992, when Netman finishes, the specifications will become part of the body of common functional specifications produced by the RACE programme to aid the equipment suppliers and network operators in building an IBCN for Europe.

Glossary

ESPRIT European Strategic Programme for Research and Development into Information Technology
ETSI European Telecommunications Standards Institute
ISO International Standards Organisation
QOS Quality of service

FiberWorld Network Architecture

W. FROST†

INTRODUCTION

Northern Telecom has introduced a complete family of access, transport and switching products in response to, and as a direct result of, the FiberWorld vision of the evolving global telecommunication network. To understand and assess the impact of these fibre-based, full spectrum service-based products, the FiberWorld Network vision (Figure 1) and implementation must be understood.

The assessment and implementation characteristics of the evolving telecommunications network are full spectrum service-based and fibre-based in response to current business service issues and business user trends in convergence with the development of state-of-the-art technology. The business service issues include new services requiring higher bit rates, service flexibility, network flexibility and reliability. Key to the issues are wideband/broadband service requirements delivered via a flexible (switched) network. Specifically note that these issues and requirements apply, not only to large business users, but also in increasing proportion to small business users.

Components of this network are available today and can be ubiquitously deployed by utilising both existing technologies, such as fibre optic access and transmission for single-facility, full-bandwidth service delivery, as well as state-of-the art technologies, such as service adaptive access and ATM switching, as developed by Northern Telecom. This technology-based network realisation does, in fact, directly and specifically, converge with the known business user trends.

The specific business user trends mandating the FiberWorld vision focus on network flexibility, bandwidth on demand, constant reconfiguration, speed of service provisioning segments from S_0,S_{2M} to SONET/SDH, with equal feature and ease of delivery to small business. Paramount in implementation is error free network operation (directly related to the demand for high speed data).

† Northern Telecom GmbH, Federal Republic of Germany

NETWORK VISION

The FiberWorld vision, in response to these issues and trends, is positioned first as a network vision and implementation assessment, and second as a network product line response. The network vision and implementation assessment project the following mandatory network attributes:

(*a*) The *full spectrum service capability* delivers all services from narrowband voice through wideband data, through a wide range of LAN interfaces to broadband services including video (including HDTV). This full spectrum service capability is based on fibre optic transmission and access, along with ATM/BISDN switching; hence, it utilises and exploits an enormous embedded line capacity. This allows for seamless service management and provisioning with plug-ins and shelves added as required. In this vision, the revenue stream matches the investment timing in the most critical area—access. Deploying a full spectrum service network therefore simplifies the network and specifically eliminates the need for overlay networks and or/overlay service distribution networks.

(*b*) In this network vision and implementation assessment, the implementation is *seamless and survivable* based on end-to-end variable bandwidth transport and switching with flexible bandwidth assignment. Multiplexing is integral by virtue of the network being seamless with flexible bandwidth assignment. In creating the seamless network,

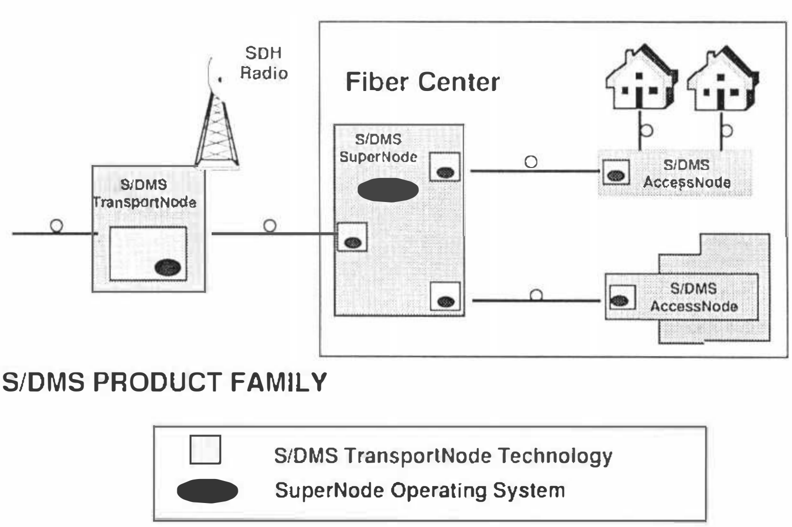

Figure 1—S/DMS product family—a common architecture

utilising a fibre-optic design throughout as a required attribute, service provisioning becomes independent of transport provisioning hence reinforcing network flexibility, ease of service delivery, ease of reconfiguration, equal to both large and small business and survivability.

(*c*) *Service adaptive access* provides the link from the end users of the network. With service adaptive access, a minimal number of access circuits are employed, each of which, via software, can be specified and characterised to provide the wide-range of specific services now required from narrowband to broadband. This technology is key to such features as network-level provisioning, flexible bandwidth assignment, and remote service provisioning.

(*d*) The network implication of a *software controlled/downloadable* network provides network level provisioning, a common operations human–machine interface, a ubiquitous and flexible OAM&P interface, along with features such as network-based remote service assignment. This network-based software controlled/downloadable attributes links directly to the service adaptive access (*c*) to provide the specified service.

(*e*) The network vision and implementation assessment is built upon a full *SONET/SDH standardised network* (Figure 2) inherently optimised not only for fibre optic transport but also by extending SONET/SDH to, and through, the access network. In designing the network products, particularly the access network, based on SONET/SDH and fibre (as opposed to a SONET/SDH fibre extension of an electronic system), the network becomes cost-effective based on narrowband services alone.

The SONET/SDH bandwidths include, but are not limited to, voice frequency, S_0, S_{2M}, BISDN, video, up to and including HDTV. Specifically note that this network vision and implementation assessment is based on the rate of 155·52 Mbit/s, thereby matching and providing a bridge to the CCITT international standard STM-1, of 155·52 Mbit/s.

While higher SONET/SDH bit rates (payloads) are employed, 622·08 Mbit/s and 2·488 Gbit/s, the basic building block is 155·52 Mbit/s.

(*f*) The network vision and implementation assessment includes a common, full-range *operations, administration, maintenance and provisioning* (OAM&P) structure, enabling network level provisioning. Coupled with service adaptive access and a software controlled/downloadable network realisation, this OAM&P structure provides, not only network level provisioning, but service provisioning of the full spectrum from narrowband to broadband. Features and services both are networked. This function is common to all elements in the network realisation and includes single-ended provisioning, remote inventory, survivability management/control, customer programmability, enhanced speed of service delivery, performance monitoring and network element specific software option control.

Paramount to network flexibility and service deployment, specifically, the ability to rapidly deploy wideband and broadband services at the network level, is a direct interface to existing and future operational support systems. In this network implementation assessment, the vehicle is the operations controller, a software driven technology serving as the programmable interface between the network elements and the operational support systems now managing and characterising the network.

Specifically, in the implementation of this network, Northern Telecom in FiberWorld, has simultaneously addressed the three essential elements—transport, access and switching—as a family of products, each of which has all of the attributes described above. In its entirety, the network deploys the full spectrum service capability, including switched broadband, based on SONET/SDH and utilising fibre-optic facilities throughout the implementation.

NETWORK PRODUCT LINE RESPONSE

The S/DMS product family is Northern Telecom's response to the FiberWorld vision:

S/DMS SuperNode The multifabric broadband switching component of the product family. Extending DMS SuperNode, the S/DMS SuperNode works with the S/DMS TransportNode and S/DMS AccessNode to address the operational needs and competitive service demands of the

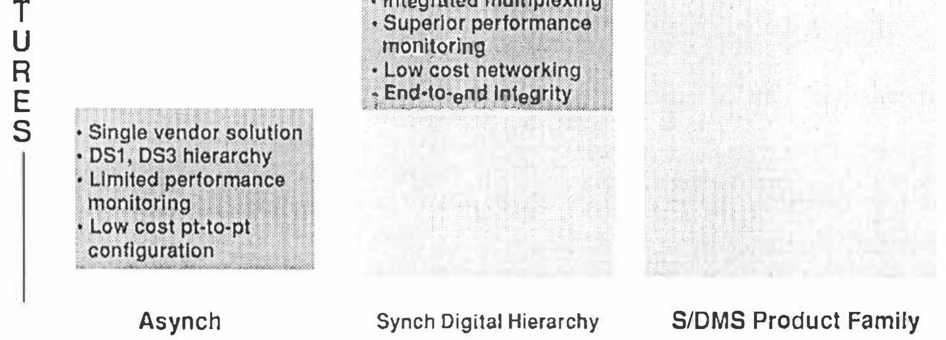

Figure 2—S/DMS SDH transport differentiators

telecommunications industry. It is the bridge that enables the demands of the telecommunications industry. It is the bridge that enables the fibre networks of the future to build successfully on today's telephone network.

S/DMS TransportNode A line of SONET/SDH based network elements serving long-haul interoffice and internodal transport, configurable for terminal, add-drop, ring and broadband manager applications.

S/DMS AccessNode An access vehicle that cost effectively delivers to the customers premises all switched and special services, with bandwidths ranging from narrowband to broadband.

Services

The S/DMS SuperNode, the S/DMS TransportNode and the S/DMS AccessNode in the FiberWorld vision provide the following range of services (Figure 3) to customers:

The S/DMS product family—with its non-blocking switch fabrics, integrated digital cross-connect function, full-service S/DMS AccessNode, and high-bandwidth management S/DMS TransportNode—can better position the operating company to compete in the special services market. With the S/DMS solution, private lines are no longer required to be special services. They can now be handled by standard provisioning practices. They become part of overall wire-centre planning, so the transport network is already in place when the demand arises. This results in savings in equipment and administration costs and improved performance and response time. With these services on the public network, the operating company can add value, such as management services, thereby enhancing its competitive position.

Today's private-line special services account for a significant portion of operating company revenues. Special provisioning and maintenance procedures require dedicated work forces that can lead to high administration costs for these services.

S2M deployment by business users is growing. Much of this traffic could be better served through switched wideband and broadband connections that would: lower operating company equipment and provisioning costs, increase service-provider revenues and account control through service differentiation, allow sharing of interoffice facilities, integrate billing with existing services, provide wider geographic coverage, provide public network robustness and survivability improvements, lower user costs by sharing only for time used, provide immediate response to service demand, and proved on-demand customer control and access to standard network features, such as closed user groups, selective call blocking, and 800 service.

The S/DMS product family provides cost-effective access to S2M and switching for dialable video conferencing. Signalling can be over either an associated POTS line (requiring no change to CPE), or over an ISDN D-channel, using the primary-rate access (PRA) protocol to control 384 kbit/s or 2 Mbit/s channels. In both cases, a single telephone set or, for example, a personal computer with standard modem, can select bandwidth on a per-call basis up to the limit of the access line.

As market needs evolve and the S/DMS SuperNode fabric is deployed, the customer will have access to full-motion video conferencing. The service can be switched on-demand through the S/DMS SuperNode system's SONET/SDH interface and STM fabric.

By the end of 1992, there will be an installed base of up to two million local area network (LAN) sites in North America. This base is expected to keep growing at a CAGR of over 20%. LAN speeds will range from 4 Mbit/s to 16 Mbit/s, with backbone LANs—such as the Fibre Distributed Data Interface (FDDI)—operating at 100 Mbit/s. New high-performance workstations, supercomputers and applications—such as medical imaging—are expected to further fuel the demand for high-speed data services.

With this rapid growth in LAN deployment and new high-speed applications, interconnection of LANs within a corporation or between corporate users will become a significant service opportunity for the operating company. Switched multi-megabit data service (SMDS) is an emerging standard for metropolitan area networks (MANs), for LAN interconnection, and for other high-speed data services at 2 Mbit/s and higher data rates.

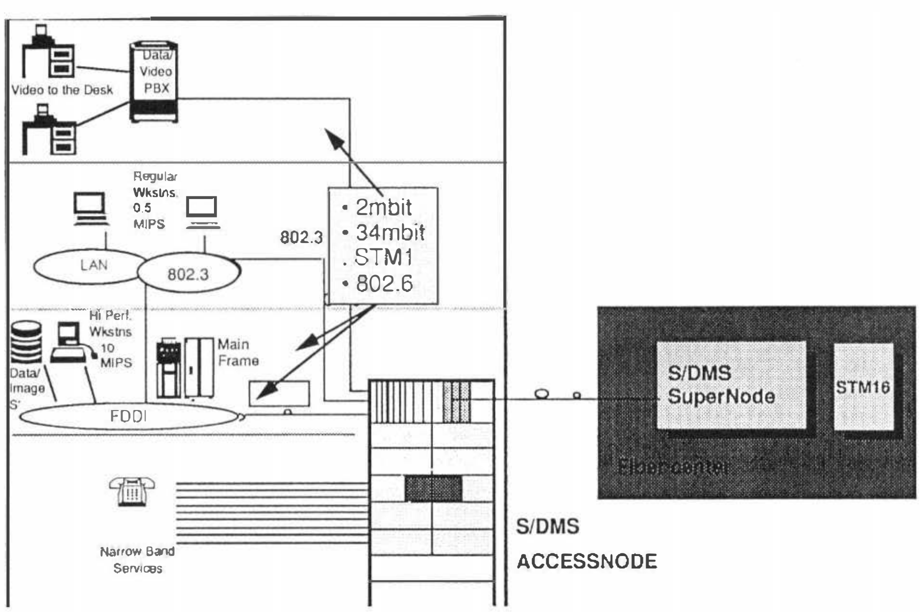

Figure 3—FiberWorld supports narrowband, wideband and broadband services

The S/DMS product family allows the service provider to offer high-speed connectionless services, such as SMDS, to corporate users as a cost-effective metropolitan area network (MAN) or wide-area network (WAN) with S2M access and high-speed SONET/SDH interoffice trunks. LAN connectivity complying with IEEE 802·6 standards is also provided for EtherNet, token ring and FDDI LANs.

As the demand for larger-scale data networks grows, network architectures based on broadband ISDN standards will offer the capacity required to handle high-speed volume data services. Deployment of this infrastructure will first allow higher-capacity transport and delivery of early broadband services, such as SMDS, as well as migration towards fully integrated high-speed data, video and multimedia services.

Asynchronous transfer mode (ATM) cell-based technology will be used for flexible, dynamic allocation of network bandwidth as a switching and multiplexing technique for broadband transport. The S/DMS product family will address this network evolution with the introduction of an ATM fabric within the S/DMS SuperNode that will offer integrated switching for broadband ISDN services.

DMS SuperNode now provides service switching point (SSP) functions with intelligent network services such as 800 service, exchange area billing services (EABS), and private virtual networking (PVN). The S/DMS SuperNode system further provides a fully integrated signal transfer point (STP) and service control point (SCP) for the implementation of advanced intelligent network (AIN) services. The application processor in the SCP provides a platform for a service-creation environment that will allow the user to develop unique applications with a UNIX-based operating system. The S/DMS product family will allow this intelligence to be distributed throughout the network, maximising its accessibility and availability. Operating companies can then provide a new level of service response with market or customer specific services.

By combining the flexibility of switched service with the bandwidth of fibre-based transport and access, telecommunications companies will gain a competitive edge in the next century's telecommunications market. They will be able to deliver the services the market demands. At the same time, revenues will increase by simplifying the operations that support the services, enabling them to tariff the services attractively.

Product Line Characteristics

The product line to deploy this network vision and implementation assessment has the following characteristics:

S/DMS TransportNode provides SONET/SDH connectivity and bandwidth management for long haul, interoffice and local applications. It includes elements for the transport of SONET/SDH over fibre or radio including integrated bandwidth management functions.

The S/DMS TransportNode delivers: high capacity up to 2·488 Gbit/s (OC-48) SONET/SDH transport fully configurable: terminal, add-drop, ring and broadband manager, network simplification through flexible bandwidth management and built-in survivability, integrated OAM&P for centralised operations and network-wide performance validation, survivability through ring and route diversity designs.

The S/MDS TransportNode product provides the following:

- single stage multiplexing process reduces redundant digital signal terminations and operations interfaces;
- capital savings through elimination of hardware and associated cabling;
- multi-vendor environment through SDH optical mid-span-meet;
- network-wide facility management; and
- ability to provide broadband services.

S/DMS AccessNode provides service distribution for narrowband to broadband services functioning as the services distribution bandwidth manager for the S/DMS product family. It provides a full range of services: digital Centrex (voice and data), ISDN (basic and primary rate), residential services (including CLASS) 2 to 8-wire specials, 2 Mbit/s services, and higher broadband services. It is fully SONET/SDH and US specification compliant, and delivers 622 Mbit/s of capacity via a SONET/SDH feeder with service termination modularity and a wide range of service termination mix.

S/DMS AccessNode has direct SONET/SDH termination capability. In-service upgrades to 2·4 Gbit/s are accomplished by the simple addition of a shelf and cards. The high capacity optical feeder removes the traditional access 'bandwidth bottleneck' and positions this access network for delivery of future broadband services.

The S/DMS AccessNode provides on-demand service delivery enabled by the service adaptive line card technology. This new technology significantly reduces service management costs, particularly labour costs, because provisioning of the appropriate bandwidth, signalling, and processing resources are accomplished via software dialogue between the remote provisioning and maintenance databases and the intelligent line card elements.

S/DMS SuperNode is a multi-fabric broadband system (Figure 4). The switching fabric cover is an enhanced network, an STM fabric and an ATM fabric. The enhanced network is a single-stage, non-blocking 64 kbit/s time switch that also supports switching of multiple 64 kbit/s connections; for example, 384 kbit/s or 2 Mbit/s. The asynchronous transfer mode (ATM) fabric will provide a switching fabric to support BISDN services.

The S/DMS SuperNode system offers the potential for a full spectrum of new services, ranging from narrowband to broadband. Special services with 2 to 155 Mbit/s bandwidth can be fully integrated with the public network by virtue of the non-blocking characteristics of the enhanced network and the STM fabric. Dialable wideband and broadband services can now be offered at 2 to 155 Mbit/s. This eliminates the long set-up times and the reservations previously required for productivity-enhancing and cost-control services, such as compressed video conferencing. High-speed connectionless services are available to provide LAN-like performance over metropolitan area and wide area networks (MAN/WAN) using 2 Mbit/s and 155 Mbit/s access. These services include SMDS and IEEE 802.6 LAN connectivity for Ethernet, token ring, and FDDI LANs.

IMPLEMENTATION INTO EXISTING NETWORKS

To gain benefits from FiberWorld it is not necessary to make use of the whole S/DMS product line family at once. The FiberWorld architecture allows PTTs and carriers to develop

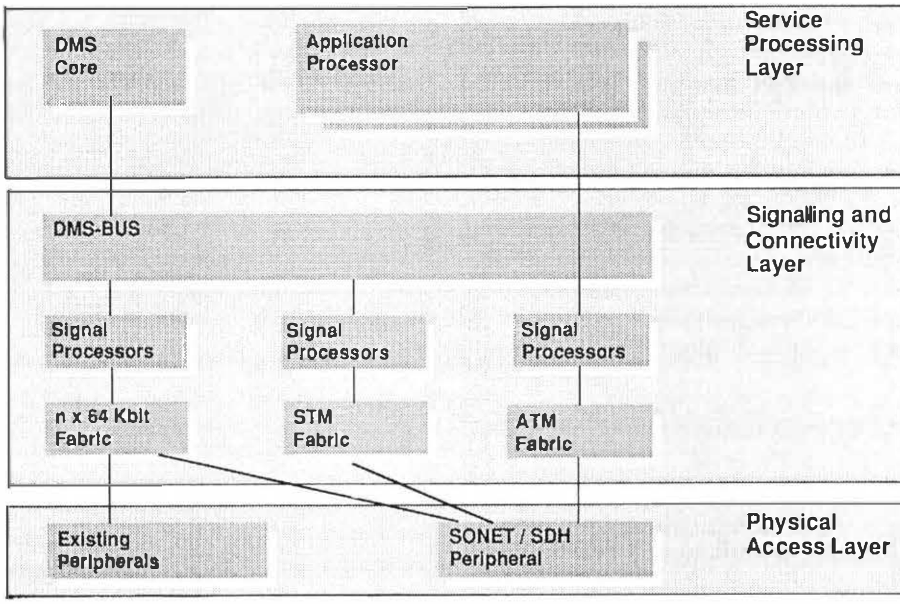

Figure 4—S/DMS SuperNode architecture

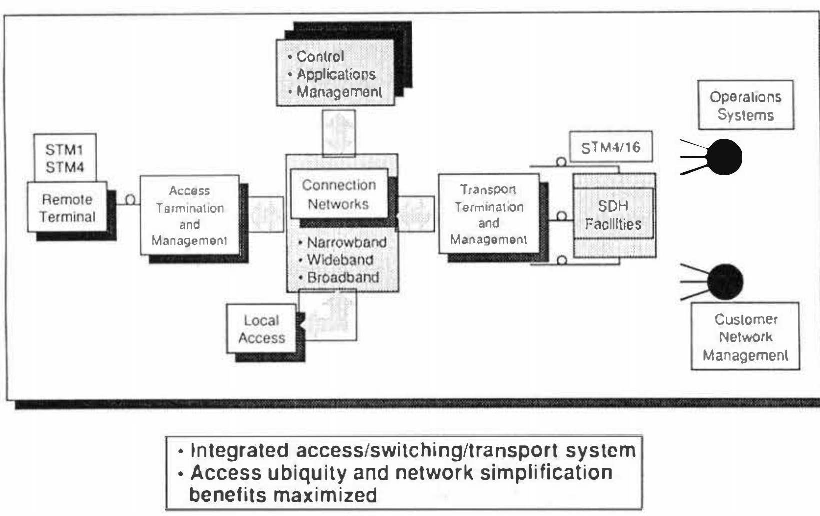

Figure 5—Simplified FiberWorld network

phased introduction strategies into existing networks starting possibly only with one of the three S/DMS product types in order to meet deployment strategies and/or user demands in an optimised way.

Such implementation strategies are only possible because Northern Telecom has developed FiberWorld compatible to the accepted standards and interfaces that must be met in the various market-places in the world.

NT gains the necessary experience and know-how through active participation and collaboration in all major standardisation bodies such as CCITT, ESTI etc.

Beyond that Northern Telecom has worldwide experience in adopting to additional customer specific norms and requirements (for example, alarm signalling, power supply, grounding, shielding etc.).

If it is necessary in the case of system overlapping co-operations, NT is also willing to open its protocols and interfaces to the benefit of its customers, when not already required by regulations.

SUMMARY AND CONCLUSION

The objective of the examination and description of the FiberWorld architecture was to use this as an example of how current almost static networks will develop to future more dynamic ones offering more flexibility in bandwidth and a variety of small and broadband services as well as faster response to user demands. With the customer oriented and technology driven FiberWorld vision (Figure 5), NT as one of the leading telecommunication manufacturers will be able to highly influence the future of telecommunication networks; that already has started now to the benefit of network and service providers and users.

Expert System for Customer Facing Environments (ESCFE): Improving the Customer Interface

M. R. GARDNER, A. J. HOUGHTON, and P. GOULD†

INTRODUCTION

In a deregulated, international market, customer care is a major consideration. The challenge for a commercial telecommunications company is to sell and maintain products and services with quality customer care to ensure loyalty and continued business.

This paper focuses on a system which aims to support the customer interface currently offered through British Telecom ServiceCentres. ServiceCentres are purpose-built units where BT staff provide a single point of contact to BT's largest customers. They provide information on all queries relating to product availability, ordering, job progressing and fault finding. A prototype expert system shell is described which supports the ServiceCentre receptionist in a dialogue with both customer and BT systems. The article examines issues involved in providing quality customer support, and then describes the rationale for expert systems for customer facing environments (ESCFE), the development approach, and how user requirements have been met so far.

CUSTOMER CARE

ServiceCentre staff provide an interface between the customer and the BT local and remote databases, sales offices and fault repair centres. Staff receive extensive training and benefit from computer-based support in the form of automatic call distribution, progress management software and terminal emulation to remote databases and testing systems.

To process a typical customer query, for example, a fault on a private circuit, the ServiceCentre receptionist will have to carry out a dialogue with the customer and with other parts of BT. This includes the agents who are responsible for maintaining the circuit (usually a BT District) and the local and remote database systems to obtain relevant information (for example, the 'a' and 'b' end circuit addresses) and to process the transaction (for example, update the circuit's fault history).

When processing a fault or supplying a new product or service, British Telecom has a contractual obligation to meet certain deadlines. For example, the cause of a fault once reported must be cleared within 5 hours. If a particular deadline has not been reached, then a message is escalated up the management chain for immediate action.

It is very important to BT that customer enquiries are dealt with promptly and efficiently. In addition to providing a quality customer image, for contractual reasons BT is obligated to deal with certain enquiries within predefined deadlines.

† British Telecommunications plc, UK

RATIONALE FOR THE NETWORKED WORKSTATION EXPERT SYSTEM

To provide quality service requires a complex range of knowledge and skills to support a dialogue between provider and customer. A vast range of product/service and fault handling knowledge is required, beyond the scope of any one person. Also required is the analysis knowledge which leads to specifying the product, and the processing knowledge to supply and maintain the product. This latter can be very complex: knowing where to look for information such as availability, existing customer equipment, installation resource requirements and who to send the order to. This knowledge must be applied in a consistent way, to reflect 'image', to ensure compatibility with other BT procedures and to satisfy contractual liabilities.

The expert systems architecture is well suited to support such a knowledge-based requirement. The separation of inference engine (the control program) and knowledge base means that knowledge bases can be loaded as required. The working memory allows the storage of answers for subsequent use. The developer interface allows a non-programmer to write, examine and modify knowledge bases. The user interface is the view of the program seen by the user.

The requirements of separation between knowledge base and control program, and the developer environment are not unique to expert systems. In computer-based training, for example, authors are able to write courses via such an interface. Similarly, knowledge can be written in a procedural program. However, expert systems technology possesses the particular mix of features required.

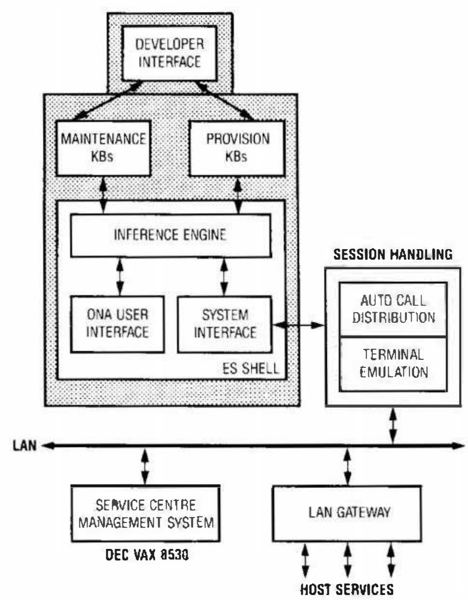

Figure 1—ESCFE functional diagram

By placing the expert system on the network it could take action on behalf of the user, obtain data from a remote database, make a telephone call, and send off an electronic mail message.

By placing the network-based expert system on a workstation, it can do part or all of these and allow user discretion. The power of the workstation allows the user to use more than one facility at a time, to put a job on hold, and to transfer information instantaneously from one application to another.

ESCFE DEVELOPMENT

ESCFE consists of an inference engine, separate dialogue knowledge bases, a developer interface for creating and modifying knowledge bases, a user interface and, in the future, a system interface to the ServiceCentre auto call distribution (ACD) computer which will allow ESCFE to utilise the ServiceCentre's own session handling and access to remote host services. The ESCFE technical outline and functionality are presented in Figure 1.

The major human factors activity was centred on fault reception in ServiceCentres. Three ServiceCentres were made available. The human factors dialogue engineer observed existing practice, and discussed future possibilities with fault reception staff. Paper screen images were shown to users, and an initial specification passed to the software engineering team. This specification was used to develop an expert system which could meet requirements.

The expert system was developed on an iterative basis to meet these requirements (there were 13 iterations over a six-month period). It is an important point that the inference engine and knowledge bases were both evolving over time so no hard evidence on how long it takes to input knowledge bases (and thus develop dialogue support) was obtained.

MIXED INITIATIVE DIALOGUE

The ESCFE system for use in the ServiceCentres seeks to maximise the opportunities that this environment presents whilst providing a method of working within it that meets the needs and abilities of all the concerned parties. It seeks to take the burden of the procedural work to enable the receptionist to concentrate on the customer care aspects of the interaction, whilst supporting and enhancing the collection of full and accurate sets of data for dispatch to appropriate authorities. To meet customers' needs requires a system that is flexible in application but supportive in use. To achieve these perhaps seemingly contradictory goals, our system provides two alternative 'views' or windows onto an activity (Figure 2).

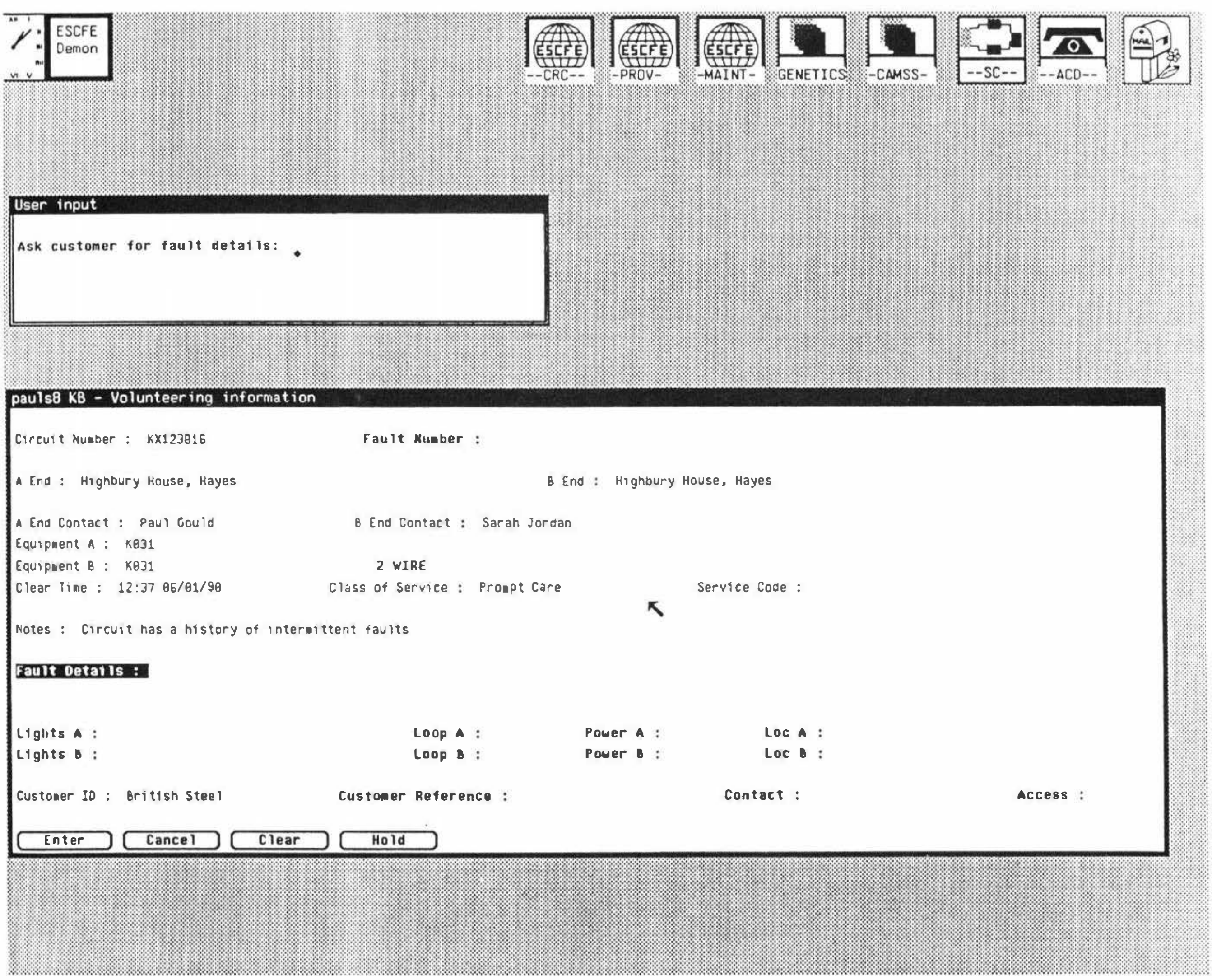

Figure 2—ESCFE system

These views are linked to enable a method of working which supports mixed initiative in information gathering and provides structured output.

Information may be submitted in either dialogue or form windows. This allows two different ways of working. The first way is centred on the dialogue window which can be used to lead the customer in the interaction. The form window is then used to check details afterwards. The second way is form centred. Here the dialogue window may be seen as providing additional support for elements in the form window. The form window permits customer input at the point at which the customer wishes to make it rather than forcing the customer into a rigid dialogue structure which may not respond to their concerns.

The current prototype supports a procedure for analogue data fault reporting which has been developed and used within an operational area. This provides for a set of actions which the customer can be asked to perform, if they are physically able to and have not done so already, to run diagnostic tests on the modems. The customer is asked to press the appropriate buttons on the modem. He/she is asked whether the test light is on. A menu selection of possible lamp conditions places the appropriate test result in the form and moves the dialogue on. Neither needs a technical understanding of the process. Following this procedure provides a valid engineering fault report without making any assumptions as to the levels of knowledge of either the customer or the receptionist.

Before confirmation, the system will ensure that all required information has been submitted and the results of the dialogue is then structured and routed appropriately.

SOFTWARE ENGINEERING APPROACH

The expert systems architecture as discussed above (and which is well documented elsewhere) was seen to be a suitable mechanism for assisting staff in dealing with technically sophisticated customers.

The ESCFE system itself must allow receptionists direct access to existing system functionality (telephony, host services and project management) or assisted access to product information and structured dialogues which unfold according to information held on-line and customer responses.

The 'run-time' system is used to support the ServiceCentre receptionist directly. This system integrates terminal emulation and remote systems into the expert system which is directly driven by the available dialogue knowledge bases. A WIMP style user-interface on the Sun workstation provides access to the available systems. Currently along the top of the screen is a series of icons which allow the user to run the support system, access remote database systems, and use other support tools such as electronic mail (see Figure 2).

For the purposes of the prototype system, an initial hook-up with the BT CAMSS database (Customer Assisted Maintenance for Special Services) was investigated. This database holds information about customers' equipment and private circuits which are maintained by BT and is essential for the fault reporting side of the ServiceCentre operation. A 'training' version of this database was made available for the ESCFE project. Third-party communications software was used to complete the SNA (System Network Architecture ™ IBM) connection to the IBM mainframe (over a KiloStream link) on which the database resided. This software enables our expert system to exchange data with the IBM host using a Datastream Access Interface (™ Sun Microsystems). Direct database access allows the expert system to act as a front-end to remote databases, hiding their complexities from the user whilst presenting a uniform user interface. This is an important factor in the ServiceCentre.

Currently, receptionists have to access and update several different database systems, often with the same information. This type of front-end means that the information has to be entered only once, and data consistency is ensured.

An important part of the current ServiceCentre is the use of an auto call distribution (ACD) system to integrate telephony within the receptionists terminal so that incoming calls are routed correctly and the management software can start up a session automatically. It is likely that future integration of ESCFE into the ServiceCentre will be via this system.

ESCFE ON A WORKSTATION

The demonstrations of ESCFE on a workstation has promoted the idea of the workstation even when they have not sold the idea of ESCFE. Multi-tasking, user control and easy transfer of data from one application to another were obvious perceived benefits to our users.

'Hands on' user evaluation of ESCFE will be on a workstation on a ServiceCentre network. As a preliminary, existing ServiceCentre functionality will be made available on a workstation. (This in itself will raise usability issues outside the scope of this document.) ESCFE can then be used under conditions of real-time access to remote databases with a customer waiting on the telephone. The fact that ESCFE is on a workstation has given us two advantages in smoothing the way from prototype to trial to implementation. Firstly, ESCFE is riding the wave driven by the advantages of the workstation (and the technical and user issues to be resolved) *per se*. Secondly, ESCFE can be iteratively developed in a live environment because if it is inadequate the user can fall back on the benefits of the workstation until such time as ESCFE is effective.

KNOWLEDGE ENGINEERING

The raw material for developing dialogue support was taken from three different sources:

(*a*) Paper call guides are already in use in telemarketing. One was taken 'as is' and a knowledge base written around it.

(*b*) A dialogue procedures consultant was employed to examine private data circuits provision procedures. Working with product experts and customer facing personnel, a flowchart was provided. This was implemented.

(*c*) The major human factors effort was to examine the fault reception duty of the customer support system. The input to software engineering was provided by a mixture of natural language description and flowchart.

In British Telecom, there are established, validated procedures for doing things. It is necessary to take the procedure or process requirements and make ESCFE reflect these. The dialogue engineers were in the fortunate position therefore, of having a lot of information available on tap, and in a format that could be used. This was not only concerning major procedures, but also local initiatives which could be picked up, again in whatever format had been developed. A user-friendly developer environment is being constructed which will ease the transformation of these agreed procedures into ESCFE dialogue knowledge bases.

USER EVALUATION

Evaluation of the ESCFE system was carried out on an iterative basis. The procedures have been produced as a result of a lengthy knowledge engineering exercise and by liaison with duties whose responsibilities include the production of procedures in ServiceCentres and in other related parts of BT. Local ServiceCentre management and the national co-ordinating body have also been consulted. This is to ensure that the procedures used conform to their requirements. Additionally, dialogues are validated and content added by marketing specialists. This ensures conformity. However, procedures on their own do not ensure use. Having identified the environment in which they are to work the system tries to match the two by providing support and an appropriate style of interaction.

CONCLUSIONS

This paper has described the rationale for a network-based workstation expert system to assist staff in a customer facing environment and the development of a prototype support system. It is proposed that this interface is crucial if British Telecom is to compete effectively in a future deregulated international market, and that expert systems technology can provide appropriate techniques for supporting the dialogue between BT, its customers, and its major back-end services.

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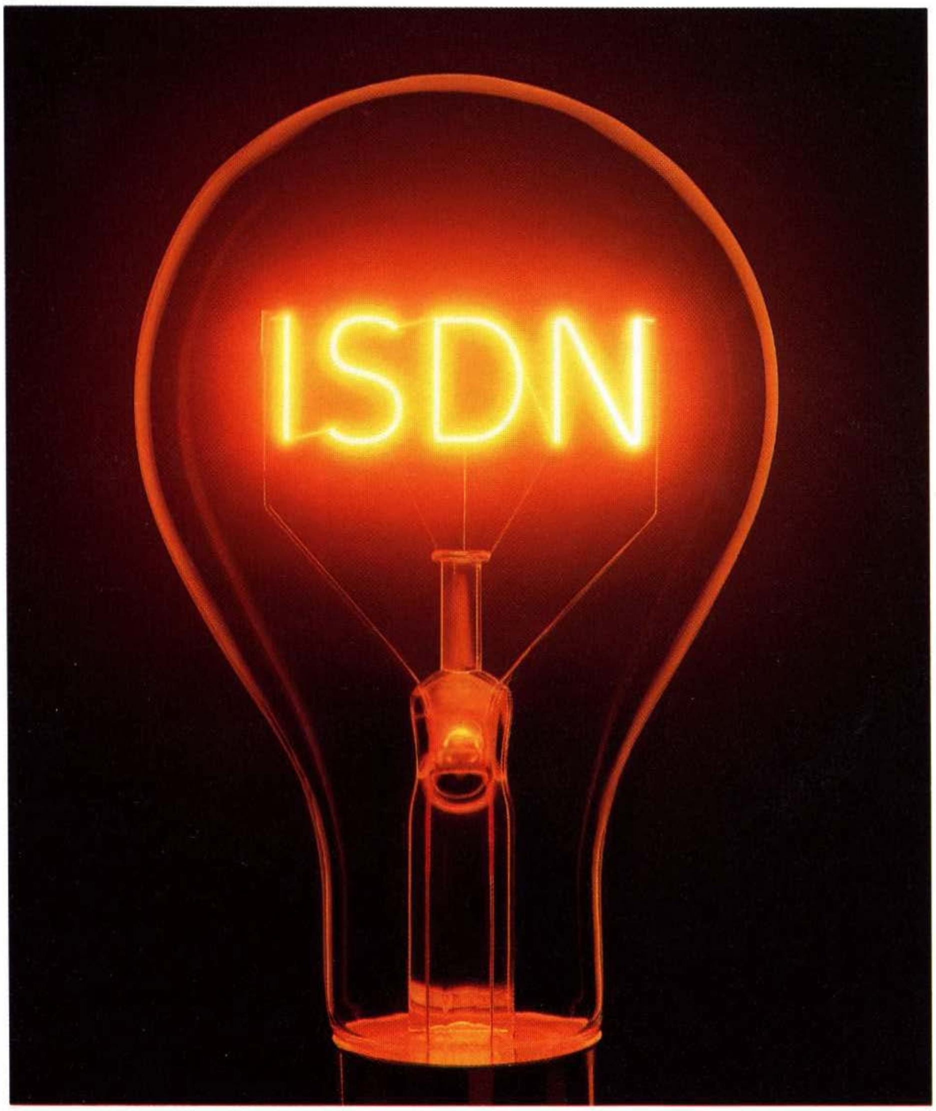

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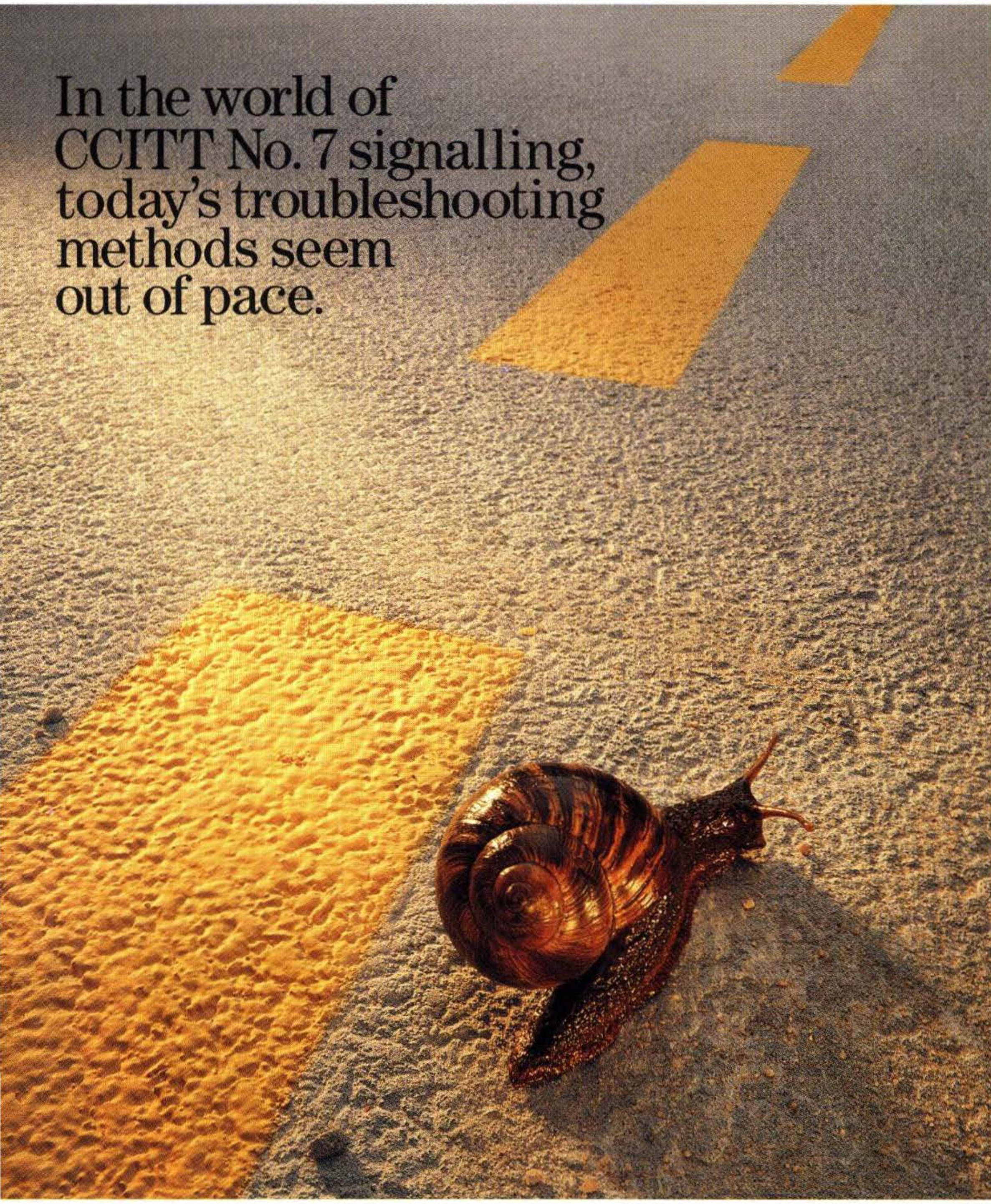

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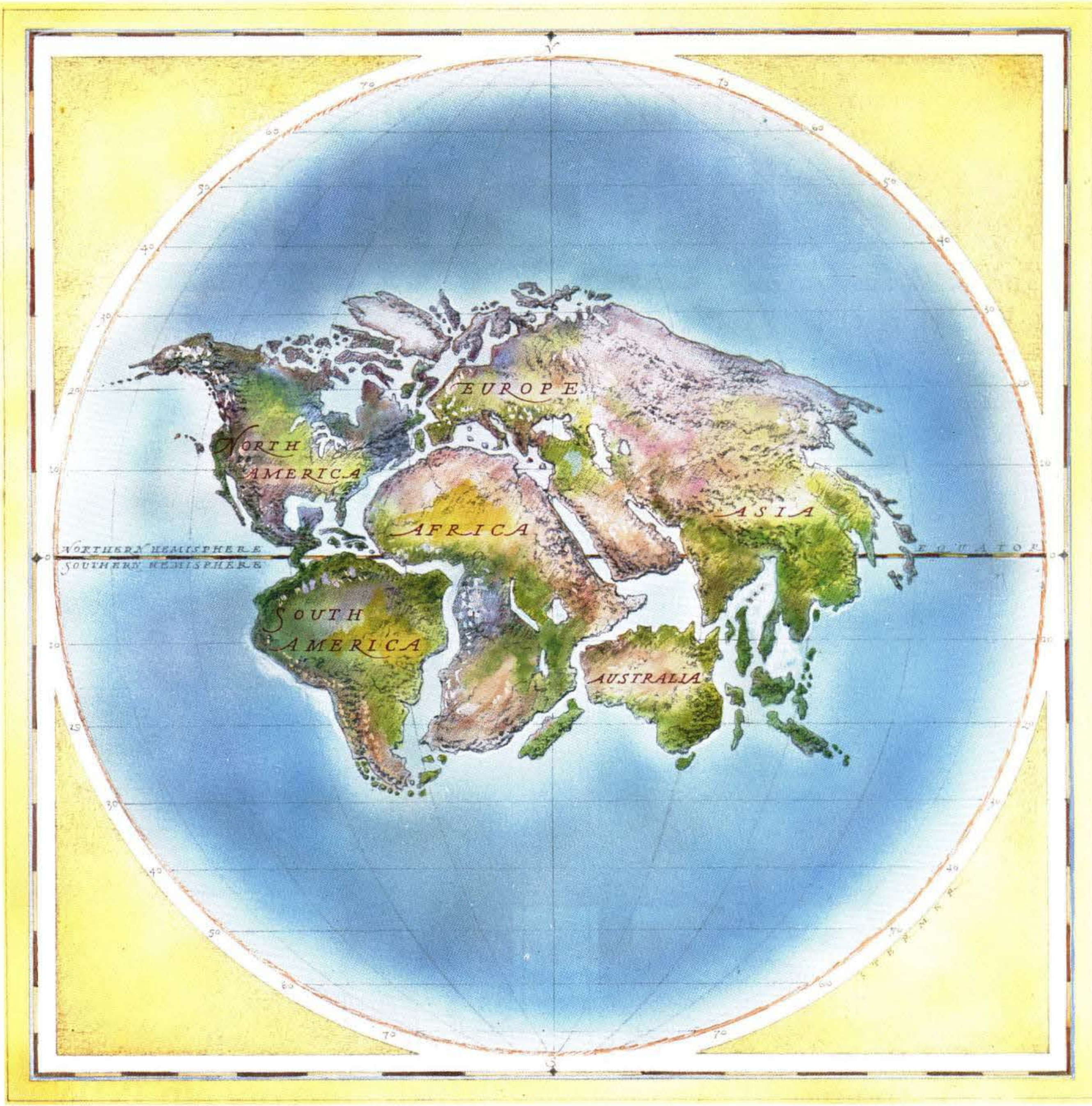

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