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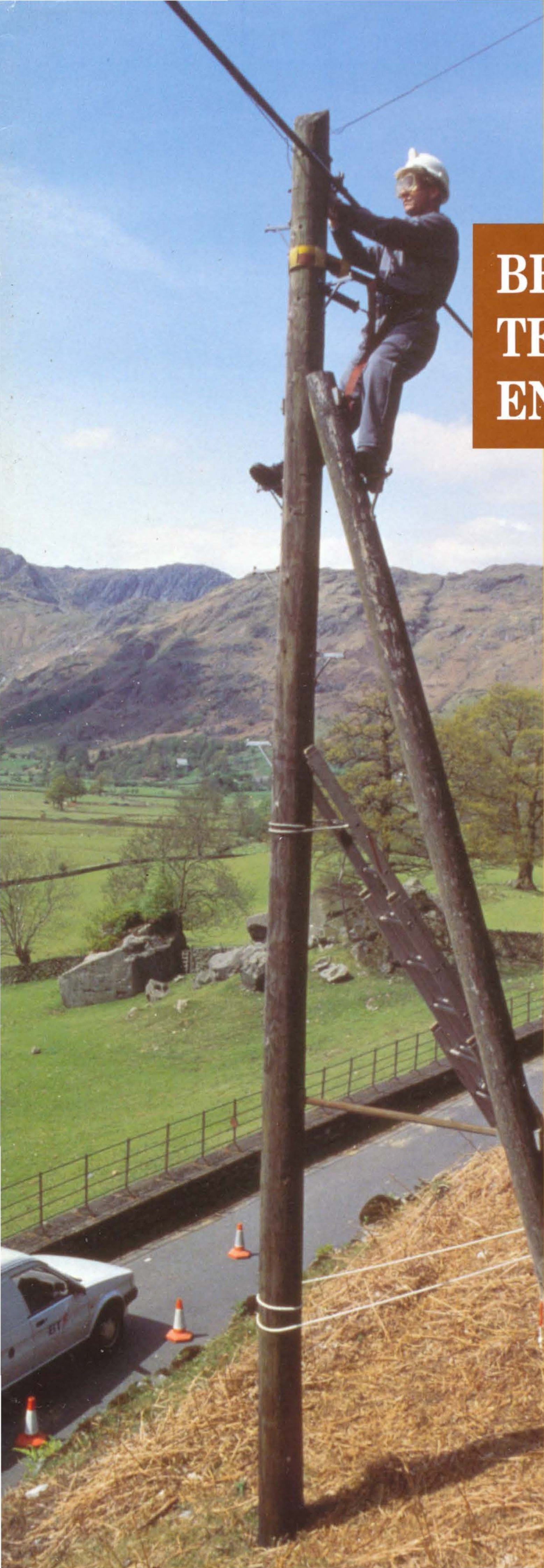

BRITISH TELECOMMUNICATIONS ENGINEERING

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Passive Picocell

The Journal of The Institution of British Telecommunications Engineers

BRITISH
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GUEST EDITORIAL

David Crampsey

External Engineering

There is now an increasing understanding of the financial savings a well-managed external network can deliver

I am both pleased and proud to be given the opportunity of introducing a series of articles on the subject of 'External Engineering'.

This area of BT's operations, vital to any telecommunications company, is also the one which is most visible to the public at large. BT's 'holes and poles' are an intrinsic part of the fabric of our urban and rural landscape and are accepted as such without fuss.

Most of the external network, like an iceberg, is unseen and passive but, nonetheless, represents an essential and 'priceless' asset to the company.

The development of the BT external network has been a continuous process carried out over the last 100 years or so. It is now a massive and quite diverse structure which continues to evolve to meet the relentless demand for new residential services and sophisticated business facilities.

The infrastructure, which serves more than 25 million customers, includes some 250 000 km of underground duct, 3·7 million manholes and joint boxes, 80 thousand street cabinets (cross-connection points), 4 million poles and 200 radio towers. The network is predominantly copper-based in the access sector and fibre-based in the core sector, and has a replacement value of more than £10 billion. By any standards, this represents a huge financial investment and, consequently, it is designed to have a life span many times greater than the electronic equipment, installed in BT and customers' premises, which is dependent on the transmission capabilities of the external network.

It is imperative that new items of plant, whether copper, fibre or radio, or new work practices, introduced into the external network, are able to co-exist with existing plant. An equally important consideration is the circumstances under which the products or work practices are applied. The people who install, maintain and repair the external network are often required to work in the most hostile conditions. With failing light and falling temperature, it is essential that it is as easy and as quick to use a device, or carry out a practice properly, as it is to perform the task incorrectly. If malpractice provides a quick and easy solution, the temptation to take this route will, under certain circumstances, be overwhelming. Unfortunately, incorrect practices will, more often than not, seriously affect the reliability of a product, which may, therefore, fail prematurely. In addition, the use of incorrect practices increases the risk of accidents.

For one reason or another, in all established networks around the world, external plant has historically been seen as a necessary requirement, rather like a public utility, but of secondary importance to terminal

The people who install, maintain and repair the external network are often required to work in the most hostile conditions

BT Corporate Picture Library; a BT photograph

BT cable laying in the City of London

equipment. However, there is now an increasing understanding of the financial savings a well-managed external network can deliver. The operation of such a network is labour intensive, incurring high current and capital expenditure. Consequently, a great deal of care is taken to ensure that all new products and practices are designed to reduce whole-life costs by increasing network reliability and providing opportunities for increased productivity.

Most external network faults are caused by network intervention, weather and product reliability. It is now well understood that fault rate is primarily related to the act of network intervention with additional problems caused by weather and natural deterioration of the plant. There is little doubt that a modern network properly constructed, maintained, repaired and managed will provide a low fault rate except under the most unusual weather conditions (that is, events that might happen only once in 100 years).

Years ago, safety in the external network was not perhaps given the high importance that it is today

Safety in the external network is of paramount importance and every practical effort is made to protect members of the public, customers, BT people and the network itself.

Generally speaking, the BT external infrastructure receives a clean bill of health from environmental groups, and the company is ever mindful of its responsibilities in this area.

Years of close cooperation and collaboration with suppliers have paid handsome technological and commercial dividends. The highest compliment that can be paid to modern external plant products and practices is that they be taken for granted. However, the world does not stand still and continuous improvement in all aspects of external engineering is essential in order to meet the ever-increasing commercial and service demands.

The first article in this series on External Engineering provides a potted history of the developments in telecommunications cables—principally, optical cables. It traces progress from the provision of the first copper cable some 160 years ago to the 240-fibre cables available today.

This will be followed by an article describing the fibre management system used in the BT network—OTIAN® (Optical Telecommunications Infrastructure for the Access Network). The OTIAN® system is designed to manage individual fibres throughout the network; that is, at the exchange end, in the cable joint housings and at the customer end.

A further article will be concerned with protection engineering. The steps taken to ensure safe working conditions for those constructing, maintaining and repairing the external network will be discussed. The protection of the public exposed to BT operations and the protection of the physical plant will also be described.

Laying ducts in the early years of telecommunications

Another will discuss the latest developments in copper technology, for example, connection systems and sheath closures, as well as the extensive civil engineering infrastructure upon which all else depends.

I am sure that you will find these articles to be of great interest.

David Crampsey
Manager, External Engineering
BT Networks and Systems

Saf Ahmad and Ian Gauntlett

The Road to 240-Fibre Cables in BT's Underground Network

This article outlines the development of optical-cable designs leading to the installation of 240-fibre cables in BT's network. The route starts with the early proprietary cable designs of the 1970s and progresses through to the standardised products of the 1980s which led to the requirments of BT's specifications. Recent work, as late as 1995, led to a rethink on the optical-cable designs used by BT. This has resulted in smaller and lighter cables with greater fibre packing density than previously used in the network.

Introduction

In 1837, the first telecommunication cable in the United Kingdom was provided between Euston and Camden Town[1]. This 'cable' consisted of five copper wires embedded in grooves cut in lengths of timber. In 1954, an experimental cable containing 54 aluminium conductors was installed between Dover and Deal[2].

The use of copper or aluminium as a conductor was influenced purely by the price of the metals on the world metal markets. The economic advantages of aluminium influenced the installation of production cables containing aluminium and aluminium alloy conductors into BT's network between the mid-1960s and the late-1970s.

The move to glass as a transmission medium in the network started in 1977 with the installation of a 140 Mbit/s system between Martlesham and Kesgrave.

Today, although metallic cables (primarily copper) form the greatest volume of transmission lines in the network, they are being exploited beyond the telephony-based services for which they were originally designed and the need for optical cables is ever increasing. Since 1977, BT has installed a variety of optical-cable designs within its network. This article discusses the cable designs and experiences leading to the current designs of optical cables for the BT external network.

Messages by Light

As far back as 1880, Alexander Graham Bell demonstrated his photophone. This showed how a beam of light could be used to transmit information by using a system of mirrors. However, this invention did not catch the consumers' imagination. It was not until 1960, with the invention of the laser, which is a practical device that can be modulated and used to transmit a large amount of information, that the possibility of modern-day optical systems became closer. It was not until six years later (1966) when two scientists, Kao and Hockman, from Standard Telephones Laboratories at Harlow proposed the use of glass fibres as the transmission medium, and four years after that when Corning glass developed a fibre with a loss of less than 20 dB/km, that modern optical systems started to become a reality.

Glass as a Transmission Medium

The basic material for window glass and optical fibres is the same; that is, silca. The difference is that for current optical fibres the glass is so pure that if it was used for a window one could see through a window over 20 km thick.

Optical fibres used for telecommunications are either muti-mode or single-mode. The manufacture and transmission theory for these fibres and their exploitation for systems is published in many learned books and journals[3].

Cable Design

The fundamental requirement for all cables is that their transmission and mechanical properties remain stable during the manufacturing, installation and operational phases of their lives[4].

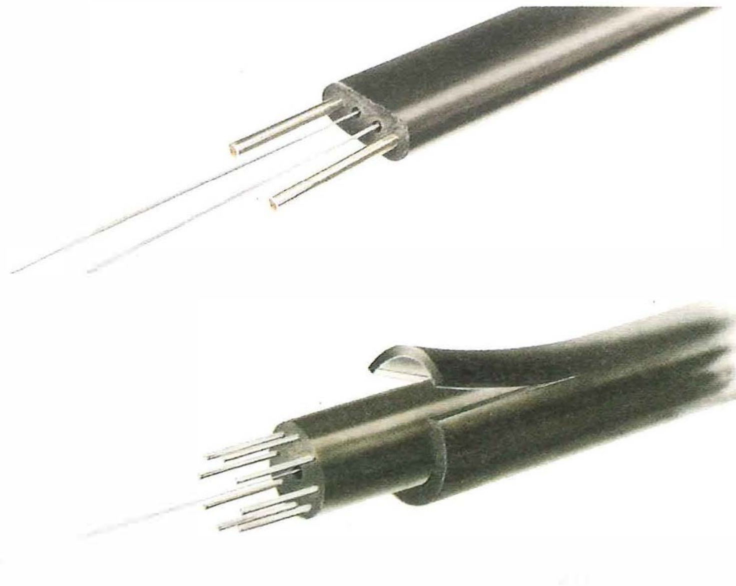


Figure 1 – Pre-POLS cables

The prime difference between metallic conductors (copper and aluminium) and glass fibres is that, as they reach their tensile strength limits, the glass fibres always fail by brittle fracture without any significant plastic flow of the glass. The maximum strain allowable for optical fibres is about 1%, whereas for copper and aluminium alloy this would be in the order of 20% and 5% respectively. This major difference between optical fibres and metallic conductors in cables radically influences the cable design and method of installation of the cables.

In the case of metallic cables the conductors are not only the transmission highway but also form part of the strength element of the cable. This cannot be achieved with optical fibres, which form the transmission highway within the cable. The optical cable therefore needs:

- strength elements within the cable structure,
- decoupling of the fibres from the strength elements,
- careful selection of materials for use within the environmental window of operation of the cable[5], and
- control of the tensile load on the cable during installation in order that the maximum specified strain on the fibres is not exceeded.

Network Optical Cables—Background

As mentioned previously, BT's involvement in optical cables in the network started in 1977. However, the first production cables and systems for the network were not ordered until 1979. These became known as *the proprietary optical line systems* (POLS). Prior to these systems the cables were of an experimental nature and used for demonstration purposes. These early cables contained strength elements embedded within the polyethylene sheath of the cable (these were known as *peripheral strength elements*). The fibre (multi-mode) was contained within a cavity formed within the sheath, thus decoupling it from the strength elements of the cable. Examples of two such cables are given in Figure 1.

From 1980–1985, the cables installed in the network were production cables containing up to 16 optical fibres. The early cables used multi-mode fibres whereas the later cables introduced single-mode fibre into the network. These were within the POLS1 and 2 schemes. At this stage, the cable manufacturers were allowed total freedom in their cable designs since the schemes were bought as 'turn-key' systems. The systems ranged from 8 Mbit/s–140 Mbit/s. The cable designs varied from manufacturer to manufacturer. Both primary-coated and secondary-coated fibres were used within the cable constructions. At the extreme ends of the designs were cables with an overall diameter of 8 mm and weight of 35 kg/km and a cable with an overall diameter of 23 mm and weighing 350 kg/km (see Figure 2).

The designs of the various POLS cables were generally incompatible and this led to BT defining the basic parameters (for example, the central strength member, fibre packaging, minimum cable diameter, permissible fibre strain, number of copper conductors, mechanical and temperature performance) for the next phase of optical cables in the network, which

Figure 2 – POLS cables

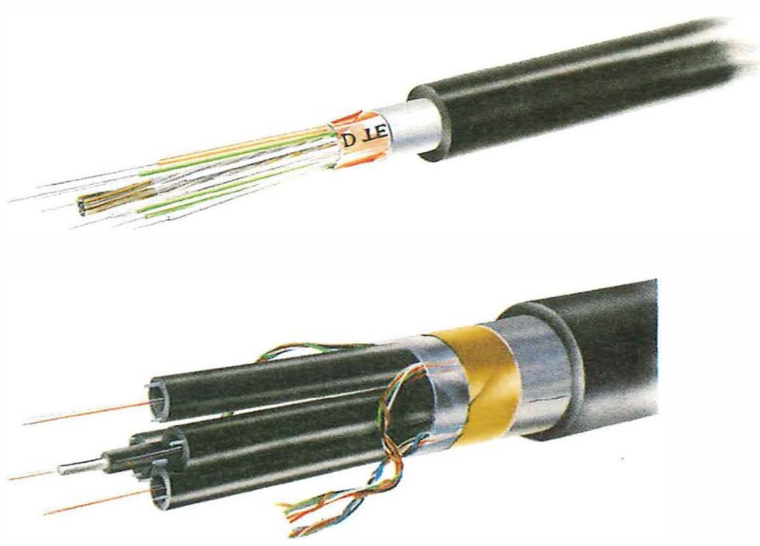
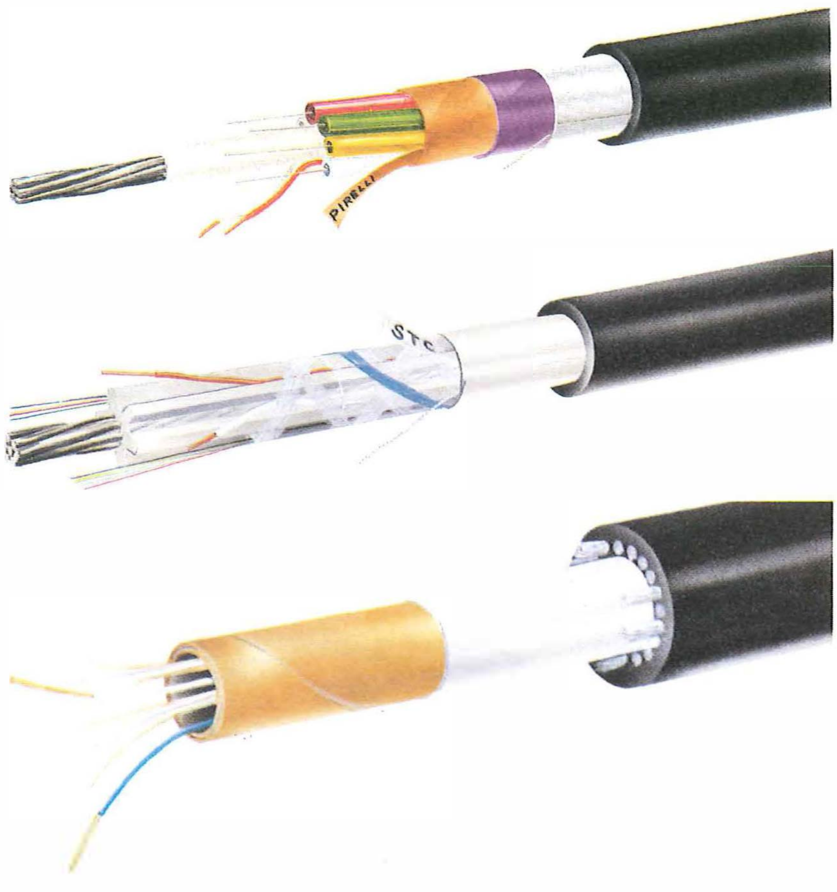


Figure 3—Standard optical systems cables

became known as *standard optical systems cables* (see Figure 3). This allowed the mixing of cables from different sources. These cables started to be installed in the trunk and junction networks from 1985 onwards.

Although the standard cables were considered suitable for 34 Mbit/s and 140 Mbit/s systems, the design constraints on the cables were considered to be uneconomical for 2 and 8 Mbit/s systems in the junction network. This therefore led to a relaxation of the cable design and greater freedom for the manufacturer, within the specified mechanical and environmental constraints, to produce alternative cheaper cables.

Figure 4—Cost-effective cables



These cables were fondly known as *cost-effective junction cables*. This exercise produced a variety of designs, these being with loose fibres in tubes, fibres in slotted cores, fibres in a central tube and fibre ribbon in a tube. Examples of these cables are shown in Figure 4.

Network Optical Cables—Current

BT's current optical-cable designs are based on requirements for cables for the access network. The fundamental design concepts of these cables were specified in 1986. This range of cables was known as *Cable Optical Fibre 11* (COF 11).

The essential features of these cables were:

- 4–96 fibres in loose tube construction,
- cable diameters 15–22 mm,
- central steel strength member,
- no copper conductors,
- cable interstices filled with petroleum jelly,
- strength to weight ratio of 3:1,
- maximum fibre strain during installation not to exceed 0·25%, and

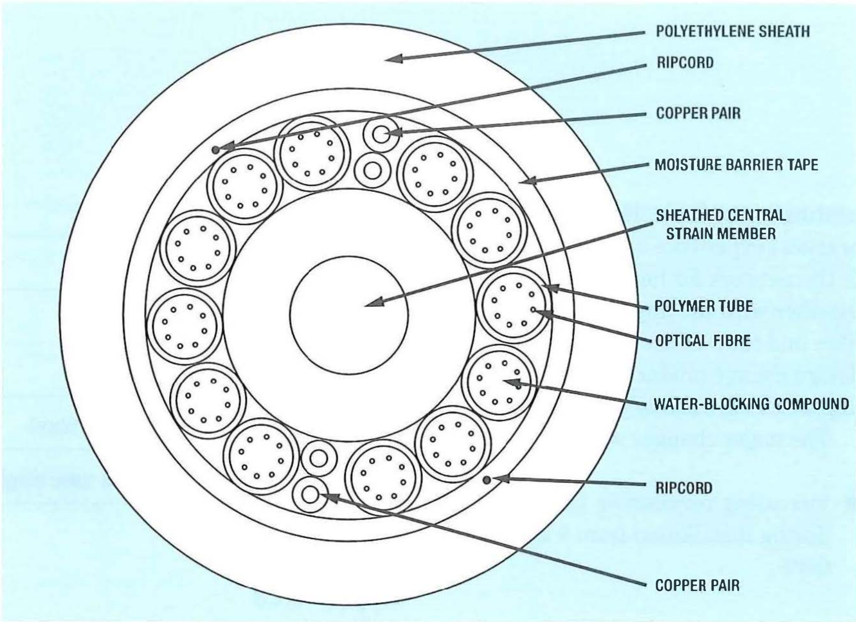


Figure 5 – COF 27 (8–96 fibre)

- polyethylene sheath with an overlapping aluminium moisture barrier.

Other mechanical and environmental parameters to ensure the survival of the cable in the network were also defined. Variation of this design (up to 16 fibres and a pair of copper conductors) were produced for the junction network. The cable manufacturers were allowed freedom of design and materials within the specification constraints.

In 1988, the rationalisation of optical cables across the trunk, junction and access networks led to a variation of COF 11 but with four copper conductors (pairs or as a quad). These cables were available in fibre ranges from 8–96 (eight fibres per tube). This rationalised range was known as *COF18* and since 1990 became the mainstay of the optical cables bought by BT.

By now one would have thought that optical-cable designs would have stabilised; however, this was not to be the case. The need for better duct utilisation, reducing in the cost of fibre provision, the continuing demand for fibre for business use and the increase in fibre use for CCTV required a rethink on the COF18 cable design.

The beginning of 1995 saw the trials of a new range of optical cables (COF27) for BT's network. The first production version of these cables containing 8–96 fibres (Figure 5) were being installed into the network in mid-1996. In early-1997, following successful trials in the north east of the UK, cables containing 144 fibres (Figure 6) were made available for field use. The 240-fibre cable (Figure 7) currently under trial in London will be in the portfolio by mid-1997. The 8–96-fibre cables are of a single layer construction whereas the 144-fibre and 240-fibre cables are a dual layer construction.

The move from COF18 to COF27 was required to have minimal impact on the practices associated in installation, fibre splicing and

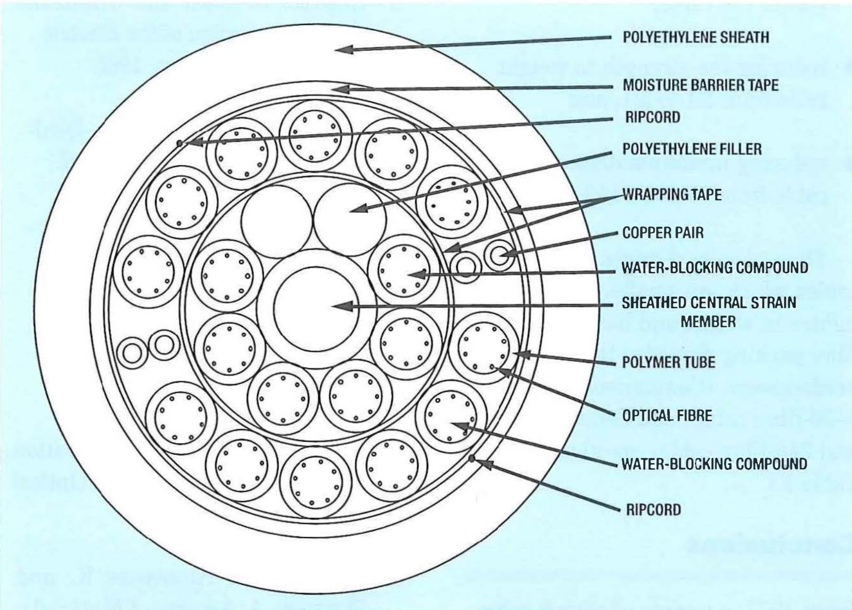
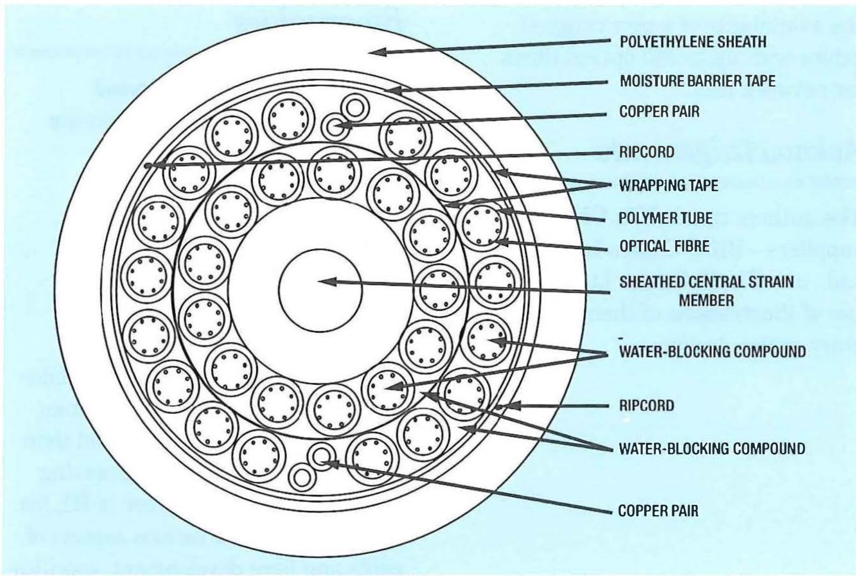


Figure 6 – COF 27 (144 fibre)

Figure 7 – COF 27 (240 fibre)



jointing of the cable. However, the practical experience of optical cables in the network for nearly 20 years, together with the improvements in fibre and their coatings, allowed for a design change producing a minimal impact on the cabling practices.

The major changes were:

- increasing permissible fibre strain during installation from 0·25% to 0·4%,
- removing interstitial jelly from within the cable,
- reducing the strength to weight ratio from 3:1 to 2:1, and
- reducing minimum diameter of cable from 15 mm to 12 mm.

These design changes have led to cables which are smaller in diameter, lighter in weight and have greater fibre packing densities than their predecessors. (Comparison of 8–96-fibre cables and details of 144- and 240-fibre cables are given in Table 1.)

Conclusions

Since 1977, a variety of optical cable designs have been installed in BT's network. The experiences gained to date, together with the improvements in fibres and their coatings, has led to the availability of a new range of cables with up to 240 optical fibres for network use.

Acknowledgements

The authors thank BT's UK cable suppliers—BICC Cables Ltd., TCL Ltd., and Pirelli Cables Ltd.—for the use of illustrations of their proprietary cables designs.

Table 1 Key Cable Parameters

Cable details	COF 18	COF 27		
No. of fibres	8–96	8–96	144	240
Cable diameter (mm)	15–22	12–19	20 max	22 max
Total weight (kg/km)	388 (96 fibre)	250 (96 fibre)	250	436
Method of construction	Loose tube single layer		Loose tube dual layer	

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Biographies

Saf Ahmad
BT Networks and Systems

Saf Ahmad joined BT in 1971, graduated in Electrical Engineering from London University in 1972, and then moved to the External Engineering Division. During his career in BT, his work has involved various aspects of cable and fibre development, specification and measurement. He leads the Cable and Fibre Engineering Team, in Networks and Service Operations, whose responsibilities include the specification, evaluation and approval of cables and fibres bought by BT and cable installation practices used by BT. He is a Chartered Engineer and a member of the IEE.

Ian Gauntlett
BT Networks and Systems

Ian Gauntlett joined BT in 1974 as a Trainee Technician Apprentice. He has spent most of his career in the External Engineering Division. His work has involved various aspects of cable and blown-fibre development, specification, measurement, installation and jointing. He is a member of the Cable and Fibre Engineering Team in Networks and Service Operations. His present responsibilities include the specification, evaluation and approval of optical cables,

Maximilian Ardelt

Exploiting Fixed-Mobile Integration in Germany

In May 1997, VIAG INTERKOM was awarded the fourth digital GSM 1800 'Mobilfunk' (cellular) licence for supplying mobile telecommunications services throughout Germany. Previously, the company obtained two other forms of licence: a national licence for public telephony over fixed networks which is effective from 1 January 1998, and a licence for the operation of mobile transmission paths. The Mobilfunk licence makes available a bandwidth of 2 × 22·5 MHz and provides VIAG INTERKOM with the opportunity to establish itself as one of the chief competitors to Deutsche Telekom AG through the use of novel technical concepts.

The Attractive German Market

The current value of the German telecommunications market exceeds DM 70 billion—representing the biggest in Europe and the third largest in the world. Over the coming decade, an average of 7–8 per cent growth is expected, with even faster growth in the early years to take the value of this market to over DM 100 billion by the year 2000. Currently, this is a market which is dominated by Deutsche Telekom AG, the privatised German PTT which enjoys a market share of over 90 per cent and which will continue to hold a monopoly in the provision of speech services delivered by fixed networks until the end of 1997. Beyond this date, the market is set to become fully liberalised with the formal introduction of several new licensed operators.

The only competition in Germany at present is in the provision of cellular mobile, data and satellite services, as well as in the field of corporate networks. VIAG, together with its partners BT and Telenor, aim to establish the joint venture company VIAG INTERKOM as the leading provider of mobile and fixed network services.

Strong Partners

VIAG, BT and Telenor each consider their entry into the German telecommunications market as a unique opportunity to expand their existing activities into an area of business with strong growth potential:

Maximilian Ardelt, Member of the Board, VIAG plc, Munich, Germany

- VIAG AG is a German conglomerate that operates in five core areas: energy, chemicals, packaging, logistics and telecommunications. With a turnover in excess of DM 42 billion and around 90 000 employees, the company ranks among the largest of German industrial concerns. A key asset that VIAG brings to the VIAG INTERKOM partnership is an infrastructure company called *Bayernwerk Netkom*, which has 4000 km of glass fibre network covering the southern region of Germany in Bavaria and Thuringia, and which is rapidly expanding this facility to provide coverage across the rest of Germany.
- British Telecommunications plc (BT) contributes its extensive know-how and its commercial position as one of the largest telecommunications companies in the world. Through BT and MCI, VIAG INTERKOM has ready access to worldwide services supported on the Concert platform, and is thereby able to

achieve global reach on behalf of German multinational customers.

- Telenor AS is one of the most successful businesses in the area of cellular telecommunications. In particular, the company possesses considerable know-how in the deployment of sophisticated cellular mobile networks and has extensive marketing experience in the development of mobile services for private customers. As a result, Norway—the principal market in which Telenor operates—is the cellular mobile 'leader' within Europe with penetration levels of around 30 per cent while in Germany the penetration of mobile service is only about 7 per cent. Telenor has long-standing links with BT through the Telenordia partnership in Scandinavia and has previously worked with VIAG in Austria.

Currently, VIAG INTERKOM is a joint venture company in which VIAG and BT each have a shareholding of 45 per cent, while Telenor holds the remaining 10 per cent. However, the partners remain interested in the possibility of involving another mainly mass market orientated company as stakeholder in this joint venture and would contemplate the sale of up to 10 per cent of the shares supplied by VIAG and BT.

Ambitious Objectives

It is the main goal of VIAG INTERKOM to become a customer-orientated universal service provider in the German telecommunications market, beginning this process with the launch of both fixed and mobile services during 1998. The intention is that both business and private customer markets will be addressed using a combination of cable and cellular mobile networks.

VIAG INTERKOM is joined in this market by two other large companies which aim to compete against Deutsche Telekom AG as national providers of universal telecommunications services in all market segments:

- ARCOR is a joint venture of Mannesmann AG, Deutsche Bahn AG and the American company, AT&T. This joint venture will cooperate closely with the Mannesmann GSM mobile operator D2.

- o.tel.o. is a joint venture involving the German VEBA and RWE companies, which have a controlling interest in the third licensed cellular mobile operator E-plus.

Additionally, there will be many smaller providers of services catering for niches within the national market or in particular regions, examples being COLT and MFS.

VIAG INTERKOM is planned to achieve a turnover of around DM 10 billion by the year 2006, which represents about 8 per cent of the total German telecommunications market. The business plan for this joint venture company indicates a total investment of DM 8·5 billion over the next 10 years and suggests that break-even will be achieved by 2001.

VIAG INTERKOM was established by VIAG and BT in 1995 to gain a foothold in the liberalised German market for private telecommunications services. Since then the company has successfully established itself in this market and has started to build up a fixed network to meet its requirements using equipment supplied by Siemens. The turnover for data services, corporate networks and Concert products has already exceeded early expectations, with top German companies such as BASF, Bertelsmann, Compaq, Ford, Lufthansa and SAP being 'famous name' examples within the VIAG INTERKOM base of around 700 business customers.

With the granting of a telephone licence and the fourth digital mobile radio licence, VIAG INTERKOM has begun the second period of building up to become a universal provider of telecommunications services. This relatively young company is faced with the challenge of carving out an appropriate place in the dynamic German telecommunications market using innovative ideas and new technology.

Competitive Differences

VIAG INTERKOM enters the German telecommunications market at a later stage than its competitors but without any burden from the past. This is the company's decisive advantage. Because of this fact, an integrated fixed and mobile network can be built up from the start, without having to take any technical, organisational or social ballast into consideration. At the same time, the network can be tailored to the mass market. The infrastructure of the previous cellular operators was developed with expectations of markedly smaller market growth. In the meantime, full capacity has already been reached in many conurbations—a situation which is particularly true of regions with high traffic density.

A fundamental factor for success in telecommunications will be the quality of the competing services and there is still considerable room for improvement in the quality of cellular services. VIAG INTERKOM intends to build up a range of services that is distinguished by high speech quality and good indoor coverage in the urban conurbations, with the result that its networks should not exhibit any transmission 'holes' and customers will not suffer from interrupted conversations. At the same time, high quality means technically determined high capacity which is compatible with an aggressive strategy for the opening up of the private customer market.

The marketing strategy for VIAG INTERKOM cellular services will start with a metropolitan service in eight urban areas in mid-1998: Munich, Nuremberg, Rhine-Main-Neckar, Rhine-Ruhr, Leipzig-Halle, Berlin, Hannover and Hamburg-Lubeck—representing a population coverage of about 45 per cent. Complete geographic coverage in Germany will almost be achieved within three years.

Planning has begun to locate and acquire more than 10 000 base stations which are needed for the build up of the mobile network. Around 3500 base stations will be required for the start phase of the metropolitan service and nearly 2000 sites for this have already been acquired. Approximately one third of the required radio technology has been ordered from Nokia and Nortel.

Significant advantage for the customer, and the chosen approach of VIAG INTERKOM, lies in the integration of fixed and mobile networks with an innovative concept which has become known as *fixed-mobile integration* (FMI). The necessary conditions for this concept have been created by the simultaneous award of fixed and cellular operating licences which can be combined in Germany. From the technological and organisational point of view, adopting this approach means that VIAG INTERKOM is breaking new ground. Of course, other firms are working on the convergence of fixed and mobile networks as well; however, the integration of pre-existing separate networks for cable-connected and cellular telephones, as well as of different IT systems and independently organised company units, is both expensive and time consuming.

VIAG INTERKOM has the opportunity to plan for integrated organisational and network structures in all aspects from the very beginning. This saves time, investment and, above all, running costs, and these advantages can be passed on to the customer in the form of lower prices, superior quality and innovative services. This will be a clear advantage in a market which is expected to become fiercely competitive in Germany.

The integration of fixed and mobile means the following:

- only one central fixed network, with several mobile and fixed narrowband and, in the future, broadband access possibilities;
- only one common register of telephone numbers; and
- only one common information technology/intelligent network system, etc.

Beside saving time and money, this basic modular structure allows a high degree of flexibility with regard to the dynamic development and application of new telecommunications technology. However, this concept and the ideas supporting it still require considerable development in some areas, especially with regard to the transfer of understanding to key system suppliers. By working closely with its suppliers, VIAG INTERKOM can drive technological innovation and is expected to greatly influence developments within and beyond its home telecommunications market in Germany.

The most important thing is that the customer will benefit from all of this in the following ways:

- In the future, customers will have all telecommunications service requirements satisfied through a single service provider, covering mobile and fixed network services for voice, data communication and access to both national and international on-line services.
- Customers will be able very simply to make use of innovative service concepts such as having a single bill with a constant discount arrangement across a range of services, one telephone number, one electronic mail box, and having the same service and operating point of contact.
- With mobile services, VIAG INTERKOM will, for example, even-out the price difference between fixed network and mobile radio connections through a service offering known as *Home Cell*. This scheme allows a customer to phone from his designated 'home' with his cellular handset for about the same price as using a fixed telephone connection. Using the GSM 1800 system as a wireless local loop solution is another possibility for rapidly opening-up the private customer market without the need for sharing the copper lines of Deutsche Telekom AG.

The Regulator is the 'Market Maker'

The telecommunications law introduced into Germany last year is widely recognised as being one of the most liberal in the world and sets the scene for widescale competition in this industry. In a similar manner to the actions taken in Britain and the USA, VIAG INTERKOM expects the German government to introduce proactive regulation of telecommunications that will have the effect of encouraging the rapid development of effective and fair competition. With this in mind, the organisational and political aims of the regulatory body that oversees this market will be crucially important. There is a clear requirement for an efficient and independent body similar in nature to OFTEL or the American FCC which, above all things, is committed to the development of fair and effective competition.

In addition to having staff qualified in law and technology, business management skills are required to provide for a politically independent and courageous leadership that is experienced in the laws of competition. In Germany a lot of these necessary decisions have still to be taken. Action needs to be taken very quickly so that a functioning regulatory body will be in operation on time at the beginning of 1998.

German regulation exhibits some special features:

- An important area of regulatory interest is interconnect. The purpose of this is to provide ready access by one network operator to the networks of another, with prices for both connection and the carriage of traffic at international standard rates. The German telecommunications law states that the prices and conditions of interconnection have to be negotiated by the parties concerned, and that only if they cannot reach an agreement can the regulator be called upon to intervene. This is a long-winded procedure which is greatly to the advantage of the established network operator and, in consequence, represents a significant barrier for all newcomers. At the beginning of June this year, the German Minister for Post and Telecommunications, Dr. Wolfgang Bötsch, decided that Deutsche Telekom AG must make an offer to its competitors concerning interconnect access to the regional fixed network—meaning the local loop. This can be regarded as a positive step, but the important question of interconnect prices remains unanswered just a few months before the introduction of market liberalisation.

  VIAG INTERKOM believes that it must not only enjoy equal rights to the use of fixed network access lines to the customer, but must also have access to the rural networks of existing mobile cellular operators—networks which are not used to their full capacity and which currently belong to companies which enjoy a dominant position in the market. The rapid introduction of competition into the private customer market for mobile services can only occur if the necessary arrangements are integrated into the interconnection regime in the shape of a national roaming facility covering the rural areas.

- The prices for rented regional lines are three times higher in Germany than they are in Britain. Clearly this is a situation that must be corrected.

- Important matters connected with call numbers have still to be decided. Efforts to provide telephone numbers for new competitors, and to lay down rules concerning number portability as customers change from one operator to another in the fixed network, are progressing very slowly. Regulation around call numbers also has a decisive influence on the market feasibility of establishing an integrated fixed and mobile network. The threat of allowing inflexibly allocated Call Number blocks must not be allowed to hinder this innovative concept.

VIAG INTERKOM trusts that the political establishment in Germany will act effectively to support market deregulation and remove those anomalies that represent barriers to market development.

Migration to the Next Generation

VIAG INTERKOM is developing its network and marketing strategy while continuing to examine trends that are likely to affect future market requirements and drive developments in technology. The diverse and constantly changing requirements of the customer are always the centre of attention. Trends toward mobile, broadband services and multi-media applications which often first arise with the availability of technology will quickly and permanently change the demand for telecommunications services. Already during the on-going planning process at VIAG INTERKOM, the next generation of technology is becoming visible. Network users, manufacturers and regulators are working worldwide on the telecommunication systems of the near future. VIAG INTERKOM sees the chance to participate actively in this process—unburdened by the past—and will invest today with the necessary flexibility to meet the standards and requirements of the future. In this way, VIAG INTERKOM will not only be a partner of Concert in the large German telecommunications market, but will also be a technological innovator in the wider industry.

Biography

Maximilian Ardelt began his career as a reserve officer in the German Navy and followed this by studying for a Masters degree in Commercial Engineering at the Technical University of Berlin. Through the 1970s, 1980s and the first half of the 1990s he worked for the commercial German companies of Klöckner-Werke AG and Salzgitter AG assuming the positions of Director of Processing, Corporate Development, Plant Engineering, Environmental Technology and Information Technology. From July 1994 he became a member of the management board of VIAG Aktiengesellschaft, based in Munich, in charge of the Divisions for Logistics and Telecommunications, and with special Group responsibility for technology and informatics. He is currently also a member of the supervisory board of several German companies, including Computer 2000 AG, Georgsmarienhütte GmbH, Klöckner & Co. AG (Chairman), Kühne & Nagel International AG and Radex-Heraklith Industriebeteiligungs AG of Vienna.

Andrew Catchpole and Simon Davies

VideoPBX Computer Telephony Integrated Applications

The VideoPBX offers a real alternative to the current videoconferencing technology. Using computer telephony integration, it has been shown that high-quality desktop video can be offered in conjunction with a normal office telephone. Video communications has never been easier!

† Meridian and Norstar are trademarks of Northern Telecom (Nortel)

Introduction

Previous articles in this theme[1,2,3,6] have introduced computer telephone integration (CTI) and looked at CTI applications such as Callscape[6]. This article discusses a video telephone system, known as the *VideoPBX*. VideoPBX uniquely uses CTI technology to integrate any existing telephone system with a video communications system. This article describes both the VideoPBX system and demonstrates some of the diverse benefits and applications of CTI technology.

Overview

The VideoPBX is arguably the world's easiest-to-use desktop video telephone system. The telephone, as part of a business switching system, provides most of the day-to-day real-time communication needs of today's business. VideoPBX adds video automatically to any business telephone system, without taking away any of the time-proven advantages.

Based around the Norstar system, VideoPBX uses conventional Norstar telephones. The user's desktop video display can be integrated into a PC or Apple computer, or can take the form of any television. Even a video wall could be attached to the opposite side of the desk for the ultimate in face-to-face communication. Similarly, any type of camera can be used. Quality within the building is similar to conventional television at home. VideoPBX can call another standards-compliant (ITU Recommendation H.320) video terminal anywhere in the world, direct from the desktop. Only a single external video link is needed, so that a premium-quality video codec can be shared among several users (just like a telephone system, where there are more extensions than outside lines).

For busy executives, all calls, including video calls, can still be diverted to a secretary and transferred as required at a touch of a button. VideoPBX even supports three-party conference calls with 'continuous presence' video. This means that three people can see and talk to each other simultaneously at their desks. A choice of business TV broadcast channels (such as EBN, NBC, Reuters TV etc.), or any other video feed such as a VCR, can be called up at the press of a button, and watched on demand. VideoPBX uses standard structured cabling and does not in any way affect the performance of the local area network (LAN). BT's skills in CTI bring the facilities promised tomorrow—today.

History of the VideoPBX

Today's VideoPBX is based upon a pioneering BT Laboratories design dating from the latter part of the 1980s, called *Argus*[4,5]. Argus was based around the Monarch PBX and used a video switch to shadow the progress of calls.

The Argus design used a bespoke BT-designed visual services terminal (Aster). The integrated terminals consisted of a high-quality colour monitor, combined face and document camera, loudspeaking telephone and separate handset for privacy. Internally, the unit contained all the telephony processing and control electronics plus the video and audio multiplexing and interfacing circuitry.

Calls made within the Argus system were automatically enhanced with TV quality video. A gateway to other locations was provided via video codecs linked by BT MegaStream circuits. On-screen messaging detailing call progress, and document image transfer were standard features.

The system was further enhanced by experiments carried out over a wideband network across London, using Westminster Cable's switched star system.

Customer Trials

Eight fully functioning Argus prototypes were commissioned. Two customers were selected for the Argus trials on the basis that they were existing users of videoconferencing, and could demonstrate the need to converse regularly in communities of interest both intra- and inter-site. Video codecs (BT VideoStream MkIV) were provided on dedicated MegaStream circuits to link Argus users with a videoconference room at another customer location.

The results showed that the Argus terminals were little used, both within the building and using the remote site link-up. The hands-free audio option built into the terminals was criticised by nearly all the users. Furthermore, it was evident that users wishing to converse with colleagues in the same building were either picking up their normal telephone, or walking around in person.

It is worth remembering in the late-1980s there was no ISDN2, sector-specific TV broadcasting, structured cable or desktop videoconferencing. In the era British Telecom was trialling Argus, a conventional videoconference facility necessitated a dedicated studio to house the equipment and cost upwards of £50000.

Hindsight suggests that Argus was a concept some years ahead of its time, and perhaps the many features built into the system, in particular the bespoke Aster terminals, were a little over-specified.

The fundamental difference between the Argus trials and the VideoPBX is that the 1989 users were expected to use a separate telephony interface and dial different numbers, instead of using their familiar telephone, which was still required for communications outside the Argus user group. They chose the convenient option. Many desktop videoconferencing users today tend to do the same.

Unfortunately, some of the electronic components used in the design were discontinued during the evaluation period, necessitating major redesign work being required before volume production could commence. The Argus/Aster development was ceased in 1989.

In 1994, BT Business Multimedia Services sponsored and managed two new trials with customers in the insurance and media sectors, using third-party equipment based on the PBX's call-logging information, not CTI. The insurance company selected eight members of staff with regular calling patterns in one building using a GPT iSDX, and a manager located in another site approximately one mile away, connected via ISDN. Unfortunately, the trial was beset by technical problems and there were also staff changes, resulting in less-intensive communication. The remote site was rarely staffed, and the company withdrew from the trial.

The London-based media company trialled a system with their board of directors, and purchased a BT VC7000 videoconferencing terminal for their New York office. They timed the trial to coincide with another trial in the same location of the market-leading conventional room-based videoconference system. The trial resulted in an immediate sale for VideoPBX.

The media company directors particularly liked the luxury of conducting business from their personal office, where all their reference documentation was close to hand. They also liked being able to bring in another colleague at the press of a button, and having their secretaries handling incoming and outgoing calls on their behalf.

Current Video Communications Systems

Current digital videoconferencing systems, such as BT's VC8000, require a dedicated ISDN line. Commercially, the public ISDN service is now more commonplace, but there are few PBXs that support ISDN capabilities to the desktop, and these do not handle internal call transfers in a straightforward manner. Therefore, videoconferencing terminals are usually connected directly to the public ISDN service and so cannot make use of the company's PBX facilities. Some ISDN PBXs, known as *ISPBXs*, have been tested with BT's VC8000 product for basic call connections. However, PBX supplementary services, such as call transfer and conference, are not possible. All video communications products, not just BT's suffer from this limitation.

For most customers, the ISPBX solution is unacceptable owing to the high cost of upgrading existing systems and the lack of PBX functionality. However, these are difficulties which must be addressed if ISDN and ISPBXs are to be successful.

Weaknesses of ISDN/PBX video-telephony

These are:

- high cost of upgrading telephone systems and providing ISDN to every desktop;

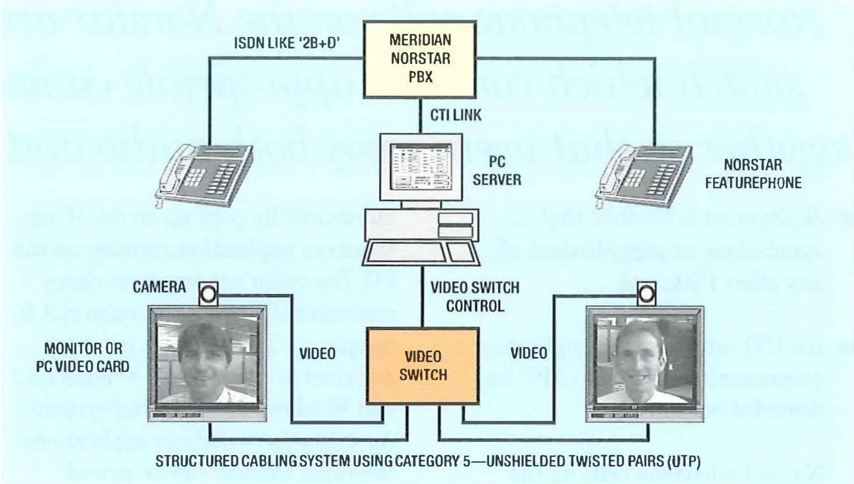


Figure 1 – Separate switching of voice and video information

- expensive equipment on every desk (digital codecs) to purchase and maintain;
- requires 128 kbit/s to every desk for acceptable video quality; and
- every desktop system may become obsolescent over time as new standards and equipment are developed.

Advantages of ISDN/PBX video-telephony

These are:

- integrated PBX carrying voice, video and data services;
- multimedia applications supported; for example, voice, video, file transfer, workspace sharing etc.; and
- ideal for small and large numbers of users alike.

Integrated multimedia switching with ISPBXs

Integrated multimedia switching is achieved by multiplexing the digital video, voice and data signals into one, or more, digital channels. The proportion of bandwidth allocated to video, voice and data is variable depending on the digital coding standard used.

In the future, most video-telephony services will probably use an integrated multimedia service, but at the moment most PBXs do not offer support for video services and if they do then it is not justifiable owing to the high cost of equipment such as the digital codecs required by each user.

In the medium term, as coding standards improve and the cost is reduced, the integrated multimedia solution may be the most attractive; thus considerable research and development has been done in this area and will continue.

In the longer term, asynchronous transfer mode (ATM) switching in the public and private domains will probably be used to deliver high-quality multimedia services.

Business Requirements for Video Communications

It is probably true to say that the penetration of video communications has not been as fast as anticipated. Improving the use and acceptability of video communications within the business environment could be achieved by:

- easier-to-use systems,
- integration with existing business telephone systems,
- higher picture and sound quality, and
- reducing the cost of purchasing videoconferencing systems.

Commercial Development of VideoPBX

Also in 1994, Advanced Multimedia Services sponsored the development of the VideoPBX prototype, using the basic design concept of Aster, but taking advantage of the new developments in CTI.

With modern key-system telephones and PC displays now commonplace, the need for bespoke terminals is over, greatly simplifying and reducing the cost of the product.

A key advantage of using CTI was integrating a customer's telephony and video requirements under the control of a single telephone. This feature alone made the VideoPBX unique.

Two Norstar VideoPBX demonstrators have been in place for two years, and a significant number of BT account managers and their customers have had the opportunity to see the concept in action. The system in Euston Tower, London, is in day-to-day use in a live business environment. There has been a great deal of interest in the system with many customers inquiring when the product would be available for sale.

BT Business Multimedia Services has licensed a third party (Perex Ltd.) to manufacture and sell VideoPBX alongside the Norstar telephone system, in conjunction with Nortel UK, using software commissioned from BT Laboratories. VideoPBX is believed to be the first CTI product to be designed, built and productised at BT Laboratories.

The VideoPBX Solution

BT has identified the concept of separate video and voice switching (see Figure 1) as offering the most potential for short-term benefit and niche applications. It is for this reason that BT Laboratories was asked to build a prototype video telephone system based on the Meridian Norstar PBX. Rather than using proprietary interfaces, such as the Argus system, the VideoPBX uniquely uses CTI to monitor call progress.

The advantages of using the Meridian Norstar system as a switching platform can be summarised as being as follows:

- Norstar is a BT portfolio switching system with a large installed base of over 60 000 sites in the UK alone;
- Norstar is a high-functionality low-cost modular system;

Normal telephone calls on the Norstar are shadowed by a video switch which connects appropriate cameras and TV monitors together so that users enjoy both audio and video communications.

- deployment is flexible; that is, stand-alone or piggy-backed off any other PBX; and
- the CTI interface and application programming interface (API) are powerful but low-cost.

Normal telephone calls on the Norstar are shadowed by a video switch which connects appropriate cameras and TV monitors together so that the users enjoy both audio and video communications. Any type of TV monitor and camera combination can be used that supports a composite video signal; for example, PAL. If a user has a desktop PC, then the TV monitor can be replaced with a PC video overlay card so that the video is displayed on the PC screen.

With VideoPBX, only one telephone is needed for all normal telephone calls and video calls alike and there is no difference in operation. In fact, one aim of the system was to develop an **easy-to-use** video communications system which anyone could and would use.

All normal Norstar system features such as call holding, transfer and conferencing are maintained for both voice and video parts of the call. Therefore, senior managers can still have their calls filtered by a secretary, even video calls.

Internal video calls on the VideoPBX enjoy television-quality pictures while off-premises calls use an ISDN gateway to route calls off the VideoPBX.

Desktop PC application

One of the very early limitations of the VideoPBX was that a video call required the user to answer the telephone and click the appropriate PC application buttons to bring the video window in to view.

Therefore, an additional VideoPBX application has been developed for users who choose to use their desktop PC for displaying the video image.

Using the VideoPBX PC software has the advantage that a video call automatically pops up on top of any Windows application running on the PC. The video window then closes automatically when the video call is completed. The software has been designed to run on both Windows 3.1 and Windows 95 operating systems. As with other windows applications the video window can be moved around and set to any required size on the screen including full-screen mode. Using this software greatly simplifies video calls—the user needs only to pick up the telephone handset to control the video window.

Future developments to the desktop application could include CTI capabilities such as desktop PC dialling and on-screen calling line identity as offered by CTI applications like Callscape[6].

Multipoint videoconferencing

A normal Norstar system supports three-party voice conference calls which needed to be shadowed by the video switch. The VideoPBX system allows any video user to establish a simultaneous voice and videoconference call using exactly the same conference set-up procedure for the Norstar system.

The video part of the conference works by switching in a multipoint video control unit that allows up to four video sources to be combined on to one window-like video output. The combined video picture is then distributed to each of the parties involved with the conference call.

Each of the three parties in the conference appears in one of the quadrants. The fourth quadrant is used to display a logo or for future use.

ISDN gateway

An ISDN gateway allows any VideoPBX user to make external videoconferencing calls. The gateway consists of a video codec and an ISDN line which is shared among all VideoPBX users. Access to the ISDN gateway is by a feature button on the Norstar terminal or dialling an access code in the same way as dialling '9' for an outside (voice only) line.

The user is then prompted by the Norstar terminal's liquid crystal display screen to enter the required destination number. Even the video codec's stored numbers can be listed and dialled.

One of the advantages of the VideoPBX system is that potentially any existing video codec can be used. Investment in videoconferencing systems need not be wasted; VideoPBX just makes it more useable. Any upgrade of the video codec is required only once for the gateway, not for every desk. It is also possible to connect a video codec with up to 30 ISDN channel capability. The improved video and audio is then economically shared across a number of desktops without loss of quality.

Business TV

Additional applications have also been identified for the Norstar VideoPBX system. One is the distribution of television channels to the desktop using the VideoPBX system. Business TV, satellite or even terrestrial broadcast channels can be selected by pressing buttons on the Norstar terminals which connect the required programme to the user's monitor.

CCTV applications

Closed-circuit television (CCTV) security cameras can be connected to the VideoPBX system and accessed on demand from the Norstar terminal.

Stand-alone Norstar VideoPBX

The VideoPBX has been designed to be highly integrated with the Meridian Norstar telephone system. As a stand-alone system, Norstar has the advantage of being a highly featured digital telephone system which is BT's small-to-medium key telephone system or PBX. In this mode, the Norstar is connected directly to the public telephone network using either analogue or digital lines.

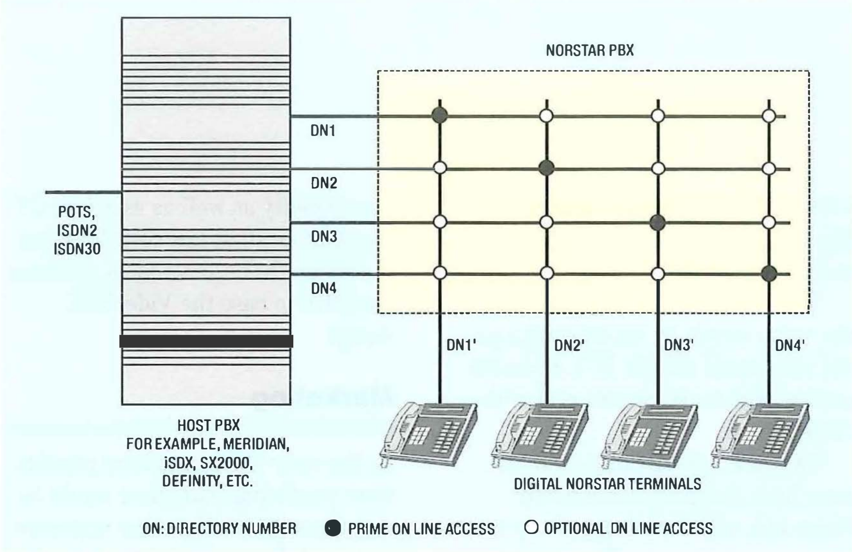


Figure 2 – Piggy-backing a Norstar system behind a host PBX

PBX-hosted VideoPBX

Where there is a need to deploy the VideoPBX system on a larger or existing PBX, then the Norstar system is connected to the analogue extension ports of the host PBX (see Figure 2). This configuration allows the VideoPBX system to be offered, for example, to existing BT customers with Meridian 1 PBXs or to non-BT portfolio PBXs. As a *piggy-backed* system, the Norstar PBX functions transparently so that the full functionality of the host PBX is maintained. The ordinary PBX telephone is replaced by a digital Norstar terminal which is configured to make and receive calls automatically from the original directory number (DN) of the host PBX. Most PBX supplementary features are still possible from the Norstar terminal.

How VideoPBX Works

The VideoPBX control computer (PC) needs to monitor the Norstar telephone system. This is achieved by a single CTI connection (see Figure 3). The Norstar CTI link, known as *Norstar ACCESS*[2] physically connects the Norstar telephony domain to the computer domain.

The PC controller is also connected to the control port of a high-bandwidth analogue video switch router. Commands can be sent by the control software to connect and disconnect video sources to destinations.

Each VideoPBX user is equipped with a small camera and either a PC video overlay card or a separate TV style monitor if a PC is not required on each desk.

Video distribution

Conventionally, base-band video signals would normally be carried by coaxial cables but these are bulky and expensive to install. Instead, the VideoPBX system uses balancing transformers (baluns) to convert the balanced video signal into an unbalanced signal which can be carried over an unshielded twisted pair (UTP) of a structured wiring system.

Structured wiring is now very popular for providing a common communications infrastructure to carry computer, telephone and video traffic. Typically, each office desk would have a number of structured wiring outlets wired back to a central distribution panel, which can be used to patch services to each outlet as required.

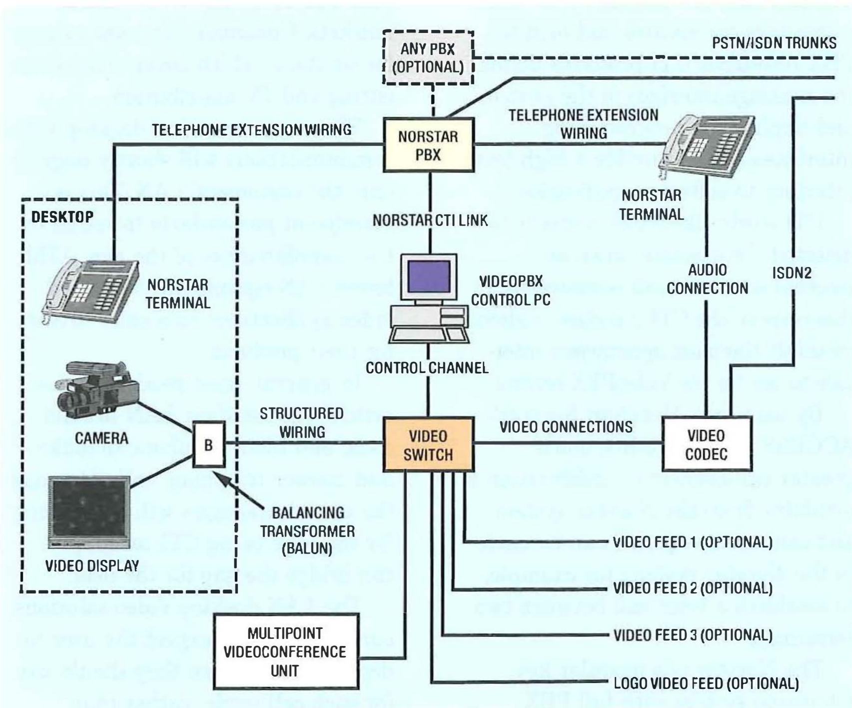
Generally, passive baluns can be used for sending signals up to 130 m before the video signal becomes noticeably degraded. New active baluns are becoming available that can combine the sending and receiving signals into a single structured wiring outlet, which halves the number of baluns and thus halves the number of structured wiring outlets required. Active baluns are now capable of working up to 400 m.

Video switching

In the prototype VideoPBX system, a single non-blocking video switch router is used. This switch is limited to a maximum of 16-source by 16-destination ports. By using a video expansion frame and four routeing frames, a non-blocking 32-source by 32-destination matrix can be formed.

Non-blocking video switches are not required for person-to-person video calls. However, for advanced features, such as business TV, the

Figure 3 – Schematic diagram of a typical VideoPX system



video and audio sources need to be distributed, without loss, to potentially every desktop user.

The VideoPBX software controls the video switch by sending appropriate commands via the PC's communications port to the control port of the video switch.

Two new non-blocking switches have been designed and built by Perex Ltd. which can support up to 32 ports and 96 ports. These new video switches can switch both the video and audio paths required for distributing TV feeds. The video switch has been designed specifically for the VideoPBX system and has integrated baluns, further reducing equipment needed.

VideoPBX controller

The Norstar system is connected to the VideoPBX controller via the Norstar ACCESS CTI link. The VideoPBX controller PC has a configuration screen so that Norstar extension numbers can be logically associated with a camera and monitor set. Extensions listed on the configuration screen are monitored by the CTI link for events or activity.

Norstar ACCESS CTI

CTI provides an interface over which computers can control and monitor PBX resources. CTI protocols define the message interface to the switch, and application programming interfaces (APIs) provide a high-level interface to software applications.

CTI easily allows call events to be detected; for example, when an internal telephone call is answered. In this respect, the CTI interface is almost certainly the most appropriate interface to use for the VideoPBX control.

By using the Meridian Norstar's ACCESS CTI capability, much greater call-connection information is available from the Norstar system, and command requests can be made to the Norstar system; for example, to establish a voice call between two terminals.

The Norstar is a modular key telephone system with full PBX functionality as well as excellent CTI capabilities all at low cost. This fact makes the Norstar an ideal platform on which to base the VideoPBX design.

Marketing

In the early 1990s, industry pundits were predicting that there would be a desktop videoconferencing explosion, and used the rapid growth of the fax machine as a model for their predictions. Although desktop videoconferencing hardware costs have recently fallen below £2000 per user, the market has yet to live up to the pundits' expectations.

Market research suggests that the VideoPBX is most likely to be specified for senior management use. This is because the system, being based on a standard Norstar telephone handset, is extremely easy to use, and retains the vital features that managers use regularly, such as call diversion, manager/secretary working and call transfer. It does not require a desktop computer, and can be integrated into almost any display medium. New television services aimed at the corporate sector have been launched over the last four years, particularly in the finance markets. Customers are now asking for solutions which cover videoconferencing and TV distribution.

There is a view that desktop video communications will shortly migrate onto the customers' LAN. This is a standpoint particularly favoured by the manufacturers of the new ATM-based LAN equipment, who need video applications as a sales driver for their products.

In general, most readers of this article will use their LAN to send data, and their telephone to make and answer telephone calls. One day the two technologies will merge, but for the time being CTI techniques can bridge the gap for the user.

The LAN desktop video solutions currently offered expect the user to decide which device they should use for each call made, rather than instinctively pick up the telephone. It is arguable whether this represents real progress.

As a sales prospect, for the price of a premium quality rollaround videoconferencing unit, requiring a dedicated room and booking facilities, a complete Norstar VideoPBX system supporting 11 users could be purchased. No other desktop system offers the full PBX facilities, internal multipoint conferencing and business TV.

This exciting new development may offer BT's sales forces the opportunity to go into major accounts where their PBX has been supplied by a competitor, and sell a BT Norstar VideoPBX to work alongside, in 'piggyback' mode.

The Future

Future developments of the VideoPBX could include automatic call distribution (ACD). As the number of desktop video terminals and multimedia kiosks grows then the need for multimedia video call centres becomes more important. Even the idea of multimedia television is becoming a reality. The call centre of the future will need to seamlessly handle multimedia communications, such as electronic mail, World Wide Web and face-to-face video calls as well as the ubiquitous voice-only telephone calls.

Call centres normally require calls to be held in queues and transferred between telephone agents. VideoPBX may ease the routeing of multichannel video calls through the call centre systems and facilitate use of existing call centre technologies rather than out-dating it.

One of the features of current videoconferencing systems is the data and application-sharing tools. These collaborative working applications could be integrated into the VideoPBX at a later date using industry standards such as the ITU T.120 recommendation, which defines data protocols for multimedia conferencing.

Conclusion

Undertaking a project to integrate video communications into an existing telephone system, such as the Norstar, has been made possible by using CTI technology. CTI has traditionally been confined to expensive call centre applications. However, as the associated costs fall, the CTI applications will appear on the office desktop computer. VideoPBX shows how CTI can be put to use to solve other problems too.

Even though ISDN videoconferencing has established itself in the market, the VideoPBX system has generated substantial interest. If video communication is to be successful then it must be as easy to use as the ubiquitous telephone. CTI has made ease of use achievable in the VideoPBX.

The VideoPBX is available now and it is planned to have a system on display in the customer centre at BT Laboratories, Martlesham Heath, later this year.

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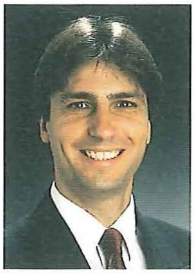
Glossary

ACCESS Meridian Norstar's computer telephony integration interface
API Application programming interface
ATM Asynchronous transfer mode
Balun Balancing transformer used for coupling the video feeds to and from the structured cabling system
CTI Computer telephony integration
DN Directory number
PBX Private branch exchange
H.320 ITU Recommendation for narrow-band visual telephone systems and terminal equipment
ISDN Integrated services digital network
ISDN2 BT's public ISDN service
ISPBX PBX with ISDN capabilities to the desktop
ITU International Telecommunications Union
PC Personal computer
T.120 ITU Recommendation for data protocols for multimedia conferencing
VC7000 Integrated videoconferencing terminal
VC8000 PC-based multimedia conferencing system

Biographies



Andrew Catchpole
BT Networks and Systems

Andrew Catchpole joined BT as an apprentice in 1981 in the Norwich Telephone Area. In 1989, he transferred to BT Laboratories and is now a senior professional engineer in the Network Intelligence Engineering Centre. His main work is investigating computer telephony technology and applications for the desktop, office and call centre environments. In his most recent project he has been evaluating and exploring opportunities with multimedia video call centres. He is one of the first students to be awarded the Martlesham M.Sc. degree from the University of London; his M.Sc. project was to design and build the Norstar VideoPBX telephone system using his CTI knowledge.

Simon Davies
BT Internet and Multimedia Services

Simon Davies joined BT as an adult entrant in 1983. Originally working as a business telephone systems installer in Surrey, he transferred to the information technology division in 1986. In 1988 he joined BT Videoconferencing, and worked for three years installing and maintaining video equipment, both in the UK and overseas. Simon is now a product manager in the Business Multimedia Services division of BT IMS, based in Euston, London.

Steve Harris, Chris Musson and Paul Martin

Advanced Personal Mobility Services

The challenge for 21st century mobile services is to combine emergent multimedia technologies with the existing telecommunications services offered to customers. A truly mobile service must allow customers to control all their voice and data applications from anywhere at anytime. Existing voice networks, radio or otherwise, can be exploited and expanded by adding value. This can only be achieved if the new complexities can be presented sympathetically to customers, preferably using familiar interfaces and terminals. The World Wide Web is just such a device; this must be exploited to the full to present and sell new and even old services to customers.

Introduction

The telecommunication business has always had two 'poles': customer service management at one end, and customer presentation at the other; everything else is middleware; that is, routeing technology. Traditionally, with a simple telephony network, the network has absorbed most of the investment. This is now changing as customers demand, and use, more sophisticated audio-visual terminals. This, together with the competitive requirement to keep ahead, forces telcos and service providers to innovate at a greater rate. While still in command of the core technology, telcos and service providers have now to address the 'pole' technologies of service creation and customer presentation; a corollary to this is that new and powerful players have now the opportunity to cream off significant revenue streams.

The initial response to the competitive threat has been to evolve new service creation and downstreaming strategies such as intelligent networks (INs) and associated service-creation environments. In effect, the IN technology builds upon the existing fixed-network model, which uses existing signalling protocols and network hierarchies. The intelligence of the network is fixed, physically, in one place and acts, using overlay channel-independent signalling, to progress calls in other parts of the network. Overlay networks of this type have enabled telcos to deliver new services to the customer but the dream of a rapid service-creation environment has so far failed to materialise. Nevertheless, IN technology is a powerful tool for opening up existing fixed and mobile networks and has been used to good effect by value-add overlay networks.

An example of IN technology that has evolved to address the multimedia service environment is the BT Magic platform. It is one of the first examples of an integrated service platform to bridge fixed, mobile and Internet technologies. A direct benefit to BT Magic customers is the familiar World Wide Web interface which provides on-line help and complete control of sophisticated voice and fax services.

A cornerstone of any IN platform is its ability to abstract a telephonic environment so that new services can be added more easily. This can be achieved by inventing a generalised set of functions (an application programming interface (API)) with which to manage calls to and from customers. In traditional telephony networks, managing calls would have been enough; however, new services require new resources, often distributed in some way within the platform or even remotely on other platforms. The control of these resources is effected by the API set and allows the service script programmers to connect the caller to resources such as voice clips, voice mail and fax modems when required. To do this effectively, and make the job of the script writers easier, each application operates within the environment of the service logic execution environment (SLEE). The SLEE can be considered as an extension to an operating system and functions in an analogous way; that is, device drivers are analogous to the signalling protocol stacks, resource management is equivalent to memory and disc management, and most interest-

The BT Magic service combines an advanced personal numbering service with a voice mail, fax messaging and e-mail storage capability

ingly muti-tasking is similar to the muti-threaded application. The success of the BT Magic service has been mainly due to the flexibility of the SLEE and the mechanism it uses to communicate to the stack of intelligent peripherals that make up the service control point.

Role of the Internet

This section discusses the role played by the Internet in the development of the BT Magic service and how new browser languages like Java will enhance the customer experience.

The Internet is undoubtedly becoming a serious force in the telecommunications industry. This is to be expected as the industry is about people keeping in touch, both in the parochial sense and in the cosmopolitan sense of the global community. The ubiquitous presence of the personal computer has meant that the initiative has been lost by the simple telephone. New services are now required that exploit the capabilities of the personal computer. A brief transitory phase, while customers adjust to the new technologies, will allow those service providers who wish to compete to adjust their services accordingly.

The Internet has been the most potent enabler of this revolution, in that the hypertext mark-up language (HTML) protocol (as used by the World Wide Web (WWW)) allows Internet users to communicate using sound and pictures. Not only that, Web consumers have full control of what they see and do. For some the insatiable desire to 'surf the Net' is enough; however, those that are commercially aware have seen the possibilities of reaching out to new, and old, customer bases.

For the telecommunications industry and especially service providers, these events are to be welcomed. The technological straight jacket of the simple telephone makes unwarranted demands on customers' patience. They are expected to dial streams of incoherent digits, even sometimes to effect just a simple call. In other cases, customers are expected to semaphore, using key presses, their end of a diabolical conversation with an automaton. Speech recognition is a step forward but is hardly a substitute for intelligent and context dependent 'conversation recognition'.

The combination of the WWW and a suitably hosted browser gives the service provider the opportunity to involve itself in a rewarding dialogue with customers. New services can be published easily, customers can choose to use them, customers can be given control of their telephone, fax machine and messaging services. Dynamic billing may become a feature of every customers' personal account with the service provider. And the telephone as we know it today will be no more.

BT Magic Service and its Architecture

The BT Magic platform has evolved to meet the requirements of the Internet and its technologies. The original architecture is based on a highly successful IN service node developed at BT Laboratories, Martlesham Heath. The BT Magic platform can now fulfil the role of a value-added service platform at any point in a network, customer premises equipment (CPE) or other licensed operator (OLO). The BT Magic service is based on a managed call-routeing facility controlled by the customer. It also integrates fax, voice and e-mail messaging with the Web. For those customers who are unable to get access to the Web there is a comprehensive telephone management interface.

The service

The BT Magic service is currently on trial in the UK and will soon be tested with the Concert voice network. It combines an advanced personal numbering service with a voice mail, fax messaging and e-mail storage capability. Customers may access their stored messages, and configure the service, using the telephone, or by accessing the system via the Web. The telephone management interface can be driven by the customer using multi-frequency (MF) keys or simple voice recognition using key words.

Features

The service offers customers with the following features:

- a personal number by which they may be contacted (07070 00xxxx);
- diversion of these incoming calls to the customer's current location (either home, office, mobile number, or a specified number);
- call screening of incoming calls, permitting the customer to decide whether he/she wishes to accept a call before it is connected;
- an override facility for call screening to permit selected people to contact the customer without screening;
- a messaging facility to record all calls that were not passed through to the customer;
- detection of incoming fax calls, and the storage of these faxes, or forwarding of these faxes to a specified fax machine;
- notification of voice and fax messages that have been stored by the system (notification either by pager, GSM short message service, or e-mail);
- a diary facility to divert calls to specified locations at certain times of the day;
- ability to telephone the service and configure it remotely (using tone dialling or speech-recognition techniques); and
- ability for the customer to hear their stored voice messages over

the telephone, or to get a summary of their stored e-mail messages.

Service packages
The product is available in different service packages that offer different levels of service capability (such as the type of destinations permitted for the personal numbers to divert to):

- *Gold* permits personal numbers to be redirected to global numbers;
- *Silver* permits personal numbers to be redirected to UK and continental numbers; and
- *Bronze* permits personal numbers to be redirected to UK numbers only.

Costs
This service is billed on a monthly subscription basis to the customer's credit card. This is a fixed fee that covers all of the features and call costs incurred by the chosen service package. The service package will provide the customer a limited amount of credit for these forward calls every month that must not be exceeded. Calls to the customer's personal numbers (07070 00xxxx) will be charged at a set rate.

The architecture

The control processor (see the Magic trial platform in Figure 1) uses a commercially available multiprocessor computer system with optically connected data storage to a large redundant array of independent discs (RAID).

The RAID provides a secure and easily-maintained storage media for customer data. This data is backed up frequently using an auto tape loader.

The control processor's operating system is Unix, upon which BT Laboratories has developed a service logic execution environment (SLEE) that can support more than one service at a time. Recent trials have proved this concept and it is probably one of the first live systems to support multiple concurrent voice and data services.

The digital switch is the traditional 'front-end processor' for the platform. It provides the interconnectivity with the intelligent peripheral resources. By providing switched circuits to announcements, fax processing and voice-recognition peripherals, customers are able to interact with the system.

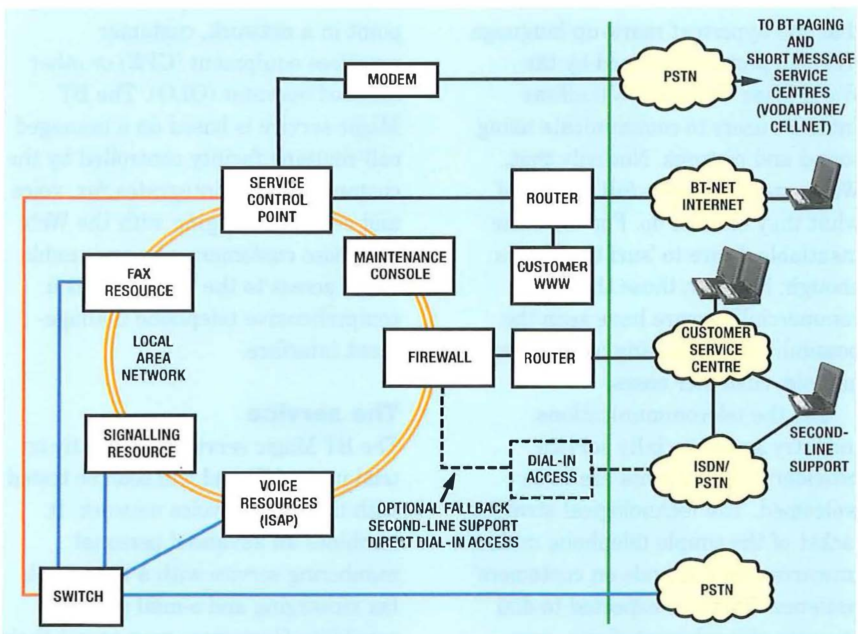
The digital non-blocking switch, which is modular in design, can be expanded to support 7936 speech and data channels within a single 19 inch cabinet.

The switch is controlled via the control processor using a dual Ethernet for security. MF, fax detection and conferencing capabilities are available to all channels thus minimising the reliance on external provision.

A cornerstone of voice service provision on the BT Magic platform is the intelligent speech applications platform (ISAP). This is another multiprocessor system using Unix. It has been specifically designed by BT Laboratories to provide a range of voice services such as recording and play back of speech, speaker dependent and speaker-independent voice recognition, and text-to-speech. In addition, several reusable generic dialogues can be combined to provide menu-driven interactions with customers. It is modular in design, and a single 19 inch rack can support up to 60 channels of announcements. A full cabinet has three racks. The configuration used depends on the combination of applications required.

The original service control point used C7 signalling; however, the new role of the platform as a value-added service platform requires a diverse number of signalling interfaces. Even in the UK, which uses E1 interfaces, there are a variety of choices; for example, digital access signalling system (DASS) is normally used to connect a PBX to the central office in the UK; and digital private network signalling system (DPNSS) is another protocol similar to DASS used in many BT systems but more highly featured for the inter-PBX signalling market. European influence will require BT to support DSSS1 (based on Q.931) in the future. Some European countries still use channel-associated systems similar to R2. With these needs in mind a third-party supplier has been chosen who

Figure 1—BT Magic platform



can supply a common API to the variety of signalling systems.

For the current services, DASS and DPNSS are used. The signalling API allows the SCP (via the SLEE software) to control calls independently of their signalling type. Applications are unaware of the underlying signalling system. It is a feature of DASS and DPNSS that time-slot 16 is used to control the calls associated with the 30 channels on the pulse-code modulation (PCM) system it belongs to. Unlike C7, a signalling engine is required for every time-slot 16 on every E1 stream.

In the current implementation, PCs are used to house the signalling engines and the fax resources. Special software written by BT Laboratories allows these resources to coexist on the same PC. Again Unix is used for the operating system. To give an element of redundancy, some signalling engines are not used. Often the signalling resource is shared over two or more PCs, especially for the larger systems. Should a signalling engine fail, the control processor automatically attempts to switch in a spare and maintain signalling continuity, although calls in progress are lost. This is a feature made possible by the presence of the digital cross-point switch.

The comprehensive voice, fax and e-mail services require a significant internal bandwidth to the platform. This is provided by a dual attached FDDI ring of 100 Mbit/s. This is a feature new to the architecture and specifically designed to facilitate Internet services as large quantities of data are transferred between the Web server and the RAID. Much of the internal data flows are hidden by the Unix operating system, as the Unix network filing system protocol is used. All voice and fax messages are stored on the main disc array as are e-mails .

Media Capabilities

The BT Magic WWW message viewing pages are currently written in HTML. While this provides a good system for formatting information, it becomes user-unfriendly when the customer has a large number of messages. The customer finds that a lot of scrolling is required, and the messages cannot be easily arranged in a way that the user requires them.

Another problem occurs when functionality such as reply-and-forward messages are added. While HTML frames can be used to display more than one page, it is not easy to display message headers, messages being used and the message being composed at the same time, and it is impossible to 'drag and drop' information from one message to another in a user-friendly way.

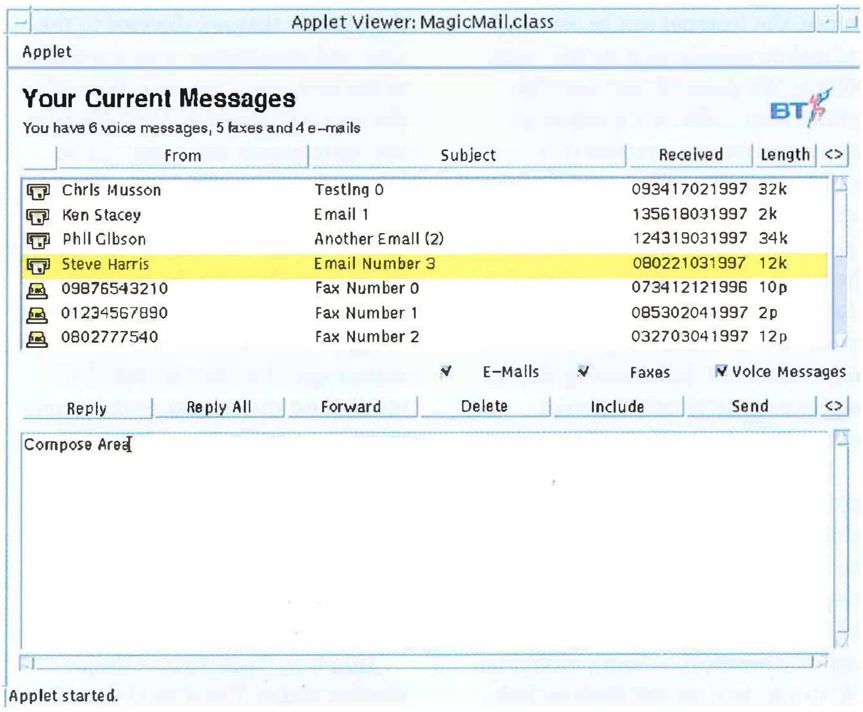
Java is a cross-platform programming language which allows the programmer to customise the information shown to the user in ways not possible with HTML. The program is run on the client browser, allowing the user to change the way messages are viewed without having to wait for interaction with the server. The display is created in such a way that it has the same look and feel as programs specifically written for whatever operating system is running on the client, thus creating a user-friendly environment.

The message viewer applet, currently in an early stage of development, is shown in Figure 2. The user will be able:

- to order messages according to type, who the message is from, subject and time received;
- to select which types of message to view;
- to reply, forward, delete, view and send messages (viewing messages will be done by double-clicking the message);
- to include files and other messages in a message that they're composing using drag and drop; and
- to save messages and included files to disk.

The Java applet can receive information in one of two ways. The first method is by posting requests to

Figure 2—Message viewer applet



a hypertext transfer protocol (HTTP) server in the same way as HTML forms do, and the second is to request information from a dedicated server. Both methods are viable. The first allows the use of existing software, but requires more processing at the client end. The second is a quicker method, but requires new software for security, usage monitoring, etc. to be developed.

The BT Magic Java mail client will initially use the first method. This will require extra buttons to be put on the menu pages to allow the user to select either the Java mail client or the existing HTML mail client (not all browsers are Java-compatible, and the current large size of Java applets makes accessing them over slow links, such as GSM, expensive). The second method may be developed in the future because this will allow the user faster access to their messages.

Mobile IP

The Internet has traditionally been associated with computers that are wired to fixed points of attachment such as Ethernet LANs. However, various technologies are arising that are changing this model. For instance, the Internet can be accessed via mobile phones such as the Nokia 9000 or Windows CE devices. This service uses GSM for its transport layer and Internet protocol (IP) traffic runs on top. Thus mobile users can access Internet-based services, such as e-mail and the WWW, as if they were wired to a fixed point of attachment. This section of the article is about achieving similar, but more restricted, functionality for the mobile user using only Internet protocols and specifically mobile IP.

Many of the developments being formulated in the Internet world are addressing the needs of users to be mobile. The increasing popularity of portable and laptop computers has led to the need for easy detachment and reattachment as users move from site to site or even just desk to desk. Such needs are addressed by protocols such as dynamic host configuration protocol (DHCP) where a new 'local' IP address is allocated to the computer when it is attached to a LAN. This avoids the need to involve the local administrator, who is probably very busy, to allocate the IP address manually. DHCP is a scheme that relies on all IP-based services that are being used on the computer being stopped and restarted in the new location and therefore all current service context is lost. If we are investigating the possible use of continuous applications such as a time-consuming Web page look-up for mobile users then DHCP is inappropriate as the look-up would be cut off as the terminal is moved from one point of attachment to another.

Alternatively an evolving scheme called *mobile IP* can be explored. Mobile IP uses a forwarding mechanism that relies primarily on home agents. Home agents manifest themselves as a process running on a computer that is attached to what is considered to be the mobile user's 'home' LAN. When the user is on his/her home LAN then the home agent plays no part. However, when a mobile user detaches from their home LAN then the home agent collects all the packets that are directed to the user and undertakes to forward them to the new site if possible. Typically, the user will attach to the LAN they are visiting soon after and will be allocated a 'care-of' address. This new address can be relayed back, using 'redirect' messages, to the home agent so packets for the mobile host can be forwarded.

This simple scheme has two major advantages. The first is that the mobile host can continuously communicate using the same IP address after it has been disconnected and reconnected at a different point. Secondly this form of mobile IP could be gradually deployed as waiting for the whole infrastructure to be updated is unreasonable.

However, there are two major disadvantages. The first is that all packets have to be forwarded when the mobile host is away from home. This requires 'dog-leg' routeing and may lead to network congestion. Secondly the 'redirect messages' may prove to be a temptation to hackers. If a 'redirect message' can be forged then the hacker can collect all the packets intended for the mobile host. Work continues to overcome these shortfalls.

We are only now seeing mobile computing becoming a reality. IP extensions for mobility are being developed and showing a good deal of promise. As Huitema† points out, many experts believe that all tomorrow's computers will be mobile. The current protocols have been designed in a conservative manner and there is a lot of work still to be done.

Conclusion

BT Magic has for the first time integrated the fixed network, mobile network and the Internet to create a new value-added service encompassing the voice, fax and e-mail domains. The product is thus able to reach out to a new global market place while utilising the assets of existing networks. The use of the Internet has opened the way to giving customers user-friendly control of their communications. Magic is the first of many such capabilities. The capability set used to deploy Magic, and the associated rapid service development approach, are now ready for exploitation across a wide variety of services and market sectors. Further developments are showing that multimedia applications can be created using these advanced service platforms linked to Internet technologies and that even mass-market mobile real-time multimedia communication services can be bought to market in development timescales approaching those seen in the Internet application area.

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† Huitema, C. Routing in the Internet. Prentice Hall, ISBN 0-13-132192-7.

Biographies

Steve Harris
BT Networks and Systems

Steve Harris graduated with a B.Sc. honours degree in Physics from Manchester University in 1978. After a career with GEC as a PBX hardware engineer and software group leader, he joined BT in 1986. At BT he became a lead engineer in the call control and signalling development of the Monarch PBX. Since 1992, he has been working in the IN arena, concentrating on applications development and element management and in particular the influence of the Internet on IN architectures. More recently, he has become the BT Magic team leader in the Intelligent Solutions Unit at BT Laboratories. He was awarded the BT M.Sc. in 1996.

Paul Martin
BT Networks and Systems

Paul Martin graduated from Bath in 1982 with a B.Sc. in Mechanical Engineering. After this he entered the CAD/CAM industry with posts at Rolls Royce, PA management consultants and CADCentre. He joined BT in 1991 to research the use of object-orientated modelling techniques in communications. Currently his main research interest is in the application of distributed objects technology to telecommunications systems.

Chris Musson
BT Networks and Systems

Chris Musson is a software engineer in the Intelligent Solutions Unit at BT Laboratories, and is currently developing Java-based user interfaces for the BT Magic project. He joined BT in October 1995 after spending six months as a student in the Distributed Computing and Internetworking Unit at BT Laboratories, while completing an M.Sc. degree in Telecommunications Technology at Aston University. His first degree was a B.Eng. in Electronic Engineering gained at Salford University in 1993.

David Wake and David Moodie

Passive Picocell—A Future Integrated Wireless Communications Network

The demand for wireless services is expected to grow at a terrific pace over the next decade. Traditional ways of satisfying this predicted demand are expensive and inflexible. The passive picocell, *a radical new concept invented at BT Laboratories, could provide an integrated wireless network using radio base units that are low-cost, small and unpowered.*

Introduction

Wireless communication has experienced enormous growth over the last decade, and the next decade is expected to be no different. People instinctively like the idea of personal communication, where they can be contacted anytime and anywhere. In addition, the use of wireless data communication is set to increase dramatically, driven mainly by the desire for wireless access to the Internet. The combination of an increased number of users and the trend towards multimedia services means that the capacity of wireless networks will probably need to grow by a factor of between 10 and 100 over the next decade.

Several types of wireless communication system will play a part in this revolution. Operators of cellular systems such as the global system for mobile communications (GSM) will want to capture as much of this increased traffic as possible, and there is much research on ways of improving system capacity through increased spectral efficiency. The data capability of these networks is quite small however, and is unlikely to satisfy demand. The new digital cordless systems such as DECT (digitally-enhanced cordless telecommunications) have been designed with data in mind from the start, and will offer data services at roughly the basic-rate integrated services digital network (ISDN). For higher data rates, wireless local area networks (LANs) at present can deliver around 1 Mbit/s, and in the near future the HIPERLAN (high-performance radio LAN) standard will increase this to more than 10 Mbit/s[1].

With any of these systems one thing is certain—to provide high capacity with a limited amount of spectrum will require the use of a large number of short-range systems. In cellular communications, microcells are already being deployed in densely populated urban areas and picocells within buildings. Microcells are usually defined as having a base station below roof height to provide coverage along city streets within a range of a few hundred metres at most. Picocells can be defined in a number of ways, and the definition used here relates to single offices with a range of around 10 m.

The reason why the use of microcells and picocells has not been more widespread is the very high cost in relation to the extra revenue that could be generated with today's market. Each radio base unit (even those specially developed for small cell size) is expensive, large and heavy, and contains huge amounts of electronic processing capability. Furthermore, each of the systems previously mentioned needs its own special type of base unit. Ideally a radio base unit should be small, light, inexpensive and could act as a transceiver for all of today's wireless communications systems and even those of the future. The *passive picocell* concept could provide just such a radio base unit.

What is It?

The passive picocell is a radical new concept invented at BT Laboratories, designed for high-capacity, short-range wireless networks of the future[2]. It makes use of a radio base unit which acts as a wireless connection point to 'the network'. One of the key features of this approach is that 'the network' can be whatever we choose, such as cellular (for example, GSM), cordless (for example, DECT) or wireless LAN. Furthermore, these systems could be combined together and used simultaneously. Even systems and standards that have not been developed yet could be accommodated, making the passive picocell a truly future-proof technology.

If this potential is realised, a network constructed using the passive picocell concept will allow for the first time a fully integrated wireless network without the need for special terminals or asynchronous transfer mode (ATM) adapter cards. Someone in a passive picocell would be able to use their existing mobile or cordless phone, their existing wireless computer, or in the future their own personal multimedia communications terminal. The passive picocell will provide access to all of the users' communications requirements without the need for cabled terminals.

The passive picocell concept allows the radio base unit to be:

- *unpowered* The signal energy alone is sufficient for radio transmission without the need for amplification or power supply. The lack of a power supply enhances system reliability and means that the unit is very easy to install.

- *small* The current prototype is the size of cigarette packet, which again means that installation is relatively easy. For microcellular systems, the size of the base station is a major problem, where building owners can charge extremely high rents for siting the base stations. Since microcellular networks require very many base stations, this site rental is a very significant operating cost.

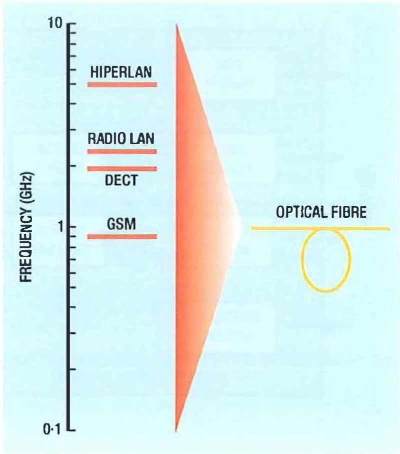


Figure 1—Graphical representation of frequency-division multiplexing illustrating the multi-system capability of the passive picocell

- *lightweight* The current prototype weighs only 25 g.

- *maintenance-free* The unit has virtually nothing in it to go wrong since it consists of just a single optical-to-radio transceiver chip connected to an antenna.

- *broadband* The current prototype works between DC and several gigahertz, and with further development could also operate in the 60 GHz bands. This bandwidth can accommodate signals with extremely high bit rates (limited only by problems associated with multipath distortion in the radio path) or can accommodate a combination of signals—see below.

- *multi-system* If the system can be proved to be fully transparent then signals can be combined using frequency-division multiplexing (FDM). FDM allows signals to be combined and transmitted over a shared medium by virtue of their unique frequency. Filters are used to select the required signal and to reject unwanted signals. For example, GSM uses frequencies around 900 MHz, DECT operates around 1900 MHz and current radio LAN systems operate around 2·5 GHz. So if all three signals are combined and radiate from the passive-picocell base unit, then the GSM handset will only respond to the GSM signals since the antenna and input stages are highly frequency selective and will therefore reject the DECT and radio LAN signals. This situation, illustrated in Figure 1, includes future and emerging standards.

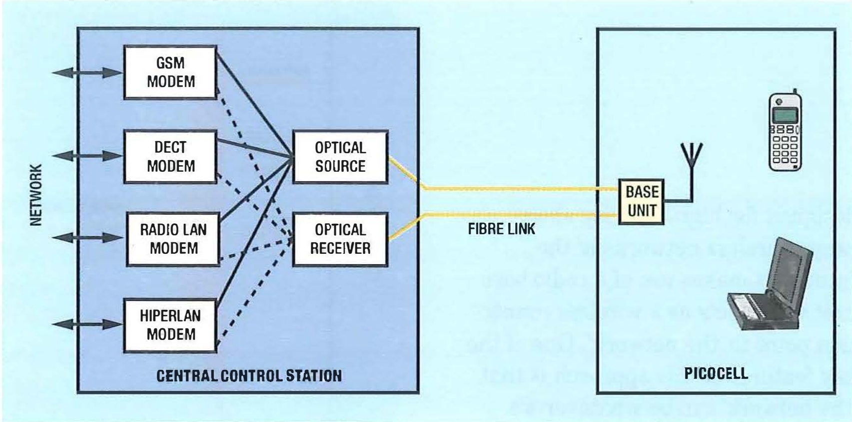
Figure 2—Passive picocell base unit with existing GSM base station in background

A prototype base unit is shown in Figure 2 alongside an existing GSM base station which is included to emphasise the difference. This is not really comparing like with like however, since the GSM base station is designed to cover a cell size of more than a kilometre, but even a GSM microcellular base station is significantly bigger and heavier than the passive-picocell base unit.

The passive-picocell base unit is connected to a central control station using optical fibre. Optical-fibre cable is relatively low cost and simple to install in buildings using the BT blown-fibre technique where fibre is blown through plastic ducting using compressed air. Plastic ducting can be put in place very cheaply, especially where the building is under construction and where it has been planned from the start. When the passive picocell technology is ready for deployment, the fibres can be blown into their required locations and the base units simply 'hooked up'. This provides an attractive evolution strategy for the passive picocell.

The central control station contains the radio modems connected to their respective networks. These modems provide the radio signals transmitted to the radio base units. Each radio modem is associated with a particular

Figure 3—Passive picocell concept



system, for example, GSM, DECT, or radio LAN and their signals are combined for onward transmission. Figure 3 shows the passive picocell concept schematically. The central control station on the left of the figure shows a variety of radio modems and includes ones for emerging standards. The picocell, which could be an office or a street, shows a range of terminals all of which should be able to operate simultaneously without inter-system interference.

How it Works

The single component optical-to-radio transceiver chip referred to earlier is at the heart of the passive picocell concept. It is known as an *electroabsorption modulator* (EAM), and is a semiconductor device constructed from materials based on indium phosphide. Although EAMs can be obtained from several suppliers, the ones used for the BT work were designed and fabricated at BT Laboratories.

The EAM has an optical waveguide which transfers light from the input to the output fibre. The intensity of the output light can be controlled (modulated) by an electric field, which can be imposed using electrical contacts across the optical waveguide. The modulation process is *electroabsorption*, where input light is partially absorbed or transmitted depending on the strength of the electric field. Figure 4 shows how the transmission and absorption vary with applied voltage. A low voltage gives high transmission and low absorption and vice versa.

If a GSM signal is applied to the EAM for example (using an antenna connected to the device contacts), then the light transmitted through the EAM and collected by the output fibre will have an intensity that varies exactly in time with the GSM signal. This process is used for the system uplink (mobile–base), where the input light is supplied by an optical source at the central control station.

The absorption process is also used to transfer information, this time for the downlink (base–mobile). When light is absorbed in the EAM it generates an electric current that varies with the intensity of the light signal; that is, the device acts as a photodetector. This electric current generates an electric field, which is transferred to the antenna and radiated to the mobile terminal. So if the light coming in to the EAM has been modulated by a GSM signal, for example, at the central control station, then this signal is radiated from the base unit.

An important feature of these two processes (modulation and detection) is that they take place simultaneously, which means that the link between central control station and base unit can be full duplex[3]. This is because the EAM is operated at a point where some of the input light is absorbed and some is transmitted. In the schematic representation of the EAM transceiver in Figure 5 the red arrows show the light signals and the blue

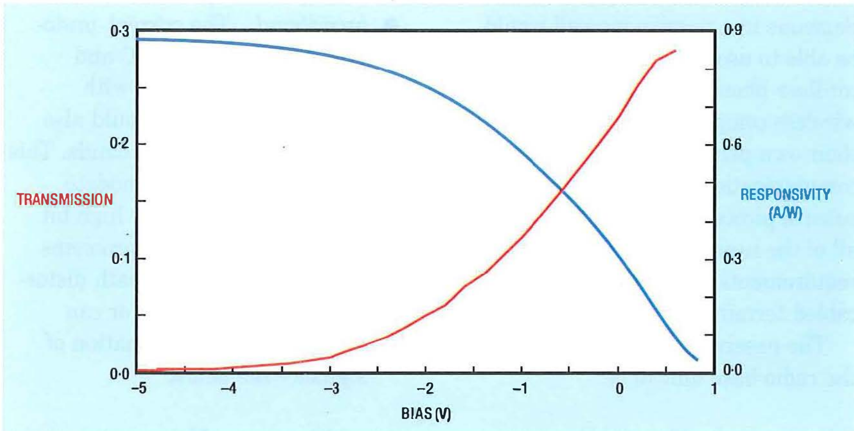
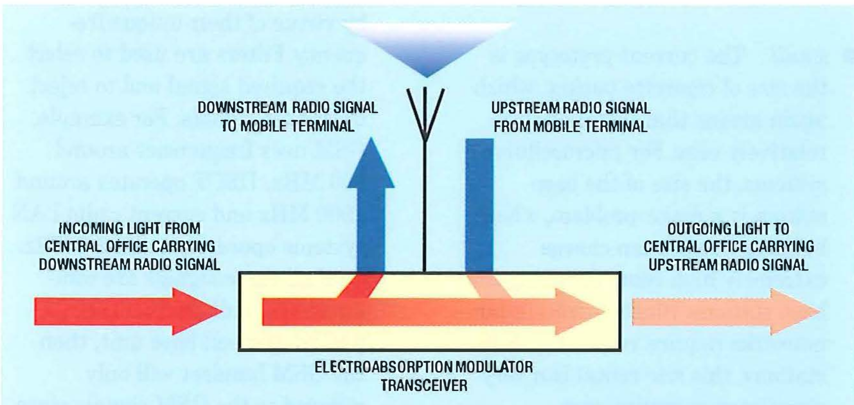


Figure 4—Electroabsorption modulator transmission and adsorption (responsivity) variation with applied voltage

Figure 5—Schematic representation of the EAM transceiver



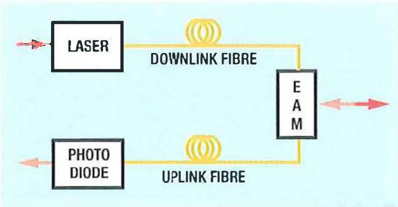


Figure 6 – Optical-fibre link based on the EAM transceiver principle

arrows show the radio signals. Figure 6 shows the layout required for an optical-fibre link based on the EAM transceiver. The laser at the central control station is used to provide the light which is modulated by the downlink radio signal. This light is also used to 'bring back' the uplink radio signal using the process described above.

Another important feature of this transceiver is that it also works without a separate voltage source (power supply) to set the operating point. In other words, the EAM functions as a transceiver at zero bias, as indicated in Figure 4. Here, the EAM functions better as a modulator than as a detector so that the downlink loss is slightly higher than the uplink loss. The performance of this optical-fibre link together with power levels and margins are given in the next section, using a 2·5 GHz radio LAN as an example system.

Demonstration

The feasibility of using an unbiased EAM as a remote transceiver to give an unpowered radio base unit was demonstrated with a commercial BreezeNet 2·5 GHz radio LAN system[4]. Figure 7 gives the layout of the demonstration, and power levels at each stage. This is essentially the same layout as for Figure 3 except that now there is only one radio modem at the central control station.

The BreezeNet radio modems had a transmit power of +17 dBm and a sensitivity of –82 dBm for operation at a raw data rate of 1 Mbit/s. The optical-fibre link had an insertion loss of 40 dB for the downlink and 35dB for the uplink. An antenna with a gain of 8 dBi was used at the radio base unit (with a beam width of about 70°), which gave an effective transmit power at the radio base unit of –15 dBm. The antenna used at the mobile terminal was omnidirectional,

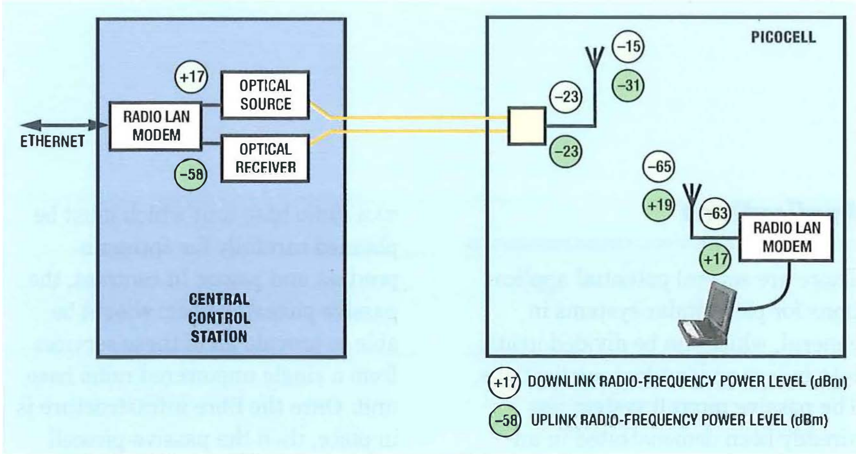


Figure 7 – Layout of the demonstration system

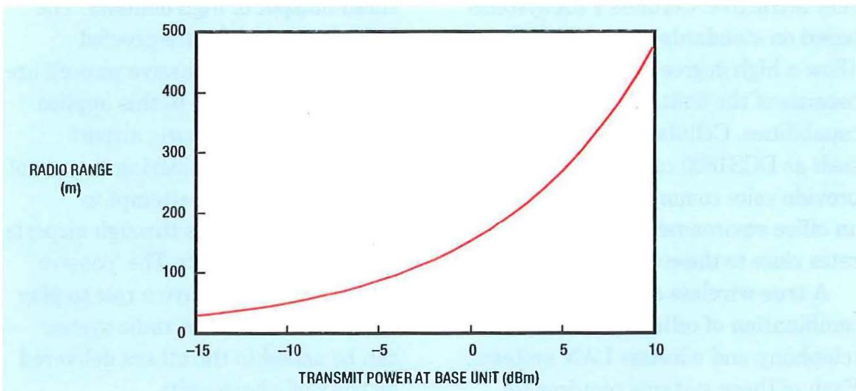
with a gain of 2 dBi, which means that the effective receiver sensitivity of the radio modem was –84 dBm.

The original picocell used for this demonstration consisted of a meeting room with dimensions of 6·5 m × 3·5 m. The radio propagation loss within this room was typically 50 dB and was relatively independent of antenna position. Using this value and the transmit power at the radio base unit gave a received power of –65 dBm at the radio modem antenna and therefore the downlink power margin was 19 dB. The uplink power margin was 24 dB since the optical-fibre link had 5 dB lower loss in this direction.

The radio LAN system operated robustly with a variety of broadband applications such as video streaming without any obvious degradation due to the optical-fibre link. If free-space propagation is assumed for simplicity, then the radio range of this system was calculated to be a few tens of metres. With further optimisation it is expected that a radio range of around 200 m should be possible for line-of-sight propagation[5], and this is the subject of work in progress. Figure 8 shows how the radio range varies with the transmit power at the radio base unit using the simple assumption of free-space propagation. For a range of 200 m a transmit power of 2 dBm is needed, which is 17 dB more than could be obtained for the demonstration. It should be possible to gain this increase in power by using a more efficient optical source at the central control unit.

The optical-fibre link length was less than 100 m for this demonstration. Much greater lengths are possible (at least 10 km) since the incremental optical loss is only 0·2 dB/km. This translates into an incremental electrical insertion loss of 0·4 dB/km for the downlink and 0·8 dB/km for the uplink as a result of the way the link is constructed. There is a trade-off however between optical-fibre link length and radio range, which must be taken into account depending on the application.

Figure 8 – Radio range variation with transmit power at the radio base unit assuming free-space propagation



Applications

There are several potential applications for picocellular systems in general, which can be divided neatly into indoor and outdoor applications. The passive picocell system has already been demonstrated in an indoor environment, and this is likely to be its first application area. Future optimisation (outlined in the next section) will see the radio range being extended and the temperature sensitivity reduced, which will start to make the passive-picocell system attractive for outdoor applications. Some of the possible applications are discussed below.

Indoor

Offices

The wireless office has long been the holy grail for data communications managers, mainly because the cost and complexity of re-cabling due to office moves can be very high. Users, too, appreciate the benefits of cable-free working—greater mobility and no unsightly cable spaghetti to worry about. Unfortunately, the low performance and high cost of present wireless systems have prevented their widespread use in the office, although this is starting to change as the technology matures. In a few years time wireless systems based on the HIPERLAN standard will provide much higher data rates than present systems and it is expected that costs will be reasonably low as a result of the large potential market. Wireless voice communications in the office is also very attractive. Cordless PBX systems based on standards such as DECT allow a high degree of mobility because of the built-in roaming capabilities. Cellular radio systems such as DCS1800 can also be used to provide voice communications within an office environment at charging rates close to those of a fixed line.

A true wireless office will use a combination of cellular and cordless telephony and wireless LAN systems. Each of these systems requires its own radio base unit which must be planned carefully for optimum position and power. In contrast, the passive picocell system should be able to provide all of these services from a single unpowered radio base unit. Once the fibre infrastructure is in place, then the passive-picocell radio base units can be connected when and where they are required. This will give an enormous advantage in terms of flexibility and ease of use. The future-proofed aspect of these radio base units is also a very powerful selling point.

Warehousing and retailing

Wireless LAN systems are already finding a niche market for warehousing applications where the absence of trailing cables is clearly an important consideration. This is therefore an ideal application for the passive picocell, which is able to offer a future-proofed service that can be integrated with any additional requirements for voice communications. In the retail sector, the flexibility offered by wireless systems is beginning to be appreciated. For example, electronic point-of-sale equipment can be moved around easily when the store layout changes. Again, the passive picocell is in a good position to provide this wireless connectivity within an integrated system where future-proofing is perhaps the key consideration.

Airport concourses

An airport concourse is a good example of a present-day picocell—a small hotspot of high demand. The full-service and future-proofed capabilities of the passive picocell are again ideally suited to this application. In the near future, airport authorities are considering the use of radio tagging in an attempt to 'shepherd' travellers through airports and improve security. The 'passive picocell' may also have a role to play here, where this new radio system can be added to the others delivered by the radio base units.

Outdoor

Fixed radio access

Fixed radio access, also known as *wireless local loop*, is seen as an economical way of providing service, especially for other licensed operators trying to take market share from an incumbent operator. From a BT perspective, this may be an attractive option for joint venture companies. The passive-picocell system could be used in this type of application as long as the range is not too great. An architecture whereby fibre extends to the radio distribution point (DP) would see radio base units mounted on street poles with a range of up to 200 m, the range predicted for the passive picocell with further optimisation. This arrangement would remove the need for dropwires into customers' premises, and would also avoid problems caused by using active electronics in hostile environments. These radio DPs could also act as base stations for cordless or cellular systems at the same time, a major bonus that could swing the economics in favour of this technique.

Fibre to the home is often referred to as the ultimate objective for a truly broadband access network, and is likely to be the access medium of choice in the long term. The passive picocell has an important role to play in this architecture too. Once the fibre is installed in the home, the passive-picocell base unit could be used to avoid further cabling. This is clearly a desirable objective. The base unit could be installed in the roof for example to give wireless communications throughout the home.

Microcells

Microcellular systems are being deployed at an ever-increasing rate to satisfy the capacity demands on cellular networks. These systems have a typical range of a few hundred metres and are used in dense urban environments where the base stations are below roof height. They radiate low power levels and a typical coverage area would be a city street. To avoid handover problems for fast moving mobiles, they will be used in a hierarchical arrangement with 'umbrella' macrocells which are designed to cover for this eventuality. The prospect of a small, lightweight, low-cost and unpowered base station is obviously attractive for this application. This is especially true since the cost of renting building space for the base site is expensive and getting more so as building owners begin to realise their value to cellular operators.

Sports stadia

The sports stadium is a good example of an outdoor application requiring high capacity. It is also a good example to illustrate the concept of dynamic capacity allocation, or capacity on demand, which is made possible by the passive picocell system. A typical sports stadium is used for major events for a few percent of the time at most. Conventional systems would need to provide fully-equipped base stations to cater for peak demand which ties up valuable resources. The passive-picocell system is capable of switching capacity to where it is needed on a dynamic basis. So when the football game is on, the passive-picocell base units are connected to sufficient network capacity to cater for the half-time peak demand, and when the ground stands empty, the same network capacity can be used for other locations.

This capacity-on-demand concept can be used on a larger scale; for example in and around a major city. During the day, the capacity could be diverted into the city and in the evening the same capacity could be spread across the suburbs—in other words the capacity can follow the people. This type of scheme can uniquely meet the demands of high localised capacity at an economical cost.

Future Work

Device optimisation

Although the optical source and receiver can be made more efficient to give increased range, the key component in the passive picocell system is the EAM. Several aspects of its performance need to be addressed:

- *Cost* EAM devices are presently very expensive owing to their low volume market and labour-intensive manufacture. If the passive picocell can provide a mass market application for this device then a simplified manufacturing process could lead to low cost. There are several options available to simplify their manufacture and these are being explored at BT Laboratories.

- *Optical power handling* This is a key factor in determining the transmit power at the radio base unit, which in turn determines the radio range and ultimately the range of applications in which the passive picocell concept could be used. BT is currently investigating what the limit is and how it can be increased.

- *Linearity* The relation between the efficiency of the EAM and the input power is non-linear, especially when the device is unbiased as is the case in the passive-picocell system. This non-linearity results in a process known as *intermodulation distortion*, which mixes the various frequency components in the signal and produces interference in adjacent frequency channels. Although the full effects of this distortion still need to be quantified, it is desirable in general terms to reduce the device non-linearity by re-engineering the electroabsorption layer.

- *Temperature sensitivity* Present devices are sensitive to temperature, which comes as a consequence of the operating principle behind the EAM. For indoor applications this is important, but the performance must be improved substantially for outdoor systems.

  Currently preferred solutions involve the optical source, which can either be broadband (so that changes to the EAM operating wavelength fall within the source bandwidth) or made to track the EAM operating wavelength using a control loop (which would be simple to implement since the passive picocell system is itself a loop).

System and network studies

The passive picocell demonstration showed what could be achieved with probably the simplest system configuration in a point-to-point link. Many other system configurations could be used, and each has its own cost and performance implications. Furthermore, other networking possibilities may be feasible rather than the obvious star arrangement. Some of the system and network types that warrant further study include:

- *EAM in central control unit* For the passive picocell concept to be successful, the cost of the EAM in the radio base unit must be very low. If this is the case then full use of this cost advantage can be made by using the EAM at the central control unit in an externally modulated arrangement with a high-power unmodulated optical source. The cost of this source could be shared between a number of links to keep the overall cost within acceptable levels. This configuration may result ultimately in lower overall cost than the simple link used in the demonstration.

- *Bus or ring architecture* A star type of network is the logical progression from the point-to-point link used so far for the passive picocell system. This may not be the most practical or cost-effective arrangement owing to the large number of fibres and optical sources required. A bus or ring architecture is attractive because these fibres and sources can be shared. Some preliminary experiments have been performed to investigate these possibilities and show that a small degree of concatenation is technically feasible, limited by the cumulative optical loss across the bus or ring. Whether these arrangements can be used in a viable network remains an open question for now.

Conclusion

The passive picocell is a radical new concept, invented at BT Laboratories, for an integrated wireless network of the future where the radio base units are small, lightweight, low-cost, broadband and unpowered. These attributes combine to give some attractive and powerful advantages, and have been outlined in this article. Perhaps two of the key benefits are worth re-iterating briefly:

- The multi-system capability means that an integrated wireless network can be achieved without special terminals or adapter cards.
- System capacity in terms of hardware is located centrally and can be allocated dynamically to where the demand is greatest.

Potential application areas for this exciting new technology are numerous. If the passive picocell lives up to only a fraction of its early promise then we will witness a major shift in the way wireless networks are designed and constructed. Exploration of some of the more subtle possibilities afforded by this new technology has only just begun.

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Biographies

David Wake
BT Networks and Systems

David Wake joined BT in 1979 after graduating from Cardiff University with a B.Sc. degree in Applied Physics. His early work involved the design and fabrication of a range of advanced semiconductor optoelectronic components in both discrete and integrated form. This work, specifically the monolithic integration of photodiodes and amplifiers on InP substrates, led to a Ph.D. awarded in 1987 by the University of Surrey. He was part of a team which won the 1993 Queen's Award for Technological Achievement for the downstreaming of technology to BT&D (now HP). His recent work has been mainly concerned with using analogue optical-fibre links for distributing radio signals for mobile, cordless and wireless LAN communications systems.

David Moodie
BT Networks and Systems

David Moodie joined BT Laboratories after graduating with a B.Sc. (Hons.) degree in Physics from the University of Durham in 1989. In 1995, while at BT, he was awarded an M.Sc. degree in Telecommunications Engineeering from the University of London. He helped to develop a range of advanced optoelectronic components. He was part of a team which won the 1993 Queen's Award for Technological Achievement for the down-streaming of semiconductor laser technology to BT&D (now HP). Since 1992, he has designed, characterised and supplied electroabsorption modulators for use in a series of prototype networks and field trials. He has shown that their unique properties enable systems to be configured in radical new ways. This work has resulted in a series of patents and over 50 scientific papers.

Chris Seal, Maurice Gifford and David McCartney

Iris Recognition for User Validation

This article examines the applicability of biometrics to telecommunications and presents results from an initial evaluation of an iris-recognition system.

Introduction

Virtual banks and shops, kiosks and teleworking are expected to become common place in the not-too-distant future. System security is vital in such applications as these systems contain private or privileged data. Conventional computer security and cryptographic techniques[1,2] largely address the end-to-end communications issues, but still leave one key problem unresolved: how can you be sure that the person using a service is who they say they are?

Today's user-validation methods fall into two broad categories: access tokens (for example, identity badges, credit cards, keys) and memorised data (passwords, user-names, personal identification numbers (PINs)). The problems with these methods are that access tokens are easily lost or stolen and that memorised data is all too likely to be forgotten. The two methods may be combined, but customers can still inadvertently weaken security by adopting bad habits such as writing down PINs and passwords or re-using them for multiple applications.

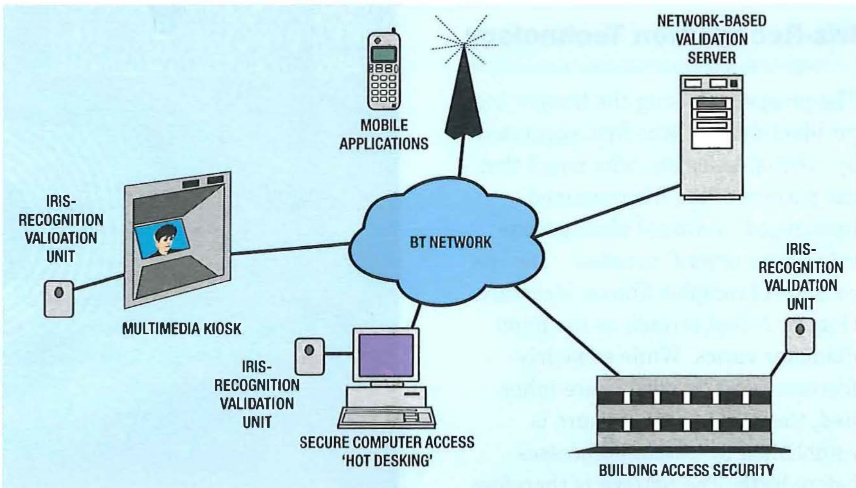
From the user's perspective, none of these validation methods is ideal. Why should we have to carry dozens of cards or remember lots of passwords? Why can't the technology recognise us, open the secure access channels and customise the application environment?

Biometrics offer new solutions that are user friendly and yet secure access. They work by inspecting biological features of ourselves that distinguish us from others. Examples include fingerprints, hand geometry, and voice recognition. Here we concentrate on iris recognition, a relatively new biometric technology that has some key advantages in terms of speed, hardware simplicity, accuracy, and applicability.

Biometrics in Telecommunications

There are three principle ways in which BT can benefit from biometric technologies (Figure 1):

Figure 1—Networked biometric applications



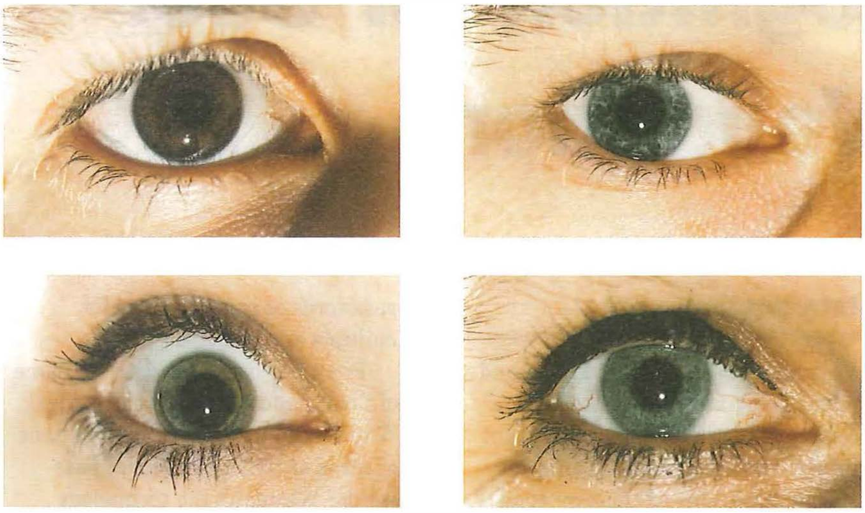


Figure 2 – The pattern in the iris is different for every eye as can be seen in these photographs

- *Improving internal security and access control* With over 6000 BT buildings in the UK access needs to be granted for contractors and employees and be properly controlled.

- *Enabling new value-added services* Unfriendly, complicated, access procedures hinder service uptake and biometrics could simplifying the access barrier and thereby increase uptake.

- *Providing a validation services* A network-based validation bureau would take on the task of managing user checks for the service providers and raise revenue by transactional charges.

Iris-Recognition Technology

The prospect of using the human iris for identification was first suggested by ophthalmologists, who noted that the pattern of the iris remained unchanged in clinical photographs taken over several decades[3]. The iris consists of complex fibrous structure (Figure 2) that stretch as the pupil diameter varies. While some iris features (such as colour) are inherited, the detail in the texture is established by random processes before birth. The pattern is therefore specific to the eye (left and right eyes differ as do identical-twins' eyes).

In 1993, an effective strategy was developed[4,5] for deriving a set of characteristic parameters from the iris texture, using a mathematical technique known as *wavelet analysis*. The parameters form a 256-byte code which is a unique description of an individual's eye (Figure 3). This code, known as an *iriscode*†, is structured to allow rapid comparisons to be made with a database of authorised users (at up to 40 000 eyes/second on a 486 PC). An exact match need not be found, as the identification algorithm can accept up to 33% mismatch and still make a high-confidence identification. This robustness is because the remaining code still contains a vast number of characteristic features of the iris.

Using iris recognition involves little more than looking at a video camera. The software identifies that an eye is present, produces an iriscode and compares it to the list of all known authorised users. Current commercial systems[6] (Figure 4) require a degree of user cooperation since the user must position his/her head so that the captured image is properly focused and aligned. Future developments are likely to increase the usability; for instance, with the use of autofocus lenses, and head-tracking[7].

† IrisCode™ is a registered trademark of IriScan® Inc., New Jersey, USA

Biometric Criteria

To determine the potential of a particular biometric technology for consumer applications, we need to consider three major issues; security, practicality and user acceptance.

Security

The biometric technology must offer a substantial improvement over

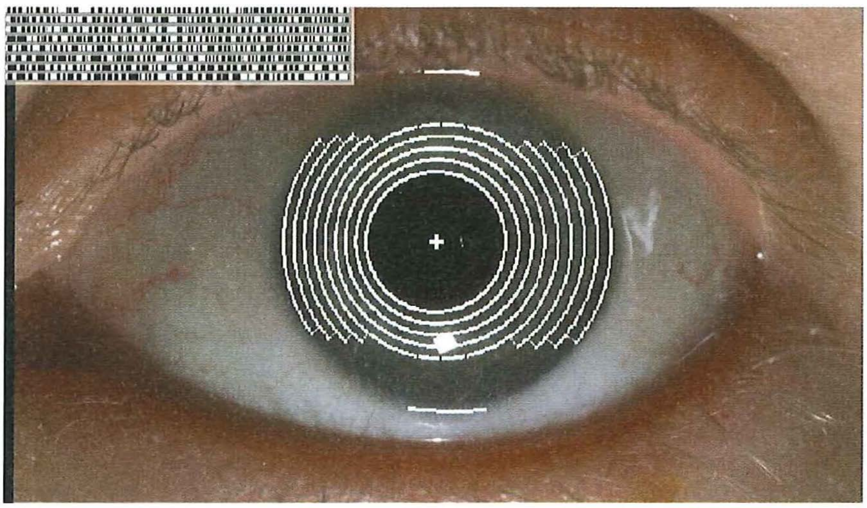


Figure 3 – Iris with analysis regions and resultant iriscode (top left)

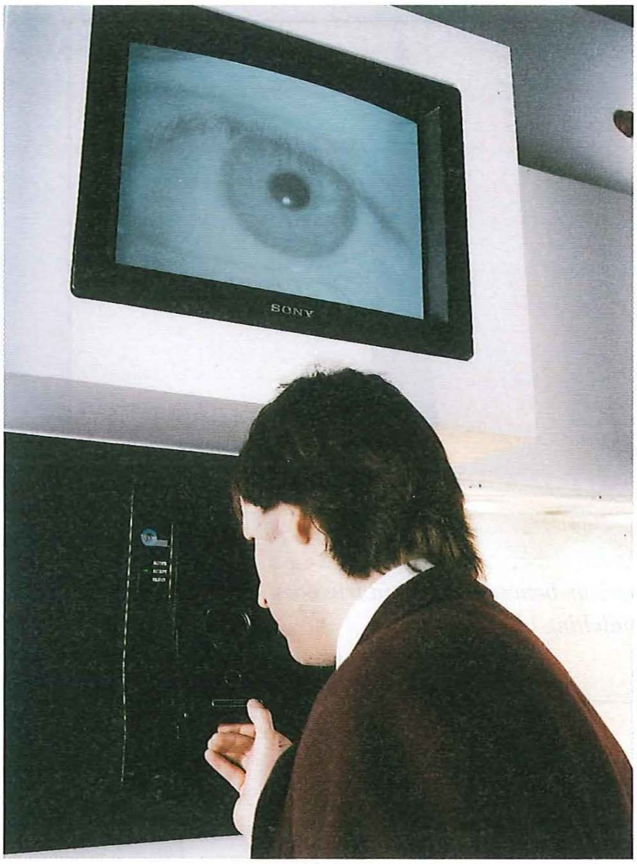


Figure 4—Iris recognition is already commercially available for access control systems (photograph shows demonstration at BT's Innovations 97)

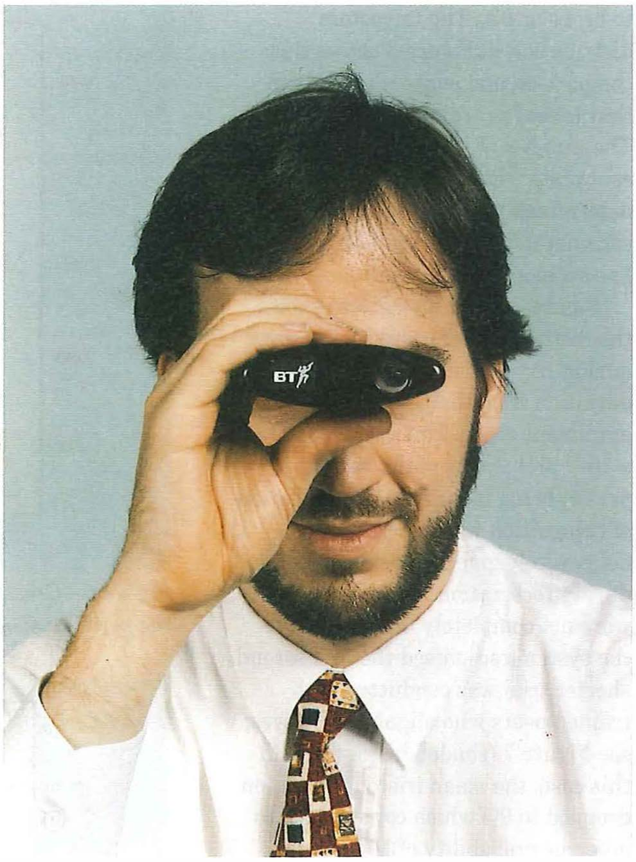


Figure 5—Prototype hand-held device built using an inexpensive black-and-white CCD camera and light-emitting diode (LED) illumination. The user looks through the unit just as one would through a camera viewfinder

current methods. Iris recognition has sound mathematical foundations and is the most selective biometric technology known. The odds of the wrong person being identified—a false accept—are extremely low (see results).

As the iris is internal to the eye, it is difficult to change surgically (even criminals value their eye-sight!). Using a dead eye, although gruesome, has to also be considered. The solution is to look for various tell-tale movements in the eye that indicate life. One of these, hippus, is caused by small continuous movements of the pupil.

Practicability

The basic hardware requirements for iris recognition are known technology (low-end processors and charge-coupled device (CCD) cameras). We have demonstrated that the user interface can be miniaturised and be built into mobile equipment (Figure 5).

Biometrics initially need to work in conjunction with an existing infrastructure, perhaps replacing PINs used with cards. A single one-to-one iriscode comparison is sufficient to verify the users' identity. However, to perform identification (that is, without cards), it is necessary to do real-time searches of large customer databases. Iris recognition is currently the only biometric system capable of this.

Public acceptance

Many biometric systems have suffered from public acceptance issues such as fingerprints being associated with criminal records and scanning systems requiring lasers. Iris recognition does not carry a social stigma, is non-invasive and non-contact, and uses ordinary cameras and lighting.

Evaluation

A statistically significant sample of 268 people from a variety of ethnic origins had both eyes enrolled. Each subject then attempted to be recognised. There were no false accepts and every eye was successfully recognised (typically within three seconds). If spectacles were especially scratched or dirty, then the quality of recognitions was affected. Contact lenses caused no problems.

A cross-comparison of all enrolled iriscodes allowed the degree to which a code is characteristic of an iris to be assessed. Two unrelated iriscodes should have about half of their bits disagree (all bits being equally likely to be 1's or 0's). The impostors distribution in Figure 6 shows this comparison and supports the claim that iriscodes are unique (Table 1). The number of independent variables contained within an iriscode has been determined to be 266 which is considerably higher than any other known biometric system.

Figure 7 (open histogram) shows the distribution of iriscode similarity during recognition with an 18% deviation from their respective enrolment codes. This corresponds to a 10^{-23} probability of the wrong person being identified. The variation of recognition was generated by deliberately giving little or no help during recognition. Typically, users were not completely in-focus before the system recognised them. A second shorter trial was conducted with trained users who aligned their eyes; see Figure 7 (shaded histogram). In this case, the mean iriscode variation dropped to 9% which corresponds to an error probability of 10^{-40}. This improved performance is more typical of a fully developed product.

Finally, Figure 8 shows combined distributions of impostor comparisons and the spread of authentic recognised iriscodes. As can be seen the two curves are clearly separated making the decision task of identifying the bona fide users fairly easy.

Table 1 Odds of an Iris Being Misidentified

Hamming Distance Criterion	Percentage Matching Bits	Odds of the Wrong Iriscode Being Identified
0·01	99%	1 in 10^{68}
0·03	97%	1 in 10^{59}
0·05	95%	1 in 10^{53}
0·07	93%	1 in 10^{47}
0·10	90%	1 in 10^{39}
0·11	89%	1 in 10^{37}
0·13	87%	1 in 10^{33}
0·15	85%	1 in 10^{29}
0·17	83%	1 in 10^{25}
0·20	80%	1 in 10^{21}
0·25	75%	1 in 10^{14}
0·30	70%	1 in 1·05 billion

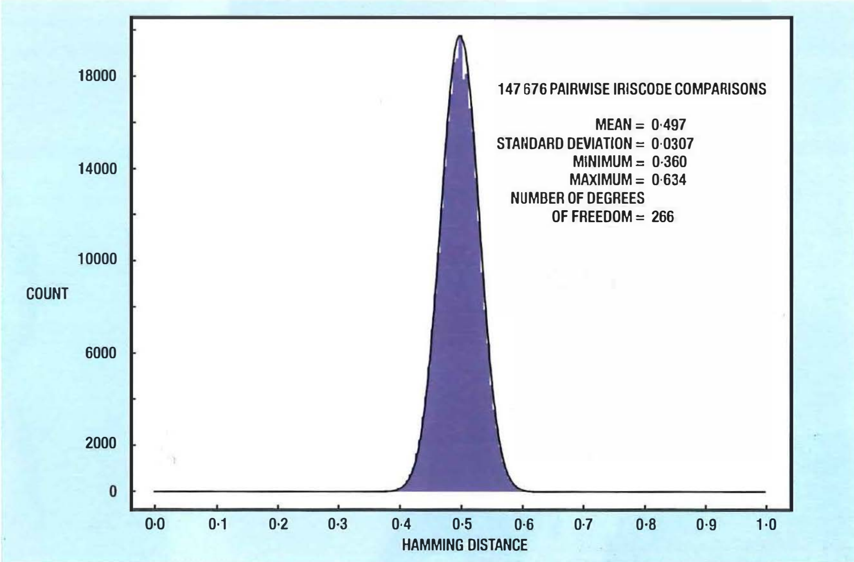


Figure 6—Cross-comparison between unrelated iriscodes (Hamming distance is the percentage of mismatching bits)

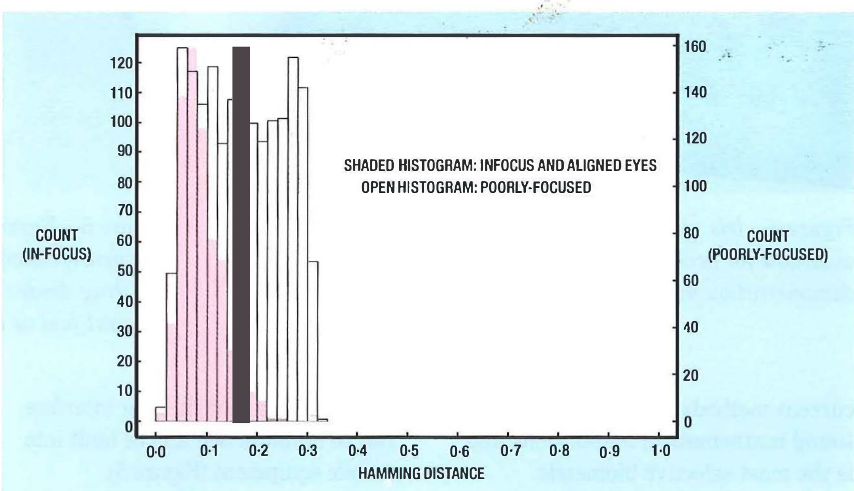
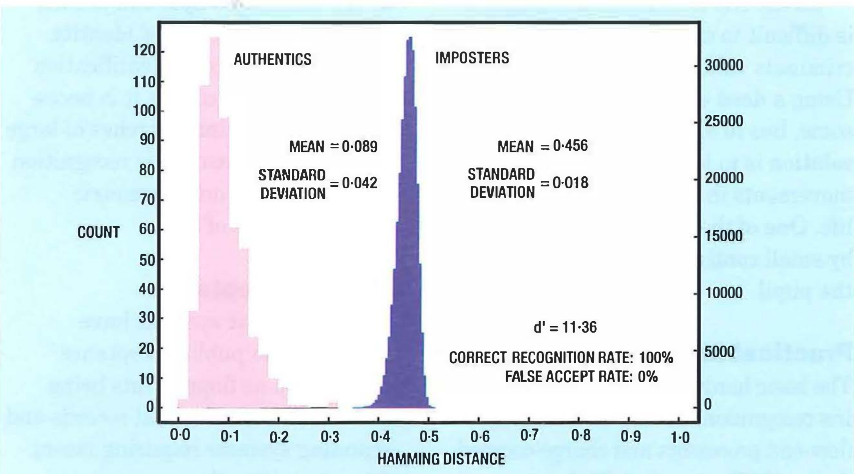


Figure 7—Similarity of recognised iriscodes to their respective enrolment iriscode

Figure 8—Identified iris falls within the left-hand peak whilst comparisons with any other iris fall within the right-hand peak.



Conclusion

Iris recognition offers the potential to unlock major IT opportunities by providing high-confidence customer validation. Although the mathematical foundations of the technology are strong, the user interface still requires refinement for widespread deployment. This work has given confidence that iris recognition is a reliable, unique and robust biometric technology.

Acknowledgements

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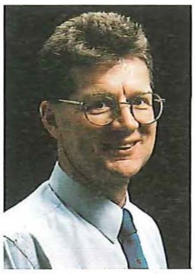
Biographies

Chris Seal
BT Networks and Systems

Chris Seal obtained a B.Sc. in Physics from University of Reading in 1988 and subsequently an M.Sc. in Optics in 1990. He took up a full-time post at BT Laboratories in 1995 having previously worked as a contractor during 1990–92. Previous projects include three-dimensional displays, retro-reflective optical communications, head-tracking for virtual reality and, more recently, Internet shared virtual environments (inhabited TV). Chris now works in the Advanced Research and Technology department at BT Laboratories.

Maurice Gifford
BT Networks and Systems

Maurice Gifford received a B.Sc. degree in Electronic Physics at the University of London in 1983. He joined BT Laboratories in October 1989 initially working on the development of a digital switch. He is currently team leader for the Iris Recognition project. Previous work has included network management systems design and development for BT and computer system design for Ferranti Computer Systems.



David McCartney
BT Networks and Systems

David McCartney received B.Sc. and Ph.D. degrees in Physics from Queens University, Belfast. In 1979, he moved to BT Laboratories to work in optical communications research. Initially, he was involved in research on splicing and fibre-specification issues associated with single-mode optical-fibre systems. Since then he has had research and development interests in passive optical networks and components for fibre networks, in holographic optical element design and, in stereoscopic and three-dimensional imaging systems. Latterly, he has been working on video, security and service applications development. He is a Fellow of the Institute of Physics and leads a group in the Advanced Research and Technology department at BT Laboratories.

Alwyn Lewis and Fred Westall

Whither Speech?—Fantasy and the Evolution of the Telephone

The telephone is so successful and yet has changed so little in form and function that any possibility of substantial change is commonly neglected. Yet the convergence of telecommunications with the computing and entertainment industries promises profound change. The authors explore some potential developments in telephony and describe why they challenge key aspects of the traditional culture of telecommunications.

† First article: LEWIS, ALWYN; and WESTALL, FRED. Whither Speech? Convergence and the Future of Telephony. *Br. Telecommun. Eng.*, April 1997, **16**, p. 39. The third article is expected to be published in the October 1997 edition of *British Telecommunications Engineering*.

Introduction

This is the second of three articles† dealing with key technical issues in the convergence of computing, telecommunication and entertainment. The series looks forwards, backwards, sideways and around to discuss the potential cultural and organisational consequences for the future of telephony.

Clairvoyance

'Around the world thought will fly, in the twinkling of an eye'—Mother Shipton, in the 16th century.

Unlike Mother Shipton, ordinary mortals see the future through the shifting and cloudy veil of today. William Preece's famous remark about messenger boys (see panel) is often quoted to show how poorly the future of telecommunications has been foreseen. When some new technology arises it is tempting to think how, in isolation, it could change things. This leads equally easily to wild optimism or blind pessimism. What is difficult to do[2] is to remember that everything else can change or interact too.

The authors suggest that focusing on the human benefits, rather than the technical capacity, of a new idea provides the best foresight—because human needs change much more slowly than technology. Therefore, with almost no sense of guilt, the authors invite the reader to seek truth in unreality and to 'boldly go' to the next section.

Enterprising Communications

When Gene Roddenberry[3] and his team of script-writers created the

William H. Preece

William H. Preece was the Post Office Engineer-in-Chief from 1892–1899. From a Welsh Nonconformist background, he was much influenced by Faraday, Thomson and Airy. In 1879, he gave testimony about the telephone to a House of Commons committee, saying '... Here we have a superabundance of messengers, errand boys and things of that kind.... Few have worked at the telephone much more than I have. I have one in my office, but more for show. If I want to send a message, I use a sounder or employ a boy to take it.'

This quote maligns his vision[1]. He was probably giving his political masters the kind of message he knew they wanted to hear, emphasising short distance operation to deflect criticism. It seems the Treasury wanted the telephone to fail, to defend revenue from the State-owned telegraph service. He had previously been enthusiastic about Bell's telephone and he subsequently co-wrote *The Telephone*, the first authoritative book on telephone engineering published in the UK. Political interference in telecommunications is not new.

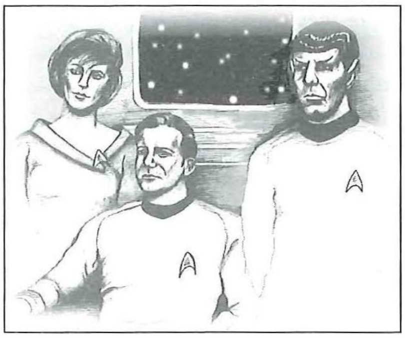


Figure 1—The crew of USS Enterprise *in 'Star Trek'*

TV series Star Trek† (Figure 1) in 1966, they little knew how frequently or how closely their work would be scrutinised. By a combination of imaginative flair and an eye for detail, they transcended the limits of a small budget to produce science fiction that still has something to tell us today. It is not the power of the photon torpedoes nor the warp drive that astonishes the authors, it is the communication system of the *USS Enterprise*. Its performance so completely realises the potential that today's speech processing technology has begun to reveal.

If Mr. Spock saw a 1997-vintage telephone in a time-warp, he would no doubt say '...It's communication Jim, but not as we know it'. There are no telephones aboard the *Enterprise*. There are no handsets, no keypads and no bells—so what is left? In a sense, the *Enterprise* is one huge telephone. Speech recognition has replaced the keypad and the telephone number—you speak to distant people by saying their name.

In the first *Enterprise*, small boxes on the wall use acoustic echo cancellation to provide two-way wideband hands-free speech. On the surface of a planet, the crew carry a communicator (Figure 2). This is still not a handset—it is simply opened and held in the hand to both listen and speak. In the second *Enterprise*, technology has moved on. Beam-steering, multi-microphone arrays are installed on the ceiling of every room, corridor, nook and cranny. These allow unhindered and natural hands-free communication, from any point in the ship to any other.

The speech technology in the *Enterprise II* is provided by hugely-distributed massively-parallel digital signal processing (DSP) computers, with a staggering number-crunching capacity. Each microphone array has over 500 tiny diaphragms, with an organic semiconductor DSP device painted on the back of each one. There are a total of 94 248 such arrays, fitted at 6 m intervals throughout the ship, with a combined processing power of approximately $2{\cdot}4 \times 10^{15}$ operations per second. The computational requirements of the speech synthesis, recognition and interpretation systems are, of course, very much lower per channel. But these systems have to track many simultaneous conversations, resulting in a broadly similar processing load.

The badges worn by the crew (Figure 3) are not miniature mobile telephones, but merely serve to authenticate the position of their owners to the communication and security systems. It is interesting to note that despite the ship's ability to hear every word said on board, no person of malign intent has yet breached the security software which protects personal confidentiality.

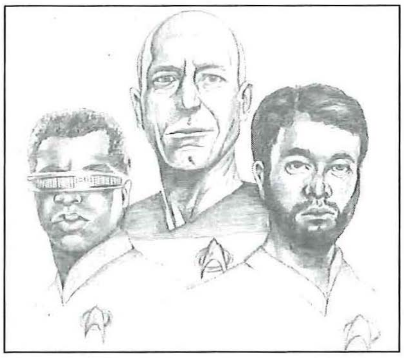
Figure 2—An Enterprise I *communicator*

Comfort and Convenience

Staggering speech technology is used abundantly on the *USS Enterprise*, often to add mere convenience not facility. This illustrates something that Microsoft recently realised and that Apple knew since birth—a machine interface matching natural human behaviour brings benefits that justify complexity. Bell knew this in 1878 when he said: 'The great advantage [the telephone] possesses over every other form of electrical apparatus consists in the fact that it requires no skill to operate the instrument.'

The designers of the *USS Enterprise* show a deep and subtle understanding of this point. They have chosen to put the interests of the crew first, whenever and wherever possible. Speech-processing technology allows the crew to talk to each other or to the ship's records, wherever they are, with the same effortless ease as to someone standing alongside. Plotting a new course, or targeting an enemy vessel, needs little obvious effort from the crew—because the *Enterprise* recognises and interprets the relevant words in the speech of key people on the bridge. The ship's computer talks with a voice that sounds entirely human but shows due deference to the captain's rank. Yet at times of external threat or internal stress, the computer's vocal inflexions and choice of phrase can change—to chide or even rebuke the captain as an equal. The computer

Figure 3—The crew location badge in Enterprise II



† Star Trek is from Paramount Pictures

In future, the needs of users will define the machine, rather than the needs of the machine dictating the behaviour of its users.

speech system of the *Enterprise* has aspects of a synthetic personality.

Optimum Interface

However, the ship's designers also understand the occasions when safety or security demands a different approach. If you fire a photon torpedo at someone, you'd better mean it. The safe operation of the *Enterprise's* weapons and navigation system demands the utmost level of reliability and integrity, as well as an unambiguous audit trail to show who did what, when and where. That is why the weapons are fired by the antique technology of the push-button and why the helm is controlled by tactile feedback. Those buttons and levers take your finger-prints and capture a tiny DNA sample, when you operate them. Sometimes, buttons are best.

People in Charge

It may have been compelled by a low budget, but all the technology in Star Trek—even the most awe-inspiringly powerful—remains reassuringly human-sized or even invisible. Furthermore, technology is constantly taken for granted in Star Trek and is always secondary to the main theme of interplay between minds—human and non-human. Star Trek machines have to adapt to their users' needs. How different from the viewpoint about 30 years before, in films such as Chaplin's 'Modern Times' or Lang's 'Metropolis', where people are powerless slaves to the great machines.

This inversion of emphasis has already started in telephony. Fifty years ago, customers had to contact the operator for long-distance calls and accept a radical reduction in speech quality. Today, customers can dial calls regardless of distance, with similar expectations of quality. In future, the needs of users will define the machine, rather than the needs of the machine dictating the behaviour of its users. As Cochrane and Westall say[4]: 'Stop bending people into the technology, and start bending the technology into people.'

Rothenberg[5] uses the phrase 'deep technology' to mean a philosophy of deployment that emphasises the interrelatedness of humanity, nature and technology, leading to a potential reformation of cultural attitudes. He stresses how technology, used correctly, can be transparent, extending human insight and enhancing our appreciation of value, in each other and in the natural world. With an outlook that encapsulates the same attitude to technology as Roddenberry's Star Trek, he says: 'Technology is empty if it considers only itself. Deep technology ...does not hide us from the world and does not teach us to feel more powerful than we really are.'

Alien Thought

From this 'deep technology' perspective, how well do today's telephones perform? Familiarity breeds difficulty in just thinking about, let alone answering, this question. So, shed all previous experience. Shed all humanity and step into an alien's skin and mind. What might you see and say about telephony?

'Remote communication is their biggest machine, but frustratingly we have not identified the tribe who built it. Its connectivity is impressively rapid and planet-wide, using symbol sequences that humans call numbers. *Humans forget these numbers. They often carry a device for linking numbers to other sequences they do remember, called* names. *Curiously, their remote communication machine is entirely unresponsive to these names. It is also odd that their remote speech uses a much smaller range of sound than their native mode.*

*When remotely communicating, humans hold an object against one side of their heads. This is shaped like that strange 'bah-nah-naah' fruit, which our late anthropologist Om*rty foolishly tasted, although more sombre in colour. This object is common in their communication mythology. The simple task of holding it fully occupies one of their upper extensor protrusions, of which they have only two, for the entire communication. Humans willingly accept this functional loss. Om*rty was convinced that this behaviour symbolises an earlier tradition of ritual sacrifice, perhaps in payment for knowledge lying beyond their native senses.'*

Handsets are such a familiar and integral part of the telephone that, to some people, the idea of not having one is almost as alien as Om*rty. Handsets are clearly preferable for tasks needing privacy or mobility. But not having to hold a handset can be more convenient in some applications and closer to the experience of face-to-face contact. Yet loudspeaking telephones, available for over 40 years, have had only modest market success—because of acoustic limitations.

The First and Last Metre

When optical fibres reach that final domestic doorstep, some communication engineers might feel their dreams have come true—perfect transmission at last. But the real channel in human communication stretches from one mind to another. And sound propagation through the air can be a very nasty channel indeed (Figures 4 and 5), with hundreds of times more fluctuating multipath propagation than a radio engineer's worst nightmare. This is the technical strength of the handset, placing the electroacoustic transducers so close to the mouth and ear that acoustic transmission is largely free of noise and multipath effects. In future telephony systems, the properties of the acoustic channel will be the dominant technical impairment.

In loudspeaking or hands-free telephones, for desktop or room conferencing, the transducers are usually better coupled to each other than to the user. This causes two problems. First, a serious risk of oscillation from loop instability and second, multipath contamination of the outgoing speech signal—the

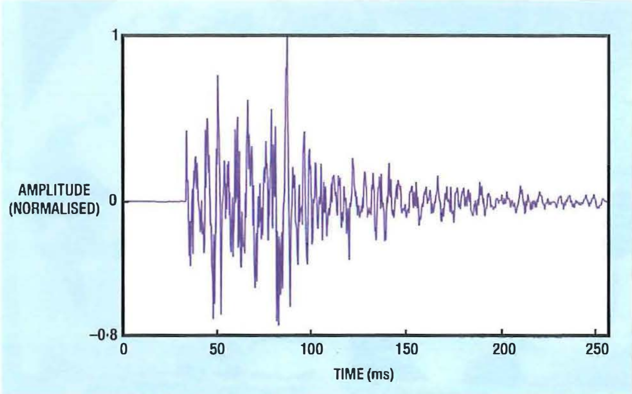


Figure 4—Typical acoustic response between transducers

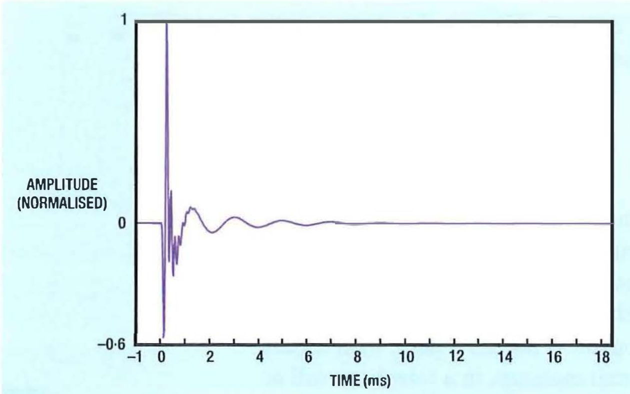


Figure 5—Typical electrical analogue of response in Figure 6

bathroom effect. Incoming speech also suffers similarly, but the listener's ear and brain processing essentially removes such contamination.

In 1979, South et al[6] proved the feasibility of solving the first problem with echo-cancelling adaptive filters. This technique[7] provides the same duplex (both-way simultaneous) transmission as a handset and avoids the syllable-clipping degradations of earlier voice-switching methods. The impact of the second problem can be reduced by using a beam-steering microphone array, using an associated set of adaptive filters. This can produce a highly-directional pick-up beam[8], rejecting angularly-separate multipath and noise signals, to give a speech quality like that of a handset microphone but from a distance. Such array microphones could also reduce the impact of environmental noise or nearby conversations on speech-recognition systems.

$$f_{max} < \frac{c}{2d} < \frac{(n-1)}{2} f_{min} \qquad \{n \geq 3\} \ldots\ldots(1)$$

Equation 1 relates the number of microphones n in a linear array of spacing d with the frequency range f_{max} to f_{min} when the speed of sound is c. The directionality of a seven-element, experimental array is shown in Figure 6. In practical teleconferencing systems, with wideband hands-free audio, a physically large array of many microphones is implied by Equation 1. Such an array could be wall-mounted in a decorative mural, painting or poster. Logarithmic spacing, array weighting or sub-array techniques can be used to avoid an undesirable increase in array directionality with frequency. Efficient algorithms for beam adaption and talker steering in practical environments are the subject of current international research and development.

There are other alternatives to holding a handset, such as lightweight cordless headsets, cordless lapel microphones with loudspeakers or cordless earphones with beam-steered microphones. Low-power radio or optical transmission[9] could provide such cordless links.

Reality Limited

In some situations, a significant delay in replying to a question implies the opposite of the verbal meaning. As other impairments in communications are reduced or removed, customers will come to regard excessive delay as infuriating[10] and a significant barrier to natural interactions. This is likely to reinforce the current economic trend toward the use of ground-based links for long-distance and international calls, freeing satellite bandwidth for mobile services.

The quality of conventional telephone sound—fit for purpose, but hardly high fidelity—might seem a major barrier to greater realism. However, wideband speech coding (with a bandwidth of 50–7000 Hz and a bit rate of 64 kbit/s—G.722) has been technically feasible for many years. It requires new telephones and exchange equipment, but is compatible with existing switching and transmission systems. It can provide much more natural sounding speech and a useful improvement in intelligibility. The effects of competition and the enormous inertia of the telephone market have prevented its widespread use. The computer and entertainment industries have used wideband audio-coding techniques for many years.

Variety and Adaptability

In the light of these potential improvements, today's telephone is nonetheless a remarkably successful device. Anyone daring to predict its radical evolution must analyse what customers think is good, and not so good, about the thing. Human needs vary and variety enriches life. Different messages, for different purposes, suit different media. We are remarkably adaptable creatures,

Figure 6—Polar response of an experimental array at 1 kHz

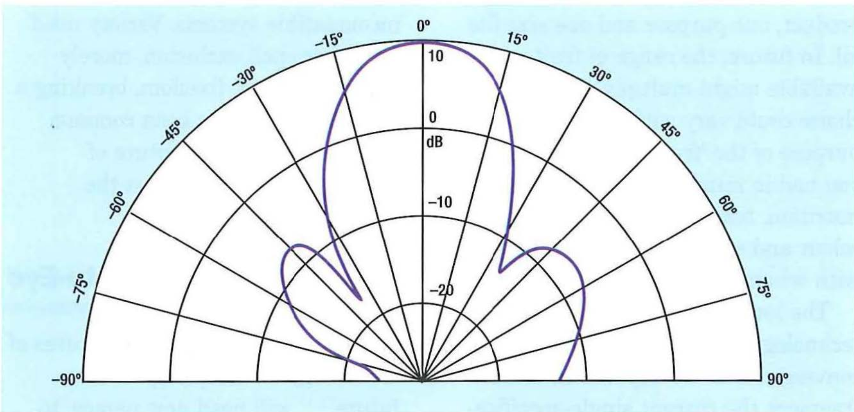


Figure 7—High-quality immersive teleconference

moulding our behaviour to the circumstances. We unconsciously adopt quite different psychological attitudes in a hand-written letter, a business fax, an e-mail, with a voice mail message, in a telephone call or during a videoconference.

Only in the videoconference do these attitudes approach the way we communicate face-to-face, but not every message needs or suits face-to-face contact. Television has become an enormous success. But it has not killed radio, not least because radio listeners are mentally captive while physically free—to get on with something else. Less can be more. Much of the power of conventional telephony, and the appeal of its mobility, lies in the spontaneity and casualness with which calls can be made and received—wherever we are, whatever we are doing and however sloppily or scantily we are dressed.

The authors are sure the evolution of the telephone will be just that—evolution, rather than revolution. New forms and features will be added, without abandoning the power and availability of the existing service. Likely changes include greater convenience, improved ease of use and more naturalness in communication. Cochrane[11] describes an ultimate kind of telephony interface that is 'so kind, so beguiling to humans that they can't resist it...'.

Plural not Singular

The experience of telephony today is rather like buying a piece of fruit, in a world that has only one kind—one product, one purpose and one size fits all. In future, the range of fruit available might multiply and your choice could vary with the nature and purpose of the 'fruit experience' that you had in mind. What sort of taste, nutrition, texture, vitamin content, colour and size? When, where and with whom will you eat the fruit?

The low cost of signal processing technology, added to the effects of convergence and competition, could fragment the current single-specification market. A burgeoning variety of customer equipment and services would then arise, to meet a previously-suppressed variety in human communication needs. The authors confess to heresy, believing that the future of telephony will be plural not singular.

Singular uniformity of specification in telephony has gone unchallenged for so long it seems like bedrock—it was always absurd to consider anything else. This has inhibited improvements in sound quality and limited variety in modes of use. These were small sacrifices compared with the mammoth task of achieving efficient global connectivity. Furthermore, uniformity of specification led to one of the most important achievements of telephony today—the universal interoperability of any two telephones anywhere in the world.

A plural set of telephone-with-computer-with-network specifications seems fatal to this vital achievement. Fortunately, the same speech processing technology that economically enables pluralism can also supply future-proof interoperability, by signal conversion between otherwise incompatible systems. Variety need no longer spell exclusion, merely 'mix-and-match' freedom, breaking a restriction that has been common lore for decades. The future of telephony need not be just the telephone.

Face-to-Face and Eye-to-Eye

New ways of using plural mixtures of technology for telephony in the future[12, 13] will need new names, to describe the different but interoperable services that will arise. Such services might include:

- shared-computer-desktop cordless-headset narrowband telephony,
- cross-computer-platform white-boarding with hands-free narrowband telephony,
- wideband hands-free audio and video multi-person-person calls, and
- high-quality spatial audio and videoconference calls.

These new options arise when multimedia technologies[14], such as shared computer workspaces, eye-to-eye video and immersive conferencing, are integrated with conventional telephony. A remote location could virtually 'appear' through one wall of a conference room (Figure 7). Additional hardware or new delegates could be added to a meeting, even though their need had not been anticipated—something impractical in a real remote meeting.

Developments in speech synthesis and recognition could replace or augment the role of a human operator in simple or well-defined tasks. An electronic 'secretary' could spot key words and recognise action points in a business teleconference. Speech technology could also extend the human--computer interface, long dominated by the keyboard, button and screen, by adding an intuitive speech interface. An Internet browser

All these dreams lead the same way, to a style of remote communication more like natural face-to-face contact.

might gain a voice-driven and voice-responding fuzzy search engine, particularly sensitive to the expression of uncertainty.

Looking further into the future, imagine using eyes-and-hands-free natural speech, in any language, to instruct intelligent agents about the kind of information you seek. Imagine roaming seamlessly from reality into shared, virtual workspaces, and being able to see, hear and touch synthetic objects and distant people as intuitively as in the real world.

All these dreams lead the same way, to a style of remote communication more like natural face-to-face contact. This is the true destiny of telephony, not in the single mode of narrowband handset speech but in a choice of mode, spanning multiple human senses if appropriate, that addresses previously unsatisfied human needs in communication. But these radical opportunities also imply fundamental challenges to the traditional attitudes and culture of telecommunications, which will be the subject of the next article.

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Biographies

Alwyn Lewis
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Alwyn Lewis is an Advisor in Advanced Applications and Technologies, BT Networks and Systems. He gained a B.A. from Cambridge University in 1971, and an M.Sc. from Essex University in 1972. After a spell with Plessey on formant-tracking vocoders, he joined BT Laboratories to work on acoustics, telephonometry and telephone design. In 1984, he became head of a team developing a duplex hands-free telephone with a custom VLSI chip-set and a DSP microprocessor. He then led the speech coding team, helping develop and test DSP software for CallMinder™ and for Skyphone™ facsimile and data services. His interests include beam-steering microphones, speech coding and enhancement, adaptive audio signal processing and the social impact of electro-technology. He is a Chartered Engineer and a Member of the IEE and IEEE.

Fred Westall
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Fred Westall is the Engineering Director of Brite Voice Systems, formerly a manager with Advanced Applications and Technologies, BT Networks and Systems. He gained a B.Sc.(Eng.) from University College London in 1973 and a M.Sc. from the University of Manchester Institute of Science and Technology in 1975. After a spell in microwave development, he joined BT Laboratories to design speech-band modems and has been closely associated with digital signal processing ever since. In 1982, he became head of speech coding, developing novel speech-and-data multiplexers, and became manager of data products development in 1987, responsible for packet terminals and high-speed modems. Recently he was manager of the speech technology unit, downstreaming applications in the fields of speech coding, analysis, recognition and synthesis. He is a European Engineer, a Fellow of the IEE and a Senior Member of the IEEE.

Simon Ringland

Listening Machines

Speech recognition technology is coming of age and machines that obey our spoken commands will soon be commonplace. Here we look forward to what speech technology will deliver at the start of the new century.

Introduction

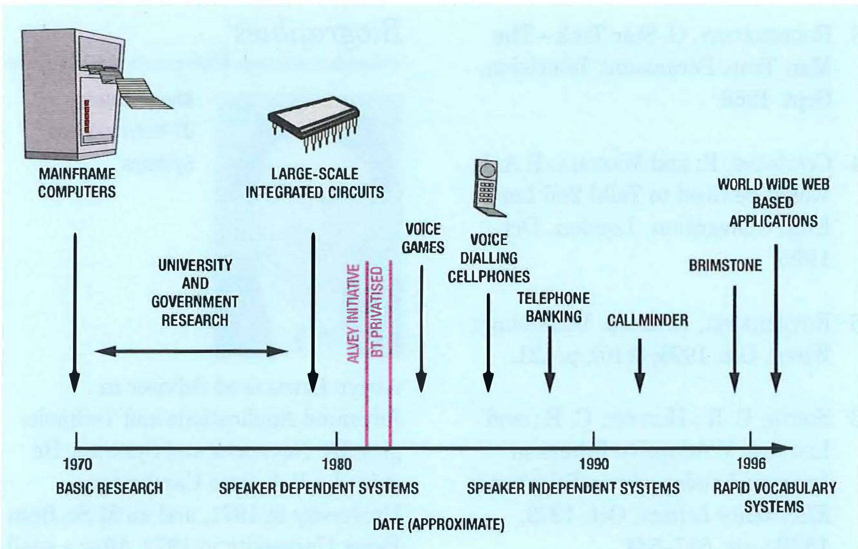
In Stanley Kubric's film '2001—A Space Odyssey' the computer, HAL, was supposedly first activated on 12 January 1997 and it was soon conversing fluently with its creator. What is the reality, now we are in 1997? How close are we to making HAL for real? Can machines actually understand speech?

As early as 1986, the speech recogniser in a *Topaz* hands-free, voice-dialling carphone allowed us to just 'call office', rather than have to punch the number in using the telephone keypad. Making a call with this phone simply meant saying 'dial' and the name of the person being called. A decade on and mobile phones are now so small the keypad and display are the primary limitations to the telephone's physical size. We are fast reaching the point where voice dialling will be the only option. Figure 1 shows the history of listening machines to the present day in graphical form.

Talking, listening machines offer the promise of new revenue streams and cost savings through the automation of services. Telephone banking and home shopping are just two possibilities. BT launched CallMinder™, its first nationwide service to use speech recognition in May 1995[1,2]. This voice-controlled answering service currently supports nearly a million customers with relatively simple recognition technology—but it is not exactly a version of HAL in the telephone exchange. More advanced recognisers, though, are currently being tested in trial services such as the BT Corporate Directory Servicewith a vocabulary of thousands of surnames.

While the recognisers underpinning *CallMinder* and *Brimstone* directory system are usable now, they are still far from perfect. Their limitations force the services to follow rigid dialogues, with pre-programmed sequences of questions and answers, where the computer is firmly in control of the direction of the 'conversation' (Figure 2a). Imagine instead if users could simply ask for what they wanted as if they were talking to another human being (Figure 2b). This natural interaction is the goal of current speech and language research and requires the convergence of

Figure 1—The history of speech recognition in BT



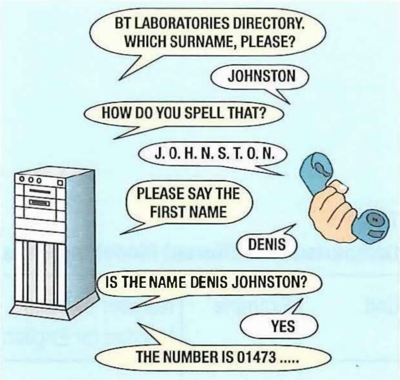


Figure 2a—Example dialogue from the current Brimstone directory system

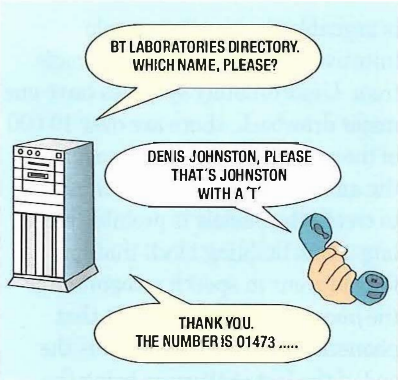


Figure 2b—Preferred directory dialogue

speech recognition, synthesis and natural language understanding technologies. The prize on offer is HAL as a reality.

How Does a Recogniser Work?

The ideas underlying a speech recogniser are straightforward:

- first, record lots of examples of people speaking the words that have to be recognised;
- second, take lots of measurements of these recorded words;
- third, from all the measurements, build a representation or *model* of word sounds; and
- finally, when you want to recognise an unknown word, compare with the models, and opt for the best fit.

Simple—in theory. In practice a state-of-the-art recogniser will comprise several hundred thousand lines of code. Figure 3 shows the recognition process graphically.

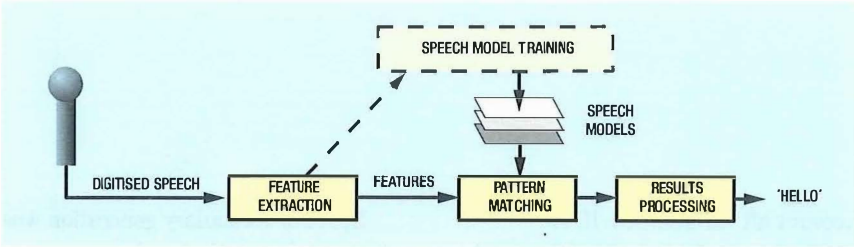


Figure 3—The basic components of a speech recogniser

Speech capture

For a telephony-based recogniser, speech is captured by the microphone in the telephone handset and digitally sampled within the telephone network.

Feature extraction—making the correct measurements

The key to success in speech recognition is to make the correct measurements on the incoming speech. The trick is to measure only those aspects of the sounds that will be useful in telling one word from another. Making extra measurements that do not provide useful information will mean unnecessary computation later on, ultimately making the recogniser slower and more expensive.

Pattern Matching

If we all spoke each word in exactly the same way every time pattern matching would be easy. Unfortunately, no-one ever pronounces a word the same way twice (Figure 4 shows the same word being spoken by three different speakers). On top of this intrinsic variability are the distortions introduced by both the telephone handset and the network. These difficulties are compounded by the presence of background noises ranging from crying babies to the rumble of traffic. In this light, the scale of the problem facing the pattern matcher becomes apparent.

The solution is to build statistical models of the speech[3,4], that take into

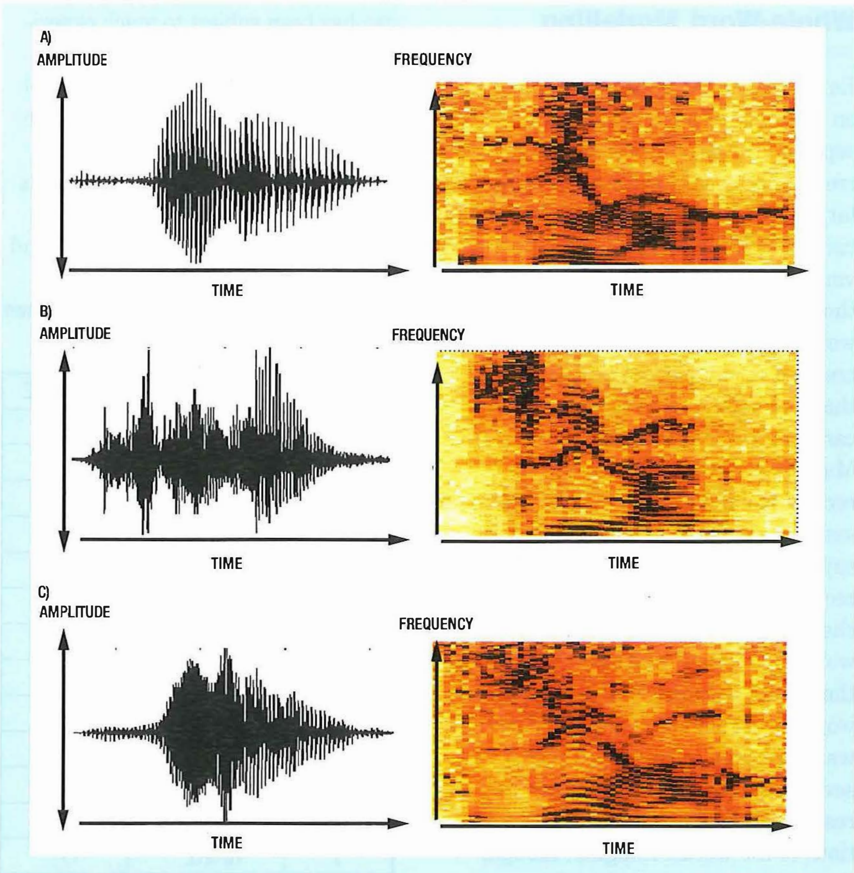


Figure 4—Three different people saying the word 'zero'. Left: the raw digitised speech. Right: a frequency-versus-time plot (dark areas representing high energy) illustrating the results of the first stage of the feature extraction process.

account all variabilities. If, for example, a model is built of the word *banana*, its job is to provide a score indicating how similar any given segment of speech is to the word *banana*. If it is a good model, then it will give high scores for segments that correspond to the word *banana* and low scores for segments that correspond to other words. The pattern matcher then has to find the sequence of models that best explains the entire utterance; that is, the sequence of models that have the best combined score.

Building the statistical models of speech is, however, not straightforward. One of the biggest decisions is what unit of speech is to be modelled. Should a separate model be made for each word, or for smaller sub-word units, perhaps one for each syllable, each phoneme or some similar fundamental building block of speech?

Whole-Word Modelling

Early speech recognisers were based on whole-word modelling where a separate representation would be created for each word in the vocabulary. To construct reliable models to cater for all the possible forms of variation, hundreds or maybe thousands of spoken examples of each word were needed. For example, to create a telephone banking service that needed a vocabulary of credit card names (for example, MasterCard, Visa and Amex), recordings had to be made of thousands of people telephoning in and saying each of the card names. These recordings then had to be manually checked to ensure that the correct words had indeed been spoken. Only then could the models of each of the words be automatically built. This was very time consuming, taking several months. It did, however, result in very accurate representations of the words. Imagine, though, the problems created when the customer, at the last minute, realised they needed the word 'Access' in the vocabulary!

Speed of vocabulary generation was not the only practical problem in creating whole-word-based recognisers. If a vocabulary of more than a few tens of words was needed, then the sheer amount of speech data that was needed became prohibitive in time, effort and storage. A solution was needed that would allow the rapid creation of large recognition vocabularies without the need to record any more speech. The solution found was to model speech not at the level of whole words, but by sub-words.

Smaller Than a Word

In the sub-word approach, a limited set of basic building blocks for words is identified. These building blocks can then be strung together in different sequences to form any desired word.

Deciding which units to use

The choice of what sort of sub-words to use has been subject to much experimentation. Large units have the advantage that they generally model the speech more accurately, but have the drawback that it takes a larger repertoire of units to cover all sounds in the language. The syllable is an example of a relatively large unit, and is arguably the one that people intuitively feel that words are made from. Unfortunately syllables have one major drawback: there are over 10 000 of them in the English language. So the amount of recorded speech needed to create the models is prohibitively large. One building block that has found favour in speech recognition is the *phoneme*. This is the unit that phoneticians identified towards the end of the last century as being the basic building block of words. From just 46 phonemes it is possible to construct every word in the English language. Table 1 shows a comparison of the number of different units needed for various strategies.

Most dictionaries indicate the pronunciation of words using phonetic symbols (Table 2) which correspond to these phoneme building blocks. Table 3 shows examples of the 46 phoneme

Table 1
Comparison of Different Modelling Units

Unit	Example	Number of Units Needed for English
Word	elephant	>100 000
Syllable	e le fant	>10 000
phoneme	El@f@nt	46

Table 2 SAMPA (speech assessment methodology phonetic alphabet) for British English

PHONEME	EXAMPLE	PHONEME	EXAMPLE	PHONEME	EXAMPLE
p	pear	t	tear	k	king
b	bear	d	dear	g	gear
f	fear	T	thing	s	sing
v	very	D	this	z	zing
S	sheer	l	leer	j	year
Z	treasure	w	wear	r	rear
m	men	n	near	N	wing
tS	cheer	=n	button	h	hear
dZ	jeer	=l	bottle		
@	ago	{	bat	E	bet
I	bit	Q	cod	U	good
V	bud	3	bird	A	bard
i	bead	O	bore	u	boot
@U	zero	aI	pie	aU	cow
E@	hair	eI	pay	I@	peer
OI	boy	U@	Ruhr		

Table 3 Example phonetic transcriptions

Word	Transcription
apricot	eI p r @ c o t
banana	b @ n a n a
cherry	t S e r I
date	d eI t
elderberry	E =l d @ b e r I

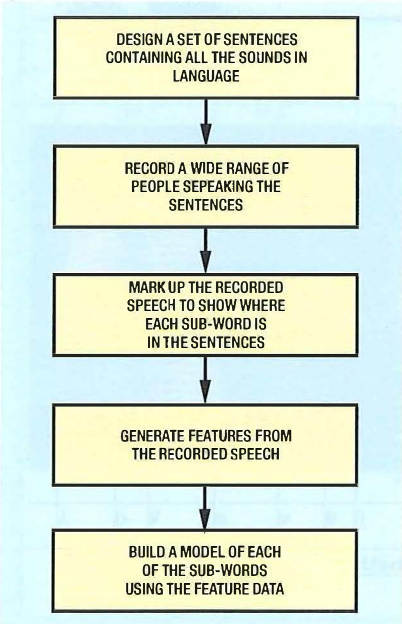
models. Although even this approach requires a large amount of speech to build the 46 models (5000–10 000 sentences are needed to capture all the range of variability in every sound), it is a manageable task and only needs to be carried out once.

Returning to the telephone banking example, our bank can now change its mind over which credit card names to use at will. Adding 'Access' to the vocabulary is no longer the three month job of the whole-word approach. It is now a three second job—the limiting factor is how fast we can type!

Building sub-word models

The ability to create new recognition vocabularies instantly has a price. It requires a major up-front investment to build the phoneme models (Figure 5). Several hundred recordings of each sub-word unit are needed, and they cannot be spoken by just anybody. There must be a balance in the numbers of male and female voices, all the different age groups must be represented, and perhaps most importantly, all the different regional and ethnic accents. The last of these is particularly important in the United Kingdom, where there is a very rich variety of accents for such a small area. Once the recordings are made, they have to be annotated so that each sub-word segment of speech is identified. Only then can the automatic processing to build the models begin.

Figure 5 – Steps needed to create a set of sub-word models



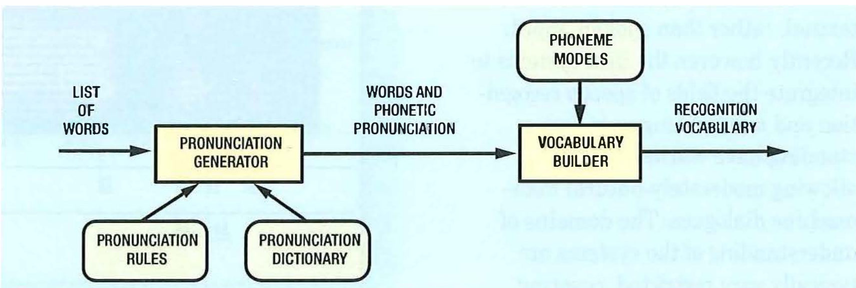
From spellings to pronunciation

As any school child will attest, spelling is not easy. How a word sounds and how it is spelt often have little in common. In building a sub-word-based speech recogniser, we have the opposite problem to the school child. We have to work out how a word is pronounced from its spelling. Common words are easy, as we can look them up in a pronunciation dictionary. Uncommon words and made-up ones like brand names are the real problem. Imagine, for example, we are trying to build an automatic telephone-based catalogue shopping system. The range of products on sale, and hence the recogniser's vocabulary, will be constantly changing. That means that we will constantly be needing to work out the pronunciation of new brand and product names for the recogniser. Employing a linguistic expert is not the answer[5]. Instead, we have been able to develop an automatic system that builds a new vocabulary in a fraction of a second, rather than the months the process formerly took with whole word modelling (Figure 6).

More mountains to climb

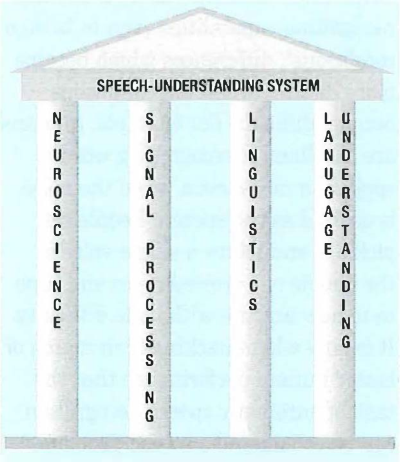
Tests have shown that humans still outperform machines in their acoustic-recognition capabilities even in benign conditions[6], differences which become more distinct when the conditions become difficult. For example, humans are excellent at recognising words spoken in noise, even when the noise is as loud as the speech. People can pick out and follow a single voice in the babble of a crowed room and tune in to new accents with little difficulty. It is only when machines can match or better human performance that the task of automatic speech recognition can be considered a solved problem. The way forward will be via developments in several disciplines: neuroscience providing a better understanding of how the human brain processes speech; linguistics giving improved understanding of the structure of language and developments in signal processing giving access to cleaner signals. The lesson of the last 10 years is that to be successful, the insights gained from all these fields of study must be integrated. The apocryphal quote 'Every time I fire a linguist, the error rate drops 5%', if ever actually spoken, was surely not a comment that linguistic knowledge is irrelevant. Rather, it must have been intended to emphasise the importance of incorporating that knowledge appropriately within a sound engineering framework. One of the

Figure 6 – Generation of new vocabulary



challenges facing speech recognition is to learn how to apply the knowledge

Figure 7—The challenge of the next decade: the integration of knowledge from a range of disciplines to create the next generation of speech-understanding systems



gained in these related disciplines (Figure 7).

Beyond recognition... understanding

Speech recognition—converting speech into text—is rarely an end in itself. In a conversation between a man and a machine, the machine needs to know not which words the man is speaking, but rather to *understand* what the man means and *respond* appropriately. Is the statement 'Look at the sun!' telling you to look at a beautiful sunrise or is it a reference to a copy of a certain newspaper? Only world knowledge and an understanding of the context in which the statement was made will allow such a judgement to be made. Natural language understanding has been key in artificial intelligence research for many years, but has tended to concentrate on textual, rather than spoken, input. Recently, however, the first systems to integrate the fields of speech recognition and natural language understanding have started to appear, allowing moderately-natural man–machine dialogues. The domains of understanding of the systems are typically very restricted, covering topics such as railway timetable enquiries, local area tourist guides and hotel room reservations. Nevertheless, they do demonstrate the potential for more natural man–machine interaction.

The natural language understanding components will need more from the recogniser than just a textual version of the spoken input, if the understanding engine is to perform at its best. The recogniser must provide information not just about *what* has been said but also about *how* it was said. Was it a question or a statement, was it said in a sarcastic tone of voice, or were certain words stressed (Figure 8)? For example, there is a significant difference in meaning between 'No, I meant the *red* box' and 'No, I meant the red *box*'. These questions are ones that the recognition research community has yet to address seriously, but they will

Stages of Data Preparation for Sub-Word Models

The illustration shows the data preparation stages needed before sub-word models can be built. First the speech is digitally recorded (top). The recorded signal is then processed to give a frequency-versus-time or spectral representation (middle). A simplified form of these spectral features is used by the recogniser in the pattern matching process. The final stage, before the models can be built, is the labelling of the data. Each segment of the speech must be marked with the correct phonetic label (bottom), a time consuming process that can only be partially automated, still requiring the expertise and patient attention of a phonetician.

Top: The original sampled waveform showing part of a sentence '...in a bath of muddy...'

Middle: A frequency-(vertical axis, 0–4 kHz) versus-time (horizontal axis) representation of the signal showing how the energy of the signal at any given frequency varies with time. (Yellow—high energy, blue—low energy)

Bottom: Transcriptions showing how the phonemes (above) and words (below) align with the signal.

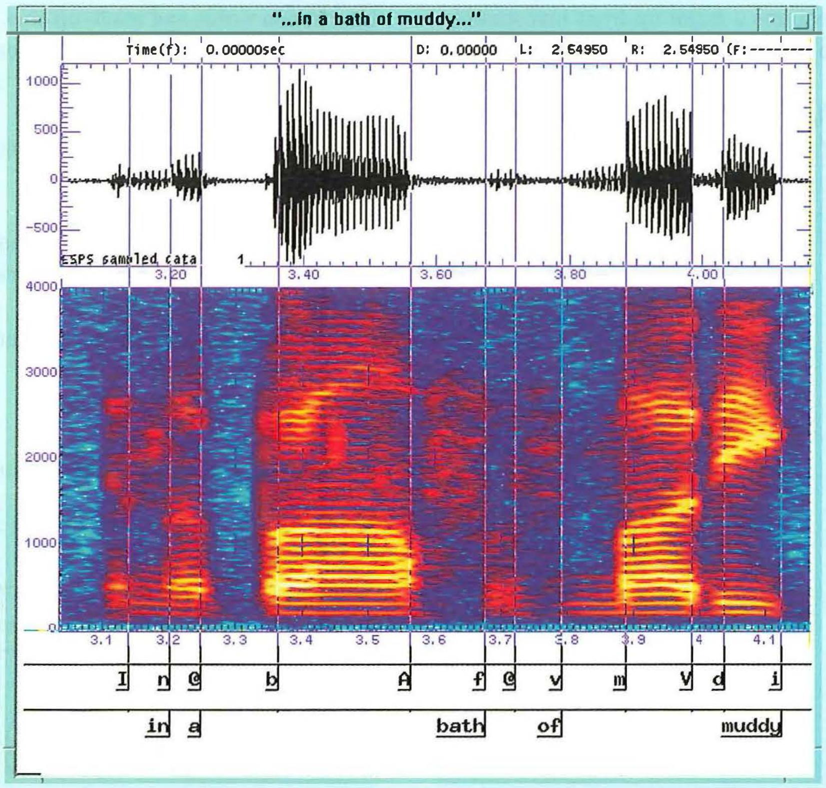


Figure 8 – The importance of prosody!

become the priorities as soon as the recognisers can reliably determine *what* has been said.

The Shape of Things to Come

Speech recognition is just one of a range of new technologies that will revolutionise the man–machine interface. The combination of voice identification and facial recognition could make computer passwords a thing of the past, while talking heads will give machines a human face. Computer users can expect to see synthetic personae appearing on their screens ready to obey their spoken commands. Soon your computer will welcome you by name as you walk in the office door in the morning, give you your messages, tell you your appointments for the day and then ask if you want to place that conference call you mentioned yesterday.

Conclusions

The availability of fast, cheap computing power has enabled the commercial exploitation of simple whole-word based speech-recognition technology, most notably with the use of yes/no recognisers in the telephony environment. The advent of sub-word based recognition has opened up the possibility of a much wider range of applications. The next few years are going to see an explosion of new voice-controlled services, ranging from voice dialling, through automated telephone attendants and directory services, to telephone-shopping and information-provision applications. The interactive voice application will become the first point of contact, the effective public face, for many organisations—available 24 hours a day, 7 days a week. Today's clumsy 'speak one word at a time' interfaces will soon be seen as quaint and it will not be long before they give way to machines capable of holding a reasonable conversation. Indeed, the real question is how long it will be before our computers, like HAL, are monitoring our conversations by reading our lips!

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Biography

Simon Ringland
BT Networks and Systems

Simon Ringland received the degree of BA in Electrical Sciences from Cambridge University in 1986. He then joined BT Laboratories and began work on speech recognition algorithm research. In 1991, he led a team developing speech recognition for one of the world's first automated directory-enquiry trial systems. He currently manages BT's Speech and Speaker Recognition Research team which develops algorithms aimed primarily at telephony-based interactive voice-response systems, such as those used in the BT CallMinder™ service.

Mike Evans

Managing Change Within BT's Operational Support Systems

BT has around 1300 applications covering all aspects of its operations. Designing and managing changes to such a large integrated applications portfolio to keep pace with the increasing rate of change in the telecommunications industry is a difficult challenge. Computing technology and design methods are also advancing, and both old and new technologies have to work together. Achieving a balance between replacement and enhancement of applications within the constraints of money, time and skills availability has to be carefully managed. New ways of looking at the portfolio have been developed so that coherent strategies for the design and management of change can be implemented.

Introduction

BT's operational support systems (OSS) consist of the total systems capability that supports the sales, service, network and business operations of BT. They touch every aspect of BT's operations and are used, either directly or indirectly, by every member of the company. By the year 2000, the leaders in the telecommunications industry will include those companies who have successfully exploited their OSS to create and meet new market opportunities. Hence, leading-edge systems capability is critical to BT's long-term success.

BT's OSS capabilities are world class; the reliability and cost-effectiveness of the service, billing and network management applications are second to none. BT's customer service system (CSS) remains one of the most highly integrated customer service applications deployed by any PTT and has been successfully adapted to serve new products and support several new BT organisational structures. The deployment in 1995 of elapsed time charging within the billing architecture provides the BT group with a highly flexible infrastructure with which to face a rapidly changing competitive scene. The operations management centre (OMC) system provides comprehensive switch management capabilities, and its links to CSS provide automated service configurations for the public switched telephone network (PSTN).

The OSS portfolio has been developed over the last 20 years, growing from applications which were sponsored by functional and organisational groups. Today, those systems have been progressively interlinked in order to meet ever-rising service standards. This integration has in itself brought its own issues that need to be addressed. The family of systems contains too much diversity of data and infrastructure. Additionally, their original organisation, product and customer segment focus have in many cases been affected by rapid change in those dimensions. System development capabilities are struggling to keep pace with the commercial drivers, and in parts of the company are perceived to be a barrier to the fast introduction of new products and services, delivery of service excellence, or support of global ambitions. The data is locked into those systems preventing exploitation of the information needed to maintain and retain BT's market share.

In numerical terms the systems portfolio over the last five years has doubled the number of applications to around 1300, and tripled the number of interfaces between applications to around 3000, with each interface typically being hand-crafted to meet a specific business need (see Figure 1). It is estimated that the portfolio contains in excess of 80 million lines of code with an annual increase of 8 million new

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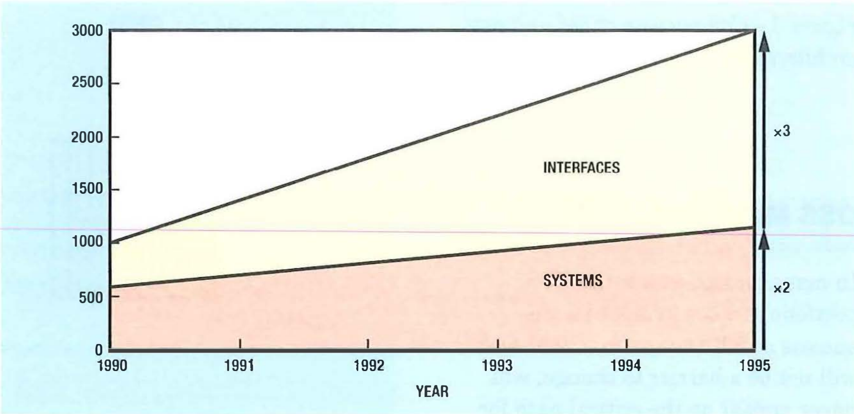


Figure 1 – System and interface growth

lines of code written and 4 million lines of code replaced.

A recent review has identified about 30 major systems that are critical to the operations of the company and account for most of the system operating costs. These are called *hub systems* (see Figure 2). Surrounding these hubs is a much larger set of systems manipulating and feeding data into these hubs. The remaining systems tend to be stand-alone, with manual, rather than automated, links to other systems. This categorisation of systems has started the debate on where the limited amount of development resource should be allocated, and where the priorities for re-engineering lie.

The remainder of this article reviews the drivers causing change to systems, the management and technical vision for systems, and the approach being taken to ensure that systems continue to meet the ever-increasing demands.

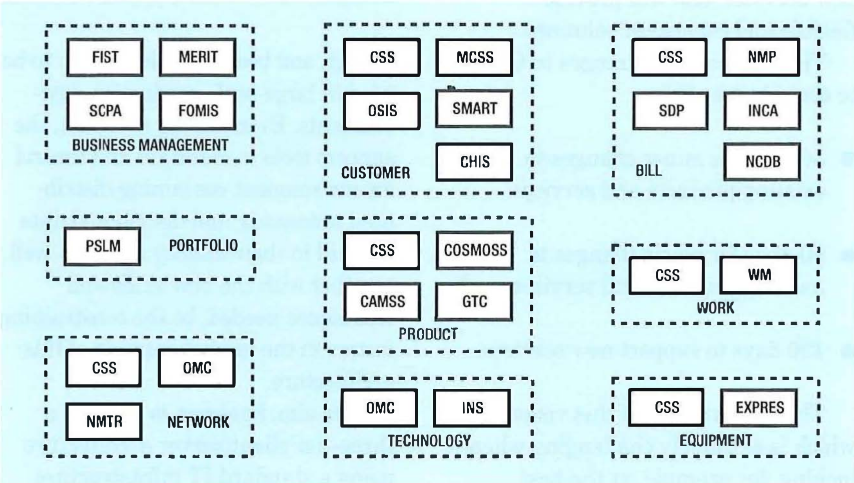


Figure 2 – Hub systems

Drivers on OSS

The telecommunications industry is rapidly changing with the emphasis very much on reducing the time to market, lower whole-life costs, and a shift of focus towards customers and service, while moving away from network technology and technology-related identifiers; for example, telephone numbers. Systems must therefore be capable of supporting change without having to go through a lengthy design, develop, test and release life cycle, and be deployed on standard rather than bespoke infrastructure. This must be achieved at a price that is appropriate to the product and service being delivered or the internal process being supported.

Regulation is having an impact upon OSS either as new requirements, such as number portability (which requires specific telephone numbers to be treated as a resource that can be passed between licensed operators), or increasing the interaction between BT and other operators with equal access and other licensed operator (OLO) interconnect. System designs for the future must therefore ensure that systems can be linked to other systems outside BT while protecting commercial interests and meeting the legal obligations of protecting data relating to customers or their installations.

Partnerships, joint ventures and strategic alliances are being formed to extend or open up markets. These are often based on the linking of computer systems, sharing systems between partners or using common software as a means to reduce or stabilise costs, share risk, and improve time to market. The OSS of the future will need to cater for all of these needs and will require clear business decision-making to provide direction and priorities.

Network technology changes, with the introduction of higher bandwidth and intelligent components into the network, will enable new products and services to be created and configured much more rapidly than at present. These new technologies, together with the services they promise, will require changes to the present OSS base if their features are to be exploited and mass customisation (that is, services packaged and tailored to an individual's needs) is to be delivered.

Information technology is changing rapidly with year-on-year price/performance improvements and increasing commoditisation. A mixed technology infrastructure where different suppliers' products, both hardware and software, have to coexist and work together is rapidly become the norm. Personal computers are being increasingly deployed as 'front-ends' to existing systems to provide additional intelligence, work-flow features, data and linkages between systems. However, these gains from advances in technology may be offset by the increasing demand on computing operations management in a distributed-processing and data-storage environment. The Internet, particularly with the ability to write, distribute and run applications using tools like Java™, has come of age as a commercially viable infrastructure that will deliver service reliably. The question is how to make best use of it.

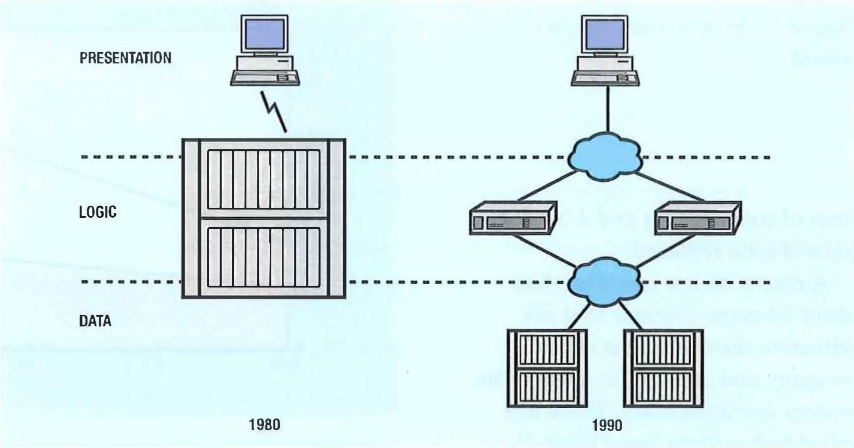


Figure 3—Comparison of old and new architectures

OSS Management Vision

In management terms, the OSS portfolio is a key enabler for the success of BT. The vision is that OSS will not be a barrier to change, will never appear on the critical path for new services, and will provide flexible and consistent solutions.

The goals are for changes to OSS to occur in less than:

- 30 days for minor changes to existing products and services,
- 90 days for major changes to existing products and services, and
- 120 days to support new services.

The achievement of this vision, which is extremely challenging when looking, for example, at the best timescales for delivery of changes today, is dependent upon the ability to design and deploy a systems and management structure that is capable of controlling change happening at an order of magnitude greater than at present.

Technical Vision

The need to partition BT's systems into small modules to provide the flexibility, delivery-time improvements and exploitation of computing technology advances requires a different architecture from the mainframe and limited intelligence terminal that have served BT well over the last two-three decades (see Figure 3). Industry thinking has been moving towards a three-tier model that separates out the functionality associated with the terminal, from that associated with the 'true' processing and from that functionality required to manipulate and protect the integrity of data.

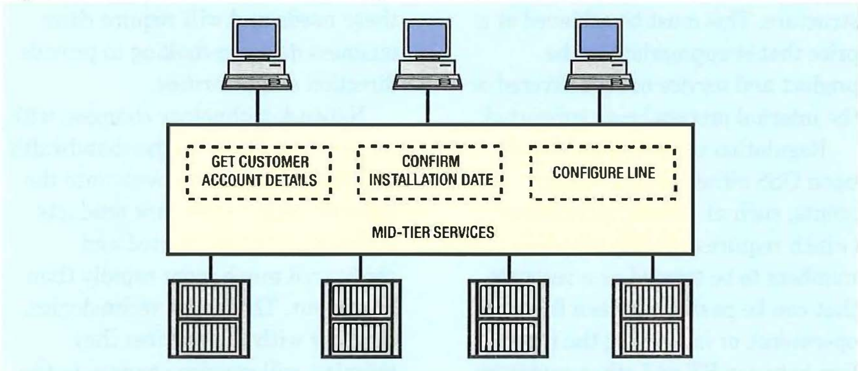
While methods have been available for many years to design systems along these lines, it is only over the last year or so that the operating system software capable of controlling such an environment has matured enough and been reliable enough to be used in large-scale production environments. Even having said that, the support tools to maintain and control an environment containing distributed processing and distributed data are still in their infancy and may well, together with the new skills and techniques needed, be the constraining factors in the implementation of this architecture.

The aim, however, is to build a three-tier client/server architecture using a standard IT infrastructure built from a small set of proven off-the-shelf components. The tiers will, in general, align to the model of presentation, function, and data[1].

To capitalise upon existing assets, data will be held and managed in 'back-end' systems developed by the evolution of existing hub systems. Similar or duplicate data that is currently locked into different systems will be released either by developing a specific database designed to meet future needs, or made accessible by implementing data gateways that direct applications to a database. A current example of this type of development is the operational customer database project which will, over a period of time, bring together customer data currently dispersed in systems like CSS[2] and COSMOSS[3]. The main business benefits will be that this data is now available to many applications (and not just the one associated with the database), alternative sources of the same data can be eliminated, the data can be cleansed, and, as there is one source, the maintenance of the data is simplified. Where a single database is not achievable, for example where delays in accessing the data would be unacceptable, duplicates could be created with automated processes to maintain a master/slave relationship to preserve data integrity.

The middle tier will consist of a set of self-contained *services* or *objects* that can be called upon to perform a specific function; for example, 'Get me account details for this customer', or 'Configure this line for these network services'. Each service will be designed to fulfil a specific need identified by an analysis of current functions and future requirements. They would be independent of other services and capable of being changed without affecting other services or functions in the other tiers. They would have published interfaces into and out of the service by which they communicate to other tiers or other services

Figure 4—Mid-tier services linked to presentation and data tiers



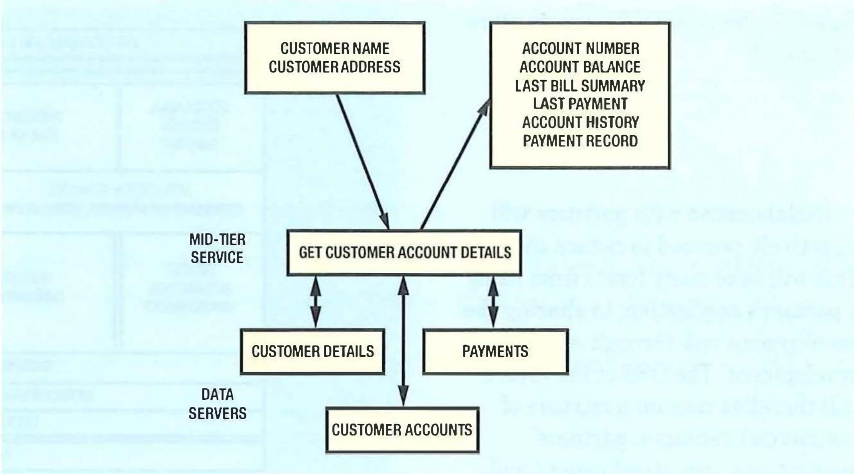


Figure 5 – Example of mid-tier service interfaces

(see Figure 4). They will be defined so that they can be reused to support many products and services and be capable of being assembled to support as yet unknown needs. Development of these mid-tier services will either be bespoke or by re-engineering them out of their existing back-end system. Each service will have a range of deployment options and can then be replicated and distributed over the standard IT infrastructure as demand for that service changes.

Mid-tier services are self-contained groupings of functions and data that can be called using known interfaces (see Figure 5).

The front-end 'clients' will contain applications that present the services, say, on a terminal screen, and manage the order in which the services are offered. In their current form these clients exist as personal computers or telephone keypads. In the future they will exist in many other forms and be capable of being operated, if this is what they want, directly by customers to initiate an order or change of existing services directly into BT's OSS. The aim is for this to happen with no or little involvement from BT people. For example, a customer may initiate the call-off of additional bandwidth from a terminal on their premises directly into the OSS, the service configured, records updated, and billing triggered, without any BT person being involved.

Approach Taken

The tile architecture defined in the BT OSS architecture[4] sets the overall direction for systems planning and ensures close links between the evolution of systems and the visionary processes that BT could operate. The tiles provide a map showing how functions to support all the operational needs of BT can be grouped around specific sets of data. Mapping today's systems on to these tiles clearly brings into focus many of the difficulties faced when trying to integrate systems to meet today's needs. Using the tiles as a template, a series of top-level designs, known as *tile evolution plans*, have been defined for each tile. These plans have provided systems designers with a high-level evolution path spanning four–five years. Designs that follow these evolution plans will ultimately lead to a much simplified systems structure built from a rationalised OSS portfolio.

For each hub system, a review of current and planned capabilities was undertaken by their chief designer. This exercise brought out a business view of what products and services were being or were planned to be supported, as well as the data used, technology employed, and existing or future interfaces. These systems evolution plans forced a longer-term view of systems, out beyond the next two or three releases, and enabled key changes to be identified that would start the re-engineering of these systems towards the three-tier architecture. Additionally, disjoints between system plans were made visible much earlier than they would have been if the requirements specification route had been followed. This enabled corrective action to be taken before the development processes started.

The next step has been to consider the design of future OSS in business rather than system terms. Broad-level 'business activities' such as customer handling, billing, provisioning and work management have been defined. By gathering the management of systems within these domains, both design and development can be coordinated to deliver, over a period of time, a set of integrated systems. This grouping also provides a forum in which business needs and priorities can be discussed and agreed. Decisions, such as which system will be enhanced to deliver new functionality, can then be based on pan-organisational needs and implemented in a way that still enables progress to be made towards the future architecture.

Using this approach, the major (hub) systems in the OSS portfolio will evolve to become the 'back-end' data management engines. Those functions that manipulate the data, read or write data to the database, or carry out data integrity checking will remain. Other processing functions will be re-engineered, or replaced by new code, into services that will be deployed in the mid-tier. This has already started with the customer-handling interface server (CHIS) project which has delivered a set of encapsulated services, originally CSS transactions, to provide simple network services. Interestingly the client tier for this application is a telephone with voice commands from a speech application processor. This application has been deployed on a retailer's premises and requests for changes to certain of BT's Select Services can now be carried out by the retailer directly, using the telephone, a speech application processor[5], the re-engineered services, CSS and OMC[6] directly into the network switch[1].

This strategy will reduce the number of systems by directing new functions, and by redirecting existing functions and data (if still required) currently realised in non-hub systems, towards hub systems. The evolution plans will form the basis for tracking the delivery of new capabilities and progress towards system simplification.

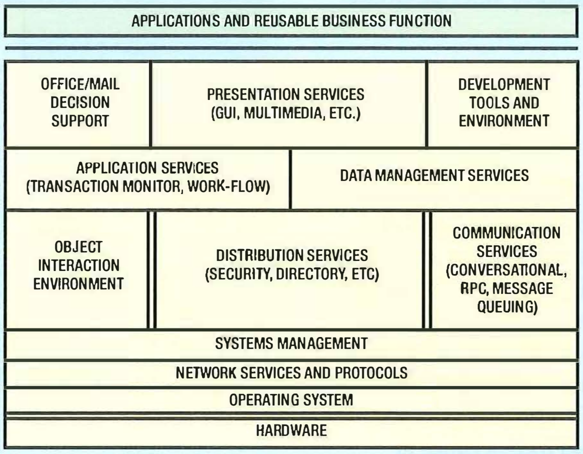


Figure 6—Standard IT infrastructure framework

Collaboration with partners will be actively pursued to reduce costs. This will take many forms from using a partner's application, to sharing the development risk through a joint development. The OSS of the future will therefore contain a mixture of commercial packages, partners' applications, joint development and (internally developed) bespoke applications. Harmonious working to deliver 'seamless' service will require conformance to interworking, data and technical standards that has never been achieved to date.

Forming strategic partnerships with suppliers will provide long-term benefits for both parties—for BT by having access to a supplier's skills and expertise and the ability to focus the supplier on BT's development needs, and for the supplier by having an outlet for their products and an insight into the future direction and needs of BT.

Technical standards and design practice that will be used are being defined. A sub-set of technologies, covering hardware, operating systems, network service/protocols, system management, enabling components (distribution services, data management, presentation services, etc) and development tools, has been selected, from which future systems will be constructed. An implementation plan is in place to educate designers and engineers about this standard portfolio (see Figure 6). The move towards this set of technical standards will take place over many years, as, for example, it is unlikely that a database would be re-engineered to conform to a standard database management system, if it was satisfactorily performing and still being supported by the supplier.

Conclusion

The demands being placed on BT's OSS are escalating. Satisfying these demands requires step changes over and above those achieved by implementing improvements to what already exists. The new ways of looking at the structure of OSS developed over the last two years provide the framework to ensure that what is designed and developed meets business needs and will form an integrated OSS portfolio. Re-engineering existing hub systems either as back-end data servers or mid-tier services will make best use of existing assets. Implementation of a three-tier architecture is the radical change that will deliver the flexibility and radical reductions in the development life-cycle times. Achieving these key business goals will depend on a technically and managerially challenging design and development discipline.

Acknowledgements

Many people from all parts of BT have been involved in the debate on systems strategy. The key people who have contributed to the ideas in this article and have presented this work are Sinclair Stockman, Phil Dance and Paul Kenny.

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Biography

Mike Evans
BT Networks and Systems

Mike Evans joined BT in June 1976 after graduating from the University of London with a B.Sc. in Applied Physics. He has been involved in the design and development of computing systems ranging from network design systems to CSS, and has been responsible for technial and data standards and architectural design. He currently heads the Work Manager programme.

Clive Selley, Steve Baker and Rachel McKay

SMART—Improving Customer Service

The quality and consistency of customer service offered by telecommunications providers is a key differentiator in the residential market place. BT's SMART customer handling system provides competitive advantage through world-class levels of customer service. SMART exploits the existing functionality, data and security mechanisms of an established mainframe system and adds ease of use, reduced error rates and a focus on 'service' and 'selling'. The article discusses key issues of security, performance, resilience and operability, and presents the solutions implemented.

The Business Challenge

BT faces ever-increasing levels of competition in the UK residential telephony market place. Cable companies, long-distance service companies and mobile operators all offer competing products to entice customers from a market place of 22 million people.

Marketing techniques are becoming more sophisticated. Free call allowances, progressive discounts for higher call usage, discounts for calls within calling circles and free or discounted network-based services are all part of the marketing game. Faced with a barrage of operators all touting ostensibly similar products with a profusion of tariffs and options to pick from, customers will often place their business with the supplier offering the best overall quality of service—a fair price, reliable service, understandable bills, a helpful and efficient enquiries service. Customer service is becoming a critical differentiator in the residential market place. Current support-systems development is aimed at offering a customer experience of BT on the major inbound sales channel ('150') which is second to none.

The '150' sales channel is a formidable undertaking. BT has 34 customer service centres across the UK, employing 5000 customer service agents (CSAs), taking 5 million customer calls each month. Customers call to place orders for telephone service, select services, charging options (such as Friends and Family) or to make enquiries about bills, payment methods (such as direct debit or budget account) and BT's entire range of products, services and tariffs. This wide range of call types imposes major challenges for the channel. The agents must understand the full product set and be able to advise on the most appropriate services for individual customers. They must be fully conversant with billing and payment policy. They must be adept at spotting sales opportunities, and articulate in conveying benefits in the course of a short telephone conversation. They must be competent at processing orders and enquiries against the customer service system (CSS)—the powerful computer support system that supports a wealth of order- and bill-related functionality. They must also be efficient—with such vast call volumes to cater for, fast and accurate call handling is essential to controlling the costs of the channel.

CSS provides a broad range of business functions, developed and honed over many years. It is supported on a number of large mainframe computers and has a partitioned database. Customer and account data are held in a single logical database and distributed on a geographic basis across 29 physical databases. The combination of broad functionality and vast data supports the day-to-day operations of the '150' channel agents. Through CSS, an agent may examine and update customer, account and order records for any one of the 22 million customers. Through a technique known as *transaction switching*, transparent access is provided from each of the 34 customer service centres to each of the 29 databases.

This article is a revised version of SELLEY, C. J.; BAKER, S.; and MCKAY, R. SMART—Improving Customer Services, *BT Technol. J.*, Jan. 1997, **15**(1), p. 69.

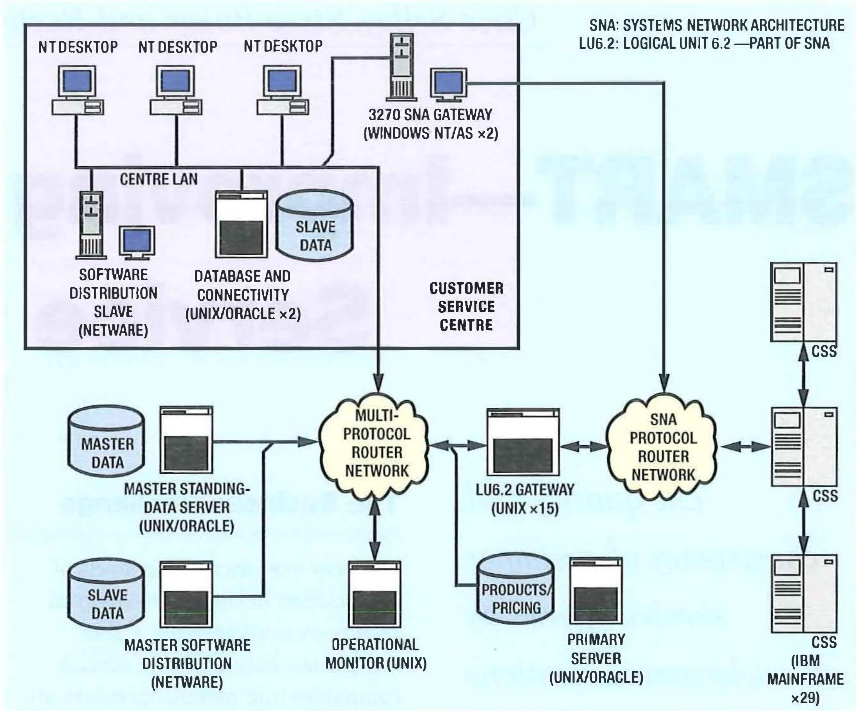


Figure 1—SMART top-level architecture

While immensely powerful, CSS does pose some challenges for the '150' channel. The CSS training period for CSAs is 6 weeks. The familiarisation period, to full competence with CSS for all call types is estimated at 6 months. The CSS system is efficient for order taking and enquiry taking, but is not orientated towards 'selling'. The need to invoke a sequence of CSS programs to fulfil a single business function (for example, provision of telephony service may require 20 programs) can lead to user error and in the worst case can impact upon customer service. Thus the SMART system was developed to provide a new interface to CSS services and the services of other 'host' systems to achieve:

- reduced call handling times, to reduce costs;
- reduced system error rates, to improve the quality of customer service;
- reduced system training times, to reduce costs; and
- improved selling support, to improve the quality of customer service and enhance '150' channel revenues.

SMART—A Distributed System

Design overview

The physical architecture of SMART is illustrated in Figure 1. In addition to the desktop PCs, the middle-tier servers (MTSs), SNA gateways and local Netware servers are replicated at each customer service centre. The management components, master data servers and systems interconnect service shell (SISS) gateways are located away from the centres.

SMART is a three-tier distributed system. At the desktop tier, a PC runs the Microsft Windows NT/3.51 operating system. The NT operating system supports multi-threaded applications—fundamental to the design of the SMART application. Multi-threading is used to achieve customer profiling against the CSS database without adversely affecting call handling times. It is also used to process orders and 'customer contact' records against CSS on behalf of the CSA while the CSA moves on to talk to the next customer.

The principal middle-tier components of SMART (Figure 2) are:

- standing-data database,
- order error database,
- products and service database (PSD),
- Connection Manager,
- System Monitor/6000, and
- SNA server.

All but the SNA server are supported on a replicated Unix platform. The SNA server is supported on a replicated NT/AS platform and serves to provide a 3270 service to CSS. This is required at log-on time (when SMART screen-scrapes a native log-on) and on-demand from the CSA, to make use of an emulator (Attachmate Extra!) for CSS access in native mode for business functions outside of the current scope of the SMART product.

The desktop SMART application provides a graphical interface to the user, offering a set of about 20 basic 'business services' such as 'provide telephone service', 'provide product', 'provide chargecard', 'bill display'and 'provide charging option' via graphical icons. The application enforces business processes, many of which are driven from rules held in the mid-tier standing-data database. Data entry is via simple forms or radio buttons or simple menu selections. Data vetting on input ensures that the CSA is offering appropriate products for the customer. Checks are made to ensure that services offered are compatible with exchange technology and with the customer's other existing services.

The desktop application interacts with the Oracle-based products and services database (PSD) and with the CSS hosts via a component known as *System Manager*. This presents a data model view of the basic business entities (customer, product, service, bill, etc). and its role is to mask the population of those data entities from either the PSD or CSS. In practice, interactions with the PSD translate to SQL*net/ODBC (open database connectivity) calls to the Oracle mid-tier database and interactions with CSS translate to Distributed Computing Environment/remote procedure call (DCE/RPC) request messages sent via the mid-tier Connection Manager component. The

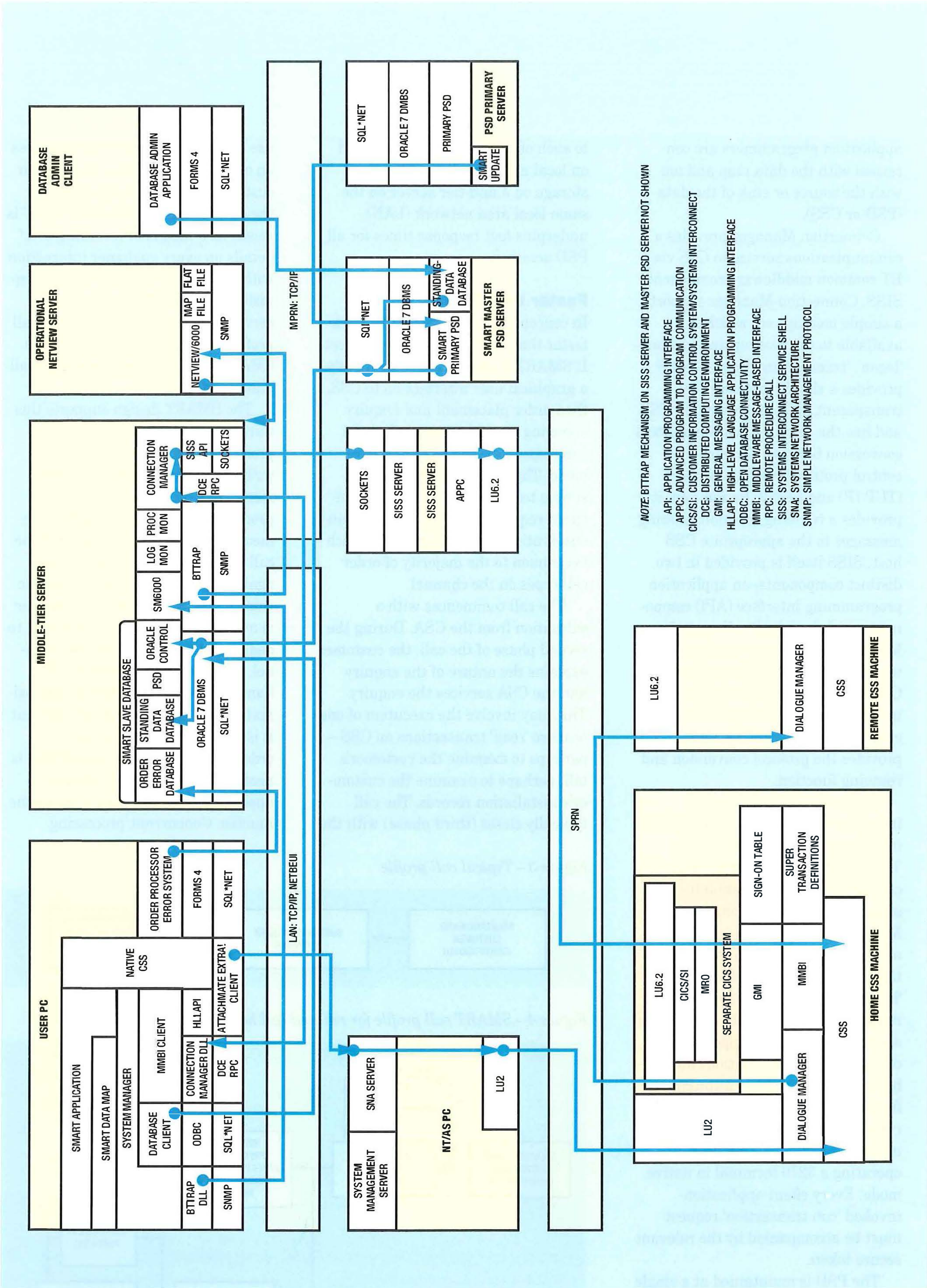


Figure 2 – SMART software component design

application programmers are concerned with the data map and not with the source or sink of the data (PSD or CSS).

Connection Manager provides a communications service to CSS via a BT common middleware component, SISS. Connection Manager supports a simple message set which is available to the desktop application—'logon', 'transfer' and 'logoff'. SISS provides a simple interface for transparent message passing to CSS and has the role of providing protocol conversion between transmission control protocol/Internet protocol (TCP/IP) and LU6.2. In addition, it provides a routeing function, passing messages to the appropriate CSS host. SISS itself is provided in two distinct components, an application programming interface (API) component which is linked to Connection Manager and a server component, which receives traffic from multiple Connection Managers on multiple mid-tier servers located at the customer service centres, and provides the protocol conversion and routeing function.

The generalised messaging interface (GMI), another BT common middleware component, services 'logon' and 'logoff' requests from clients (SMART application instances) received via Connection Manager and SISS. Secure tokens are exchanged between the application instance and GMI for each GMI 'logon'. An application instance may request up to three concurrent 'logon' sessions, in order to support three concurrent CSS interactions on behalf of the user. This technique is fundamental to the delivery of reduced call handling times when measured against a CSS user operating a 3270 terminal in native mode. Every client application-invoked 'run transaction' request must be accompanied by the relevant secure token.

The PSD is maintained at a single site and is subject to daily updates. The Oracle 'snapshot' facility is used to mirror changes to the PSD master to each of the read-only copies held on local mid-tier servers. Local storage on a mid-tier server on the same local area network (LAN) underpins fast response times for all PSD accesses.

Faster than CSS

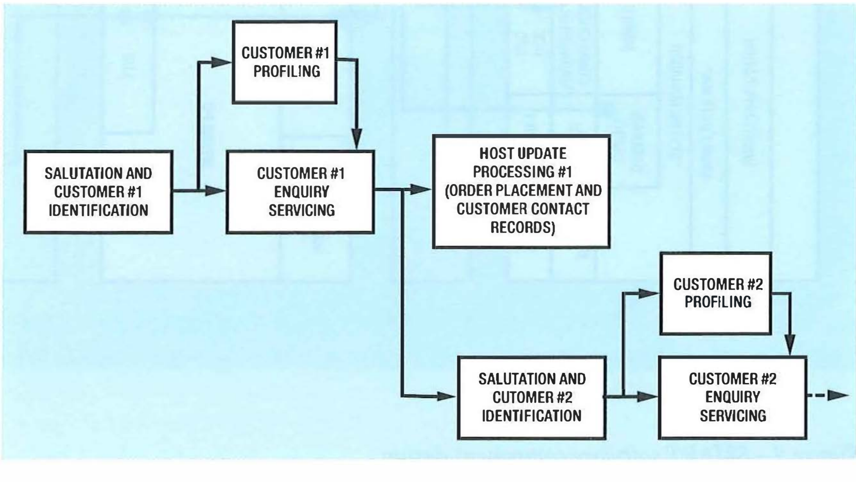
In concept, the requirement to work faster than CSS was difficult to meet. If SMART is considered to be merely a graphical user interface on to CSS, then order placement and enquiry servicing would be executed at the same speed as CSS used in native mode. The SMART design offers a simple technique for addressing the speed requirement. It is based on an observation of the call pattern which is common to the majority of order call types on the channel.

The call commences with a salutation from the CSA. During the second phase of the call, the customer explains the nature of the enquiry and the CSA services the enquiry. This may involve the execution of one or more 'read' transactions on CSS—perhaps to examine the customer's bill, perhaps to examine the customer's installation records. The call typically closes (third phase) with the use of update transactions to process an order and to register an issue (or customer contact record) recording the customer interaction. An 'issue' is raised as a means of recording brief details on every customer interaction with BT and is regarded as a prerequisite for world-class customer service. Figure 3 shows a typical call profile, while Figure 4 illustrates a SMART call profile with reduced call-handling time.

The SMART design supports this third phase of the call, the order processing/issue processing phase, without CSA or customer involvement. SMART captures the order processing/issue processing requirement during the second phase of the call and automates the processing against the host system. During the third phase of the call, the customer is not involved and the CSA is free to deal with the next call on the channel. This technique reduces call handling times. It applies to approximately 80% of '150' channel calls but it is not applicable in instances of orders where customer interaction is necessary; for example, making an appointment or selecting a telephone number. Concurrent processing

Figure 3—Typical call profile

Figure 4—SMART call profile for reduced call handling time



within SMART is supported by concurrent threads in the application and in Connection Manager, and by the mechanism of multiple concurrent logical channels into CSS supported by GMI.

To guard against host (CSS) update failures, which would not be noticed by the CSAs since they run in a background thread, SMART stores all updates on the local mid-tier server database ahead of processing against CSS. In the event of a successful CSS update, the record is immediately deleted from the mid-tier database. In the event of a failure, the record persists and a separate, off-line Oracle forms application is supplied to allow the order database to be managed by a pair of users at each customer service centre.

SMART was designed as a Windows application, to be driven primarily from the mouse, augmented by keyboard input. Practical experience during the early months of roll-out has provided some useful feedback. Users find switching between mouse and keyboard to be a hindrance. It adds seconds to call-handling times, which may seem petty, but when considered in the context of call-handling time targets in the region of 260 seconds, can be significant. It is likely that future SMART developments will support keyboard-only operation in addition to mouse-and-keyboard operation.

Certain features of block-mode character-based interfaces applications offer easily overlooked performance advantages over equivalent Windows applications. Owing to features such as pop-up warning dialogues, it is more difficult for a Windows user to type ahead, as compared to CSAs using native CSS, who in certain scenarios are to be found typing into screens which have not yet appeared! Their familiarity with certain programs on CSS is such that they simply ignore CSS response times and type on regardless. Future releases of the SMART application will attempt to address such issues by establishing as consistent user interaction as possible.

As available as CSS

The CSS has evolved over a decade or more. The development, implementation and support processes have been refined and honed and the system achieves an impressive level of availability for a system of such scale. It services a population of some 60 000 on-line users and supports batch programs producing tens of thousands of customer bills per day.

For the defined 'on-line' day and for defined performance levels (expressed in terms of screen response times), CSS achieves availability levels in excess of 99%. The introduction of SMART is intended to have no adverse impact on CSS availability as perceived by the CSAs. Hence, when CSS is available, SMART must be available.

This poses a challenge, since SMART is implemented in a three-tier structure with PCs at the desktop, Unix and NT/AS at the middle tier and CSS at the host tier. The SMART solution offers more components, each a potential point of failure. The approach to maximising SMART availability is based on the following principles:

- To cater for the possibility of PC failures, each customer service centre is over-provided by 5%. In practice it is more economical to over-provide standard desktop PCs than to provide highly-reliable PCs or to pay the cost of a very fast PC support contract.

- The Unix and NT/AS mid-tier servers are replicated. Each user has an Oracle account (with replicated password) at two Unix mid-tier servers at the same centre. Recovery from loss of a Unix mid-tier server is not transparent—only the logon process detects non-availability of the primary mid-tier server and initiates recovery to the secondary. Mid-tier server failure necessitates a logoff and logon by the affected users. A similar situation exists for the SNA gateways—at log-on each user may pick up a terminal session via one of two mid-tier NT/AS servers, but should one fail during a session, the user is forced to logoff and logon again.

- Each user has a principal CSS account and a secondary CSS account. These two accounts are on different hosts. The secondary account is used only when the CSS host serving the primary account is unavailable. While use of the secondary account, under these circumstances, still precludes access to customer or network data held on the 'unavailable' CSS, all data on other CSSs will be accessible and hence most '150' calls will be serviced without an interruption to service.

- The key 'network' component in the SMART architecture is the SISS server. Loss of (or slow response from) a particular SISS server is detected at run-time and the SMART mid-tier server will redirect traffic via an alternative SISS server without loss of service to the user.

- The underlying 'bearer' network supporting traffic between SMART and CSS is common to that which currently supports traffic between terminals (block-mode, IBM 3270) and CSS.

- Under failure conditions which render the Connection Manager–SISS–CSS path unavailable and when the Attachmate–SNA server–CSS path is available, then recourse to native CSS provides a fallback of last resort.

In the production environment SMART matches CSS availability.

Easier to train than CSS

CSS supports thousands of programs. Each is invoked by a program name—a three- or four-letter acronym (for example, MFFN, 'modify Friends and Family numbers'). '150' channel CSAs are conversant with approximately 200 programs which they use on a regular basis to service the range of call types on the channel.

SMART 'hides' the CSS programs from the CSA. The SMART desktop application has a Windows 'look-and-feel'. Core business functions are presented as icons on an icon bar. Once invoked, the business function will lead the agent through a sequence of inputs and outputs—some of which will involve dialogue with the customer. The application is structured around business functions which have meaning to the customer and have been derived from a requirements-capture technique based on Jacobsen's use-case method†. Panel 1 lists services supported by SMART.

CSS provides some 200 commonly-used programs. SMART provides approximately 20 business functions. CSS programs are self-contained and alone do not satisfy a business process. SMART business functions implement complete business processes for which CSS training is six weeks and the SMART training period is three days.

† Jacobsen, I. Object Oriented Software Engineering—A Use-Case Driven Approach. Addison-Wesley, 1993.

Panel 1—Services Supported by SMART

Direct debit/budget account
Itemised billing
Postpone payments
Payment advice
Duplicate invoice
Charging options
Select services
Send standard letter
Provide product/service
Cease product/service
Shift product/service
Provide PSTN service
Cease PSTN service
Caller redirect
Renumber
Bill enquiry
Sales prompt
Refunds
Chargecards
Order enquiry
Phonebook ordering
Directory entry.

Less error prone than CSS

CSS in its current form provides a set of low-level functional building blocks from which business processes can be assembled. Hence, to provide a new customer with basic telephony service might require a CSA to invoke 15 or 20 CSS programs. Some programs manipulate the new account, perhaps recording the detail of charging options or payment methods. Some manipulate the installation, recording the apparatus and network-based services required. Some record details of the customer. Some are concerned with appointments, others with the allocation of a telephone number. There is no single program to 'provide telephony service'.

The partitioning of CSS functionality into such a large number of small building blocks provides a high degree of flexibility. Business processes may be re-engineered quickly, essentially because the 'process' is captured in the sequence of CSS program invocations and not enforced by the programs themselves. The process is implemented by the CSA and basic process changes are implemented in written instructions to the agents. The drawback to this approach lies in the inconsistency of 5000 agents following written instructions. This leads to errors and can be illustrated by examples:

- Certain network-based services (CallMinder, Call Waiting) are only available to customers served from specific exchange technology. Although CSS has a facility to order network-based services, there are no checks to validate the installation for an appropriate exchange type. The business process step of 'validate exchange technology for chosen network-based service' is a rule which can be serviced via CSS, since CSS offers a program for analysing exchange technology, but its invocation is a process step to be implemented by the agent.
- Current rules for the 'Friends and Family' product permit only a single 'mobile' number and a single 'international' number to be included in the list of 10 telephone numbers for a particular customer. Yet the CSS programs permit any number of telephone numbers (up to 30) to be included for a customer and no check is made within the program to police the 'one mobile number' limit or the 'one international number' limit. This provides the business with the flexibility to change the features of the Friends and Family product, but in practice imposes a responsibility on the CSAs to implement the business rules concerning the number mix for the Friends and Family product.

SMART assumes a greater responsibility for the implementation of business processes. It implements product compatibility checks, product-network compatibility checks and the full set of business rules regarding charging products. During the pilot trial, SMART users achieved a significant reduction in error rates on the host system. This has a direct impact on customer satisfaction—there is nothing worse than selling a product to the customer only to discover at a later date that the service cannot be provided.

SMART has delivered a business rules engine implemented at the client and middle tiers of the architecture. It has avoided the need to enhance the suite of CSS programs to achieve this objective. Flexibility has been accomplished through the definition of simple rules defined in data and held at the middle tier. The most volatile rules may be altered through data-only changes.

Support 'selling'

SMART profiles all customers as soon as they are identified. The agent enters the customer account number or telephone number into the 'welcome' screen and SMART initiates profiling of the customer to determine basic data such as call bill size, payment history, products purchased/rented, services rented. The customer profile is matched against a set of marketing segments. For each marketing segment, a product set is referenced. A 'sales prompt' is displayed, indicating the most beneficial products/services to be offered to the particular customer. It would for example, indicate Premierline for a customer with a high call bill who does not currently have the relevant charging option. It also calculates the potential saving from Premierline based on the latest call bill.

All market segmentation rules and product sets are defined in simple data structures at the mid-tier of the SMART system. They are read once at logon time and reused for each customer call.

The sales support features are designed to enable customers to make the most of BT. BT has a broad product set and must talk to its customers at every opportunity about products of relevance to them. This feature is designed to enhance customer service and generate additional revenue.

In order to provide rich and accurate customer profiling during the course of a call, SMART interacts with CSS to read customer-, account- and network-related data. To do so at the beginning of each call would, if carried out in sequence before all relevant enquiry/order handling, extend the call handling time. This would be unacceptable. Within the SMART desktop application, customer profiling is carried out within a separate application thread. This allows the agent to service the customer request without delay. Typically the sales prompt appears about 15 seconds into the call. Despite the elimination of any call-handling time impact, customer profiling does impose an impact at the host. The profiling must be executed for every call (5 million per month) and the nature of the profiling is such that it requires a range of data available from programs within different CSS subsytems (billing, networks, order handling, repair). In practice the task of profiling has given rise to the development of a 'service' transaction on CSS which amalgamates database 'reads' taken from numerous programs in several CSS subsystems into a single new program. The service transaction delivers a much-simplified interface to the SMART application, improved run-time performance and reduced processing load on CSS, as compared with the alternative of making use of the existing CSS programs.

Sales support facilities in the area of charging options are particularly sophisticated. For example, in support of the massive TV-based marketing campaign behind the Friends and Family product, SMART provides a facility to read a customer bill from CSS, analyse the contents with respect to the Friends and Family product and recommend the 10 best numbers to the customer. The focus throughout is on implementing business processes end-to-end. SMART fills functional gaps on CSS and provides complete business process support.

Segmentation data may be changed by the customer using a separate Oracle forms application supplied with SMART. Forms are supplied to permit users to manipulate many of the business 'rules' that determine the behaviour of the SMART application at run-time.

As secure as CSS

The security of BT's data is a high-visibility issue inside and outside the company. Security procedures to protect mainframe data have been put in place at some cost, and the introduction of SMART had to maintain the high level of security CSS had already put in place. In addition, the cost of SMART's access control had to be minimised without jeopardising its effectiveness.

The security issues surrounding SMART can be categorised as follows:

- access control to the host data SMART relays to the users,
- access to the storage of customer data on the failed order database, and
- access to software on the client PC.

Access to CSS

Existing screen-scraping applications connect to the host systems via a standard 3270 emulator alone, but this was insufficient for SMART, owing to its requirement for three concurrent CSS sessions. Current security arrangements dictate that a user may only connect one session at a time to prevent fraudulent reuse of a known user ID and password.

GMI, a component of common middleware was enhanced to provide concurrent session access for SMART. Since it cannot be accessed directly by user terminals, the single session restriction was lifted for connections via GMI. However, trebling the number of sessions for each of SMART's 5000 users would have imposed an unacceptable load on CSS resources. As a compromise, each of SMART's sessions on GMI was defined as a cut-down session holding no context information.

When a SMART user connects to CSS using GMI, GMI reuses the existing CSS authentication functions to validate the user ID and password. Assuming success, one GMI token per session is returned to

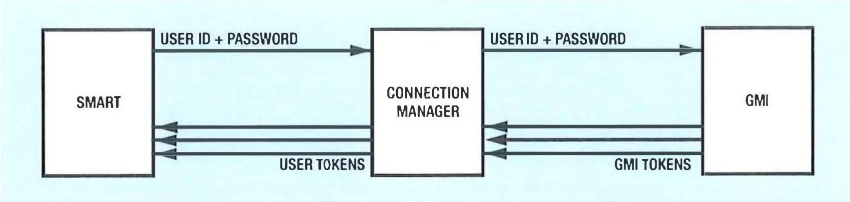


Figure 5 – SMART logon using GMI

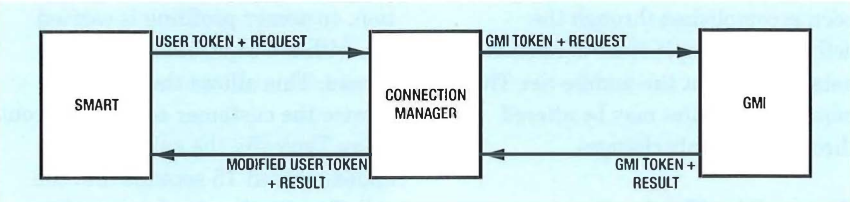


Figure 6 – Changing token authorisation

Connection Manager on the Unix mid-tier server (Figure 5). It in turn creates one user token per session which can be used by the System Manager component of the SMART client.

When the client wishes to invoke an MMBI (middleware message-based interface) transaction on CSS, it supplies one of its user tokens to Connection Manager, which validates the token, and passes the request to CSS with a valid GMI token (see Figure 6). GMI, given a valid GMI token, allows the execution of the transaction and return the result to Connection Manager. This component returns the result to the SMART client, together with a new user token which replaces the original one used.

This constant changing of user tokens between client and Connection Manager means that even if a token is fraudulently intercepted, it can be used only once. Its subsequent (legitimate) use by the real SMART client would be detected and flagged to the operations unit using the BTTrap mechanism.

Using the existing CSS user ID and password validation means that a user needs only to be disabled using the standard CSS procedures to effectively lock them out of SMART as well. The only alternatives to this would be costly and require an inordinate amount of coordination.

Access to the mid-tier

Security restrictions need not be so heavy with respect to the PSD. The information contained therein is public domain and need not be so heavily protected. Each user is set up on the mid-tier Oracle servers to be able to access all the PSD data in a read-only capacity. The failed orders are also stored on the mid-tier.

Access to the desktop

Though no key information is stored on the client PCs, it is crucial to ensure that the software installed on the machine is not tampered with in any way. Each user's access is restricted using the Windows NT domain-based security, such that they cannot modify important configurations on the client. Windows NT security also has the benefit of ensuring non-SMART people cannot gain access to the SNA servers, thus maintaining a consistent level of service for the SMART user community.

SMART does not compromise the security of the data stored on CSS, a key requirement for the project. Unfortunately, the simple fact that SMART is based around (relatively) expensive and in-demand PCs makes the likelihood and cost of theft far greater than for 3270 terminals. Despite the security of the data, the security of the hardware cannot be overlooked.

Low impact on CSS

More than ever before, CSS is changing to respond to market pressures, new products and services and changes in the regulatory climate. As a client of this system, SMART must track changes if it is to continue to operate correctly. Thus, the demands on SMART to accommodate these changes will continue to be high for the foreseeable future. CSS functionality must never be held up by SMART, nor may SMART impact upon the tried and tested test, delivery and pilot processes.

At any one time there are likely to be two major releases of CSS in the field. A user switching between CSS databases may see two completely different versions of the same program, and usually, with a little intuition, can cope with the changes. As intuition is not an option for SMART, it is vital that as soon as a new release of CSS is brought to the pilot stage, SMART is already deployed nationally to deal with any deviations from the previous version of CSS. The MMBI protects SMART from cosmetic changes, but where different information is required or available, SMART must operate in a way appropriate to either release. In the most complex case, SMART may only offer a function to the user if the customer being dealt with is on the latest version of CSS. This adds an extra level of complexity to the configuration management in SMART, and this is one of the greatest challenges for the project.

In order to avoid the necessity of deploying SMART nationally at the same time as a new CSS release enters the pilot stage, SMART has adopted a delivery strategy which mirrors that of CSS. While the 'old' release of CSS is deployed nationally, SMART will deliver a pilot version which works against both 'old' and 'new' CSS releases. This is a low-risk strategy which enables the operation of a new version of SMART to be monitored closely. Assuming everything is correct, SMART will then be deployed nationally a week or two later. When the 'new' release of CSS enters the pilot stage, all the SMART clients in the field should recognise it correctly and act accordingly. In this way, service-affecting problems can be trapped before the wider user base is affected.

As operable as CSS

The great strength of a mainframe-based operational support system, in terms of operability, lies in the fact

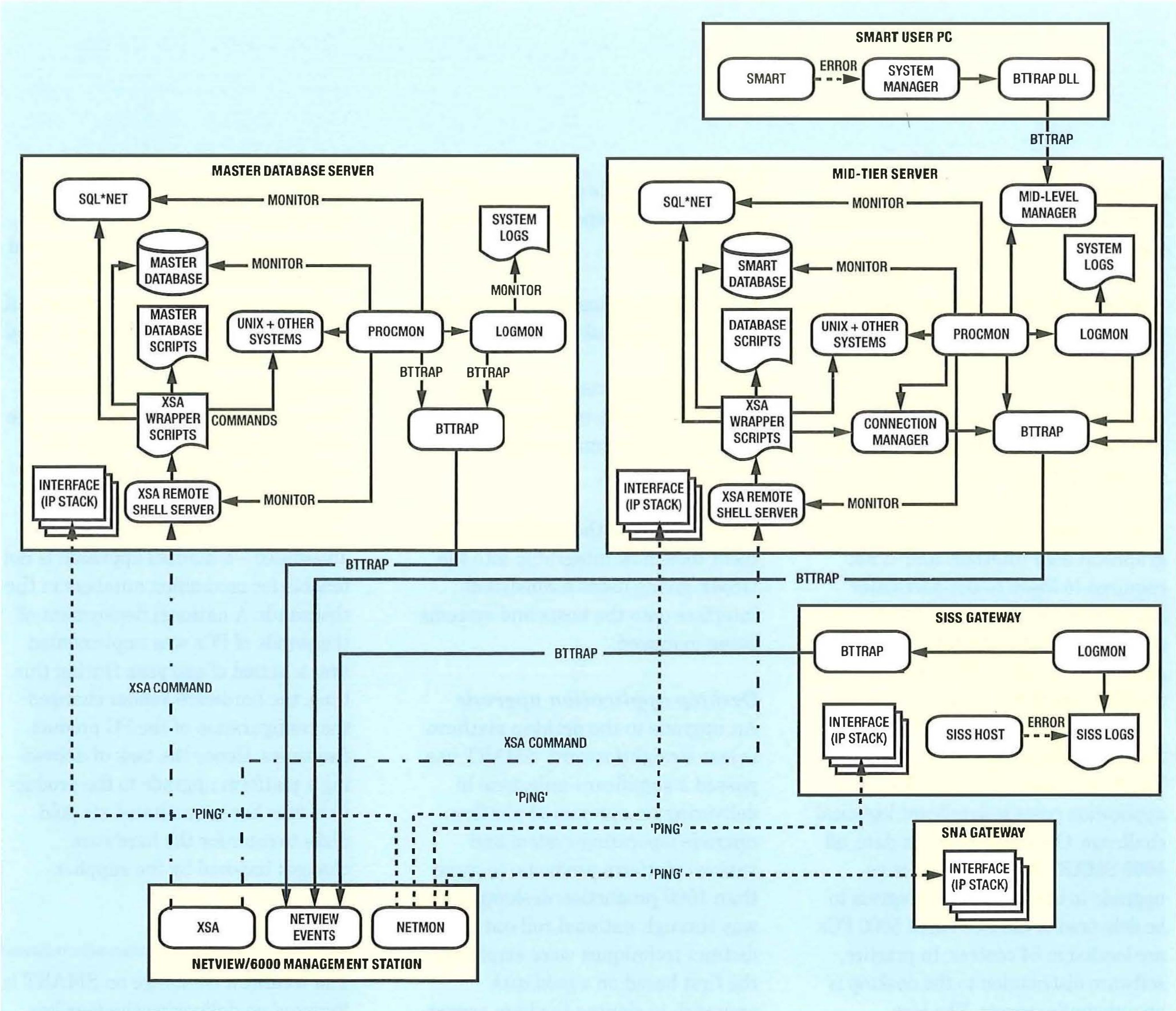


Figure 7—SMART systems management architecture

that the mainframe is the principal 'active' device to be managed. Manage it well and a potentially very large user community will benefit from fast performance and high levels of availability. The terminal device is a 'low-tech' item without CD drive, hard drive or floppy disk drive or any of the peripheral items which compromise reliability and pose a serious operability challenge. Yet, when in the three-tier distributed system, the computer at the desktop has a hard drive and access to a mid-tier server with drives, databases and wide-area network connections. There are additional communications devices (in the case of SMART, SISS servers). A three-tier distributed system has all the hallmarks therefore of a less operable, reduced 'availability' option.

SMART offers an approach to four major aspects of operability:

- event and error reporting,
- remote control,
- software distribution, and
- desktop platform upgrade.

Event and error reporting

The key operational support tool employed for SMART is the BT open systems management framework (OSMF), based on IBM's Netview/6000 and System Monitor/6000 products and developed in-house by BT's computing services division.

The production SMART system has been 'integrated' into the framework. The SMART support teams monitor the production installations via a graphical representation of all its constituent hosts and software components on a network of Netview/6000 management servers (see Figure 7).

At the system level, OSMF agents (LogMon and ProcMon) monitor the health of mid-tier servers and raise BTTraps under predefined error conditions. At the application level, BTTraps are raised within the code on both the mid-tier (Connection Manager and Oracle) as well as the PC (SMART application and System Manager). The BTTraps raised on the PC are despatched via designated mid-tier servers and all BTTraps are then forwarded to the Netview servers.

For SMART, an effective event and error reporting mechanism is a prerequisite for acceptance into production. Without it, service level agreements at customer service centres, which are not permanently staffed with operations personnel, would not be attainable.

Remote control

Remote control facilities are provided for the use of the SMART support teams. Automated scripts, such as 'start Connection Manager instance', 'stop Connection Manager instance', 'backup PSD master database', are provided to carry out basic remote operations on the mid-tier servers and the primary PSD server. All such scripts are offered as simple menu items via the Netview/6000 proprietary product. The operator utilises a graphical user interface and is not required to logon to the particular SMART server or to type native Unix commands. These facilities are made available via IBM's XSA extension to the Netview/6000 product.

Software distribution

The distribution of the SMART application poses a significant logistical challenge. On a single roll-out date, all 5000 SMART users will expect an upgrade to the application program to be delivered to the PC. These 5000 PCs are located in 34 centres. In practice, software distribution to the desktop is an automatic process. The new application is delivered to Netware servers at each centre. At log-on time, a common control file located on the Netware server is read automatically. If the control file indicates the current SMART release is different to that already on the desktop, the new release is down-loaded automatically. This simple process has proven reliable in operation and straightforward to implement.

Software distribution to the mid-tier servers has also been partially automised. In full deployment over 70 mid-tier servers will be sited at the 34 centres. The tool currently in use is Platinum Xfer, modified and customised by an in-house development team to meet BT requirements. Packages are created containing compressed archives of the software along with pre- and post-installation command scripts and other configuration data. Currently, the Connection Manager application, the Oracle scripts and the OSMF mid-tier configuration files are delivered using Xfer. The main benefits that using Xfer give are:

- the ability to install and back out packages cleanly as required, and
- the ability to control software distribution to mid-tier servers using XSA commands from Netview/6000.

Xfer is one of the many management tools now integrated into the OSMF giving users a consistent interface onto the hosts and systems being managed.

Desktop application upgrade

An upgrade to the desktop platform is less straightforward. SMART has passed a significant milestone in delivering an automated platform upgrade (operating system and various platform products) to more than 1000 production desktops, part-way through national roll-out. Two distinct techniques were employed—the first based on a *gold disk* approach to cloning the base operating system platform, and the second based on the use of a proprietary product, OnDemand's WinINSTALL.

A gold disk is constructed from the image of a PC disk in the laboratory with only the operating system installed. The gold disk is downloaded on to the target PC's disk, thus giving a fully-configured clone of the master. Manual intervention is restricted to a small number of parameters including IP address and workstation name. The third-party platform products are then made into self-installing, self-configuring packages so that they can be loaded onto the target PCs as the second stage of the PC gold-build method. This is achieved using WinINSTALL, which takes 'snapshots' of the PC before and after the manual installation and configuration of one or more software products. The subsequent WinINSTALL package contains instructions covering all the actions that have to be carried out on the PC during installation; for example, source and destination of files, NT registry edits, INI file edits, icon and group creation, etc. A WinINSTALL package was created for each piece of third-party software and downloaded as a whole on to each target PC as the follow-up step to the gold build. The entire operation took an average 20 minutes to build a SMART PC with only a minimal amount of operator intervention at the outset.

Platform upgrades must be automated—a manual approach is not tenable for production numbers in the thousands. A national deployment of thousands of PCs was implemented over a period of one year. During this time, the hardware vendor changed the configuration of the PC product five times. Hence the task of delivering a platform upgrade to the production sites has necessitated six gold disks to cater for the hardware changes imposed by the supplier.

SMART Futures

The technical challenge on SMART is focussed on delivering the four key business benefits listed in the first section of this article. To that end, current SMART developments include:

- Integration with the customer service centre 'voice platform'—the DMS automatic call distribution (ACD) system which allocates incoming '150' calls to available CSAs. Computer-telephony integration (CTI) offers the promise of further reductions in call-handling times, through delivery of calling line identifier or a telephone number sought from an intelligent voice-recognition (IVR) system which answers the customer call ahead of the CSA and solicits the telephone number or account number from the caller. By this mechanism the agent is delivered 'voice' and 'data' simultaneously. Customer profiling can begin the instant that the customer is answered by the CSA. A second benefit concerns the use of CTI technology to allow call-and-data transfer within a customer service centre. This would enable agents to consult managers in-call, to transfer selected calls to appropriately skilled groups of agents and to enable a different approach to training particular groups of agents within the service centre. It opens the possibility of a range of organisation and procedural changes which would deliver improved customer service and potentially lower training costs.

- Integration with the BT operational customer database (OCDB) as a source of customer profiling information—the current approach imposes a significant processing load on the CSS hosts and is subject to onerous real-time performance targets. The OCDB development will deliver a capability to source much of the profiling data from a database designed for the purpose, offering improved profiling times and reduced CSS loading.

- The SMART product is to be extended to include business functions relating to repair. The BT '151' repair channel will benefit from a simple-to-use graphical interface to fault record entry, remote line test, fault modification and fault despatch services, while sharing the more general 'enquiry' and 'ordering' services currently supported in the SMART product.

- SMART will migrate to a more classical three-tier model, utilising customer handling intermediate server (CHIS) mid-tier services via a DCE/RPC interface, such that business logic (rather than simply the data that drives the business logic) is available from a common middle tier which is shared by a range of applications. CHIS services have proven stability and performance in serving the BT voice applications platform, ACE and the volume business outbound sales system. The promise of CHIS is to deliver common business services; for SMART that translates to lower development and maintenance costs and lower production costs through the use of shared CHIS platforms.

- SMART will focus on lifestyle data capture for BT customers. As a sales and marketing tool, lifestyle data is known to be highly valuable. SMART will offer mechanisms for on-line capture of such data and storage on an appropriate host system. Lifestyle data will be utilised dynamically during the life of the customer call to tailor the sales prompt displayed to the CSA.

Biographies

Clive Selley
BT Networks and Systems

Clive Selley joined BT Laboratories from university in 1986. He worked for two years in a development team to specify and implement a communications achitecture for the New Generation Systems computing/ telephony platform. In 1988, he joined the BT London Systems Engineering Centre working as an engineer and project manager to deliver a series of network management systems, billing systems and the SMART customer handling system.

Steve Baker
BT Networks and Systems

Steve Baker joined BT after gaining an M.Eng. in Software Engineering at Imperial College in 1991. He spent three years designing network management and billing systems based on object database technology. He now leads a team delivering business-critical systems solutions in the customer-handling arena.

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Rachel McKay obtained an HND in Computer Studies from Leicester Polytechnic in 1988 and joined GEC-Marconi Software as a software engineer, working on a variety of real-time safety-critical systems for both the civil and defence industry. After graduating from the University of Hertfordshire with a B.Sc. (Hons.) in Computer Science in 1992, she joined BT to work in network traffic management. Currently she is the SMART operability team leader within the SMART development project. Her work involved developing, configuring and implementing a wide range of support and software delivery tools for SMART. In addition, she provides consultancy to other BT projects on these areas of open systems operability.

David Elliott and David Biggs

Provision of a VSAT Network for Barclays Bank in Africa

Custom-designed satellite networks can help provide global telecommunications networks to meet the needs of multinational companies. This article details some of the design and implementation considerations associated with a very small aperture terminal (VSAT) satellite network for Barclays Bank in Africa. It details the factors that led to the decision to use a satellite transmission system and outlines some of the technical features associated with the service design, implementation and operation.

Introduction

In 1994, Barclays Bank identified a need to modernise the IT facilities into its branches in the AFCARME region (Africa, Caribbean and Middle East). The bank asked the Aeronautical and Maritime (A&M) Unit of BT to assess the feasibility of providing a satellite communications network in Africa. A&M's Offshore and Customised service team has for many years provided customised solutions to the hydrocarbon industry using a range of technologies; for example, satellite, line-of-sight radio, tropospheric scatter and fibre-optic cable. In this case, Barclays required a satellite telecommunications network connecting 88 sites, spread across Zimbabwe, Zambia and Botswana, and its main regional computer centre (RCC) in Harare, Zimbabwe.

The bank had to provide all of the front-office staff at these branches with real-time banking applications, including information on customers' accounts, signature enquiries, foreign exchange etc. In addition, the new facilities had to improve the efficiency of the bank's operations by enhancing the range of real-time back-office applications, such as file transfers. In some cases, the facilities proposed would even be in advance of those currently available in the UK; for example, foreign language capabilities. The network had to be flexible to cater for growth in terms of traffic and the number of sites supported, and had to operate with very stringent quality-of-service targets to ensure that customers' transactions were dealt with promptly.

This article outlines some of the factors leading to the selection of a very small aperture terminal (VSAT) satellite solution, and details some of the technical considerations associated with the design, implementation and operation of this satellite network. It also illustrates how bespoke satellite solutions can be designed to provide cost-effective solutions for complex data networks.

Customer Requirements

The principal node on the communications network was the RCC in Harare, Zimbabwe, which was responsible for operating and maintaining the local area network (LAN) and X.25 servers and databases for the bank's operations in Africa. Since the availability of high-performance telecommunications infrastructure in the countries of interest was limited, updating information on the databases relied on, at best, the use of low-speed analogue or digital leased lines, or, at worst, the manual delivery of computer tapes. Consequently, many banking operations in Africa were based on information which was several hours out of date. A real-time data network was therefore vital to enable Barclays to introduce new banking services to its staff and customers.

A key requirement for the new telecommunications network, illustrated in Figure 1, was to provide Internet protocol (IP) connectivity between the LANs in each of the 88 branches in Zimbabwe, Zambia and Botswana and the RCC in Harare, Zimbabwe. This traffic would be used to support real-time enquiries from the bank's front-office staff (for example, checking customers' signatures or balances) as well as

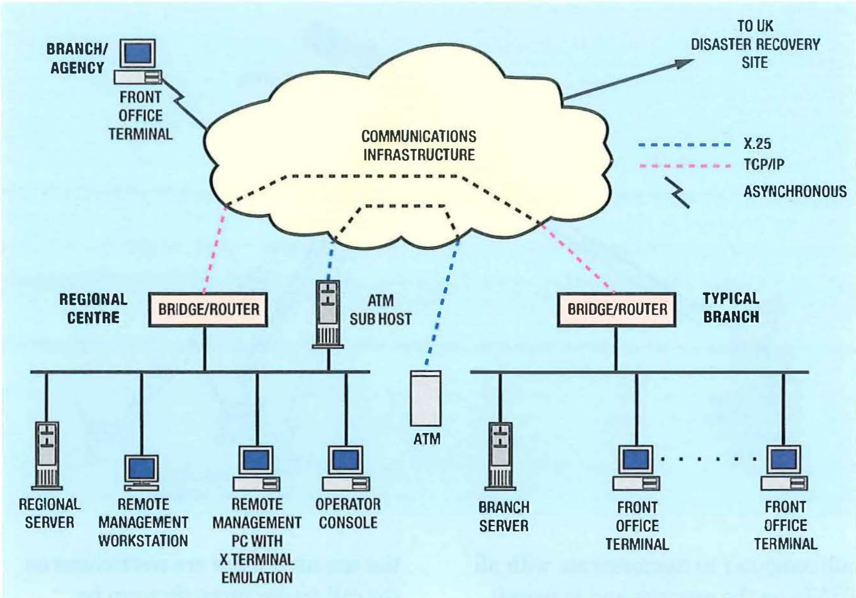


Figure 1 – Schematic of Barclays network requirements

handling background communications such as file transfers and remote printing. Many of the branches also had automatic teller machines (ATMs), operating with X.25, which had to be linked to a database, also in Harare. In addition, certain information had to be accessed from the UK for support disaster recovery.

The amount of information to be transmitted could vary substantially, depending on the differing applications in use and the time of day. Barclays decided that the most simple, yet flexible, approach at the customer application level would be to make use of remote procedure calls (RPCs). This approach provides a flexible means of transmitting a wide range of message types in a well-structured manner, while minimising the number and type of data messages to be transferred over the network. This customer application is then encapsulated within TCP/IP at the transport/network-level protocols, and within Ethernet packets at the data-link level protocol.

Approximate message sizes, including TCP/IP/LAN protocol overheads, for a variety of the message types, are illustrated in Table 1. The total traffic volumes for the network were estimated to be of the order of 60 000 customer transactions during the busy hour in the initial phase of operation, potentially growing substantially with the introduction of new applications and branches to many hundred thousand transactions during the busy hour. It also had to be recognised that customer transactions may typically involve several combinations of the individual transaction-types given in Table 1.

Another important requirement for the network was that the round-trip response times, from the branch ATM or branch computer to the server in Harare and back again, should be extremely short. A performance target of better than 3 seconds was set for 95% of all high-priority transactions during the busy hour, in particular ATM and selected real-time customer enquiries. For certain other applications the response times were less critical and could be relaxed to between 3·5 and 5 seconds; for example, for larger file transfers (see Table 1). In addition to the bank's traffic, the network was also required to support a certain amount of network management traffic, using the SNMP protocol, so that the health and status of the bank's IT equipment at the branches could be monitored.

The reliability and availability of the network were critical, both at individual branches and for the network as a whole. Target availabilities were set to be better than 99·95% for the RCC connection, while for the branches the availability was set to lie in the range 99·85% for key branches to 99·7% for branches in outlying regions. These targets were well in excess of those experienced by Barclays using the local terrestrial leased lines. In addition, the network would have to be resilient to failures of the RCC, and be capable of handling significant growth in the number of applications and countries supported. Given the above, the challenge was to design a satellite solution which would meet most, if not all, of these requirements and provide a reliable, yet cost-effective, telecommunications network.

Table 1 Summary of Approximate Transaction Message Sizes (bytes)

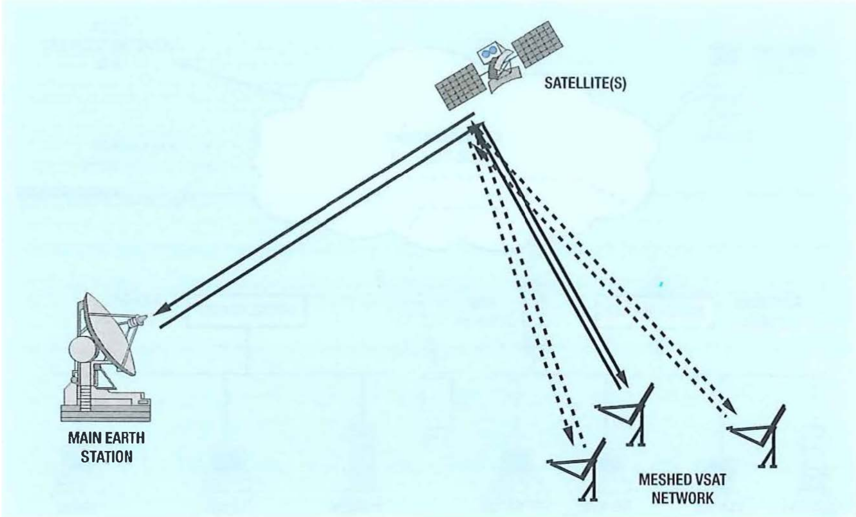
Message Type	VSAT to RCC	RCC to VSAT
Account enquiry	100	600
Withdrawal	350	100
Deposit	600	100
Foreign exchange enquiry	1100	100
Travellers cheque sell	1100	100
Signature enquiry	100	100
ATM transaction (typical)	130+230+230+90	360+160+160

Satellite Solutions

General

Satellite communications have been in use for more than 35 years and have been proven to be a powerful and flexible means of providing telecommunications services over wide geographic regions. Satellite communications have developed significantly since those early days, and are now used in virtually all countries in the world as an important part of their international telecommunications capabilities. The principal benefit of satellite commu-

Figure 2 – Schematic of typical meshed VSAT network



nications is that it can provide either broadcast or two-way communications over large geographic regions, by means of earth terminals ranging from relatively small and compact terminals (less than 1 m) to major satellite terminals up to 32 m in diameter. Today, BT operates from more than 100 major terminals in the UK to provide a wide range of national and international services that complement the company's terrestrial services. The most widespread uses of satellite communications are:

- aeronautical and maritime communications (for example, ships, planes, land mobiles etc.);
- one-way TV distribution/collection (for example, Sky, news feeds);
- international direct-dialled telephony routes to 115 countries to complement terrestrial alternatives; and
- international private circuits/business networks.

The Barclays' requirement falls into the category of a custom-designed business network requiring the use of VSATs. In general, VSAT is a term used to denote satellite communications to terminals typically 2·4 m, or less, in diameter. Over the past 10 years, many manufacturers have developed proprietary satellite systems which cater for specific markets and services. The types of satellite networks most suited to meeting Barclays' requirements were meshed networks and time-division multiple access (TDMA) networks.

Meshed VSAT Systems

Several proprietary products are available on the market but the most widespread combine the benefits of a single-channel-per-carrier (SCPC) solution with an advanced network-management system (see Figure 2). A common-channel signalling system is typically used to permit the central-hub computer to communicate with all VSATs on the network and to permit either permanent or 'on demand' circuits to be established, in a manner similar to terrestrial circuits. Once the circuits are successfully established, the customer's data is encoded and modulated into a suitable form for transmission over the satellite, with a carrier radiated for each direction of transmission.

As a consequence, this system is capable of permitting any VSAT to communicate with any other VSAT, and could be operated from the UK. This system could make use of established earth-station facilities and skills, and would meet the customer's requirements to provide communications between many sites in Africa and the central processing centre in Zimbabwe. The disadvantages of this system are that when permanent-type connections are used the system requires large amounts of satellite capacity, which is expensive. Conversely, when the on-demand capabilities are used there are restrictions on the call set-up times that can be provided—typically 1–3 seconds.

TDMA VSAT Systems

An alternative type of VSAT network is the TDMA network (see Figure 3). This type of solution is analogous to a terrestrial packet-switched network and provides capacity which is shared between a large number of satellite terminals/customers. In this system, the VSATs communicate to a central hub by using shared channels (or *inroutes*) operating in a shared manner, either in contention or in a reservation mode typically at data rates of 9·6–256 kbit/s. In the reverse direction, the central hub communicates to all VSATs using a single time-division multiplexed (TDM) signal, typically at a data rate of 64–512 kbit/s.

The benefits of a TDMA approach are the fact that the available capacity is shared between sites, which reduces the space segment requirements, while providing high instantaneous

Figure 3 – Schematic of 'star-based' packet network

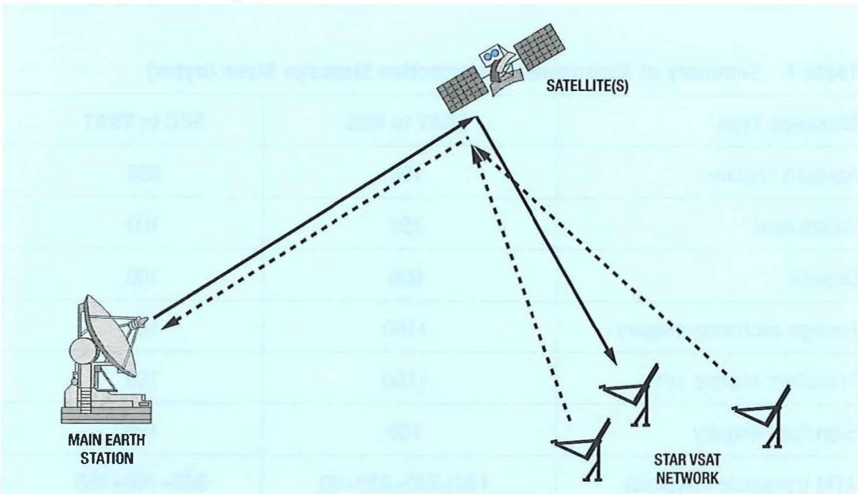
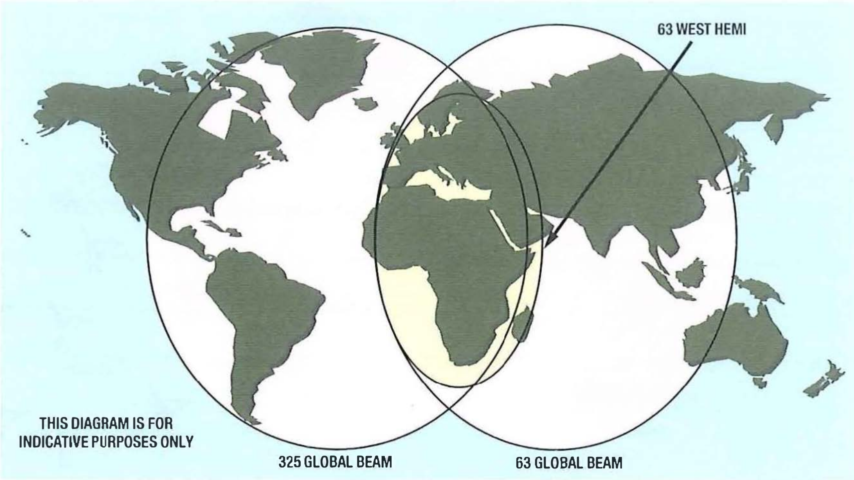


Figure 4 – Satellite coverage accessible from the UK



VSAT access rates. This can be compared with the capabilities of BT/Concert's frame-relay service which provides minimum and committed information rates (MIR/CIR). These networks use relatively low-cost terminals, although this is offset by a more complex, and costly, hub. The limitations of this type of network are that it normally operates in a star configuration, which would dictate the location of the hub at the processing centre in Harare and involve significant capital expenditure on a major new satellite uplink facility.

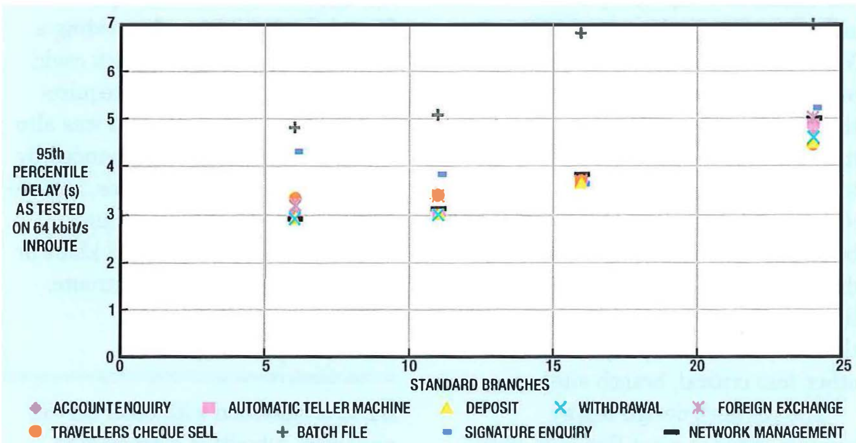
Barclays' Network—Design Considerations

Careful consideration of the customer's wide range of requirements and the available satellite technologies available led to the recommendation that a Hughes TDMA solution was most appropriate. This system was well proven in the field and offered a range of facilities, such as different satellite access methods and protocol prioritisation, which made it suitable for this particular customer's requirements. Moreover, it was proposed that the Hughes ISBN VSAT hub be situated in the UK and uplinked to a satellite providing coverage of the whole of the African continent. Several satellite options were considered (see Figure 4) but the recommended capacity was that available on a hemi-beam of the Intelsat 63°E satellite, which can be accessed from BT's communications centre at Goonhilly Downs, Cornwall. One benefit of this solution was that BT's established earth-station facilities and trained satellite personnel could be used, thus avoiding the need to provide and maintain a new large dedicated uplink terminal for the VSAT hub in Africa. This approach also ensured a simple means of providing communications between VSATs in some African countries and computer servers in the UK, either for primary or back-up purposes.

However, in order to meet Barclays Bank's requirement for all VSATs to communicate with the RCC, it was necessary for all data communications to go firstly to the VSAT hub in the UK, before being passed to the RCC via a **second** satellite connection. This approach was somewhat unorthodox as all data exchanges would require information to undergo a minimum of four satellite hops—or the equivalent of travelling six times around the earth's circumference. Careful consideration of the customer's application, the LAN and X.25 protocols and the performance targets led to the conclusion that a satellite solution with the required response times could be achieved; that is, 95% of selected transactions in the busy hour to be provided within three seconds.

Given the unorthodox nature of the proposal, and the importance of demonstrating that a satellite solution could deliver the required performance, a test bed was established to measure the performance of the proposed solution. This test bed utilised facilities readily available, albeit operating at a different frequency band and with some different transmission characteristics; however, the test bed enabled a range of different satellite access methods to be assessed and the response-time implications to be measured. Figure 5 illustrates the round-trip response times for the transmission of a variety of transaction types over the test bed. From this it can be seen that 95 percentiles with response times of less than 3 seconds could be achieved. using a transaction reservation satellite access method at an appropriate inroute loading level. This method enables capacity to be requested and reserved for short, or long, periods of time, and was found to be suited to handling the diverse range of transaction types with a consistent impact on response times. It was notable that the response times were resilient to increases in traffic loading, with the response time degrading gracefully. It was also possible to confirm that the efficiency of the network could be improved by using user datagram protocol/Internet protocol (UDP/IP) as opposed to transmission control

Figure 5 – Transaction response times



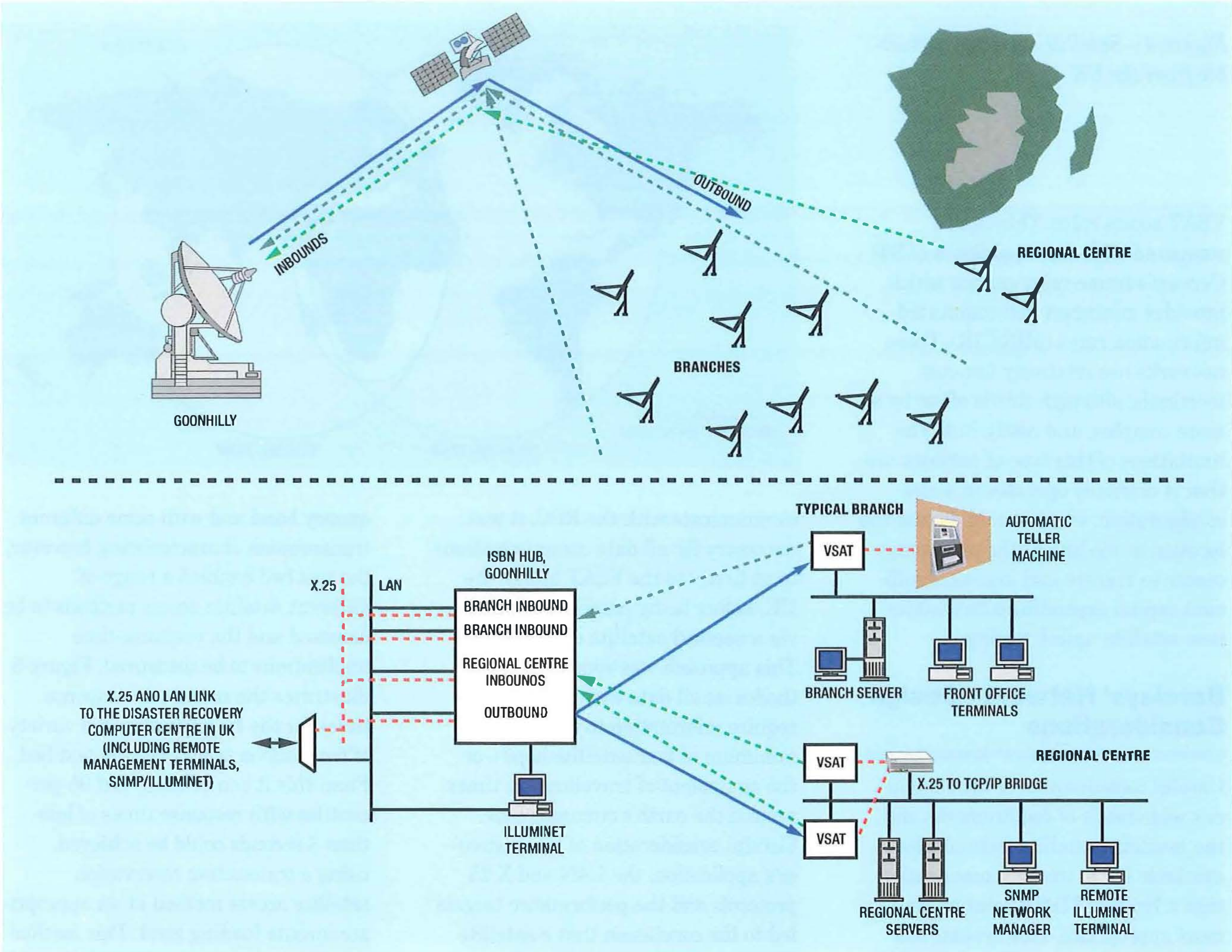


Figure 6—Network solution for Barclays network

protocol/Internet protocol (TCP/IP) as the transport protocol. UDP is different from TCP in that any errors in the packets at the transport level are not corrected but passed up to the application level to correct.

An important requirement of the network was the need to have very high availabilities, both for the network as a whole and for the RCC link in particular. As a consequence, it was recommended that the RCC should be provided with two VSATs: one acting as the primary and a second acting as a hot stand-by. Moreover, in order to optimise the availability on the different sections of the network it was further recommended that the branch VSAT terminals should be sized at 2·4 m (C band) while the RCC VSATs should be sized at 3·7 m. The use of larger dishes at this site would provide extra link margin, and hence availability, at this critical site compared with the other, less critical, branch sites.

The network design finally recommended to meet Barclays' initial network requirements is illustrated in Figure 6. It includes a TDM outroute of 128 kbit/s which provides traffic between the hub and the RCC and information between the hub and the VSATs; an inroute of 128 kbit/s operating in a 'stream' mode of operation and dedicated to the high data volumes between the RCC and the VSAT hub and finally a minimum of 6 × 128 kbit/s inroutes to provide a means for the VSATs to access the VSAT hub at Goonhilly. Test-bed simulations had successfully confirmed the feasibility of providing a VSAT satellite solution which could meet the stringent service requirements. The proposed system was also flexible since it could be expanded by providing additional inroutes, increasing the capacity of the outroute transmission rate above 128 kbit/s or providing a second TDM outroute.

Customer Proposal

BT, in competition with other service providers, submitted a proposal in March 1995 for the provision of a VSAT network. In addition to the technical design, a key element of the proposal was the ability of the selected service provider to obtain the necessary licences/agreements from the PTTs to operate a satellite transmission system and hence provide and maintain VSAT terminals in the countries of interest. After extensive work carried out by BT's Global Communications, Middle East and Africa division, working in partnership with the PTTs, and with the active support and cooperation of Barclays Bank in the territories concerned, BT was able to secure the necessary collaborative agreements. In April 1995, BT was selected as the service provider and the roll-out of the VSAT network commenced.

Implementation

Goonhilly Satellite Earth Station is located on the Goonhilly Downs on the Lizard peninsula 40 km (25 miles) from Land's End, the most southerly and westerly parts of the UK. The site

Figure 7–BT's Goonhilly 3 Earth Station

occupies an area of 64 hectares (160 acres) with a perimeter of 3·5 km (2·2 miles) and has been used for satellite communications since 1962. The station supports a wide range of aeronautical and maritime services, TV, telephony and business communications to more than 115 countries, as well as providing cable restoration for TAT9 (transatlantic), UK–Spain 4 and UK–Channel Islands 8. The site is manned 24 hours a day, 365 days a year.

The Hughes VSAT hub was installed in the west wing of the main building, which also holds most of the ground communication equipment for the international direct-dial and international private circuits accessing the Intelsat satellites. The hub made use, where possible, of existing SHF up- and down-conversion equipment used for other BT services, and accessed the Goonhilly 3 antenna, an existing 32 m C band antenna, which operates to the Intelsat 63°E satellite. The Goonhilly Satellite Earth Station (see Figure 7) enjoys the benefits of redundant RF equipment as well as an uninterrupted power supply (UPS) and back-up generators.

The VSAT hub and the system control processor were provided with high levels of hot stand-by and spare equipment to meet the stringent network availability targets. A collocated VSAT was also situated at Goonhilly to model one of the African sites and permit any design/operational problems to be simulated. This facility has proved to be extremely useful in the evaluation and diagnosis of reported faults from the distant remotes as it can be used to give an instant 'health check' on the performance of the network. The hub was successfully installed and commissioned in August 1995 and brought into operational service in October 1995.

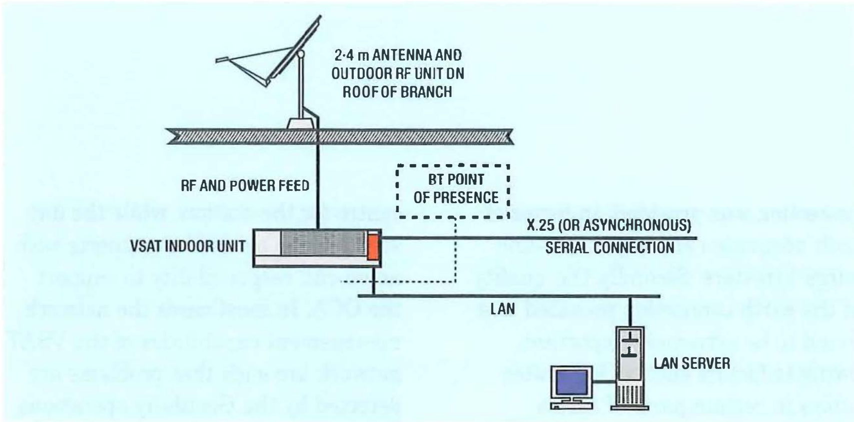


Figure 8–Schematic of VSAT configuration

A phased roll-out of the VSAT was conducted by BT's Global Communications, Middle East and Africa team, starting initially with the RCC and branches in the city regions of Harare, Zimbabwe. The roll-out then continued over an 18 month period, firstly throughout the more remote parts of Zimbabwe, and then throughout Zambia and Botswana. At each site, a detailed site survey was conducted to assess the requirements for mounting the VSAT antenna, for making the necessary ironwork and for cabling to the customer's computer facility. The VSATs are straightforward in their design, being comprised of three main elements:

- an indoor unit which provides the interface to the customer equipment—for example, 10 Base 2 connection for LAN and RS232C for X.25—and modulates the signal to an intermediate frequency for forwarding to the SHF transceiver;
- an outdoor unit comprising an antenna and SHF transceiver for transmitting the signals over the satellite; and
- an inter-facility cable which links the two and supports the customer's data, RF power lines and monitoring and control information.

Figure 8 illustrates the VSAT in schematic form while Figure 9 illustrates a typical bank installation.

During the roll-out of this network, several important practical considerations had to be borne in mind. Firstly, adequate earthing and lightning protection had to be provided. Zimbabwe has an extremely high incidence of lightning and it was essential that appropriate

Figure 9–Typical Barclays Bank branch VSAT

protection was provided, in terms of both adequate earthing and in-line surge arrestors. Secondly, the quality of the earth connection provided was found to be extremely important, owing to factors such as low water tables in certain parts of Africa during hot periods. In many cases, it was necessary to provide two completely separate earthing routes to the VSATs. Thirdly, a stable and reliable power supply was important. In all cases, the use of an uninterrupted power supply (UPS) is recommended to reduce the harmful effect of power spikes and surges common in many parts of Africa.

Once the VSAT has been installed and the antenna pointed to the appropriate satellite, commissioning of the VSAT is straightforward. Commissioning takes about 20 minutes to complete and allows the TDMA timing offset and VSAT power levels to be confirmed. Once the commissioning phase is complete, then operators at Goonhilly allow access to the network by enabling the hardware and LAN/X.25 configurations.

Operations and Maintenance

BT's customer service centre (CSC) in Manchester acts as the principal customer interface for this service, in common with BT's other services for Barclays. Faults detected by a branch are firstly passed to the regional computer centre for analysis (for example, to assess whether the fault is at an application level or due to the bank's computer equipment). In the event that problems are attributable to the satellite network, then these are relayed to BT's CSC for tracking and escalation, instigating the support of either the Goonhilly operations team or the in-country support agent. The operation of the Goonhilly station is under the control of the Satcoms Field Unit of BT's Network and Systems Operations. The operational communications area (OCA) is staffed 24 hours a day by two people and acts as the first-line fault maintenance and reporting centre for the station, while the day staff are the second line experts with an on-call responsibility to support the OCA. In most cases the network management capabilities of the VSAT network are such that problems are detected by the Goonhilly operations team and flagged to the CSC in advance of a customer fault being reported.

The 88 remote sites currently operating throughout Zimbabwe, Zambia and Botswana have produced a variety of faults, which the hub operators have dealt with. Any fault occurring on a remote site is seen in the OCA which then carries out a first-line evaluation of the problem. Over 90% of faults have been related to in-country power supply problems, ranging from the local cleaner disconnecting the personal earth station power supply to plug in the vacuum cleaner, to mains-borne spikes affecting several branches, despite the provision of UPSs. Because of the similarity in time between the UK and African countries, the type and amount of work that can be done on the hub is restricted to 'non-risk' activities within the normal working day. While the bank's business takes place over the X.25 and LAN during normal hours, the requirement for permanent connection of the X.25 for the ATMs and their use of the network to complete overnight print runs restricts even the out-of-hours maintenance windows.

Customer Relations

The service has challenged the conventional concepts of customer support. Whereas most satellite communications services require cooperation with other administrations, the management of VSAT networks is more intensive since BT's responsibilities extend to the physical connection on the customer's LAN/X.25 device and include the performance of the particular data protocols. The Hughes ISBN hub permits monitoring of the performance of the VSAT to this physical port and to information pertaining to the data protocols and the satellite link performance. As a consequence, this has elevated the customer's expectation of both support and performance. While this adds a level of complexity to the operations and maintenance requirements, it has the benefit that a strong working relationship has to be established with the customer's operations personnel and is indicative of the type of support that will increasingly be the norm when working with customers on complex, and service critical, networks.

Network Growth

Since the successes of the initial roll-out phases in Zimbabwe, Zambia and Botswana, the Barclays' VSAT network has been extended, both in Africa, the Caribbean and the UK.

In Africa, the inroute and outroute capacity has been increased to cater for the increased usage of the network. In October 1996, one year after the commencement of the service, the outroute capacity was increased from 128 kbit/s to 512 kbit/s to provide a four-fold increase in the capacity of the network. It is noteworthy that the number of inroutes on the VSAT network can be increased from the initial eight up to a maximum of 31, and consequently the network has substantial scope for expansion. Barclays Bank has more than 200 branches in Africa and the Middle East that could ultimately be connected to the network, including branches in Cyprus, Ghana, Kenya, Mauritius, Seychelles and Sierra Leone. BT hopes that, by working in partnership with the PTTs and the customer, it will be possible to provide Barclays Bank with a satellite solution which meets their needs in most countries in Africa, and the Middle East,

In the Bahamas and Caribbean Islands, Barclays Bank operate from approximately 50 branches on the islands and had a requirement to provide similar banking services to those in Africa. A design for this network was proposed which was similar to that of the African network but with a number of important differences. Firstly, because of the risk of tornadoes, it was considered necessary to restrict the size of the VSAT to 1·8 m to minimise the wind loading and simplify rapid restoration in the event of a major service interruption. Secondly, as a consequence of the satellite capacity required to connect to the Caribbean, the VSAT hub could not 'see' directly its own transmissions. It was therefore necessary to propose a more complex timing arrangement which involved the provision of additional reference timing VSATs. In September 1996, less than one year after the launch of the Barclays Bank African network, the network was expanded to provide a dedicated outroute and associated inroutes to serve Barclays' branches in the Caribbean and Bahaman islands.

In the UK, the service has been expanded to provide extensive 'breakout' facilities for the LAN, X.25 and network management traffic to permit the branches in certain countries to be supported by computer servers in the UK for full-time and disaster recovery operations. This has the benefit of providing Barclays with a more resilient network while at the same time increasing the efficiency and improving the response times of the satellite network.

Finally, an important aspect of the network design has been its ability to cater for growth in the traffic. The first year of operation has seen a steady growth in the number of sites operating on the network. In future years, an equally important consideration will be the number and type of new/different transactions required to be supported. As new applications and services are added to assist both the bank's users and its customers, the satellite network will be required to grow in a flexible, yet controlled, manner. The satellite solution provided can support significant growth. By careful design control and change management, the network has the potential to trade off key commercial considerations, such as application response times and network capacity, to ensure an effective telecommunications network which can meet Barclays' service requirements.

Conclusion

This article has illustrated that VSAT networks can provide a flexible and cost-effective means of providing advanced telecommunications services to customers with service requirements with large numbers of sites spread over large geographic regions. By careful design of such networks it is possible to deliver solutions which support advanced data protocols, provide a responsive and flexible telecommunications network, and at a cost which, in some cases, is less than terrestrial alternatives. Moreover, such custom-designed satellite solutions can be designed to complement BT's terrestrial services to provide solutions to multi-national companies on a truly global basis.

Biographies

David Elliott
BT Networks and Systems

David Elliott heads a group responsible for the design and implementation of VSAT networks. He obtained B.Sc. and Ph.D. degrees in Electrical and Electronic Engineering at Queen Mary College, London. Since joining BT in 1981, he has worked on a wide range of telecommunications projects including the specification of international satellite systems, evaluation of digital satellite modem/coding techniques and providing consultancy on satellite systems on behalf of BT. He has represented BT at CCIR meetings concerned with the specification of satellite performance and managed teams responsible for the design and implementation of BT satellite services including Satstream, Satstar and Offshore.

David Biggs
BT Networks and Systems

David Biggs studied Marine Communications at Plymouth before serving as a radio officer with the Royal Fleet Auxiliary. Joining BT in 1981, he has been involved with the introduction of digital carriers on Intelsat satellites and the operation and maintenance of ground communications equipment at Goonhilly Satellite Earth Station. Dave is presently the Goonhilly Network Operations Manager with responsibility for traffic in both the Atlantic and Indian Ocean regions. Dave is an active member of the IEEIE and helps the City and Guilds of London Institute with the examination of handicapped candidates.

Russell Simpson and Sarah Meegan

From Regulatory Requirement to Business Excellence

The Role of the Internal Audit within BTNI

This article plots the quality journey of BT Northern Ireland, embracing Total Quality Management, company-wide registration to ISO 9000 and the all-encompassing European Quality (Business Excellence) Model, and describes the progressive roles of the internal audit function in achieving such an advanced state of quality development.

Introduction

BT Northern Ireland (BTNI) was formed in 1984 when the parent group British Telecommunications plc (BT) was privatised. The company is under the control of a Chief Executive who is responsible for all operational and support functions within Northern Ireland. BTNI serves a population of 1·6 million and manages a network of over 665 000 exchange lines.

BT does business in the most open telecommunications market in the world. BTNI faces competition for local service from cable TV, other network operators vie for its long-haul traffic and many suppliers offer alternative terminal equipment. BT's day-to-day operations are subject to regulation by OFTEL, a government appointed regulatory body which, at the time of writing, requires the company to hold its prices at 7·5% below the rate of inflation.

During the last 10 years, BTNI's very survival has depended on successful performance in this highly competitive yet tightly regulated environment. It faced the imperatives of moving from bureaucratic monopoly to customer responsive service provider, growing income, reducing costs and minimising loss of market share. Simultaneously, BTNI had to improve the performance of a network which at privatisation comprised obsolescent electromechanical and first-generation electronic exchanges quite unsuited to the information age. Managing the transition from analogue technology to leading-edge digital systems posed a major managerial challenge.

All the while, there was a background of continuing civil unrest.

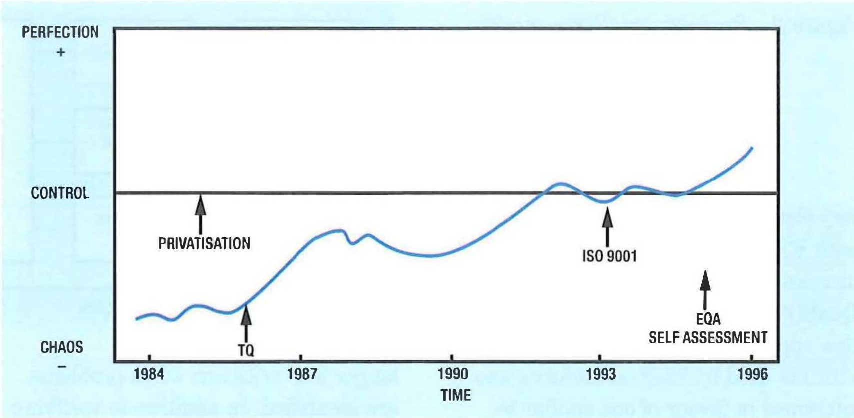
In the Beginning—Total Quality Management

As BTNI emerged from the public sector, it was realised that if it was to be successful, a significant cultural change had to be stimulated and managed within the organisation. Accordingly, BTNI embraced enthusiastically the philosophy of Total Quality (TQ) using TQ as a medium to drive continuous improvement into all parts of the company.

The formal TQ initiative in BTNI commenced in 1986 (see Figure 1) with a 'top team' conference for the Chief Executive and his board members. After the conference, the team drew up BTNI's vision statement, set in train a study to determine the cost of quality and established the Quality Council. The strategy adopted by the top team for the implementation of TQ was based on changing managerial culture and style, plus concentration on meeting customer requirements.

Reportedly, 80% of TQ programmes fail and by 1990 the outcome of the BTNI initiative could at best be described as disappointing. Despite management commitment, enthusiasm from the participants and allocation of considerable resources, tangible results were few. (It is only now that the long-

Figure 1 – Quality performance of BTNI since privatisation



term benefits of a programme that encouraged teamworking and the use of TQ techniques coupled with a thorough understanding of customers' requirements are being realised.)

Meanwhile, as BTNI endeavoured to change its culture, the external environment was altering rapidly.

Phase 1 (1987–1990)—Conformance as a Regulatory Requirement

Following liberalisation of the UK public telephone network, the Department of Trade and Industry made it a requirement that only competent organisations would be permitted to maintain switching equipment connected to the network. Accordingly, the Scheme for Accreditation of Call Routing Apparatus Maintainers (SARCRAM) was established to license maintainers. The scheme was based on BS5750, Part 2, with registration and compliance verification carried by the British Standards Institution (BSI). Approximately 20% of the workforce, both engineering and sales personnel, were directly affected by SARCRAM. Within BTNI, the management system encompassed quality procedures, work instructions, processes, performance targets, spares holdings, material handling, tools, calibration and vehicle contents.

Maintenance of privately-owned switches was a key market for BTNI, so gaining and retaining SARCRAM accreditation was an organisational priority.

SARCRAM was BTNI's first experience of a formal quality management system with its attendant requirement for an internal audit process and the BTNI Quality Office implemented a programme of audits well in advance of the BSI's first visit. The newly-trained auditors, drawn from maintenance specialists, approached their task with zeal. While internal auditing was seen as a necessary evil to achieve SARCRAM accreditation, BTNI recognised that auditing could deliver benefits such as more disciplined and consistent processes. However, the potential of the audit process to be destructive to the TQ culture was not appreciated.

Although BTNI managers in the 1980s were familiar with reviews and investigations (for example, for productivity improvement projects), the management audit as a 'formal activity to examine independent objective evidence and verify compliance with specified requirements' (ISO 10011[1]) was quite foreign as a concept and was accepted without enthusiasm. Auditees felt that audits were being imposed on them purely to find fault. Inevitably, therefore, auditees adopted techniques to hide weaknesses during the audit. Typical advice given to auditees was 'answer only what is asked, do not volunteer anything'!

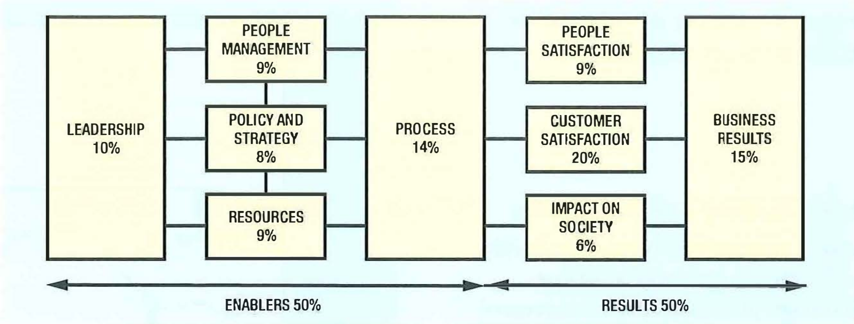
The company culture at this time resulted in the auditors taking ownership of the system, policing it and driving users towards conformance. Bearing in mind BTNI's lack of maturity in quality management and a historical tendency for managers to operate individually and act without documentation, then the basic non-conformance audit was probably the best approach at that stage. The effectiveness of this approach can be judged by BTNI's early SARCRAM accreditation in 1989. This was followed in 1991 with accreditation to the complementary Scheme for Accreditation of Call Routing Apparatus Installers (SARCRAI) resulting in 35% of the workforce operating to BS5750, Part 2.

Phase 2 (1990–1995)—Continuous Improvement Using ISO 9001

Having recognised the value of formal management systems as a basis for continuous improvement, BTNI was keen to expand the existing system throughout the organisation, and in the summer of 1991 a project was initiated to achieve company-wide registration. While the quality management system (QMS) implementation team developed the system to cover those parts of the organisation not operating to SARCRAM/SARCRAI, the Quality Office reviewed the internal audit process in the light of experience with BS 5750. The Quality Office recognised that continuous improvement was a survival issue, and believed that, with its involvement in the day-to-day operations of the business, it was in a position to reinforce the policy and strategy of the organisation. Like Oakland[2], BTNI believed that internal audits are the most honest and stringent form of assessment and as such could play a vital role in continuous improvement. However, BTNI was concerned that the 'gotcher' style of auditing adopted initially, although successful in achieving accreditation, had generated a defensive mind-set amongst auditees. This mind-set, compounded by the ongoing reorganisation and downsizing within BT, had resulted in a fear of failure among auditees and a pressure to achieve 'nil' non-conformances at audit. This in turn created a culture where the auditor was not welcome and problem areas were being concealed: the antithesis of continuous improvement.

The BTNI Board decreed that all managers and their teams would be audited twice a year. Not only would this enable BTNI to establish the health of the management system[3] but it also offered a unique channel for communicating the quality ethos and spreading best practice throughout the organisation[4,5]. As well as the manda-

Figure 2—Business excellence model



tory elements relating to compliance with BS 5750, audit scope would be increased to include the field of Total Quality (Table 1). To get the best from this approach, the punitive policing attitude used by internal auditors was jettisoned in favour of one similar to Stebbing's[6] 'The Auditor—Guide, Philosopher and Friend'. Future audits would attempt to develop an environment of trust between auditor and auditee and positive points as well as non-compliances would be identified.

The number of internal audits carried out within BTNI rose from 160 in 1990 to a peak of 800 in 1994 (Table 2). The effectiveness of the approach resulted in BTNI becoming the first operational BT unit to have organisation-wide registration to ISO 9001 in February 1993. Significantly, the relationship between auditor and auditee has now matured to the point where audit resources are stretched by unsolicited requests for 'educational audits' and 'consultancy in advance of process changes'. This indicates that the audit is now seen as a positive rather than a negative experience and that auditees no longer fear criticism when problems are identified. In addition to verifying ISO 9001 compliance the scope of audits has been widened further to include BABT 600[7] and currently plans are being made to add ISO 14001[8] to each audit.

Table 1 Quality Issues Included in Internal Audits

BT values
Quality policy
Relevance of QMS to TQ
Customer–supplier relationship
Cost of poor quality
Performance management:
Goal setting
Monitoring
Review process
Quality progress inside and outside BT
Team meeting process

Table 2 Audits

Year	No. of audits
1990	160
1991	160
1992	664
1993	708
1994	800
1995	600

Phase 3 (1995..)—Business Excellence

Achievement of BTNI-wide ISO 9001 registration was not seen as an end in itself and the BTNI Board selected Self Assessment using the Business Excellence Model (or European Model for Total Quality Management) to continue the improvement drive. The model (Figure 2) with its structured approach to the pursuit of Business Excellence by combining TQ good practice with sound results provides an excellent framework to manage continuous improvement.

Managed by the Quality Office, six externally assessed submissions have been completed to date. Use of the Business Excellence Model has re-energised BTNI's approach to TQ and provided a valuable learning tool. While continued conformance with ISO 9001 and BABT 600 remains an operational imperative for BTNI and is the driver for the internal audit programme, elements of the Business Excellence Model are being included in audits (Table 3) in BTNI's pursuit of the 'ultimate audit'.

BTNI's success in the various Quality Awards (Table 4) is at least partially due to the effectiveness of using the internal audit process to roll out TQ best practice on a face-to-face basis with managers, rather than limiting the audits to identifying system non-conformance.

Finally, in line with the Business Excellence Model, second-party audits are being carried out on BTNI's suppliers with the objective of introducing suppliers to BTNI's quality ethos. The role of the auditor in this case being one of advisor identifying areas of improvement for mutual benefit with the aim of leaving the audited company with something of value[9]. This is effectively the same aim that BTNI identified for first-party audits prior to implementation of ISO 9001 in 1991. BTNI believes that for supplier relationships, these proactive second-party audits may have more value than a third-party audit[10]. An outline of the topics covered in second-party audits is given in Table 5.

Table 3 Typical European Quality Award Topics Covered During Audit

Leadership	Management by walking around (MBWA) Reward and recognition Promotion of TQ Quality improvement projects
Policy and Strategy	Strategy formulation Strategy communication Benchmarking
People Management	Recruitment and training Performance review New ideas
Resources	Information security Supplier development Application of technology

Table 4 Quality Award Successes

- Northern Ireland Quality Award winner, 1994 and 1996
- Supreme Irish Quality Award winner, 1994
- BT Group Quality Award winner, 1994, 1995 and 1996
- UK Quality Award finalist, 1994 and 1996

Table 5 Second-Party Audit Themes

Approach to TQ
Management systems
Contract management
Environment management
Health and Safety

Summary

In eight years, BTNI has progressed from basic non-conformance auditing of a specialised function purely to satisfy a regulatory requirement, to organisation-wide auditing for continuous improvement. This equates with the static and dynamic auditing modes described by Barthelemy and Zaire[4] (Table 6).

Conclusion

The auditor is rarely popular and in recent years this journal has variously described internal audits as 'providing management with confidence that quality exists'[11] and 'coming round after the battle to shoot the wounded'[12].

The BTNI experience demonstrates that the internal audit process if managed proactively can be a catalyst for change, helping to coalesce the sometimes conflicting approaches of ISO 9000 and TQ, so that organisations can proceed along the continuous improvement path in a systematic fashion.

Acknowledgement

The authors thank Norman McLarnon, MBE, for his support and encouragement during the preparation of this article.

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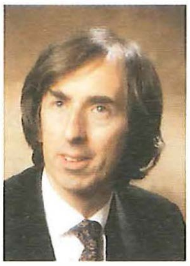


Russell Simpson
BT Northern Ireland

Russell Simpson is a Quality Assurance Manager with BT Northern Ireland and, as such, has a heavy personal involvement with TQ and ISO 9000. He began his career in 1969 as a direct entrant manager with the Network Planning Department, Telecommunications Headquarters. Before becoming a quality practitioner, his management experience included equipment planning, operator services, telecommunications consultancy and publishing. He has been involved with self-assessment using the European Model since 1993 and acts as a senior assessor for the Northern Ireland Quality Award. He compiled the BT Northern Ireland submission for the 1996 UK Quality Award.

Sarah Meegan
University of Ulster

Sarah Meegan is Lecturer in Business Improvement at the Ulster Business School, University of Ulster. Her main research interests are in quality management and organisational development. In particular, she has published journal articles and conference papers on the organisational transition from ISO 9000 to TQ.

Table 6 Barthelemy and Zairi's Comparison of Static and Dynamic Auditing

Static Auditing	Dynamic Auditing
Reduces the scope of audits	Enhances acceptance of audits and reduces fear
Enhances cost-effectiveness	Informs management and staff more adequately
Simplified auditing and auditor qualification	Identifies opportunities for quality improvement
Allows for employing less-qualified staff	Disseminates new knowledge and experience in quality assurance
Confirms meeting standards	Induces innovation
Recognises adequate performance	Enhances 'cultural change' in the company
Suffices for quality programme registration	Encourages delegated decision making, integration and cooperation
	Reviews all procedures and standards
	Provides greater challenge and recognition for auditors and auditees
	Enhances the role and status of quality assurance

Mike Webster

Investors In People

The drive for quality in recent years has produced many initiatives. Investors in People sets the level of good practice for improving an organisation's performance through its people. Divisions in BT have embraced this standard in order to further improve the organisation's quality.

What is 'Investors in People'?

Investors in People is the national standard which sets a level of good practice for improving an organisation's performance through its people. The standard was developed during 1990 by the National Training Taskforce in partnership with leading national business, personnel, professional and employer organisations such as the CBI, TUC and Institute of Personnel and Development (IPD).

The standards movement in the United Kingdom evolved from the need to establish nationally-recognised criteria to underpin quality work at every level; for example, ISO 9000, which measures the quality of core processes and systems. Investors in People is the only quality standard for people. It complements ISO 9000 but is very different from this and other process quality awards owing to its focus on people issues. It is essentially about results—not procedures. It is a practical tool for the continuous improvement of both the organisation and its people.

The Investors in People Standard

The standard provides a national framework for cohesive action by:

- specifying the principles which tie training and development activity *directly to business objectives*;
- ensuring that resources are committed to training and development and are put to the most effective use; and
- providing a clear benchmark of good practice in training and development against which any organisation, large or small, can measure progress towards improved business performance.

The standard is based on 23 criteria grouped under four major headings—commitment, planning, action and evaluation.

Commitment

An Investor in People is committed to training and developing all its employees to help achieve its business objectives.

Planning

An Investor in People regularly reviews the training and development needs of all employees.

Action

An Investor in People takes action to train and develop individuals beginning from when they join and continuing throughout their employment.

Evaluation

An Investor in People assesses its investment in training and development to ensure success and to seek continuous improvement.

One example of an Investors in People criterion is: *'A written plan identifies the organisation's training and development needs, and specifies what actions will be taken to meet these needs'* which comes under the heading of planning.

Assessment

Assessment is carried out by external assessors who are appointed by:

- Investors in People UK Ltd.;
- training and enterprise councils (TECs) (in England and Wales);

- local enterprise companies (LEC) (in Scotland); or
- the Training and Employment Agency (in Northern Ireland).

The process of assessment involves the production of a 'portfolio' of evidence against the Investors in People standard and a series of visits by assessors to interview a representative sample of people drawn from all grades and levels within the company, including casual and contract staff.

Why is Investors in People Important?

Nationally, the UK needs to maintain and increase its competitive position in world markets. To increase its competitiveness the UK must increase its commitment to developing a more highly skilled and flexible workforce. But to be effective, this increased commitment must be integrated with action aimed at improving business performance.

For BT there has been a continuing commitment to quality standards embracing ISO 9000 and culminating with its pursuit of the European Quality Award. By meeting the Investors in People standard, BT will be putting in place processes which are key to implementing the European Quality Model.

It is important for BT to be seen to be as competitive as possible within UK industry and thus to match, and then beat, the efforts of other top UK companies. Of the top 100 companies 47 currently either have the standard or are working towards it.

Several parts of BT have become recognised as Investors in People already, having decided that the benefits were significant enough to warrant the early effort required for this achievement. These are the whole of Personal Communications division, Cellnet, Yellow Pages and Systems Integration within Networks and Systems.

To endorse the importance of gaining Investors in People, Sir Peter Bonfield issued a formal commitment in writing that the rest of BT would be ready for Investors in People accreditation by the end of March 1998.

How Does BT Gain From Being Registered?

Investors in People links directly to several of the people-value programmes which are running within BT, for example the *It's a better life ..* programme in Personal Communications division and the *Investing in Our Future* programme in Networks and Systems. Investors in People can and has acted as both a driver of the programmes and a measure of how far they have been achieved.

Some of the major benefits to be gained from Investors in People recognition are expected to be that it:

- ensures that training and development is in support of a real business need that meets the needs of individuals, in the context of business objectives;
- provides a significant increase in employee competence, knowledge and job satisfaction;
- demonstrates to BT people, shareholders, stakeholders, competitors and customers BT's commitment to recruit, develop and retain the best people;
- measures the success of the implementation of BT people values during the merger with MCI and the move to trading units;
- provides BT with an opportunity to develop a workforce who are participants in the company's strategy—rather than spectators;
- ensures that BT develops a culture of vision, leadership and innovation, with a strong customer and market focus;
- directly links to the BT aim to win the European Quality Award by providing external measures of excellence in the people management and people satisfaction areas; and
- provides BT with a tangible measure of the outcomes of the improvements of its development process.

Have Other Companies Benefited From Achieving Investors in People Status?

A review of the standard was carried out in 1995 with extensive research among employers and other relevant organisations. The result was an overwhelming endorsement of the standard itself and its four principles.

In particular, organisations picked out the following factors as being of special importance to them. The standard provided:

- the opportunity to review current training and development against a good practice benchmark and an accurate audit of current strengths and weaknesses;
- a framework for planning future strategy and action; and
- a structured way to improve the effectiveness of training and development activities.

What are the Costs to BT?

There are divisional and directorate teams who are spearheading the drive towards gaining Investors in People, but none of these are full-time, all have Investors in People as one of many responsibilities.

These teams are at present mainly involved in diagnosis, answering the question: where does BT stand in relation to the standard and the subsequent action planning to close any gaps that exist. A further team within Human Resources and Development Services are constructing a corporate portfolio which will later be mirrored in the divisional and directorate portfolios.

At the individual level, it is important to realise that there are a lot of excellent practices and processes in place already but to achieve Investors in People recognition the company will need to ensure that it is using these fully to get the best out of them, both for the business and the individual. Thus, it is more about making optimum use of what the company already does and has, rather than developing anything new. Individual teams may well be asked to review existing processes and suggest improvements.

Further individual involvement in the gaining of Investors in People will be through a number of people chosen to be interviewed by the assessors. The interview usually takes up to three-quarters of an hour and involves discussing several straightforward questions about training and development within the company.

Having said that, it will be essential that everyone within BT is involved to the extent that they understand and support why the company is trying to gain Investors in People and the implications for them personally. There will be various communications programmes to make people aware of what is happening.

Further Information

BT has a series of Web pages on its intranet site for Investors in People which can be accessed from the Human Resource and Development Services home page. These pages also give details of the divisional contact points:
http://mhwww.boat.bt.co.uk/dandt/index.htm

Literature about Investors in People is available from:

Investors in People UK
4th floor, 7-10 Chandos Street
LONDON
WIM 9DE
Tel: (0171) 467 1900

Investors in People UK has its own web pages:
http://www.itl.net/features/iip/cover.html

Biography

Mike Webster
BT Group Personnel

Mike Webster joined BT in 1986 following a period as a trainer in an IT training company. In BT, he worked as a support manager for MS DOS, developed the advanced DOS course and was a trainer on the DOS and other PC based courses. Moving to Business Systems Support, he became a trainer specialising on spreadsheet and database courses. In 1989, he was promoted and moved to the Development and Training Project Management Support Group and specialised in external training policy. Since 1994, he has worked as the accreditation manager within the NVQ Support Group in Development and Training and he has recently provided support to the Corporate Investors in People Team.

Lucy Powell

Innovation 97

Innovation 97 at BT Laboratories in April 1997 gave visitors the opportunity to see some of the latest of BT's research, development and technology, and to experience how that technology might influence the future of communications

Technology Showcase

Of the 6000 or so visitors to Innovation 97, and the countless more who read all about it, there can surely be no-one who failed to be impressed by the sheer scale and prestige of it all.

Billed, and proven, as one of the highlights on BT's calendar, the event at BT Laboratories in April was a rare chance for a variety of VIP guests to see for themselves the latest in the company's research, development and technology. Most importantly, those visitors—customers, BT and MCI senior managers, joint venture partners, journalists, opinion formers and many other interested parties—were able to see and understand how that technology might actually work. No bland technology on show here just for the sake of displaying the latest gadget, then. This was a live demonstration of how BT is relating the future to business with a showcase of here-and-now and short-term developments.

'Did we achieve our overall objectives? Yes, I'm quite sure we did,' said Innovation 97 manager Dave Tonge. 'We set out to stage an exciting and stimulating experience, and we know we did—the feedback has been overwhelming.

'We wanted to build stronger relationships across all parts of our business, and we know from our partners that this has been achieved. And, as well as promoting an ongoing dialogue between our customers and their account managers, we also wanted to give our customers the opportunity to talk directly with our technology experts.'

Innovation 97 employed many principles of basic business management: understanding who your customers are and how to reach them, getting close to them, and providing the services they require. This careful theming resulted in some 56 displays throughout seven zones, described in the following sections.

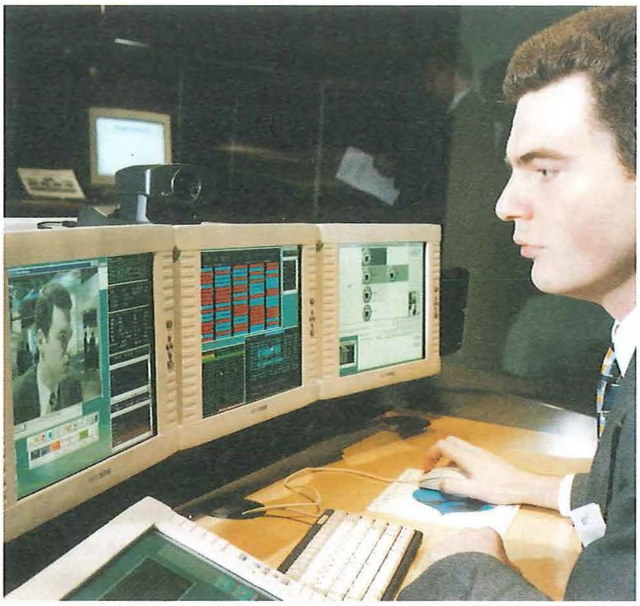
Innovation 97 attracted more than 6000 visitors, who enjoyed the 'experience' and got close to the portfolio of now, short term, and the future.

Multiple Choice

This first zone of Innovation 97 recognised that customers are not only the lifeblood of any business, they are now faced with a great range of choices, largely thanks to the advances of technology. The paradox now facing every supplier is that channels to market are becoming both more diverse and more personal. According to Multiple

Lucy Powell was the Innovation 97 BT Internal Communications Manager

Airline Interactive Services (ALIS) provides communication links from the ground to the sky, allowing airline passengers to enjoy a range of business and entertainment facilities. Interactive shopping will soon also be available.



The Concept 2010 desk works intuitively with dealers, generating information, acting intelligently upon it, and giving an holistic view of the market.

Choice, customers will be reachable any time, any place, anywhere, and this zone showed customers many achievements to date and suggestions for the future.

Attracting much attention here were multimedia kiosks, providing public access to multimedia information, irrespective of location. From news services to tourist information, from travel guides to hotel booking, from medical to charity advice, from advertising to market research, multimedia kiosks will impact not only BT's business customers, but also the man or woman in the street. And they are not far away—large-scale trials of the kiosks are already underway in London.

From the high street to the air, the customer is still contactable even 50 000 feet off the ground, according to Airline Interactive Services (ALIS). Already widely-used commercially, ALIS enjoys several information facilities, and will soon offer interactive shopping and, in conjunction with smart cards, personalised services.

Also on show was Future Home Office, offering big business functionality to the small office at home via products such as CallScape and DVS100; Education on Demand, delivering personalised learning to the desktop via Internet and multimedia services; On-line Multimedia Entertainment including Wireplay and LineOne; Telecare, showing concepts in hand designed to help people retain their independence; and Integrated Communicators, streamlining access to communications by integrating systems into products such as Orbitor, based on Java-enabled telephones, and MoBIC, which will offer global messaging and communication capabilities in the next year or so.

Positive Contact

Focusing on the part communication has to play in maintaining customer loyalty, the second zone took a two-pronged approach: how customers might use BT technology to maintain contact with their customers, and how BT does so itself. Call centres, the fundamentals of computer telephony integration, voice automation, multimedia call centres and the Internet as a trading environment were all featured here.

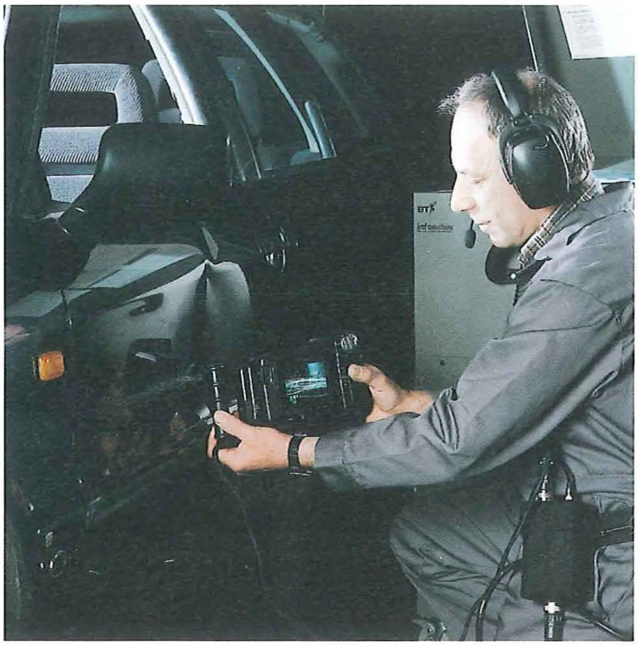
For example, Computer Telephony Integration showed how to increase productivity by 400 per cent by the efficient routing of calls to a call centre, while Multimedia Call Centres and Call Centre Design and Management looked at widening the dimensions of customer contact and optimising existing call centres to ensure valuable business is never lost.

Voice Automation, supported by the Brimstone directory prototype currently in trial at BT Laboratories, showed the technology of TouchTone and speech recognition in a functional application. Alongside it in this zone was WebWorld, a hosting and referral service helping users get the most out of this channel to market; Data Mining, techniques of which are also currently in trial, used to extract marketing intelligence from a web site; JoinIT, which allows the trading of expertise on the Internet; and 3D Retail, which not only adds a whole new dimension to shopping via the Internet, but could also form part of the basis for other technologies, such as the home local area network (LAN).

Finance and Security

Electronic trading systems will clearly form an everyday part of people's working, shopping and entertainment lives, and security is a fundamental issue. BT is investing heavily in this area, as well as systems designed to aid the City, as the displays in zone three demonstrated.

For example, Iris Scanning, which uses biometrics as a means of identification, showed how the iris, with more than 10 times the number of identifiers found in a fingerprint, might provide foolproof identification and security, while eradicating the need for passwords and personal



Infomotion, which will cut the travel costs and overheads of an insurance representative, links office-based assessors to damaged vehicles anywhere in the country.

Traumalink, now in trials with Norwich and Norfolk Hospital, transmits high-quality digital pictures from the ambulance at the scene of an accident, directly to the consultant in accident and emergency, thus describing the whole scenario.

identification numbers (PINs), and perhaps, one day, even passports.

Concept 2010 showed a trading desk that thinks intelligently, working intuitively with the dealer, automatically retrieving specific portfolios according to share-price fluctuations, and even calling the investors to advise them. The desk also shows a holistic view of the markets, uses animated graphics to alert the dealer to commodity movement, and even responds to speech commands.

Also on show in Finance and Security was Electronic Trading, with on-line ordering for quicker delivery and other advantages designed to create better trading relationships; INFER, allowing fund managers to pinpoint the right information at the right time; Customer-Focused Billing, reflecting changes in structure and business priorities; and Knowledge Management, using tools such as ProSumms and NetSumm to provide fast and accurate abstracts of text.

Creating Order

Harnessing order and creating an infrastructure in a communications network, not an easy task, was the entire focus of the fourth zone, which recognised that IT can be both a powerful ally and a dangerous enemy.

Managed Solutions, for example, showed how harnessed technology allows for shared risk and reward, while a display of ServiceView and MCSS demonstrated the innovative technology BT uses to build a shared view of its major customers.

Groupware Services showed how to maximise IT and communications for the extended enterprise; for example, sharing applications and information, re-engineering and automating business processes, managing services and IT across a whole network, and delivering a single integrated helpdesk and service management system.

Intranets were also on show, showing the distribution of corporate intelligence as a tool in decision making. BT runs one of the largest intranets in the world and has already shown that a return on investment of 1500 per cent can be realised through a successful intranet implementation.

Centralised IT Management, New Service Construction, Intelligent Network Design and Operator Services Information Systems (OSIS) also formed part of this zone, demonstrating a range of benefits in IT management, from a better control over IT investment to a greater exploitation of legacy systems.

In Good Hands

Reliability, resilience and the future came under the spotlight in zone five, where the benefits of forming a long-term technology partnership with BT were made very clear. The zone demonstrated BT's commitment to investment, and underlined its credentials in the development of broadband and access network evolution, new and emerging data services, and in its own customer-handling systems.

Artificial Intelligence attracted much attention, with intelligent robots and on-screen fish both used to demonstrate programs that can solve themselves and software that can think like people. Although replication of nature is not possible in the foreseeable future, BT is learning from it and using new techniques as a result.

BT also showed its worth as a business partner via Customer Handling Systems, such as SMART and Foggy Windows, and Sheriff, an advanced global telecommunications fraud management system developed by BT and MCI. Building Broadband showed how asynchronous transfer mode (ATM) and synchronous digital hierarchy (SDH) network design supports the building of the information superhighway, while Web-based

Inside the VisionDome, an immersive environment with stereoscopic sound, the ability to visualise and experience without actually being there.

SmartSpace—a semi-immersive environment with wrap-around projection screen and 3D sound. The work space of the future?

Shared Spaces are virtual environments in which avatars—likenesses—mirror the words and actions of the real world. This is virtual networking for on-line communities.

Network Management used the superhighway to control equipment and test data circuits.

Also on show in this zone were Fasttrack, BT's new software development technique used to speed up the delivery of tools to its people; BT Data Services, such as SMDS, ISDN, Frame Relay and CellStream, Evolving Access Network, that will make copper and fibre work together; and Integrated Fixed and Mobile Services, which will mean the same quality and performance from both fixed and mobile services, even faster transmission speeds to a multi-service communicator, and data-intensive use by digitally enhanced cordless telecommunications.

Fred Briggs, MCI's Chief Engineering Officer, at Innovation 97.

Time and Motion

As the advertisement says, why not change the way we work? Do we really need to make all the journeys we do? Travel is an inefficient use of time, and this zone showed some of the ways in which BT is helping people achieve not only greater business efficiency, but also greater personal freedom.

From Infomotion, which might allow insurance adjusters to assess crash damage remotely from the office, to Traumalink, which assesses accident injuries before patients arrive at accident and emergency departments (and is now on trial), the challenge of getting there (or not) was largely removed by this zone.

Also on show was Agent-based Workflow, where BT's ADEPT project is exploring how software agents might automate many routine negotiations, and make inter-business trading more effective. Advanced Work Scheduling demonstrated the organisation of people to best effect, to get the right person to the customer, on time, every time, while Position Dependent Systems, such as the pre-journey planning system MoBIC, use satellite positioning systems to help people lead better and safer lives.

Quadrant, a consortium comprising BT, Motorola, Nokia and TRW, showed the use of effective mobile radio communications solutions to meet the needs of public safety users, while a display of Public Warning System, based on the assumption that most people have a telephone, showed how, in the event of a disaster, a generic text-to-speech warning can be quickly and automatically generated within a certain area, within just seconds.

Redefining Life

The final zone gave a longer-term view of BT's research and development. A climactic preview of the way people will access information and each other in the new millennium, zone seven also recognised that the technological advances of the past few years go far beyond the commercial world, touching society as a whole.

From VisionDome to SmartSpace, from Shared Spaces to Helpful Agents, this zone offered a feel of how we might live and work in the future, with 3D immersive spaces, virtual meetings courtesy of avatars, tagging devices, and new design perspectives. Also on show were 3D Modelling, demonstrating many of Syntegra's capabilities, Distributed Office Telephony, Advanced Cellular Communications, Advanced Mobility and Advanced Audio Conferencing.

In Conclusion

Stimulating and exhilarating—that was the general consensus of opinion among the visitors to these displays. The key to Innovation 97 was the application of technology on display to customers' businesses today, with, as one might expect in the research and development world, a careful eye on the future.

'Are You Alright?'

Telecommunications and Humanitarian Assistance

The theme for World Telecommunication Day, organised by the International Telecommunication Union on 17 May this year, was 'Telecommunications and Humanitarian Assistance'. The Day aimed to highlight the growing importance of telecommunications in the field of international aid, and the potential of new technologies such as mobile and global satellite telephones in helping out where traditional links may not exist. This article highlights some of the issues.

Cyclone Alert!

At the Geneva office of the United Nations Department of Humanitarian Affairs (DHA), the officer on duty reads the latest telex messages from the meteorological service 'TROPICAL CYCLONE HOLLANDA .... POSITION 60 DEGREES EAST 20 DEGREES SOUTH .... EXPECTED LANDFALL ON NORTH WEST COAST OF MAURITIUS WITHIN NEXT SIX HOURS ... '. DHA has the task of permanently monitoring a large number of different information sources, from news agencies and media to scientific data and reports from United Nations offices around the world, using everything today's telecommunication technology has to offer. By this process of constant monitoring, potential needs for international humanitarian assistance are identified and international resources can be mobilised in a timely fashion. In this case, a severe tropical storm approaching an island in the Indian Ocean clearly posed a major threat to safety, and required immediate attention.

At the office of the United Nations Development Programme (UNDP) in Port Louis, the capital of Mauritius, the telephone rings: DHA Geneva is asking for details of the situation. Things are under control: a cyclone warning 'class 3', has been issued, and the impact of the storm is expected within the next few hours.

Mauritius has worked hard over the last few years to modernise and improve its communications infrastructure. With the help of the Telecommunication Development

Worldwide, the incidence of natural and man-made disasters continues to increase. In 1995, over 160 million people were affected by disasters triggered by floods, earthquakes or drought. Conflict and crisis forced another 37 million to flee their homes. Just 15 years ago, a large relief operation meant assisting thousands of people—today, it means hundreds of thousands. Figures show that in 1994 US$3·4 billion was given in relief aid—six times the amount given a decade ago to the Ethiopian famine.

International aid agencies, which have traditionally often struggled to make do with insufficient resources, are now pushed to their limits, and new tools and ways of working are being sought. Telecommunications can do much to improve and speed up the delivery of aid and reduce the suffering of victims.

In addition, a new international convention is proposed to be signed early next year which is intended to facilitate the ease of movement of telecommunications equipment and personnel across national borders for disaster relief operations. The Convention on the Provision of Telecommunications Resources for Disaster Mitigation and Relief Operations should be instrumental in bringing the benefits of advanced telecommunications to relief operations in many countries which currently restrict the importation of communications equipment, even in times of crisis.

Additionally, new technologies, such as the new low-earth-orbit satellite systems that are now being deployed, should also be able to offer great benefits to disaster zones which are remote, or where existing communications infrastructure has been severely damaged.

Bureau of the International Telecommunication Union (ITU), the island has made great progress and has installed one of Africa's most modern telephone, broadcast and television networks. The modern equipment on the island has widely replaced the warning flags and radio links which were still in use when the last cyclone hit the island, more than 10 years ago.

Communications Breakdown

The UNDP representative is midway through confirming that the national disaster preparedness and response plan should minimise the danger for the population when the telephone connection with Geneva ends abruptly—the line is cut!

The DHA operations room is equipped with a variety of communications tools, and the officer on duty now tries to re-establish contact by trying other office, private and mobile telephone numbers, then by fax, and via telex and even the Internet, all with no luck. It seems that Mauritius is completely cut off.

The first offers for international assistance, should it be required, arrive in DHA's Geneva office. Meanwhile, the reason for the disruption of communications is finally identified. As a standard procedure to avoid damage by the anticipated storm, the huge 12-metre diameter satellite antenna connecting Mauritius to the outside world has temporarily been placed in a horizontal position to minimise the wind load. Before doing this, the operator in Port Louis has informed his counterpart at the satellite station in France, from where all traffic is forwarded to the international networks. Only after the passage of Cyclone Hollanda will the antenna be repositioned towards the telecommunications satellite above the equator, and only then will regular telecommunication links be able to be re-established.

The meteorological data received in Geneva indicate that the impact of the storm is likely to be very severe. Its centre touches Mauritius's northern coast, and the accompanying strong circular winds would surely have affected most of the island. An international disaster assessment team is put on standby, yet nobody even knows if Port Louis airport is still operational and if such a team would even be able to reach the island. Specialists consider the different risks. What if a cargo ship with dangerous goods such as chemicals for the textile industry could not leave the port in time, and a leakage of toxic matter has occurred? What if hospitals and first aid facilities have been damaged? What if the island's stocks of medical supplies or depots of rescue equipment have been damaged or made inaccessible due to roads blocked by fallen trees or by landslides? In all these cases, many lives may be at risk, and could only be saved by timely intervention.

News about a natural disaster of not-yet-known dimensions has meanwhile reached the worldwide media. Among those most concerned about the possible impact of the disaster are friends and families of the thousands of tourists who spend their holidays on Mauritius's beautiful Indian Ocean beaches. The uncertainty caused by a complete lack of communications only exacerbates the situation. The long-term damage such a situation can cause to the tourist industry is often much greater than the physical damage to the resorts themselves. The DHA operations room receives many calls from people concerned with the well-being of tourists—but, with no telecommunications, even this centre of information exchange cannot help them.

Meanwhile, all possible tools of alternative communication are being explored: the regional air traffic control centres for southern Africa and for the Indian Ocean and coast stations of the maritime radio networks are being contacted, and the networks of the meteorological services and of diplomatic services are alerted. Stations of the amateur radio service, a decentralised and highly flexible network of dedicated volunteer operators worldwide, tirelessly work to contact any station located on the island.

From a list of mobile satellite communications terminals registered in Mauritius, an operator at DHA Geneva calls one number after another. Finally, a fishing vessel is reached, but the response from the captain is not what is hoped for: 'We are very happy that you've called us, we are 150 miles south-west of the Maldive Islands and have no news from home. What has happened in Mauritius?'

Situation Assessment

A few hours later, the centre of the storm has moved further west, and for Mauritius the worst should be over. However, communications remained

Embarking on an international relief project requires expert logistical planning and a high-level of preparedness. Essential telecommunications equipment is packed into trunks ready for immediate deployment on the ground. Usually, a range of equipment is chosen—satellite telephones, radio systems, and so on—to ensure that, whatever the state of the fixed-line network in the disaster zone, some form of communications will be possible. Transportability is also a key factor. Equipment must be able to be moved quickly and easily, while at the same time remain operational to keep the lines of communication open. Satellite phones and mobile cellular systems are small and easily portable, while radio can be used in the form of hand-held walkie-talkies or mounted inside workers' vehicles.

When rapid response is required, such as in the case of an earthquake, portable satellite telephones can provide international communications, even if the public telephone network is no longer working. Teams equipped with satellite phones can stay in touch, phoning in damage reports to a central base or lodging requests for assistance. The ability for team members to stay in constant contact throughout the search and rescue operations can save many lives.

cut, and were to remain so for the next 36 hours. When the first information finally came through, it was learned that the storm had caused severe damage to the island's infrastructure, but that, thanks to an effective preparedness plan and effective broadcast messages to alert the population and provide advice on what to do, only very few people had been injured. International assistance was not required. Upon confirmation that the airport would soon be open for traffic again, the assessment mission from DHA Geneva was quickly on its way.

The question remained, though, as to what had caused a total disruption of communications for such a long time? The problems eventually became clear. As soon as the storm had passed, the technicians at the satellite telecommunication station had tried to reposition the big antenna. The lack of electricity, due to the closure of all power stations because of widespread damage to power lines, was overcome by the use of the emergency diesel generator at the telecommunication centre. The antenna was accurately repositioned, yet for some reason no contact with the satellite and, through it, with the station in France, was possible. Closer inspection of the antenna showed the reason: branches, which the storm had torn from nearby trees, had hit the sensitive suspension of the central element of the antenna, the so-called *feed horn*. Damage to this element meant the antenna could no longer be correctly aligned on the satellite, and for several days communication links could not be restored.

For more than 10 years prior to Cyclone Hollanda, Mauritius had not been affected by a cyclone. During this same period, the island had taken the initiative of introducing the newest telecommunication technologies. Cellular telephones provided personal mobile communications, and all international lines were concentrated in one satellite link. Because the services offered by the public networks could satisfy all the island's communication needs, all other means of communication had been subsequently considered obsolete or seen as unnecessary. No licenses for land mobile satellite terminals were therefore available, and existing radio links such as those of the meteorological service had ceased to be maintained.

International Action

The hard lessons learned from this case were quickly put to good use: in the following month, the First World Telecommunication Development Conference (WTDC-94) of the ITU in Buenos Aires unanimously adopted Resolution No. 7 on Disaster Communications. The Resolution calls upon all ITU Member States (currently 187 nations) to facilitate the use of appropriate means of telecommunications for disaster mitigation, preparedness and prevention, and disaster response, and to assist developing countries which are prone to natural disasters to develop telecommunications-based early warning systems. It also recommends the facilitation and rapid deployment of telecommunications for disaster relief by the reduction or removal of regulatory barriers and the fostering of transborder cooperation between States.

In the same year, the ITU Plenipotentiary Conference in Kyoto unanimously endorsed this Resolution. In 1995, the International Convention for the Provision of Telecommunication Resources for Disaster Mitigation and Relief Operations was drafted. This Convention will be submitted to an intergovernmental conference in Geneva in early 1998.

Conclusion

The optimum use of all available means of telecommunication is indispensable to effective disaster preparedness. The centralisation of modern networks means their vulnerability has increased: damage to one single piece of equipment had isolated Mauritius completely at the most critical time immediately following the impact of the storm. An excellent national preparedness plan, the strict implementation of a building code which gives full consideration to the effects of cyclones and, last but not least, the fact that only part of the island was affected by the storm prevented, in this particular case, the potentially tragic consequences of a loss of communications.

It is important to remember that the telecommunications network on which we all rely so unthinkingly is a fragile structure. The communications capabilities we take for granted every day can be lost in a matter of minutes during a disaster. More effective use of existing technologies, which will be promoted by the new Convention, as well as the implementation of new technologies, such as mobile satellite-based telephones, have enormous potential to improve disaster response and to save many lives.

Telecommunications technologies can play a vital role in disaster preparedness by carrying broadcast messages to radio and television, alerting the population before a disaster strikes and giving clear advice about what action should be taken.

An effective disaster plan, combined with more efficient use of telecommunications, will help to minimise the impact of natural disasters, streamline the delivery of aid to victims, and help nations get back on their feet as quickly as possible.

ITU Web site: http://www.itu.ch

Peter Cochrane, Head of Advanced Applications and Technologies, at BT Laboratories, Martlesham Heath, continues his regular column in the* Journal *with a look at the future of education and technology.

The Desert and The Oasis

When I was a young boy my home had three principle books: a bible, an atlas and a dictionary—these were the kernel of our home library. So I found school to be an oasis of information, intellectual stimulation, and learning. It had books, smart people and resources. For me, going to school in the 1950s was a transition from a desert (the home) to the oasis (the school). Today many children have the converse experience, they leave an oasis (home) and go to a desert (school). Their schools are short of books, computer power, and information, with no access to international networks. They also have large class numbers which severely limits the access of the individual to both information and teacher. So it is not unusual for children to leave this comparative desert and return home to an oasis of computing power, compact discs (CDs), network connections and challenging interactive software.

Naturally enough, each successive generation sees a widening of the gap between parent and child in terms of life's experience, educational opportunity and basic skills engendered by technological and social change. Today the accelerating technological change means this gap is wider than ever before. The average 10 year old now has more computer experience than those of 50 or more years, realising an interesting dichotomy. Young people have more time to interact with computers, more lifetime to experience their power and become expert, while the older population has no chance to catch up, no means of gaining the same depth of understanding. Paradoxically, it is older people who influence policy and make decisions on the technologies and methods of education. What they decide will impinge on all of those who are 10 years old and younger, and yet neither group is well qualified!

At university we see a similar situation with students having inadequate access to terminals. The smartest students now choose universities on the basis of the computing power available. How can you do a good or relevant degree with inadequate technology?—You can't! Many students now have to buy their own PC to maintain their work rate to stand any chance of success. For those who reel at such a notion, because all students can't possibly afford their own personal computer power, it is interesting to reflect the amount of money spent on entertainment, games, hi-fi, cameras and televisions. It is also worth reflecting that PC power is falling in price at about an order of magnitude every five years. A laptop PC in the £500–£1000 range is phenomenally powerful today. In five years such an expenditure will buy a ten-fold increase in capability. Saying that PCs are out of the financial reach of students is but an echo of the early days of the pocket calculator.

What hope then for the student who cannot afford a PC—soon, probably none at all. Lecture notes and educational material is increasingly being made available for the screen with the white board, overhead transparency, book and pad of paper gradually being usurped. Arriving for a class without a laptop will soon be as unacceptable as arriving without a pen.

It seems only yesterday that both education and a job were for life. This is no longer so. Our world is about just-in-time education, experience and information. Technology and competition are pushing us in a direction of doing more in a shorter time. As a result we need a flatter and more general education to fit us for a world of increasingly rapid change. Specialist courses and modules are now starting to dominate beyond school and first degree level.

Many companies now run their own academic, business and training courses tailored to their specific needs. BT has been running Masters Degree

programmes for several years with contributors transported across the globe to present their material in a conventional manner. The inconvenience and expense of this approach first prompted teleportation of lecturers by videoconferencing. A one hour lecture and a half-hour tutorial for only £60 using an ISDN circuit over the Atlantic is a good deal compared to the cost of air transport. This is especially so when the lecturer is the best of the best! The next step will be dial-up lectures, experience and tutorials direct to the individual on demand.

For those who balk at all this, it is worth reflecting on the objections to the printing press, the typewriter, radio and television. Education cannot remain in a time warp—it has to move on. Of course, there will still be a place for the old technologies and methods, but increasingly they are likely to be in the back seat.

Some of the medical degree courses in the USA now commence by the students taking on the loan of a laptop computer with the first two years notes loaded and ready to go. These notes, however, are not a transcription from paper to screen, but a new form—interactive multimedia. A new dimension in learning, with more depth, more meaning, and more impact, where students learn up to 50% faster and retain 80% more.

A further important factor is the extremely limited number of experiments and demonstrations that can be witnessed firsthand. Economic and time constraints allow only a subset of experience to be gained by the average student. However, an increasing number of 'on screen' demonstrations and 'hands on' experiments are being produced. These offer a new and significant advantage that can never be realised in a real-world laboratory. All the parameters and conditions can be selected and individually tweaked, with equations, graphs, and explanations embedded in the virtual environment. Optical fibre where you can adjust the refractive index, semiconductors where you can adjust the hole mobility, extreme conditions in pharmacy and aeronautics, accelerated gene mutation—the list is endless!

It is now possible to enter the world of the electron, the cosmos or indeed the human body on any scale we wish. We can witness the oxygen-exchange mechanism in the blood or the photonic interaction of light and receptors in the eye. All of this, and much more, is available in the latest CD versions of human body encyclopaedias. Such first-hand experiences illuminate our understanding of basic processes at a speed which was previously governed by the limited artistry of individual teachers on the black board with coloured chalks. What is more, it can be done without the presence of the expert or the lecturer.

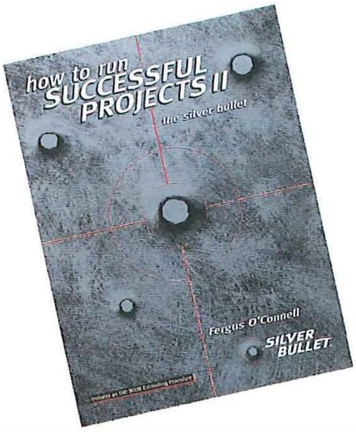
Of course, we should not abandon all practical experience, quite the reverse, but we could be more selective in choosing those that enhance understanding. The real classroom also has a further valued purpose—the bringing together of people for the chemistry of human communication and interaction. This should not be abandoned, it is too valuable, and conversely, should not be wasted. So perhaps schools and universities will become a new form of oasis—of intellect, interaction and specialist equipment and experience.

All of this goes well beyond the concept of our presently understood teaching and understanding mechanisms. It is immersive, self driven and self questioning. It is a radical change and challenge—the virtual school, college and university—the distributed oasis—open and available to everyone—all the people, all the time! It is also without geography, without limitation—a part of the new virtual community—a new dimension to living and learning.

book reviews

How to Run Successful Projects II—The Silver Bullet

by Fergus O'Connell



While reading this book, I completed a major upgrade to the software on my PC, which has left some functions previously accessible now unavailable despite having followed the detailed instructions which came with the installation. 'Just follow the instructions and answer a few simple questions and you can't go wrong' was the advice. I should have known better.

I have come away from this book with a similar feeling. It promises that 'if you do the things we *(sic)* describe in this book on your projects then your projects will always be successful'. My experience is that even the best-managed projects do not always lend themselves to being 'run by numbers' and that one of the skills of a good project manager is in determining how to adapt the received wisdom to his/her current project.

The book is different from many project management books in both its style and the areas covered and I am pleased to see that the importance of people skills in running successful projects is recognised with a whole section devoted to this area. However, some of these areas are skimmed over (the chapter on negotiation, for example, is only three pages long with that on interviewing only slightly longer at four pages).

The more usual project management topics are covered, although it is disappointing not to see a graphical form of the work breakdown structure introduced. There seems, occasionally, to be some confusion about the prospective reader's role. For example, in the chapter Assessing Project Plans, the reader is told that the critical path is the shortest path through the project, and that if the critical path has not been highlighted in some way then 'you would be quite justified in sending it (the plan) back' as the implication is that the project manager has not thought it through. However, the book is addressed to project managers, and other than expecting planning software to determine the critical path, no further explanation of how to work out the critical path is given. New project managers are not warned that there may be more than one critical path in a project and that they may change as the project develops.

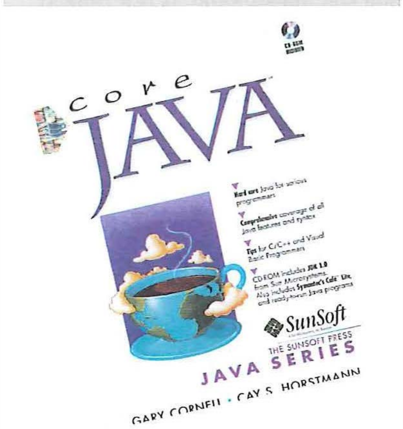
I am also concerned at the suggestion that contingency be applied as a matter of course (particularly when it is inserted into the plan as fake activities). Work will always expand to fit (or exceed) the estimated duration and for this reason alone this technique does not work. It is no substitute for a sufficiently detailed work breakdown structure used for estimating, and a thorough risk assessment and risk management strategy.

The book is written in an informal style with a running case studies of Scott's and Amundsen's polar expeditions used to illustrate points and the probability-of-success indicator focuses attention to critical areas well.

Overall I would recommend this book for those who have some experience and knowledge to use it with discernment. I fear those who use it as a teach-yourself primer will find their expectations of success raised too highly by the author's optimism.

Published by Prentice Hall
ISBN 0-13-239856-7
£26·95. xxiii + pp. 334.
Reviewed by Linsley Meadows

Core Java
by Gary Cornell and Cay S. Horstmann



The edition of Core Java reviewed here was printed in 1996 and does not cover the most recent developments, but the material covered in the book is still highly relevant and useful. It has been difficult to review this book because the people working in my group are continually walking off with it: a testimony to its usefulness.

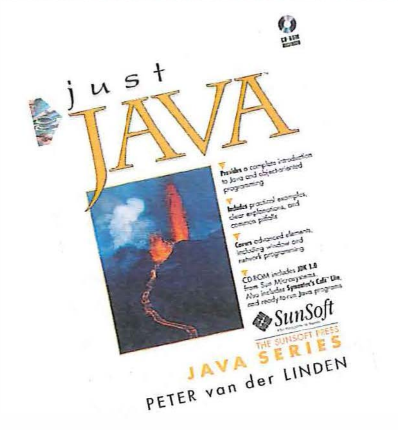
The book provides a general introduction to Java and the Java programming environment, though the release of development environments such as Symantec Cafe and Sun's Java Workshop will make the discussions of programming environment largely irrelevant. The fundamentals of Java are given a brief treatment before moving on to a reasonable discussion of object-oriented programming.

Use of the Abstract Windows Toolkit is introduced before providing a more detailed discussion of designing user interfaces. The basics of applets as opposed to applications are presented with a sufficient number of examples before moving on to the more advanced topics of data structures, exceptions and debugging, input and output, multi-threading and networking.

On the whole, the book is very useful and provides a clear explanation of the subject matter. The examples are used well to illustrate key points and the depth of treatment should satisfy the intermediate to advanced programmer. Also, in conjunction with a more basic book, Core Java would provide a good resource for someone with previous programming experience to learn Java. Even for experienced users of Java who do not want to work through a book, *Core Java* would serve as a useful reference as it is possible to examine the different sections in isolation.

Published by Sunsoft Press (A Prentice Hall Title)
ISBN 0-13-565755-5
£32·95. xix + pp. 622. + CD-ROM.
Reviewed by Tim Rea

Just Java
by Peter van der Linden



The contents of this book range from general discussions on topics such as the World Wide Web and object-oriented programming before going on to look at fundamentals of the Java language, and overview of the libraries provided on the CD-ROM in the Java Developer's Kit with a separate chapter devoted to the Abstract Windows Toolkit. The final chapter looks at future developments and the appendices cover fundamental aspects such as getting Internet access, getting a browser etc.

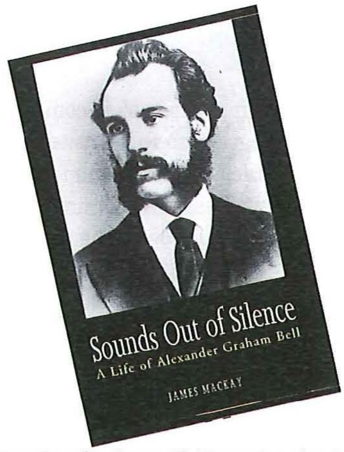
The author manages to weave the programming information together with a large dose of computing anecdotes to produce a book which not only outlines the fundamental aspects of the Java language, but also provides the reader with an insight into computing culture.

This book is supposed to be aimed at intermediate to advanced programmers, but I do not agree with this. Much of the material is explained very well for the beginner and in terms which the beginner should have no trouble understanding. An intermediate programmer would find much of the content to be a review. Unfortunately, it is not the ideal beginner's book because it does not step through some of the fundamental issues carefully enough and there are not enough detailed examples.

In isolation, then, this book will not fulfill the requirements of either the beginner or intermediate programmer learning Java. In conjunction with a more thorough beginner's book, however, it may provide an interesting and easy to read treatment of some of the fundamental aspects of the language. For the intermediate programmer I would recommend a book like *Core Java* which is also reviewed in this *Journal*.

Published by Sunsoft Press (A Prentice Hall Title)
ISBN 0-13-565839-X
£26·95. xix + pp. 354. + CD-ROM.
Reviewed by Tim Rea

Sounds Out of Silence
by James Mackay



Alexander Graham Bell anniversaries are like buses—you wait ages for one, and then two come along together. True, it is the same for anyone who dies aged 75, but the inventor of the telephone wasn't just anyone. Among other things, he was the inventor of the iron lung, an aviation pioneer, an innovative sheep breeder, a world speed record holder and co-founder of the National Geographic Society. All told, he was a most interesting man and, this being the year that marks 150 years since his birth, we have James Mackay to thank for this new—and very readable—biography.

Born in Edinburgh in March 1847, Alexander Bell (he added the Graham when he was 11) was the third son of Alexander Melville Bell, a noted expert in vocal anatomy and phonetics. He had a very inventive mind, and was an able musician. He also proved an able successor to the family tradition, and was soon helping his father with his work, a grounding that paid ample dividends later, literally.

The author covers this period well, but really gets into full flow at the stage where Bell turned his mind to developments in the field of electric telegraphs. By then living and working in North America, seemingly every twist and turn of what was only a relatively short period is covered. The original ideas, the partnerships, the frustrations, the finding of backers, and the ultimate triumph, it is all there. Never again should you believe the popular story of the invention of the telephone! Mackay tells it as it really was. Hard grind, and always with the serious fear. That someone else would get there first.

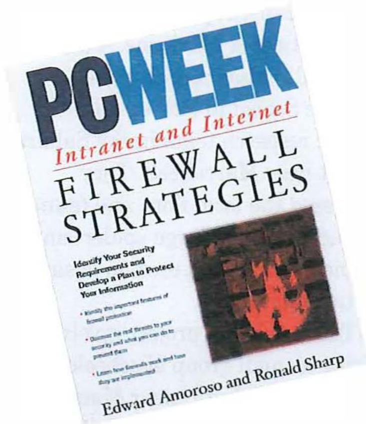
In the end, Bell quickly turned his back on the business side of the telephone. Wouldn't you when seemingly the whole commercial world was out to prove you a liar, if only to break your lucrative patents? But his money machine proved secure, and Bell 'retired' to do many other creative and worthwhile things. He also returned to the continuing theme of his life, the task of teaching the deaf to speak.

Throughout all this operational detail, Mackay manages the tricky balance between the work and the man. Bell's family and social lives are covered with equal sincerity and thoroughness and, overall, the reader is left with a clear and, I have to say, a rather appealing portrait of a human being that many would do well to emulate. We can't all invent something as breathtakingly simple—yet hugely remunerative—as the telephone, but we could all spend a bit more time doing good.

And that is the sum of this excellent book. It is a fine portrait of an even finer man. I commend it unreservedly.

Published by Mainstream Publishing Company (Edinburgh) Ltd.
ISBN 1-85158-833-7
£20·00. pp. 320.
Reviewed by Neil Johannessen

PC WEEK Intranet and Internet Firewall Strategies
by Edward Amoroso and Ronald Sharp



The title of this book intrigued me. Yet another computer term, but what does it mean? The words are constantly slipping into our business language and are increasing daily.

I liked the layout of the book as it lent itself to quick reading. All the information was easy to get at and I liked the *Contents at a Glance*, and the *Introduction* which provided a brief tour of the book. Just as helpful, were the key points, *Helpful Tips and Asides* (all greyed out for easy identification). The author are both members of the technical staff at AT&T.

This book was written for non-specialists employing analogies such as using an office building to explain how networks operate. I found these comparisons very helpful. The *rooms* were the hosts, the *hallway* the data network and the *reception* the firewall. The firewall does a little more than a receptionist, as it will record every allowed or denied request and will give the administrator a view of the audit or activity log. This will give some idea of who and how often someone has been trying to access your system.

The illustrations were more pictorial than diagrammatic, which made the hardware more recognisable and helped to see how they fit into the network. They also explained terms within the book which meant that I did not have to look outside for any terminology used.

Security on the Internet has been a problem from the beginning, as it was conceived as an open system which was its attraction but has also left it vulnerable to abuse. The firewall will not stop this abuse but will allow it to be managed. The logging and filter facility will tell you who is using the system and who is attempting to use it. It will be the quality of the equipment and the local procedures that determine the infiltration abilities of alien users.

We need a reliable protection method for networks being attacked by *Trojan Horses* or *The Worms of 1988* viruses. Although the worms do not damage data they cost valuable computer time and cause shut down. It is hard to predict where new attacks will come from given the ingenuity, motivation and time some people have to pursue their aims. We can only monitor and respond, which is why we have firewalls.

I would recommend this book to anyone who needs to be aware of these developments or is interested in what's happening with computer technology today. It is up to date, easy to read and a great introduction to the subject.

It contains useful information and will enhance anybody's appreciation of the subject.

Published by Ziff-Davis Press
ISBN 1-56276-422-5
£26·99. xxi + pp. 218
Reviewed by Erle De Neise

Launch of Pan-European ATM Academic Network

Six leading European telecommunications operators have joined forces to provide a common asynchronous transfer mode (ATM) backbone to link Europe's academic networks and enable university researchers to collaborate via the Internet. BT, Deutsche Telekom, France Telecom, OTE (Greece), Swiss Telecom and Telecom Italia have interconnected equipment from their own infrastructure networks, as part of the trans-European TEN-34 network.

The cooperation between the different operators on the TEN-34 project marks an important step in the development of a fully commercial ATM service across Europe.

The new TEN-34 network is the first Europe-wide high-speed computer network for the research community. Designed to meet the explosive bandwidth demands, it ensures that European researchers have communication facilities comparable to those of their counterparts in the US and Japan. The ATM backbone transports Internet traffic between the research networks in each country.

The selection of ATM for key parts of the TEN-34 network endorses its suitability for carrying high volumes of Internet traffic. ATM provides a flexible and cost-effective telecommunications backbone network for voice, video and data applications.

Delivery of Advanced Network Technology to Europe Ltd (DANTE) is the coordinating partner in the TEN-34 Consortium, which consists of all the national research networks in Western Europe, the Czech Republic, Hungary and Slovenia that operate the networks linking universities and research organisations in each country.

The TEN-34 network comprises two sub-networks that are connected in London, Geneva and Frankfurt. The first is an Internet protocol (IP) service interconnecting Sweden, the Netherlands, Switzerland, Spain, Germany and the United Kingdom, provided by Unisource. The second provides data transmission services based on ATM, linking France, Germany, Italy, the United Kingdom, Luxembourg, Switzerland, Austria, Hungary and Greece, provided by the six operators. A single network management service serves the entire TEN-34 community.

Satellite Carries Classrooms to Sahara

Students can now have interactive lessons beamed to them from anywhere in the world—live by satellite.

Two schools in Surrey have proved this new concept in education. Geography classes from Wallington High School and Coombe Girls School in Surrey took part in the United Kingdom's first educational teleconference live from the Sahara Desert, as part of their curriculum. The teleconference was organised by educational body Tic.Toc, using a B-Sat terminal with a BT Mobiq personal portable satellite telephone for voice calls, supported by BT Aeronautical & Maritime. A class from Wallington School visited Coombe School to link up with the Tic.Toc research team in the Sahara Desert near Marrakech. They discussed the local flora and fauna (including a very large spider) and learned about wind erosion of sand at 'virtual first hand'.

Tic.Toc's latest project involves taking a small group of schoolchildren to the Sahara (near Marrakech) to carry out curriculum-related projects, which are reported 'live' on the Internet for children in schools to follow and interact with.

Richard Jones, Geography teacher at Coombe School, commented: 'Our tele-conferencing unit is a living textbook that's proving to be cross-curricular'.

First Fruits of Global Intranet Development

BT has announced the launch of BT Intranet Complete in the United Kingdom, a ready-to-go knowledge-sharing solution for all types and sizes of organisation.

As a fully-managed intranet service—encompassing business consultancy, design and build, as well as ongoing hosting, management and support—Intranet Complete represents a new approach to intranet provision. With minimal up-front capital investment required, it also dramatically reduces the start-up costs and lead times of implementing an intranet, thus lowering the entry barriers for all organisations. An intranet can help organisations dramatically improve their internal and external information flow. Research suggests that 40 per cent of British businesses will be running an intranet by the year 2002.

The launch follows the announcement in November last year that BT, Concert, MCI and Microsoft were to bring their respective strengths to the development of global intranet services. The service will initially be marketed by BT as BT Intranet Complete in the United Kingdom and in the United States by MCI as part of the networkMCI Intranet Complete suite. This will be followed by a global rollout in early 1998 by Concert Communications Services, the existing BT/MCI joint venture global communications company.

This BT, MCI and Concert service takes advantage of software platforms provided by Microsoft to enhance BT, MCI and Concert's global networking expertise. On a global basis, consultancy, integration and systems management services will be provided by BT and MCI's global services companies, Syntegra and SHL Systemhouse.

Oftel Publishes Final Plans for Network Charges

The way BT should charge other network operators in the United Kingdom for carrying their calls over its network for the next four years has been set out by Don Cruickshank, Director General of Telecommunications. Under Oftel's plans, BT's charges for these services will fall by around 28 per cent in real terms over the next four years. This should mean even more competition in the United Kingdom telecommunications market.

Don Cruickshank said, 'BT's interconnection charges make up a large proportion of other operators' costs. At the moment Oftel sets these charges. However, I am announcing a new framework which reflects developing competition in the telecommunications market. The degree of control on prices depends on the degree of competition in each service. Regulation can pull back where competition can be relied on to regulate prices.

'Under the new arrangements:

- there will be no direct control over charges for services where network operators have a choice of suppliers;
- for services which are likely to become competitive by 2001 there will just be a safeguard cap so charges cannot increase in real terms; and
- where there are as yet insufficient alternatives to using BT's network—like call termination—average charges will be subject to charge caps and required to fall by 8 per cent below the rate of inflation.

'The use of charge caps—like the caps on retail prices—at the wholesale level is a new approach. It is much less interventionist than the current system under which Oftel determines the exact price for interconnection services. It will ensure that the sort of efficiency improvements that would be expected in a competitive market will be reflected in network charges. For these new controls we have changed the cost base appropriate for setting interconnection charges. We are moving from a system based on historic, fully-allocated costs to one based on forward-looking incremental costs. This is more appropriate in terms of the costs businesses actually have to take account of in making decisions in a competitive market. The industry, including BT, agree this is the right way forward as do other regulators around the world. Since historic costs are higher than future costs, the change means there is a reduction in the charges that will start from 1 October, compared with those that apply under the present arrangements.

'United Kingdom's interconnection costs are already among the lowest in the world. This announcement means they are set to fall further still. The reductions should increase competition in telecommunications services. In the proposals published in May for consultation, I suggested X was likely to be in the range 6–12 per cent. I have considered carefully the comments received on the range of assumptions and alternative forecasts that have to be taken into account in reaching a value for X. These include the growth of the markets, the changes in BT's share, the way costs—both running costs and capital costs—vary as BT's business expands or contracts and the scope for improvements in BT's efficiency. I have concluded that 8 per cent is the right figure taking these many factors into account.'

Oftel Helps Mobile Telephone Owners Choose Best Deal

Mobile telephone owners will, from next year, be able to keep their numbers when they switch to another mobile network under proposals unveiled by Don Cruickshank, Director General of Telecommunications.

At the moment mobile operators do not allow customers to take their numbers with them if they switch to a rival operator. This is a major barrier to people changing operators.

Oftel announced that, from July 1998, it believes the four mobile operators should have to offer *number portability*.

Announcing the new move, Don Cruickshank said, 'The mobile telephone market is becoming more competitive, and mobile telephone users want to make the most of this by choosing the best deal around. But research shows that many are put off from changing supplier because it would mean changing their telephone number. For example, a plumber who relies on customers knowing his number in an emergency is unlikely to want to change that number.

'Research has also shown that, as with fixed networks, allowing number portability is a key factor in enabling the mobile telephone market to become fully competitive.

'The overwhelming response from customers when we consulted on this was that they wanted hassle-free number portability as soon as possible. We found the number of medium to large businesses willing to switch operators would more than double from 41 per cent to 96 per cent if they could keep their number. So I am delighted that we are able to meet that demand, by proposing that operators to offer it from July next year.

'When we asked the four mobile operators how quickly they could introduce portability, we got responses ranging from a few months to several years. So we appointed independent technical experts who found there was no reason why the service could not be on offer from next July.

Internet for Schools

Proposals aimed at ensuring all schools across the country have access to the Internet at affordable rates with the participation and cooperation of the whole telecommunications industry have been published by Don Cruickshank, Director General of Telecommunications.

Launching Oftel's consultative document, Don Cruickshank said: 'Telephone bills for accessing the Internet are difficult for schools to afford and predict. Many schools want high-speed ISDN2 telecommunications links to access the Internet effectively. In January, the cable industry launched a deal to give schools unlimited access to the Internet at affordable rates. Towards the end of May BT put a proposal to Oftel to help address schools' needs for affordable and predictable bills for access to the Internet.

'The key elements of Oftel's proposals include participation by all telecommunications companies ensuring BT prices its services fairly so that there can be competition between different companies.

'When schools go on-line to the Internet they frequently use two different telecommunications companies to make the call. There is the company providing the line to the school and the company providing the link to the Internet service provider. The fact that there are two companies involved is invisible to schools but both telecommunications companies need to review their charges if schools are to have affordable prices. BT has come forward with an offer which requires the participation of other companies. How they might participate is one of the things Oftel is consulting on, so that schools have a choice of different Internet service providers on different networks.

'Because of BT's dominance in the market Oftel has estimated the costs that it would expect BT to cover in its prices for schools so that there can be fair competition between different companies providing telecommunications networks and Internet services to give schools a choice.

'This document is not telling BT how to set its prices. The estimates in the document show how low Oftel would allow BT to price down to before prices become anti-competitive. These estimates give BT considerable flexibility to develop its original offer to give schools a cheaper deal and longer hours of access.

'The approach Oftel has used for estimating BT's costs is intended specifically for schools because they are so obviously a special case. This approach does not set precedents for the cost base to be used for setting BT's charges more generally.

'There is a common goal here, and arriving quickly at a solution means everyone wins: schools, because they are better able to exploit an important educational resource, our children, because they are better equipped for the future, and the communications industry because it is strengthening links with an important market and creating a new computer-literate generation.'

BT Revolutionises Trading Over the Internet

BT has announced the launch of an innovative service, BT Trading Places, that will enable buyers and suppliers to trade electronically over the Internet. This leading-edge electronic-commerce solution allows suppliers to sell their services in a new unique manner, while buyers can quickly source the right product at the right price with minimum effort. Aimed at small to medium-sized enterprises, BT Trading Places answers market demand for a trusted independent third party to administer and operate a secure on-line trading environment.

BT Trading Places has a tender facility that invites rival suppliers to compete for a particular piece of business. Alternatively, buyers will be able to browse the system and find the best market price for the product they require. For the supplier, there is a clear advantage in selling in an environment which does not carry the overheads of retail premises. Suppliers are able to reach a national customer base and therefore compete with multiple-store outlets and larger direct supply companies.

BT Trading Places, based on software and implementation support from TDS Group Ltd, will have a dramatic impact on the way business is done, both in the United Kingdom and internationally. The service avoids the traditional overheads of purchasing and payment authorisation—processes which cost British business an estimated £37 billion each year.

Sara Giles, solutions marketing manager for BT, said: 'Electronic commerce is fundamentally changing the way the United Kingdom conducts business and will eventually affect nearly every business and every aspect of the economy. In the broader sense, it is about how telecommunications and computer networks are changing the way businesses communicate with each other. Electronic commerce erases the issue of geographical distance, restructures supply chains, cuts distribution and transaction costs and improves the efficiency of markets by providing more information to buyers and sellers.'

Nicholas Cliffe, managing director of the Thames Valley Chamber of Commerce, commented, 'As the largest accredited Chamber of Commerce in the United Kingdom, we are continually looking for services that will financially benefit our members. BT Trading Places presents us with an opportunity to be a technology leader and also offers our members significant cost savings.'

Adrian Gregory, TDS Group, CEO, concluded, 'Forrester Group research estimates that around 20 per cent of all business-to-business trading will be via the Internet by the year 2000. BT, in trialling this service, will effectively accelerate the opportunities to reduce costs and reach wider markets via electronic commerce.'

Touchpoint Hits Two Million in One Month

BT's Touchpoint service has attracted over two million screen touches during the first month of its six month trial and early indications are that usage is set to grow by more than 20 per cent per month. To date, BT has installed 180 kiosks in and around the London area, including Croydon, Ilford and Kingston. Touchpoint is an innovative touch-screen kiosk network that offers customers a unique range of interactive multimedia information and services.

Horoscopes and the street guide are proving to be very popular applications, receiving 300 000 and 165 000 screen touches in a month. The High Street is another favourite application with shoppers. The most popular items bought from these pages are flowers from Interflora, wine from Thresher and flights from BA, with customers making higher than expected numbers of transactions. Sales of concert tickets have also been encouraging, especially with the younger Touchpoint users.

More Simple Regime for Telecommunications Terminals

The European Commission has proposed a Directive to simplify the marketing of telecommunications terminal equipment throughout the European Union. When implemented, the revised framework would speed up approval for new equipment and extend the single market to all types of radio and wired-based telecommunications terminals. The Directive aims to meets the changing needs of the telecommunications market caused by the huge growth of mobile services and the prospect of full liberalisation of telecommunications in the European Union from January 1998. It includes a self-certification system by industry to replace cumbersome testing by outside bodies, and should reduce the time taken for manufacturers to bring new products to market.

British Interactive Broadcasting

BT, British Sky Broadcasting Group, Midland Bank and Matsushita Electric have announced the formation of British Interactive Broadcasting Limited (BIB), an independent company created to deliver digital interactive services to TV viewers in the United Kingdom.

BIB will be owned 32·5 per cent each by BSkyB and BT, 20 per cent by Midland Bank and 15 per cent by Matsushita Electric.

BIB will provide the interactive television platform that will enable leading High Street businesses to offer interactive services, including home shopping, banking, and travel and holiday services. The BIB platform will also have the capability to offer educational programmes and specialist local community and national public information services. Through their television, customers will be able to connect to an Internet service which will include an e-mail capability. All these services will be available through the same digital satellite set-top box, that gives access to TV broadcasts, connected to an ordinary telephone line.

Internet Restructuring

At an important International Telecommunications Union conference in Geneva, 80 organisations either signed or gave a declaration of intent to sign a new memorandum of understanding (MoU) covering the way generic top-level Internet domains are allocated and managed.

At present there are three generic top-level domains—*.com*; *.org*; and *.net*—and the exclusive right to allocate generic top-level domain addresses is held by an American company, Network Solutions Inc. (NSI), through a contract with the United States government's National Science Foundation (NSF). NSF's contract with NSI is due to expire in 1998, and it was recently announced that the agreement would not be renewed.

In order to cope with the growing demand for Internet addresses in the generic top-level domains, the generic Top-Level Domain (gTLD) MoU calls for the establishment of seven new gTLDs in addition to the existing three. These will be—*.firm*; *.store*; *.web*; *.arts*; *.rec*; *.nom*; and *.info*. In addition, the MoU provides for the setting up of an initial 28 new registrars around the world—four from each of the world's seven regions. More registrars will be added as operational and administrative issues are worked out. Registrars will compete on a global basis, and users will also be able to shop around for the register which offers them the best arrangement and prices. Users will also be able to change registrar at any time while retaining the same domain address, thus ensuring global portability.

Telephone Fraud Avoidance Guide

BABT has worked with the Network Interoperability Co-ordination Committee (NICC) of Oftel to publish the NICC documentation on guidance and best practice on the avoidance of dial-through fraud.

The telecommunications regulator, Oftel, encouraged NICC to develop a code of practice to ensure that businesses are aware of the mis-use risks to which their systems might be exposed and to provide guidelines for improving procedures. There is thought to be widespread fraudulent use of software-controlled telecommunications systems such as private branch exchanges and voice mail, with significant cost to the organisation being billed.

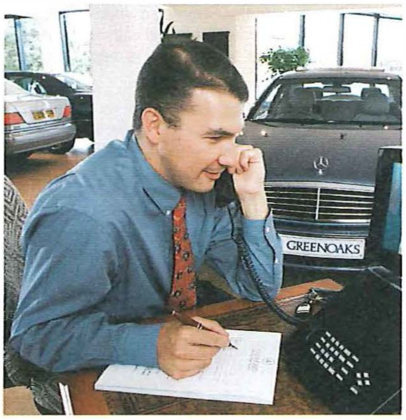
Copies of the NICC document are available free of charge from Liz Gallagher at BABT (01932) 251234.

Financial Advice by Videoconference

Customers buying a new Mercedes-Benz motor car can now receive bespoke advice from the company's own finance experts using BT videoconferencing. A significant number of dealerships around the United Kingdom are too small to support their own finance manager. Videoconferencing enables finance managers to support each dealership, at the same time as increasing their efficiency by reducing travelling time and costs.

The project has grown from five dealerships in 1996 to 19 installed systems in 1997, and the number continues to grow.

A team of finance managers is based in Milton Keynes and it is their sole responsibility to answer videoconference enquiries. They already handle around 50 videoconferences a day, and this is expected to increase as more dealerships join the project.



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