VOLUME 14 PART 3 OCTOBER 1995

BRITISH TELECOMMUNICATIONS ENGINEERING

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Shaping the European Information Society

Who Cares? Future of Telemedical Technology

Speech Technology

The Journal of The Institution of British Telecommunications Engineers

BRITISH TELECOMMUNICATIONS ENGINEERING

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VOL 14 ■ PART 3 ■ OCTOBER 1995

Front cover picture:
BT Corporate Pictures;
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Published by: The Institution of British Telecommunications Engineers, 2–12 Gresham Street, London EC2V 7AG **ISSN 0262-401X**

GUEST EDITORIAL

Bonnie Ralph

The New Information Industry

Several recent issues of *British Telecommunications Engineering* have given readers a thought-provoking and exciting preview of the dawning information age. We have been invited to rethink our whole attitude to social and work activity, our understanding of education and health care, and above all, our relationship to that new window on the world—the personal computer on our desks.

In this and the next two issues of the *Journal*, we take a look at the new information and communications industry: its environment, its structure, its customers, its concerns, the barriers to its development, and the key technologies which will support its infrastructure in the near- to mid-term.

Our objective in this series of articles is not to take away your breath, but to contribute to your thinking, on what we in the new industry need to tackle next.

Within this issue we launch our new theme 'The Information Industry and its Key Technologies' with an article that looks at the shape of the information society in which the industry operates. This article, which begins on p. 186, is based on work done last year in EURESCOM.

We have adopted a structure for the next two issues in which a 'scene-setting' article will be supported by several shorter pieces on specific areas of interest. Bob Foster, BT's Manager of Products and Services, will provide editorial focus for both issues. The first group of articles in the January 1996 issue will deal with the new industry itself, and the 'scene-setter' will describe the functional structure of the merging information and communications industry. Supporting articles will address legal problems, service providers, libraries, education and other areas of special interest.

The second group of articles, to be published in the April 1996 edition, will address those emerging technologies which are key to the successful operation of an information network. The main article will draw on work done this year in ETSI's Strategic Review Committee on the European Information Infrastructure. It will deal with the framework of interconnect, interworking and interoperability within which the technologies must be deployed if the infrastructure is to work across corporate and national boundaries, and over telecommunications and information management devices. There will be specific articles on agent technology and its precursors, security technologies and the development of distributed processing environments. Other articles will outline recent developments in user interface, application creation and the concept of the European backbone telecommunications network.

All in all, there should be something of interest for everyone. Well, we hope you will think so, anyway!

Bonnie Ralph
Manager Information Networking,
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David Greenop

Shaping the European Information Society

As we move towards becoming an information-based society, the only certainty is that all aspects of our lives will be radically affected. It is difficult to forecast accurately what tomorrow's information society will be like as the factors involved are numerous and their interactions complex. This article looks at some of the changes that we can expect and how they could alter society as a whole and the communications industry in particular.

Introduction

As with the advent of the agricultural and industrial revolutions, we are today experiencing change brought about by the availability of new technology. The widespread availability of digital technology is currently blurring the boundaries between the traditionally separate industries of computing, information content production and telecommunications. These changes have the potential to shake the foundations of today's society, affecting the way we live our lives, the work we undertake, the means by which wealth is generated, and our systems of government.

For BT it is important to understand the role that telecommunications companies may have in shaping this future. Within Europe, liberalisation of the telecommunications industry is already underway. In addition, European telecommunications companies will have to adapt to a new commercial and social environment as the industry restructures around new roles and new types of markets that will appear within the *information society*.

Other sectors of the communications and media industry, for example, broadcasting and publishing, will not remain unaffected by these changes. They will see their traditional markets change as digital information processing and transfer threaten existing skills and revenue sources. For the communications and media industry as a whole, the technology will provide many new exciting opportunities, but whether today's players can adapt and survive will depend on their response over the next few years to the changes they are experiencing.

This article is based upon collaborative studies carried out by European telecommunication companies at EURESCOM (European Institute For Research and Strategic Studies In Telecommunications). The studies investigated the influences that are shaping the future information society in Europe over the next five to ten years.

The Move to a Post-Industrialist Society

The societies in the major world economic areas of Northern America, Europe and Asia Pacific are undergoing significant changes. These changes are the result of several diverse trends; for example, new types of social behaviour, changing political priorities, rising unemployment, increasing leisure expectations, focus on individual aspirations, rapid technological innovation, business globalisation, economic uncertainty, and increasing environmental awareness. In a worse-case scenario, these changes can undermine the source of affluence and welfare of many people in Western Europe. Society is having to come to terms with the move to a post-industrial era. In a positive sense, these developments can be regarded as a liberalisation and empowerment of the individual.

In today's world, the unrestricted and rapid exchange of information is seen as a fundamental mechanism in facilitating and, in some cases, driving many of these trends. With the start of the industrial age, new enterprises emerged; today, new

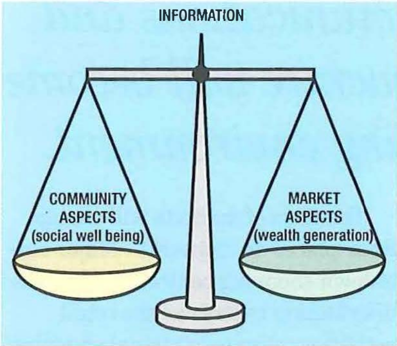


Figure 1 – The information society balance

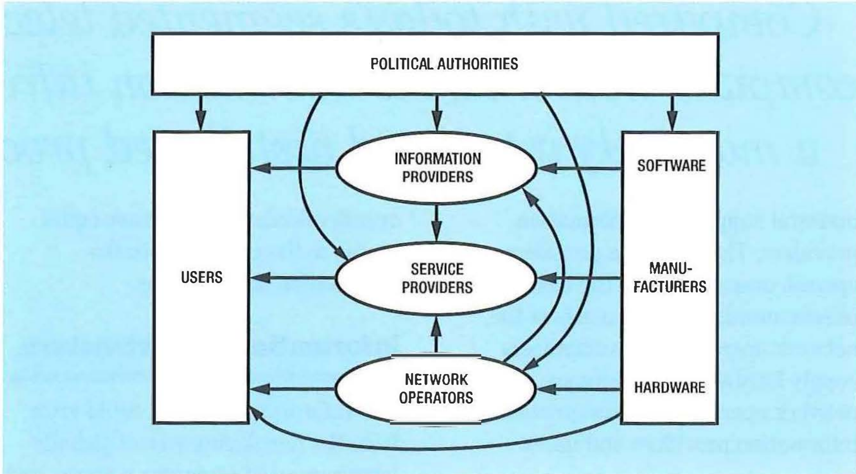


Figure 2 – The players in the information society

information companies are appearing centred on the creation, distribution and management of information. We are seeing large corporations purchasing information sources such as film studios, music and book rights to ensure that they have access to this information. In his book *Being Digital*[1], Nicholas Negroponte describes the industrial age as being about the movement of atoms, that is, manufactured goods, books, newspapers, CDs, while the new information age will be about the movement of information in the form of digital bits. We need to remember the subtle and important differences between atoms and bits. Digital information, for example, can be copied indefinitely; it can become quickly out of date, irrelevant or untrue; it may be manipulated to present a different truth about reality. These and other attributes of information are what will make the information society different from the industrial age.

The Information Revolution

Computing technology is having an all-pervasive reach into the fabric of everyday life. Processing devices are found everywhere: in washing machines, video recorders and cheap throwaway watches. The desktop personal computer (PC) of the early 1980s has grown from a typewriter replacement to an interactive multimedia workstation. The mainframe computer, once the workhorse of the computing industry, has been replaced by smaller cheaper more-powerful networked computing systems. Modern communication brings global events as they happen into the living rooms of billions.

These changes have been under way over the last three decades, but the impact is now being felt across all of society. Commentators are labelling this the *information revolution*. This will be a revolution, not just within an information context, but in the way that our lives and work are evolving. If truly a revolution, like the earlier agricultural and industrial revolutions, then it is very likely to destabilise the structure of today's society. In its place a new information society will grow, although what it will look like is still highly speculative. For this revolution to be beneficial to society, there has to be a balance between the market aspects and the responsibilities to the members of the community as a whole (see Figure 1). For example, wealth has to be generated but not to the detriment of society as a whole.

For many people, the new technologies are offering the opportunity to restructure their own lives. In the workplace, there is the appearance of the *knowledge worker*, somebody who is involved in the creation and use of information and knowledge in its many different forms. Individuals are experiencing greater flexibility in personal lifestyles, with greater choice being offered to them over the products and services they wish to purchase. Products derived from new technologies are providing new forms of entertainment and business opportunities. To entice the consumer to purchase their products, advertisers are accumulating personal details on individuals, which may often surpass that held by national authorities. Even the mechanisms of government are taking advantage of the new technology. All of this has the potential to reshape the form of our democracies. We have to guard against the information society within Europe simply focusing on new consumer information and entertainment services. The future needs to be about enabling new lifestyle choices, providing more individual freedom and a higher degree of personal self-realisation.

New Roles and New Players

The role of the communication industry, and in particular telecommunications, is pivotal to what is happening. The importance of the information revolution to the future of the telecommunications company cannot be over-emphasised. Within a very short period, European telecommunications companies are moving from being state monopolies to independent companies. Their businesses are evolving to include a wide range of new value-added activities as well as their traditional telephony activities. But more importantly, the shape of the industry in which they will operate is changing. New industry roles are emerging and new players are beginning to compete in these roles. To understand the information society this article explores these new roles and players.

Figure 2 shows some of the major interactions between these players. For example, political authorities will have an impact on all the players in the information society. Service providers are supported by the networks operated by the network operators. Service providers are likely to be the retail operators providing users with access to the content

Compared with today's segmented telecommunications and computer networks, the information infrastructure will become a massively integrated distributed processing environment.

material supplied by information providers. These service providers operate over and above the basic telecommunications offerings of the network operators. Manufacturers supply hardware and software to the network operators, service providers, information providers and users.

Information Market

The first element of this new society will be an information market, arising from the development and selling of information services. The market is being brought about by the convergent effects of industries built upon information technology; that is, telecommunications, computing and content production. There is more to the information market than the movement and processing of information in its many forms. The information market will greatly facilitate the exchange of physical goods and the pursuit of new leisure activities. It will provide greater opportunities for communication and the development of new cultures and communities. Anyone will be able to sell anything, to anybody, anywhere. It will provide new opportunities for trade, connecting suppliers of raw material to manufacturers, manufacturers to retail distributors, retailers to customers. Companies will be able to respond to customers' direct needs through mass customisation, thus meeting the specific needs of each customer. Pricing will be far more competitive, with suppliers responding directly to customers' specific requirements. These factors will indirectly lower the cost of distribution and maximise efficient use of raw materials, thus impacting upon environmental concerns. The information market will allow for greater outsourcing of specialised skills. It will provide virtual space for people to work, which in many cases will be from their homes and local communities. The global monopoly over manufacture and distribution enjoyed by today's global conglomerates will be challenged by smaller companies or individuals who will have equal access to the customers in the information marketplace.

Information Infrastructure

The information market could grow from the developing web of globally interconnected computer systems and networks, which will become the information infrastructure of the future. The Internet is one early example of such an information infrastructure. As these networks evolve and more powerful commercially-oriented networks appear, driven by user-friendly interfaces, the information market will have arrived in our own homes and work places. However, not everyone will have the same view of the marketplace. Through competition, innovation and differentiation, the market will stimulate products and services to meet individual customers' needs.

As the information marketplace develops upon the information infrastructure, new processes will link individuals, businesses and governments to a myriad of new business and lifestyle services and applications. Compared with today's segmented telecommunications and computer networks, the information infrastructure will become a massively-integrated distributed processing environment that will support:

- operation of user-oriented applications in real time;
- the intelligent processing and integration of information;
- large flows of raw and refined information;
- interactivity and cooperation between different processing devices across geographical distances; and
- delivery of any medium (video, image, text and audio) or a mix of these (multimedia).

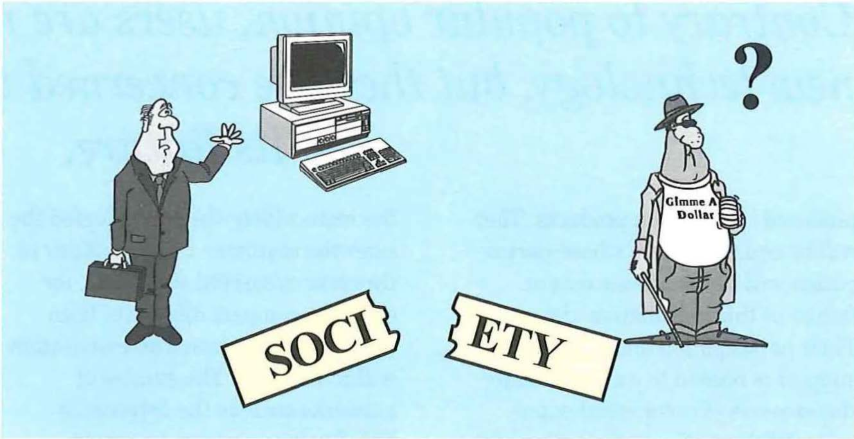
The form of markets will change from 'places' to 'networks'. Major out-of-town shopping centres will become distribution centres as the retail activities relocate to virtual shopping malls on the information infrastructure. Major nodes will appear on the information infrastructure that will have global significance, equivalent to the development of today's towns and cities.

Information services and applications built upon the information infrastructure do not have to await the installation of an advanced information infrastructure; that is, broadband optical networks. Access to the information infrastructure can be over today's copper telephony networks such as the public switched telephone network (PSTN) or the integrated services digital network (ISDN). The future information environment can be regarded as encompassing and surpassing current telecommunications networks and services. Interworking through de facto 'standards' is essential to the exploitation of the information infrastructure. The development of these standards will not be orderly or coherent (witness today's computer industry), but there will be increasing pressure from users and information content suppliers for standards to allow efficient information exchange. Work is now starting within Europe[2] to specify technically the future European information infrastructure (EII) and this will have an impact upon the development of BT's own network at home and abroad.

Future Information Society

It cannot be assumed that a balanced information society will necessarily arise from the information marketplace alone. All members of society need to be aware of, and to take an active part in, formulating the type of society that they wish to live in. The challenges and opportunities of new technology must be apparent to all members of society and its institutions.

Figure 3 – The polarisation of society



New technology can allow the efficient and cost-effective decentralisation of support services, such as medicine and education, back towards local communities. The extensive reach of the information infrastructure within an information society will enable an equalisation of opportunity and more-economic provision of support services. Local communities will be in a position to help meet the needs of those sectors of society with special needs, for example, the elderly, disabled and sick, in a proactive way. There will be an opportunity to make the support services customised to the needs of individuals within these groups; for example, continuous medical and location monitoring, sophisticated and effective telemedicine and telediagnosis, etc. There will be a movement towards supporting local communities. People may not feel so alone or isolated in the information society. The globally homogenising effects of the information market through mass media may be counterbalanced by encouraging local diversity. Local heritage and group identities could become important once again. However, the communities need not be geographically collocated: they may spread around the globe as global communities, as is already happening on the Internet.

The information society will allow the development of local groups that have a wider group identity and representation. In a Europe which, traditionally, has been physically and culturally divided, new information technology can offer unique, radical possibilities that could contribute significantly to the development of the European Union (EU). It could support cultural understanding and the feeling of being both a valuable member of a local community while also part of a larger entity such as the EU. The information society will be a truly global one, with people in many countries socialising and working together. They must be able to exchange information freely with privacy and security.

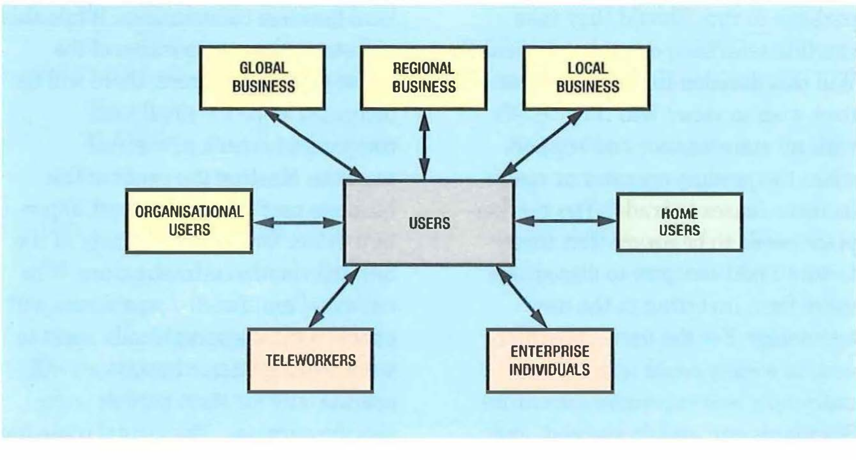
The information society will have an effect on people's working lives. A greater number of people will move from traditional working patterns to new flexible methods of working; for example, home workers, mobile workers, part-time workers and distributed teams. Education and training packages will be delivered to people's homes over the network to help them adopt these new work practices. Changing employment patterns will accelerate these demands. However, an important question is, will all members of the information society have equal access to information no matter where they live or how much they earn? If not, a new division will be created between information 'haves' and 'have nots' (see Figure 3).

The poor who cannot afford access to these services in the first place may also miss out in the information society. By not having access to its infrastructure, there will be a chance of an information underclass developing that will permanently miss the advantages of the new society. To overcome this, a new concept of universal service access may need to be developed which ensures that all citizens have a right of access to the information network.

The Users and Their Needs

The information society and its supporting infrastructure are there to support activities that are important to the users (see Figure 4). The users will determine what they want to do and which applications will support this. Individual users will have their own requirements and will demand that the information environment be personalised for their use. As a consequence, users will want a say in the use of the technologies that will eventually underpin the society in which they live. Little is being said about the users and their real needs. Many users are beginning to consider themselves victims of yet another technology revolution. It has to be questioned how much of this future vision is coming from an appreciation of people's actual needs and how much from the need commercially to justify and exploit new technology. The users of tomorrow should not be regarded as just consumers of mass-

Figure 4 – Influence on users



Contrary to popular opinion, users are not afraid of adopting new technology, but they are concerned with the consequences of its failure.

produced information products. They will be equal partners whose participation will decide the success or failure of this information vision. Their participation and enthusiastic support is needed to counterbalance the excesses of commercial enterprise. Without this participation and support, the information age vision could become an electronic nightmare.

For every type of user, liberalisation has widened the choice of communications products available. However, they are now faced with a bewildering choice of differing services, each with there own capabilities and benefits. For many, competitive choice has meant confusion as well as lower prices and new innovative products. Hard-sell marketing presents the users with conflicting information over the product most suitable for their needs. To make a choice involves taking a financial gamble on which solution will commercially succeed. To back the wrong one means that one is left with useless equipment and software. For example, a user who wishes to use e-mail has a choice of e-mail products based upon differing protocols, service providers and network operators. There is no guarantee that one e-mail system will be compatible with another. For users, standards are necessary to provide a sound basis for investment.

Similar difficulties are encountered with products from other parts of the information industry. Users have to choose which computer system to buy or which application package to run. Should they take satellite television or cable television? Will this decision limit the content they wish to view? Will they be left with no maintenance and support when the product operator or manufacturer ceases to trade? The marketplace needs to be aware that these factors could conspire to discourage users from investing in the new technology. For the users, the information society could turn into an unfriendly and expensive adventure. Standards can and do succeed, and the more widely they are adopted the safer the customer will feel. Many of the most successful standards, for example, compact disc, have been proprietary, but based on cooperation within industry. The success of networks such as the Internet is based upon a commonly agreed protocol. The Internet, until recently a non-commercial system, has seen significant growth. It provides an environment which is rapidly evolving to enable easy access to information. It also demonstrates the users' requirement for sanity and stability in the technology marketplace. Probably the most important lesson to learn from the Internet is that there is a considerable demand from all types of users for the new information capabilities on offer. Contrary to popular opinion, users are not afraid of adopting new technology, but they are concerned with the consequences of its failure.

The needs of business users

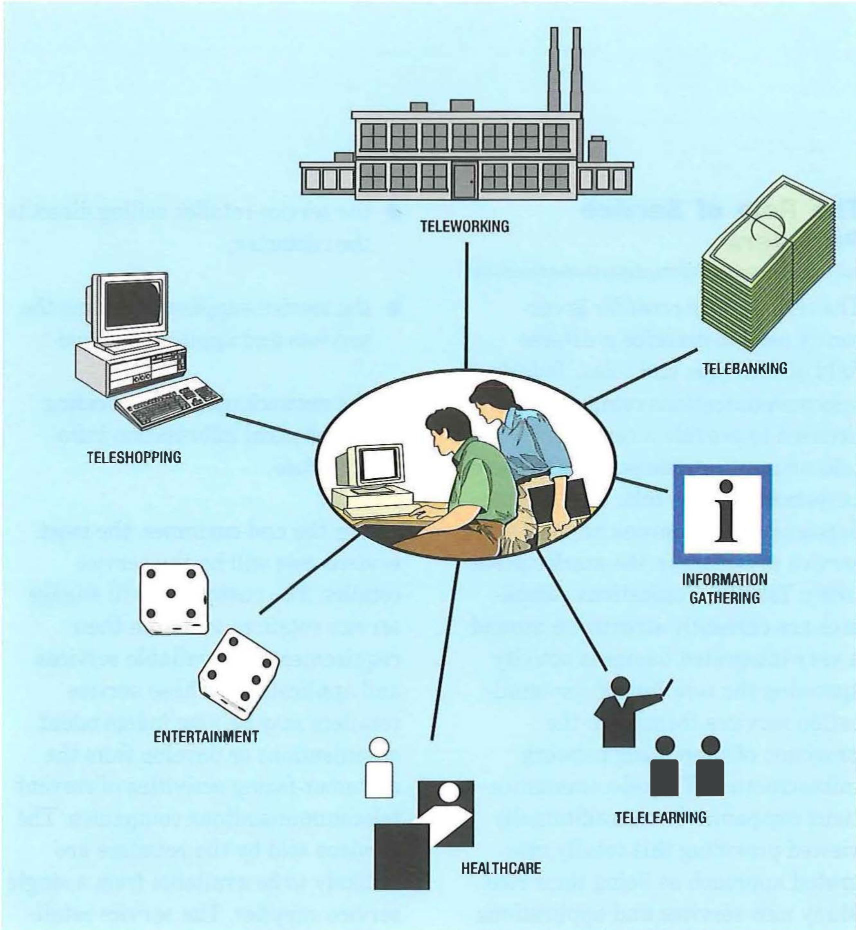
The information infrastructure has to be seen as more than just a replacement for today's public and private communications networks. It will provide businesses and other organisations with a platform for efficiently employing technology advances in many areas including education, administration and health. The information marketplace will be global. All business users will be confronted with a globalisation of their commercial activities and will face international competition. Globalisation will reach down to affect local business communities. While this will strengthen the position of the major global companies, there will be increased scope for small local companies to reach new global markets. Meeting the needs of the business user will be the most important driver for the development of the new information infrastructure. New universal multimedia capabilities will enable people geographically apart to work together. Some businesses will operate only for short periods or for specific purposes. The virtual company will become a common commercial entity. Other alternative business organisational methods are very likely to evolve. The ability of businesses to link their customers and suppliers in order to support new business activities will be critical for their competitive advantage. Today these requirements are met by specialised global infrastructure operators able to offer global one-stop shopping with end-to-end solutions. But their role is only transitory as the advantages of price differentials diminish and regional networks are upgraded and interconnected to provide direct high-capacity global interconnectivity and information processing.

The needs of individual users

In the professional, non-professional and residential environments, a multitude of new information facilities will require individuals to adapt increasingly to change. These changes will allow individuals to develop marketable skills, enabling them to be employed within the information society. The professional work available will demand better educated people with a broader range of skills. Rapid changes of disciplines will be demanded and people will require a portfolio of job experience to remain employable. They will increasingly come to rely on the support of professional knowledge-based applications on the information network. There will be a need for continuous education and new learning experiences. Telelearning will provide a flexible, accessible and potentially cost-efficient means of equipping the individual with the required skills necessary for competitive industry. Small-sized enterprises will benefit from access to sources of knowledge and skills previously outside their reach.

Everybody will be affected by the new technology irrespective of their type of employment. While the impact for professionals is perhaps clearer, it is equally important for the non-professional or trade worker; that is, bricklayers, plumbers, electricians

Figure 5 – The user's environment



and shop workers. These activities will still employ significant numbers of people. All such groups will have enhanced business opportunities if the new technology is tailored to their needs. This means inexpensive terminals, the right types of applications and information sources, etc. For the semi-skilled, most activities are locally based. To support them, good local information sources and communications will be required. The information network will be required to stimulate small enterprise operations and serve the local needs of the community.

The user at home

There are various influences of the information society on the individual users in their residential environment (see Figure 5). The integration of various media with telecommunications will touch upon a broad range of activities, for instance:

- information services,
- teleshopping,
- tele-education, and
- TV distribution.

Information services available from the home will provide people with instant access to many different sources of help and advice. A key driver for information services will be advertising (which may sponsor many of these new services). Teleshopping may make housekeeping easier. Interconnection of teleshopping with telebanking facilities will yield an integrated home-shopping facility. Apart from physical goods, a broad range of services (travel agencies, libraries etc.) will be accessed in a similar manner. Tele-education will enhance learning systems for large groups in society. Interaction with a remote tutor by means of teleconferencing will give access to high-quality educational resources.

Health care is of increasing importance in society as the mean age of people increases. Tele-observation and teleconsulting facilities will help the development of proactive rather than reactive health services for both sick and elderly people. This will reduce the number of visits to hospitals and perhaps avoid stays in nursing homes.

Entertainment facilities will expand significantly. The choice of content material will be sourced either globally, regionally, or from the local community. Entertainment is recognised as an excellent medium to impart information, and the so-called *infotainment* will play an important part in educating and informing people. Access to video material on demand will become the norm, while simultaneous broadcast will specialise on events in real time; that is, news, sports. The interactivity and increased bandwidth of the information network will encourage social and group activities such as games. People will be able to play games with anyone around the globe interactively. The use of virtual reality will add new dimensions to these social activities.

However large the opportunities seem to be, there are threats to be considered. The people that might be helped most by the new services may be the ones to have the most difficulties in acquiring the necessary skills to access them (for example, the sick, elderly and computer-illiterate people). User-friendly interfaces and active governmental stimulation in using them are therefore of utmost importance to get widespread acceptance. The user will experience challenging new issues such as having to deal with a flood of unwanted and possibly incorrect (junk) information. A major issue will be how people's privacy and the security of their information are to be ensured. It is therefore of vital importance to establish an information constitution that lays out the rights of the user within the information society.

Finally, with the development of timesaving information services, the question arises of how people will spend their increasing spare time. Will they spend more time working or will they spend more time entertaining themselves by interacting with a display screen in the home? Will there be other options open to them?

The Role of Service Providers

The term *service provider* is currently used to describe a diverse field of activities and roles. Today's telecommunications companies are licensed to provide a range of telecommunications services to their customers. In this role, they are the dominant telecommunications service providers in the marketplace today. Telecommunications companies are currently structured around a very integrated business activity spanning the retailing of communication services through to the provision of supporting network infrastructure. The telecommunications companies have traditionally viewed providing this totally integrated approach as being their role. Many new services and applications are already appearing which involve the processing of information. Much of the added value is passed to the owner and processor of the information. The revenue for transport of information is declining as it becomes commoditised and the marketplace liberalised. The dilemma facing telecommunications companies is that, although the production and packaging of information services and entertainment gives important added value and new revenues, a significant proportion of these revenues will not go to the telecommunications company. It is likely that the telecommunications companies will have to evolve their current business activities to align with the future roles of the information society.

To understand the future role of the service provider, we need to take a customer perspective. Customers will demand packages of features, products and applications meeting a spectrum of needs. As well as standard voice and visual communications, these will include interactive television, health monitoring, electronic messaging etc. The role of the service provider role may be simply broken down into three types of activities, see Figure 6:

- the service retailer selling direct to the customer;
- the service supplier providing the services and applications; and
- the network operator providing the physical information infrastructure.

For the end customer, the most evident role will be the service retailer. The customers will engage service retailers to match their requirements to available services and applications. These service retailers may be new independent organisations or develop from the customer-facing activities of current telecommunications companies. The services sold by the retailers are unlikely to be available from a single service supplier. The service retailer's role will therefore be to manage on behalf of the many suppliers the availability of services, applications and physical infrastructure. An important activity offered by the retailer will be the support activities to the customer. These include fulfilling contractual agreements for the provision of service, maintenance, quality, reliability, price, geographic coverage, etc. as well as the handling of billing on behalf of suppliers.

The retailers will provide their own window into the information environment with advertising and special offers. Premium-brand and own-brand services and applications will be sold. In this environment, the service retailers will have to concern themselves with new issues of information security and privacy. New standards of reliability will have to be adopted to ensure that customers are not disconnected from the applications to which they are subscribing. New roles will emerge; for example, acting as gatekeepers to a large number of specialised information and application providers. The retailers' emphasis will be on providing a rich and stimulating experience for their customers.

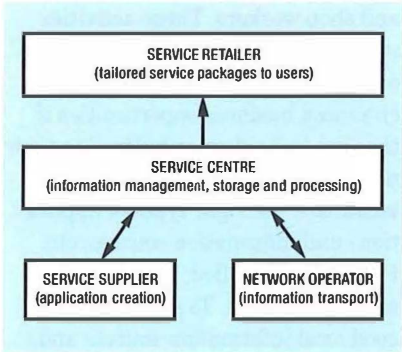


Figure 6—The roles of service provision

The Role of Information Providers

With an advanced communication infrastructure emerging, the role of the information providers will become more prominent. Information providers will be a key element in the success of the information society as they will either supply or own the information they provide to the users of the information network.

Current information providers include:

- publishers (for example, films, newspapers, books, TV, magazines, CD-ROM (compact disk read-only memory), games, music, etc.);
- broadcasters (for example, radio, TV, etc.);
- agencies (for example, Reuters, etc.), database providers; and
- traffic information providers, weather forecasters and many others.

At present, information providers develop information sources aimed at a single distribution method; for example, telephone information services (premium-rate services) are only accessible via a telephone and not necessarily via computer. Other niche, although highly profitable, markets for information providers include the production of television programme and movie titles, and information applicable to financial

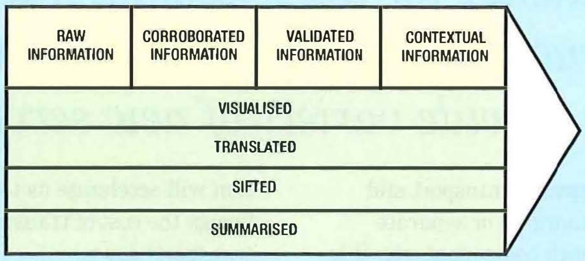


Figure 7—The information value chain

institutions that aid their investment decisions.

There is a value chain associated with the provision of information retrieval (see Figure 7). On the left side, there is raw information which has timeliness as a key attribute, but lacks corroboration and context. On the right, is information that has been processed and has contextual validity. Editors and publishers have traditionally filled the role of information processing, but with more dynamic information and more direct routes to it, the role of information processing is quickly changing. Information processing will become an important part of the information society. In general, commercial information is valuable initially, but the competitive value drops very quickly. There is thus a high premium on first access. 'Information is power' has never been so true. Other types of information such as films, books etc., drop in value much more slowly, and do not command such a high premium for first access.

A rich diversity of information providers, including many already existing, will appear in the information society. They will differ not only in size but also in their degree of commerciality, as is illustrated in Figure 8. Some providers, especially those existing for social reasons (for example, clubs), will produce information for free and others will require just a token payment. Some will have information as their main source of revenue (for example, news, broadcasting and film companies) and will therefore be highly commercialised. However, even commercial information companies will produce some information for free, such as publicity, free samples, and 'bait' services to attract potential customers. For example, movie studios are producing interactive multimedia promotions for new movies and making them available over the Internet.

As technology becomes cheaper, more powerful and more widespread, people at home will become capable of acting as information providers (or generating novels, multimedia, games, directories, music, art, etc). These people can bypass traditional distribution channels, making their products and services directly available to other customers. The development of World Wide Web server sites illustrates this possibility. There will be obvious opportunities to provide directories for this information, and marketing channels for those who wish to derive income from their work.

An information cottage industry can therefore be expected that may change the nature of information supply dramatically, since this will compete very effectively with 'mainstream' production. These 'information smallholders' will not have the same overheads as large companies but in principle will have access to most of the same information. A great deal of low cost (but high value) information will come from this sector, bringing the cost of information down in many categories, especially since much of this can come from overseas sources where costs are even lower. However, without branding, it will be difficult for users instantly to appreciate the quality of the information (factually accurate, does not breach copyright, entertainment value, value for money, etc.).

Figure 8—Information providers

Some information will simply be too difficult or expensive to be produced by smallholders. For example, large feature films may not be possible, but good-quality plays or soap operas could be within the capability of local community groups. It is possible that such local productions will challenge the American domination of the film industry.

As information has no value unless it can be found and used, directory producers will be an important value-adding component. This will obviously be a thriving market sector. Directories may also be provided by service providers and retailers. Another sector that will thrive will be the developers of software agents that will monitor and search the information world on behalf of users. Agents may perform a variety of tasks, such as observing flights at an airport and sending back a message to the users two hours before the flight is due to leave. They may also search for information, collect it, and send it back to base. Various software companies have seen the potential applications and profits that can come from using agents, and are already releasing products and services based on them.

All of this has implications for charging. This will certainly change dramatically from today's methods, with many more charging methods being used; that is, subscription, pay

A challenge for the telecommunication companies will be the construction and operation of new networks that will support a wide variety of new services and applications

per use, integrated transport and application charging or separate charges for each component, etc. It is not clear which methods will be preferred by the market and a sensible approach is to aim for as much flexibility as possible. For example, when transfers of small amounts of information are considered, payment for these transactions may be less than the cost of the billing. In these cases, an electronic form of cash (that is, Digicash) may be an alternative to that of purchasing via credit card.

Future Role of Network Operators

One of the challenges for telecommunications companies in the information society will be the construction and operation of new networks that will support a wide variety of new services and applications, while trying to evolve from today's legacy networks. These new networks are becoming known throughout the world as *information superhighways*, a term first coined by the Vice President of the United States, Al Gore. The term does not reflect any particular technology type, but rather paints a picture of a fully interconnected networked world where information, be it the 'heavy juggernauts' of interactive videoconferencing or be it the 'cyclist' delivering e-mail, can coincide with one another.

The operators of these networks will have to change their perspective of telecommunications services. Up to now, new services have been developed and run almost entirely by the telecommunications companies themselves. Noticeable exceptions to this have been telephone information services, often offered using 'Premium Rate' telephone numbers, where the content of the service is created by a third party. In the future, increased collaboration will be needed with third parties as a higher proportion of revenue will be derived by applications from the wider information field. This switch in revenue generation will accelerate as technology brings the cost of transmission (bit transport) down.

Collaboration must also extend to the building of the network, which must be able to carry the wide range of services that the user wants across national boundaries. No single country can, by itself, design and build its own network in isolation from other countries. Thus, agreement must be reached between operators about the way forward to the new multimedia networks from today's legacy systems. Ways have to be found to make these new networks easier to build and manage and further reduce their operational overheads.

Today's narrowband networks will eventually be replaced by broadband networks capable of carrying the new services and simultaneously allowing both rationalisation and cost reduction. It can be expected that new competition and new technology will change the structure of the network dramatically as well as the structure of the industry. We may see networks run across Europe by super-carriers, or at least spanning several countries.

It is certainly important to establish a sound bit transport infrastructure, since the benefits will only be partially realised if too great a compromise is reached. Care must be taken to ensure that incompatibility is not encouraged by the rapid growth of new networks, spurred by competition, market regulatory incentives and the rush for market penetration. In this event, such rapid growth would work against the best interest of the customer. The need for private companies to minimise risk may encourage joint ownership of infrastructure to spread the risk of investment in an uncertain market.

In many respects the network operator will be viewed as the bottleneck in delivering the new information services to the customer. New technology offers extremely inexpensive transport of digital information. However, this requires new investment by the telecommunications companies who themselves are faced with the uncertainties of liberalisation and new competition. To finance such investments, telecommunications companies will require some form of financial recognition of the risk associated with deployment of innovative technology to address unproven commercial markets. This will present a dilemma to the political authorities wishing to provide as free a marketplace as possible. It is very likely that, in return for political certainties, the telecommunications companies will have to agree to new levels of universal obligation and a radical restructuring and rationalisation of their industry within Europe.

Political Authorities

Political authorities are awakening to the impact of the new technology on society. In 1994, The EU published the Bangemann report[3] which looked at the development of the information society within Europe. Political authorities are keen that the advantages of the new technologies are realised in the classrooms and public libraries. But commercial forces seem to point the way to an electronic arcade (movies and games). As a representative of the Consumer Federation of America said in a speech to Congress: 'Providing socially useful applications will require direct public policy intervention, not reliance on corporate philanthropy'. The issue for political authorities is how they can promote the establishment of the information society through market forces while tempering some of the excesses and inequalities of the marketplace. Regulation will grow increasingly complex as new technologies bypass previous rules; for example, who will regulate the 'set-top box'—the broadcast or telecommunications regulator. As a result of using the new technology, issues such as copyright, security and privacy will also pose new challenges to political authorities.

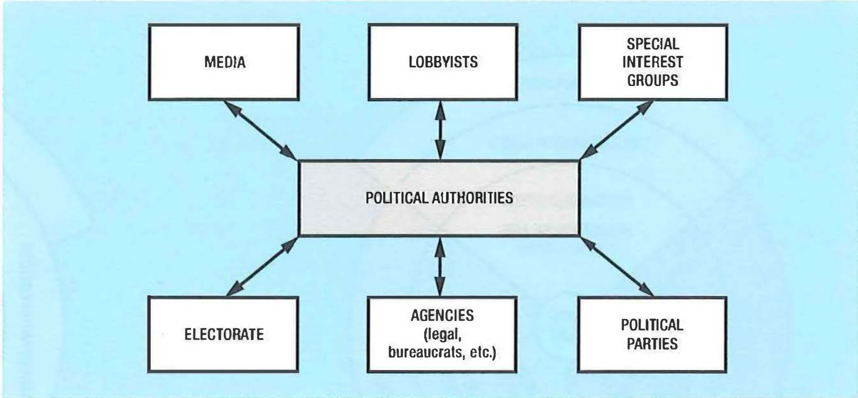


Figure 9—Political interactions

In an information society, as described at the beginning of this article, telecommunications is only a part of the larger communication and media industry. The technological revolution is provoking synergy and future convergence of these sectors. This presents a new set of challenges for policy makers. These challenges are largely due to the difficulties in anticipating the effects of new technological breakthrough. It is clear that, in time, the traditional boundaries between sectors of the industry will be blurred. At present, each sector is attempting to protect its position by reshaping its business activities through acquisitions and alliances. The industry is no longer constrained by national boundaries, and major global industries are being formed that are beyond the control of national political authorities. As part of their role, political authorities have tried to foresee the consequences of these developments and to act in due time. Decision makers such as national governments are acutely aware that the media (newspapers, TV, etc.) are having an increasing influence over the political process (see Figure 9). Perhaps more so than electoral systems and political parties.

Political authorities could use the development of the information infrastructure connected to the population at large to extend the democratic ideal. Referenda using the information infrastructure could occur more regularly with the aim of taking to extreme the goal of 'government of the people, for the people'. But can this be realised when the trend is for increasing numbers of citizens withdrawing from politics preferring to leave decision making to the political class (politicians, journalists, lobbyists and the like)?

If governments try to monitor and control the flow of information, the rights of the individual to privacy and freedom of speech may be endangered. Such actions may not necessarily be those of dictatorships but of legitimate democratic governments when threatened by a very unstable society. It may be considered necessary to regulate the information content and its flow to reduce instability. An example of instability that political authorities may wish to avoid may be the stock-market crash of 1987.

Political authorities in the past played a significant role in mitigating the extremes of the Industrial Revolution by creating the social welfare system. The imminent information revolution now needs active consideration. What are the basic guidelines pertaining to responsibility for incorrect information, fraudulent entry, copyright protection, decency (pornography and political extremism) and privacy? A set of rules, guidelines and voluntary codes of practice is needed to create a framework for the information market (see Figure 10). The Data Protection Directive is an early example. Owing to the very nature of information and its communication, this framework needs to be pan-national and ultimately global. One of the priorities of the latest round of GATT negotiations must be to address the free flow and commercial exchange of information as a tradable commodity on a global basis. Copyright and intellectual property issues pertaining to software are a major concern to all information creators.

A set of rules, guidelines and voluntary codes of practice is needed to create a framework for the information market.

The engagement of the mass market will require the establishment of a trustworthy and respectable marketplace, similar to hypermarkets and shopping malls rather than bazaars or market stalls. This requires the political authorities to develop and promote (via voluntary means) some mechanisms of enforcement.

Enforcement of laws in a situation where every citizen can be regarded as an information creator is much more difficult than in today's society, where mass circulation is limited to a few large commercial organisations in the publishing and broadcasting media. Perhaps the idea of licensing individuals to use the new information environments should be introduced. Here there is an analogy with the current driver's licence. This approach, while not limiting personal freedom or the establishment of an open market, would bring an element of control over the use of the technology and content. Universal licensing would also provide the political authorities with important sources of income for supporting other aspects of the information society.

Manufacturers

The information society depends critically on the development and manufacture of a wide range of technologies. The availability of these technologies to the mass market at an affordable price has been a key factor over the last decade for the changes occurring today. The manufacturers' marketplace has been reshaped by the adoption of common digital technology across all sectors of the media, entertainment, publishing and communications sectors. Manufacturers are therefore in a particularly

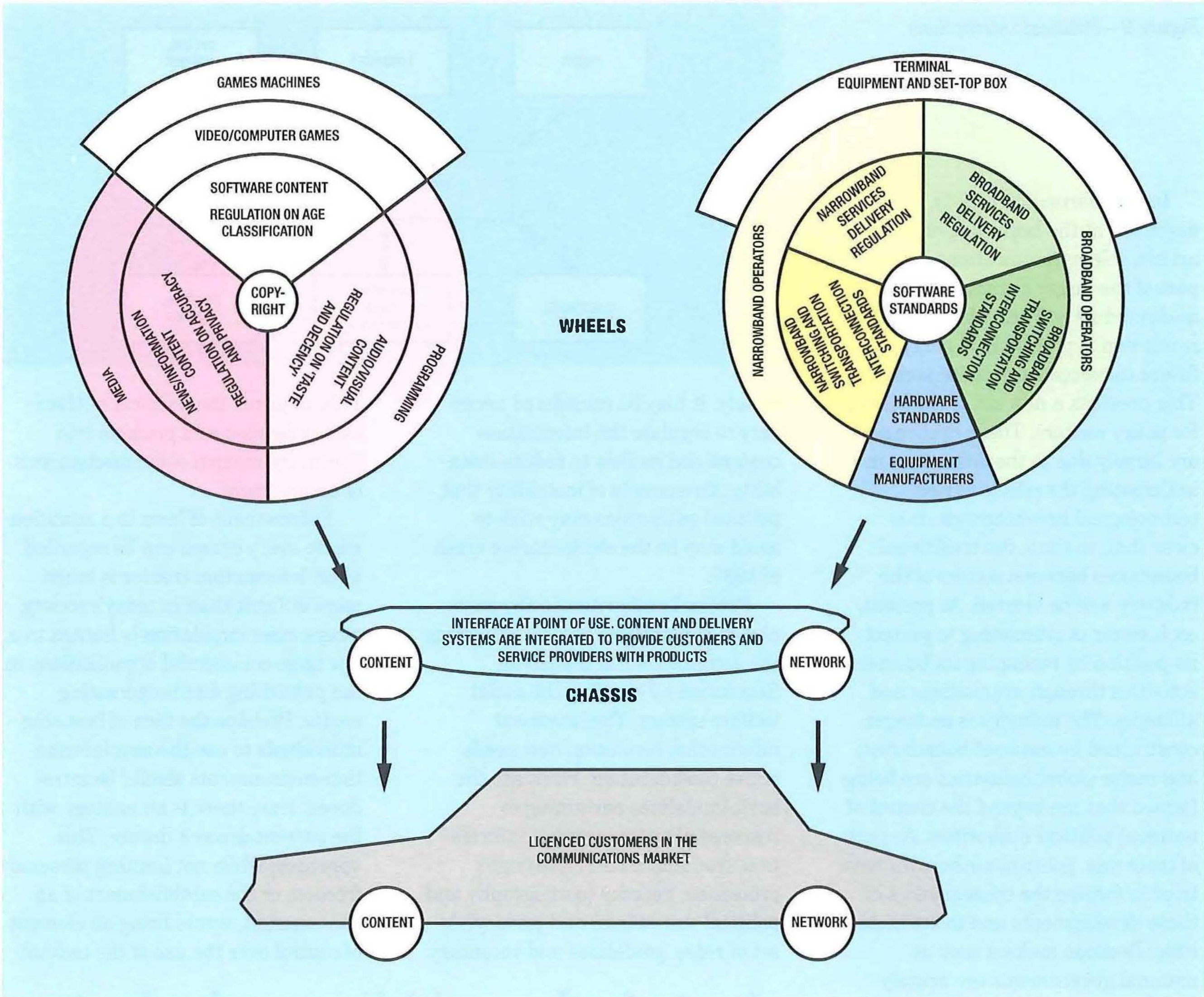


Figure 10—Regulations and standards

attractive position to determine the technological development of the information society. The information society will create a climate in which common needs and solutions are openly discussed and agreed. This could reduce manufacturers' risk in research and development in new areas. Such common concepts, coupled with investment by society in services to its members, should create opportunities for large-scale manufacturing. For the information society to develop, manufacturers will need to develop suitable standards. These are most likely to be developed through international standards bodies and industry fora. There will, however, still be a market for speedily introduced de facto standards in some areas.

With the need to provide the new interactive multimedia services, the telecommunications companies and others players are looking to the computer and software industries for the right skills and technologies. Many of the new hardware and software products are sourced from young, innovative, companies new to the IT marketplace. A large proportion of IT hardware will become a commodity product; that is, low cost and easy to obtain, with a low profit margin. To meet these challenges to their marketplace, the traditional telecommunications manufacturers will have to expand their technology base and product ranges. In doing this, the manufacturers will find that they have significant control over the choice, development and employment of the new technologies. This will not only be over their traditional customer, the telecommunications companies, but also over the new operators and new sectors that provide services and applications.

There are issues over European manufacturers' ability to provide the technology for the information infrastructure. They have strengths in the development of telecommunications hardware. However, there are weaknesses in other key areas. The manufacturing of electronic components, in particular chip technology, is dominated by the US and Japan. Development of high-speed computer processors is also dominated by American companies. Mass-market user devices are likely to be dominated by Far-Eastern manufacturers. Europe's biggest weakness has been, to date, the development of new and innovative software and applications. If Europe is not to become a minor player in the manufacturing sector of the information society, it has to encourage the development of these key industries and in particular strengthen its software expertise. To a certain degree, globalisation of these manufacturing activities will protect Europe, offering a wider market for manufacturers. There are, however, concerns. Without such encouragement, Europe will become increasingly dependent on the commercial pressures and priorities of its trading partners. If this is allowed to happen, Europe may not be able to make its own choices on the development of its information culture.

Conclusions

This article has summarised many of the issues involved in the establishment of the information society. The information society is with us today in embryonic form. The industrial world is entering a time of major changes affecting many aspects of our lives. Some of the diverse issues that Europe must address to develop its vision of this society have been described. In the information age, the winners (countries or companies) will be those who make appropriate and timely decisions based on a coherent and purposeful understanding of these issues. Many are far more fundamental than just being about technologies, economics and markets.

Today's telecommunications industry will be radically affected by the new environment. However, it is also in a position to make positive contributions to the development of the information society. No one part of society can achieve this transition on its own. Telecommunications companies, technologists, marketers, political authorities and users will have to work together to achieve the kind of information society that will satisfy the people of Europe.

Each of the 'opportunities' implied above for the information society will become very real threats if the opportunity is not seized firmly and consciously. Above all else in bringing about the information society is the necessity of partnership between the builders of the information infrastructure and the representatives of society. This could possibly be realised by political authorities making a commitment to invest in new technologies for areas such as public administration, education and health. The builders would then have the assurance of a market for the completely new services and technologies they are deploying. The challenges and opportunities of new technologies must be made apparent to all members of society and its institutions, and a healthy debate must be encouraged. With the help of such dynamism, Europe can introduce an information society that will give its people pre-eminent advantages in the next millennium.

Note: Neither the author nor EURESCOM warrant that the information contained in this article is capable of use, or that use of the information is free from risk, and accept no liability for loss or damage by any persons using the information.

Acknowledgment

This article is an abridged version of a report 'Shaping the Information Society' prepared by participants in the Overall Strategic Studies Project P311 of EURESCOM. The report is a public-domain document and copies can be obtained from:
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Biography

David Greenop
BT Networks and Systems

David Greenop works in the Future Platform Department of BT Network and Systems. He has a B.Sc. joint honours degree in Physics and Logic, and a Masters degree in Telecommunications Systems. He joined BT in 1975 and spent several years on operational planning before moving to BT Headquarters to work on the development of computer modelling tools for network planning. He has been involved in studies looking at various aspects of telecommunications networks. In recent years, he has focused on the longer-term developments in telecommunications and their impact upon BT's future network. As part of his work, he has taken a keen interest in developments within Europe through collaborative activities like EURESCOM. He has been involved for nearly four years in the EURESCOM Overall Strategic Studies area that is exploring many of the key issues concerning the development of the telecommunications networks in Europe.

Alan Croft

Implementing the UK National Code Change

This article looks back at the implementation of the UK national code change within BT. As well as looking at the impact on the telephone network and the related computer systems, it covers the publicity and customer issues, and what the changes meant to the customer apparatus business

Background

The national code change project involved three distinct changes implemented simultaneously on PhONEday, 16 April 1995, to create code capacity for new services and to achieve a structure for new service codes.

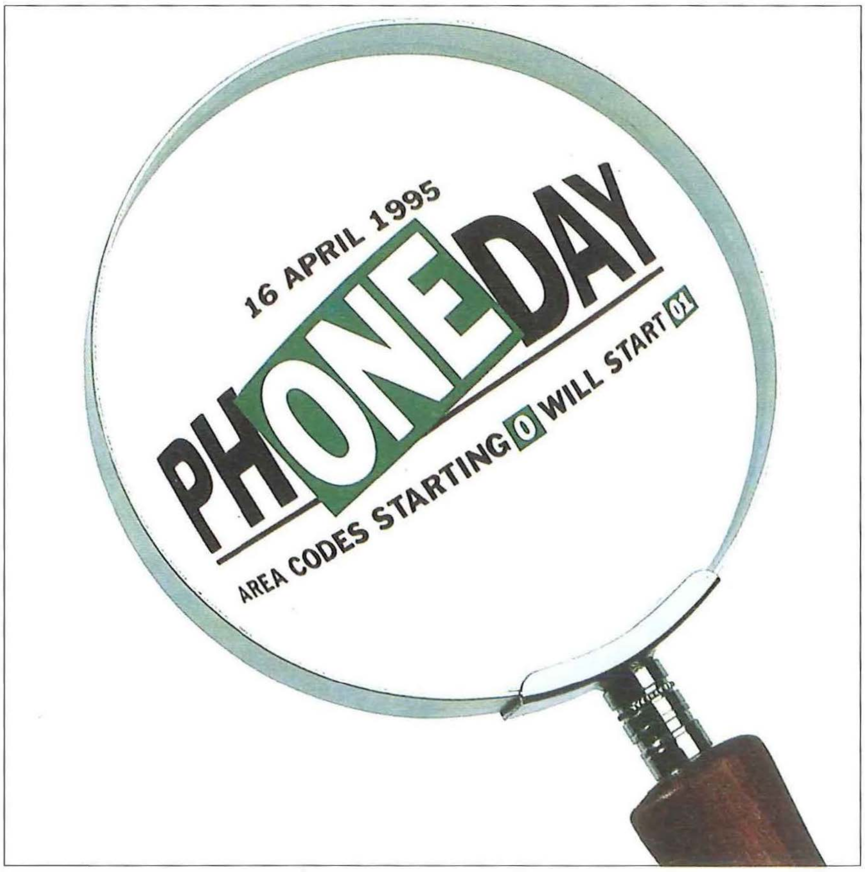
- All Area Codes were prefixed with '1'; for example, London 071 became 0171, 0274 became 01274.
- Five cities changed to seven-digit numbers with new area codes; for example, Bristol (0272) 234567 became (0117) 923 4567.
- The international direct dialling (IDD) code changed from 010 to 00.

It should also be remembered that non-geographic codes, such as mobile services and Freefone, remained unchanged.

PhONEday

Easter Sunday 16 April 1995 was chosen so that the long weekend would give both the telephone network operators and customers the greatest window (four days) to carry out the changes 'out of hours'. It also meant that the level of calls on the network would be lower than on

Some of the PhONEday publicity



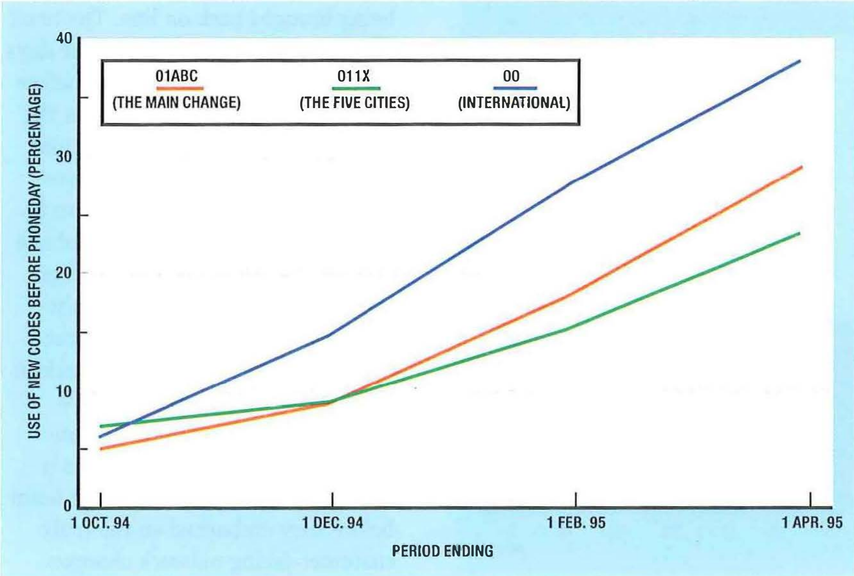


Figure 1—Use of the new codes before PhONEday

a weekday. With many people taking a spring break it would be a full week before the demand reached its peak. On PhONEday the old codes were withdrawn, after a period of parallel running or discretionary dialling.

The date for PhONEday was announced at the beginning of the project. This was a firm commitment within the industry and allowed customers to plan ahead.

BT planned parallel running from 1 August 1994 because the security industry needed at least six months to reprogram nearly half a million burglar alarms. At an early stage, the major network operators all agreed to commence parallel running on the same date, giving consistent messages to customers.

To guarantee that all the new codes would be available on the 1 August 1994, BT had to commence opening and testing new routings in the network from 16 June 1994. This meant that customers with call barring, call logging or payphones needed to implement any changes to their systems to take account of the new codes before mid-June to avoid any possible misuse of their installations. Apart from the reprogramming of auto-dial equipment, such as burglar alarms, it was not expected that many people would use the new codes until the final phases of the publicity campaign. However, significant interest was shown in the changes by the media and use of the new codes grew steadily throughout the parallel running period (Figure 1).

Networks

It was important to agree a common plan across all the UK networks so a meeting of network operators was convened. From the outset a good working relationship was developed with MCL and the other administrations serving Hull, Jersey and Guernsey. In addition to agreeing key dates and the interconnect aspects of the conversion, consensus was achieved on the policy and wording of recorded announcements so that customers would not be confused by different messages. A policy was agreed that announcements would be applied in the originating network to minimise ineffective traffic being routed across networks. It also allowed for customisation of messages—after all a caller probably knows which network he is calling from, but has no way of knowing to which network the called party is connected.

Another issue was the change of calling line identities (CLI). In November 1994 the use of CLI was to be extended from just ISDN to all BT customers (for the caller display and call return services). It was decided, therefore, that the CLI changes should be completed before November so that the new caller display service would work in the new format from the outset. As it is a requirement that the CLI number can be dialled to return a call, the CLI changes could not commence before parallel running was available. This gave the earliest start date as 1 August 1994 (guaranteed parallel running) and a completion date of 31 October 1994 (for the caller display launch in November). Each digital exchange had to be changed individually overnight so a national programme was prepared setting the date for each unit. Customers who wanted the information were advised of the actual date for each change. In a few cases, the programme had to be amended and so a process was established to keep the customers informed so that they could align their own work with BT's CLI programme.

The simple part was the cut over on PhONEday! Data had been built into each unit with switch points to switch old codes to the appropriate announcements, 23 in all for BT. Bilingual English/Welsh versions were included for all exchanges in Wales). This changeover began at 01.00 hrs. at the incoming international units (otherwise these calls would be connected to inland announcements which could mislead overseas callers) then progressed to the DMSUs followed by the local exchanges. By breakfast time, 90 per cent of calls to old codes were routed to announcements.

Network capacity had been checked to ensure that up to 30 per cent of calls could be routed to announcements without adversely affecting the quality of service. In the event, misdialling was well within those limits—20 per cent

From April 1994 to April 1995 the Helpline handled almost half a million calls

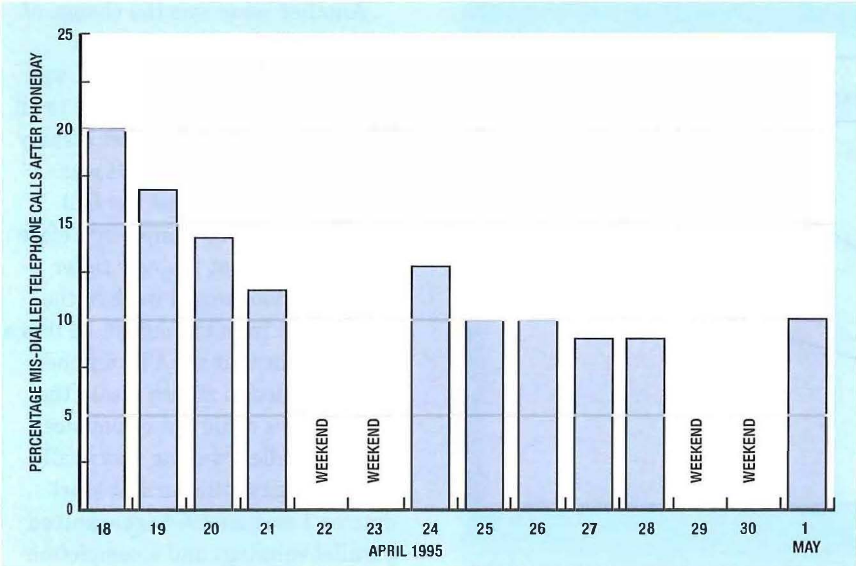


Figure 2 – Misdialled calls after PhONEday

maximum and quickly falling away (Figure 2).

The only problems encountered within the BT network involved customers with call forwarding/call diversion services where the destination number had not been reprogrammed. Callers dialling the correct number were forwarded/ diverted to the recorded announcement advising them that the code had changed. To overcome this problem it was necessary to interrogate the data for each exchange to identify these cases, and to change the destination code and number manually to the new format.

There were one or two problems with access to the non-geographic codes (which had not changed) from some overseas administrations. The range of exception codes meant that screening of codes to identify misdialled calls involved complex tables of valid and invalid codes and some errors had occurred. These were quickly corrected once the problem had been reported.

Computers

Besides the network changes, the other major technical area covered the computer support systems which manage BT's whole operation—maintaining the network, holding customer records and of course billing for calls and services. Any errors in these systems would have had serious implications for BT and its customers.

It was decided that systems would continue to work in the old format until PhONEday—which was the legal changeover date—with the systems coping with parallel running in the network and phasing in the changes to Directories and Yellow Pages.

From 1 August 1994, the billing system incorporated filters to convert data for any calls using the new codes back into the old format. Itemised bills therefore showed old codes for all bills produced before PhONEday.

On Thursday 13 April 1995, at close of business, all databases on the customer service system (CSS) were taken out of service for conversion. CSS holds all customer details and is used in support of fault repair and provision for BT's 25 million lines. Special read-only facilities were provided and manual procedures implemented to enable essential services to be maintained during the conversion period.

Each database had to be converted and then extensively tested to ensure integrity of the conversion before being brought back on line. The bank holiday weekend gave up to four days for this work to be completed before opening for normal business on the Tuesday. However, all transactions handled by the manual processes during the downtime would have to be entered on to the system and the aim was to minimise any backlog. With the staff working round the clock, using tried and tested processes, the last database was back in service late on Saturday night—before the network cut-over commenced. That achievement was a tremendous boost to the project team before they embarked on the truly customer-facing network changes.

Customer Premises Equipment

Customer equipment ranging from PABXs to private networks and roadside emergency telephones needed modification and reprogramming. All maintainers were faced with the prospect of handling this large volume of work. They each set their own policy and procedures. In the case of BT most of the work was carried out at the time of other maintenance visits such that all the work was completed before the 16 June 1994 deadline. It was for individual customers to programme their own user data into their systems. As far as terminal equipment (telephones, faxes and so on) was concerned, BT realised that many users would no longer have the original instructions. A guide to reprogramming every item in the BT portfolio was produced and sent to customers on request—or used by the helpdesk team to give advice over the telephone.

There were concerns right up to the last minute that some 'third party maintained' equipment would not be converted in time and that in extreme cases (where 01 had been barred to prevent IDD calls rather than 010) customers could find themselves unable to make any national dialled calls once the

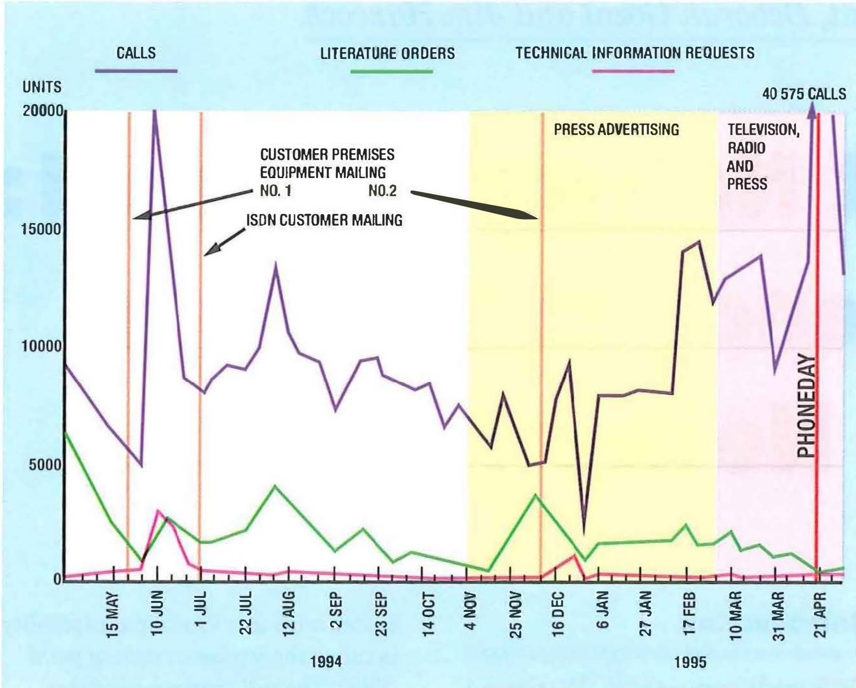


Figure 3 – Customer enquiries to the BT Helpline

network cut-over had been carried out. There was no evidence of such occurrences so in practice all who needed to make changes did carry them out in time.

Publicity

An important part of the BT project was to inform customers (and their suppliers). They had to be given sufficient notice to enable them to plan for any advance action they had to take—be it changes to telephone systems or changes to stationery and signs—and they had to be given detailed information to minimise any failures on the day.

The problem in developing such a broad campaign is that while some customers, particularly bigger businesses, need two years notice or maybe even more to develop and implement changes to telephone networks and major computer applications, other customers will be confused or unnecessarily alarmed by such a long period of notice. Ordinary telephone users only take notice and action when they really have to.

For these reasons the campaign began in 1993 with a targeted campaign using specialist press and selected newspapers to reach the suppliers of services. The first message to get across was that the growth was needed to give the country the capacity and infrastructure to see us through to the next century. It had to be seen as an industry need—not just BT. To promote this common ownership the PhONEday logo was devised for use by all companies involved.

With a year to go every customer was sent details with the telephone bill and a range of material was produced for issue on request to the Helpline. From April 1994 to April 1995, the Helpline handled almost half a million calls (Figure 3).

The final phase of the campaign used the theme 'It's One to Remember' and involved TV and newspaper advertisements featuring a range of memorable events—the humorous, the sporting and the serious.

The measures of customer awareness and the level of use of the new codes show that the campaign was a success. By the end of March, 100 per cent of businesses were aware of the changes and in the week before PhONEday, 50 per cent of calls were using the new codes. The British press and television were speculating there would be chaos and confusion over the Easter weekend—there was none!

Conclusion

The code change project ran more than four years from feasibility study to implementation. Arguably this was the biggest single change in the history of the UK telephone system. That long period enabled careful planning, and the incorporation of many of the requirements into 'business-as-usual' activities. The code change was delivered on time, to quality and to budget. This was a tremendous achievement by the hundreds of BT people involved across all areas of the business.

Biography

Alan Croft
BT Networks and Systems

Alan Croft joined BT, in 1964, straight from school and worked on exchange traffic design in south west London. As a special project, he worked on the coordination of customer information for the introduction of all-figure numbers for the South West Area. In 1970, he moved to Headquarters, working on traffic measurement requirements for local exchanges and then on to trunk network routing and planning. As a head of group in network strategy, he was responsible for local numbering policy issues and became involved in the discussions on '10 digit numbering'. In 1991, he took over as the project manager for the national code change project. Following the completion of this project, Alan is now working on a special project looking at the operational readiness processes for responding to major network incidents.

Trevor Wyatt, Deborah Gozal and Jim Hancock

Intelligent Network Phase 1: Intelligence in the Core Network

With the convergence of telecommunications and computing technologies the development of a truly intelligent network is becoming a reality. This article explains the realisation of BT's first intelligent network implementation known as IN phase 1 in the core PSTN.

Introduction

BT's intelligent network (IN) phase 1 project was launched in 1990 at a time when the industry was in the early stages of discovering the concept of intelligent networks and what it could offer telecommunications operators in terms of new services and features. At this time, in North America, Bellcore had published its proposals for the futuristic IN2 and there was much publicity about what could be achieved and by when. BT had ordered the digital derived services network (DDSN) based on AT&T technology which was being enhanced to provide a proprietary IN capability.

The IN concept and all that it implies has been well described in the recent BT Technology Journal on Network Intelligence[1]. Nearly all IN realisations operating in voice networks are based on a similar principle which is the *separation of the logic of a service* from the switching system. Put in more network architectural terms, IN moves the services and features running on a digital switch and places them in a separate real-time computer system, often called a *service control point* (SCP). In the IN environment, the switch asks the SCP what treatment to give the call, and the SCP provides the switch with the instructions on what is to be done; for example, route the call, play an announcement. For IN to be realised, a switch has to be modified to allow it to communicate with the SCP. A switch with this functional capability is called the *service switching point* (SSP). The *call treatment* is determined by the applications and logic running in the SCP. Modification of the SCP logic via service creation allows for new features to be offered.

In 1990, BT was in a position where major infrastructure changes were required to its switched network to meet the emerging IN standards. The processing power and data storage on switches were very limited, and, in terms of signalling, major changes were needed including new parts of CCITT Signalling System No. 7, transaction capabilities (TC) and signalling connection control part (SCCP) to allow the switches to communicate with remote SCPs. While BT moved forward with the longer-term strategic developments, IN phase 1 was developed within the constraints of the then existing switched network as a relatively simple early implementation, targetted to support a specific market need—number translation services; for example, 0800, 0891. The interface between the SSP and the SCP, based on existing signalling capability, is constrained to supporting a single call dropback message (CDBM), which allows the SCP to tell the SSP where to route the call. This is described in more detail later.

IN phase 1 was developed by GEC-Plessey Telecommunications (GPT) with clear objectives aimed at introducing an early phase of intelligence into BT's core PSTN. These objectives were:

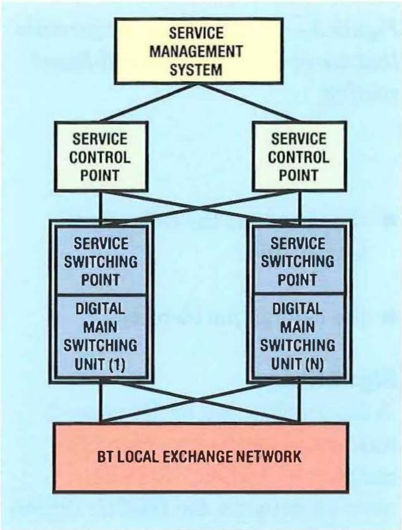


Figure 1—IN phase 1 architecture

- to gain operational experience of IN in the core network;
- to develop procedures for operating IN across the core network;
- to evaluate the use of standard computers in a real-time call handling environment;
- to meet a specific service need;
- to reduce network costs; and
- to implement the first phase of strategic IN development in the core network.

This article explores how these objectives were met as part of the IN phase 1 project.

IN Phase 1 Architecture

Overview

The IN phase 1 architecture, (see Figure 1), consists of two SCPs, a service management system (SMS) and a simplified SSP capability which resides within each of the 54 digital main switching units (DMSUs). Each SCP is securely connected via CCITT No. 7 signalling to each DMSU and each SCP is connected to the SMS via an X.25 network.

The SSP refers calls to the SCP for call treatment and then acts on instructions from the SCP, which is conveyed in a call dropback message (CDBM). Traffic originating at each SSP is divided equally across each of the SCPs by using proportional traffic distribution facilities.

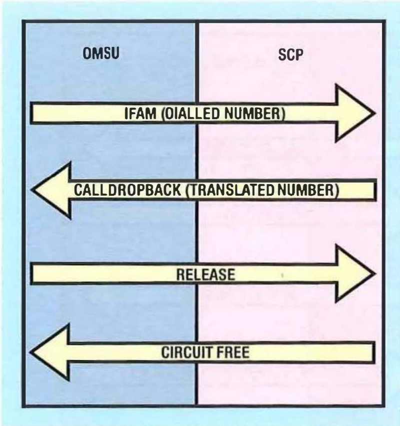


Figure 2—Message sequence for fixed translation calls

The SCP hosts a number-translation application suite, which performs number translation on calls sent up from the SSP. Typically the SCP receives a number from the SSP (for example, 0800 123456) and translates it to another number (for example, 0171 123 4567).

Each SCP holds identical sets of service/application data at all times (that is, the number translations data). The SMS provides screens for the inputting of service data and then ensures that this data is securely sent down and posted to each SCP.

IN phase 1 call setup

IN phase 1 provides two types of number translation service, which are reflected in two different types of call setup:

- *fixed translation*, where a direct translation from one number to another is provided; and
- *geographic-based translation*, where a translated number is derived based on the geography or origin of the call.

Fixed translation call setup

The message sequence for fixed translation calls is shown in Figure 2. The number dialled is sent to the SCP in a normal CCITT No. 7 initial/final address message (IFAM) and the SCP looks in its database for a translation for the dialled number. Within the SCP the dialled number is called the *service provider number* (SPN).

If the SCP finds the dialled number with a matching translation, it returns the call to the SSP with the translated number sent in the CDBM. Within the SCP the translated number is called the *translated address destination* (TAD).

If no translation is found on the SCP for a given SPN, the original dialled number is returned to the SSP.

Once the CDBM has been sent by the SCP, the SCP drops out of the call path. The IN phase 1 SCP does not act as a switching node.

Geographical-based routing call setup

Figure 3 shows the message sequences for calls that use origin/geographical-based routing (GBR). The SSP sends the IFAM with the dialled number to the SCP as in the fixed translation call; however, when the SCP looks in its database, it recognises that GBR is set up. The SCP uses the calling line identity (CLI) of the originating caller to determine the geographic location of the caller, and routes the call based on this information by returning a geographically derived translation in a CDBM to the SSP. The SCP can use full or partial CLI to derive geographical-based routings.

SSP functionality

The SSP has two functions: to act on information contained within a CDBM and to instigate the production of a call logging record, which is used to raise charges against the service provider. SSP functionality is only invoked on receipt of a CDBM. Prior to this the DMSU accesses the SCP using standard digit decode and routing functions.

The DMSU communicates with the SCP via circuit-related CCITT No. 7 national user part (NUP BT) signalling. Since the speech path for the call is not routed through the SCP, there is no need for speech circuits on the DMSU-to-SCP route. However, because circuit-related signalling is used, call processing requires a circuit reference to enable it to relate signalling messages to speech circuits. To overcome this, dummy or virtual circuits are provided. These are only provided in switch data, they are not physically provided on the DMSU-to-SCP route.

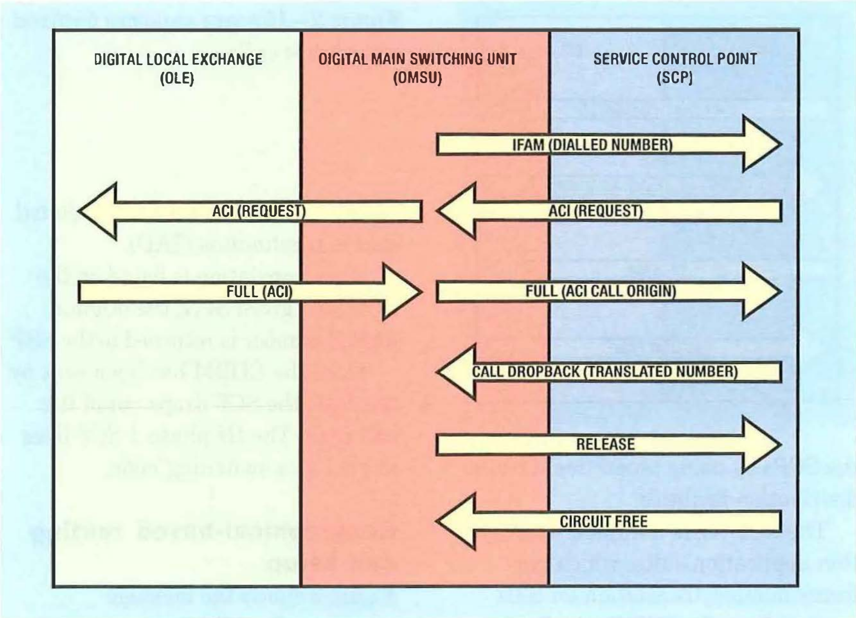


Figure 3 – Message sequence for calls that use origin/geographical-based routing

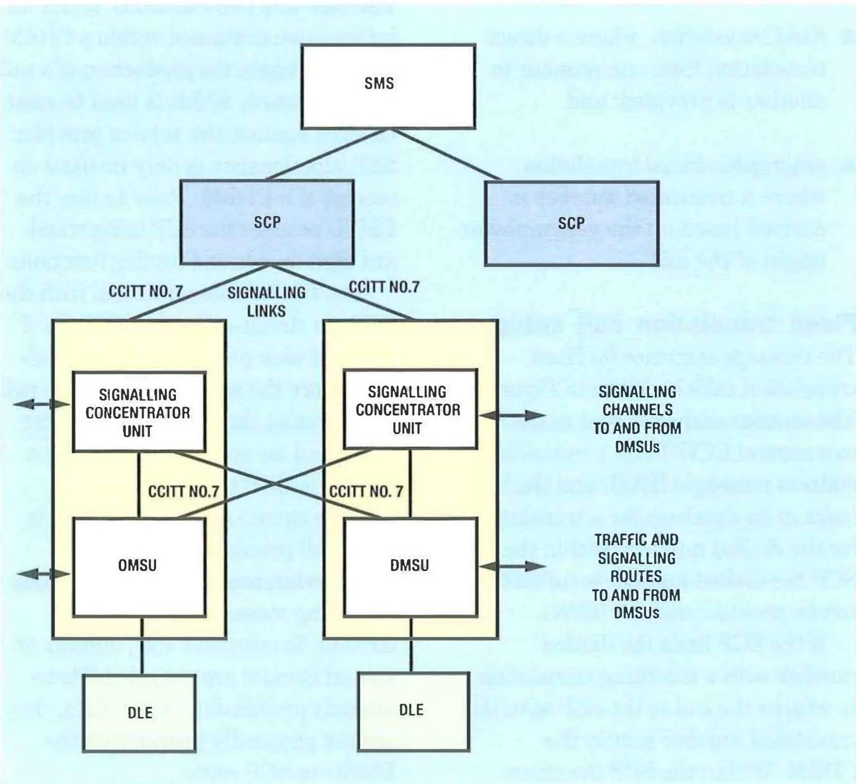
The CDBM contains data relating to the onward routing of the call, namely:

- a translated address (The SCP has derived this from the dialled digits received from the DMSU and it is used by the SSP to onward route the call.); and
- instructions relating to the production of the call logging record.

The SCP can specify that a call logging record is to be produced for both successful and unsuccessful calls or just for a successful call. An indication can also be provided that a call logging record is not to be produced for the call. The call logging record contains data to allow charges to be raised, namely:

- the dialled digits (for example, 0800 123456);
- the translated address (for example, 0171 123 4567);
- the time that the call was answered;
- the time that the call was released; and
- the calling line identity.

Figure 4 – IN phase 1 signalling interconnections



Signalling

A design objective for IN phase 1 was to ensure the provision of a completely resilient signalling network between the DMSUs (SSPs) and each of the SCPs.

There is no requirement for traffic circuits/routes between DMSUs and SCPs. 64 kbit/s channels for signalling only are required and these are provided in spare or dedicated channels within standard 2 Mbit/s PCM systems. The signalling channels from the 54 DMSUs are 'concentrated' via two specific DMSUs, known as *signalling concentrator units* (SCUs).

The signalling traffic is carried across the SCUs using 'nailed up time-slots' or private circuit connections on the DMSUs. Two SCUs are provided for each SCP, making a total of four, and every DMSU in the network has a signalling channel connection to each SCU, providing security and resilience. Figure 4 illustrates this.

An IN phase 1 performance model has been produced which models the IN phase 1 platform, the signalling links and virtual circuits and the performance in terms of throughput and congestion and response times under different traffic conditions, configurations and build levels. This model is used to ensure that the SCPs are fully utilised but not overloaded or their performance degraded when any of the above mentioned factors changes. Protection of the SCPs by preventing overload is generally achieved by limiting the number of circuits, and the model is used to determine what this limit should be.

Service control point

The IN phase 1 SCP is a two part architecture and consists of separate SCP front-end (SCP-FE) and back-end (SCP-BE) processors. The

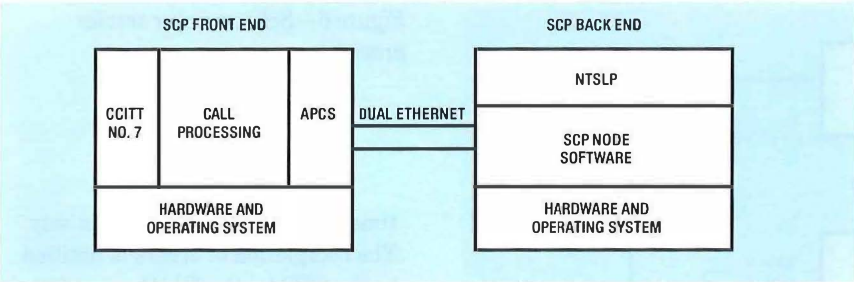


Figure 5 – SCP two part architecture

SCP-BE has a layered software architecture which hosts the number translation service logic program (NTSLP) and is based on the Tandem SCP. This is shown in Figure 5.

The FE of the SCP is a minimum-configuration standard System X switch which is configured with a base cluster and up to three slave clusters. The functions of the SCP-FE are to terminate the large number of signalling connections from the network, to unpack the CCITT No.7 messages and to send the raw call-information to the SCP-BE. Real-time call-handling communication between the SCP-FE and the SCP-BE is achieved using standard Ethernet and TCP/IP.

The System X SCP-FE hosts an additional hardware and software subsystem called the *attached processor communication subsystem* (APCS), to realise the Ethernet interface. Ethernet links between the SCP-FE and the SCP-BE are duplicated for resilience/security.

The SCP-BE is built on a Tandem fault-tolerant computer which provides resilience under single-fault conditions. Hardware fault tolerance is achieved by implementing duplicated load-sharing components (dual-ported input/output (I/O) controllers, dual-ported devices and a dual-interprocessor bus). A degree of software resilience in the Tandem environment is provided by backing up critical processes on alternate processors. Of the six processors in the SCP-BE, two are assigned to administrative functions only and the remaining four to application processing. The CPU hardware used is the VLX processor with the proprietary Tandem Guardian 90 operating system. The VLXs each have 24 Mbytes of memory and the disks equipped on the SCP-BE are 895 Mbytes (formatted).

Each SCP is capable of supporting up to 150 calls per second with 10 per cent of this capacity allocated for geographical-based routing services. The SCP introduces additional network delay which is of the order of 700 ms at maximum load, but less than this at lower traffic levels.

Service management system

The service management system (SMS) supports a number of management and operations functions for the IN phase 1 network. The principal function is the management and administration of customer service data across the SCPs. It provides screens which allow the addition, deletion and modification of customer data. The SMS holds a master copy of all service/application data. When data is entered onto the SMS, it is responsible for posting the data down to each SCP to ensure integrity of the SCP data, preventing data inconsistencies.

The SMS acts as a central point for collecting alarms event reports for each of the SCPs and provides customer statistics and reports.

The SMS is a Tandem fault tolerant computer like the SCP-BE and has a layered software architecture. The application on the SMS consists of a suite of management software called the *number translation management logic programmes* (NTMLP). The NTMLP is designed specifically to work with the NTSLP applications which reside on the SCP. The format, content and size of the database records within the NTMLP match what is resident within the SCP.

The hardware for the SMS comprises two Tandem CLX processors and disk capacity which is currently 648 Mbytes. The CLX, similar to the VLX, runs the Guardian 90 operating system. This provides standard system operations functions including system security, file management, system backup, archiving and recovery.

The SMS is securely connected to each SCP through an X.25 network over which runs the proprietary Tandem Expand application. Two X.25 Expand links are provided from the SMS to each of the SCPs. Data transfer utilises one of the two links available as the primary link, the secondary link being provided for security. A dual Expand link failure to any SCP would require data posting to cease.

IN Phase 1 Operations

Overview

A significant factor in the production and implementation of an effective and efficient operational strategy, was the close cooperation between the supplier and BT Operations during the development and delivery stages of IN phase 1. The main objectives included the establishment of a centralised network management capability for the IN phase 1 network and a single point of escalation and remote access control for the supplier support interface.

In order to take advantage of the Tandem fault-tolerant platforms and the remote diagnostic capabilities, a small team of IN phase 1 specialists was established to perform remote operations, administration and maintenance tasks. By eliminating the need for daily operational attendance at all platform sites, and by limiting the training and resource requirements to a small number of centrally located personnel, network operating costs have been minimised. The high availability of the application software, together with the comprehensive archiving and backup procedures enabling rapid recovery, have also contributed to providing a high quality of service performance.

Service provision and data audits

Customers' orders for the number translation service (NTS), from all sales channels, are handled centrally by Telemarketing Services. If

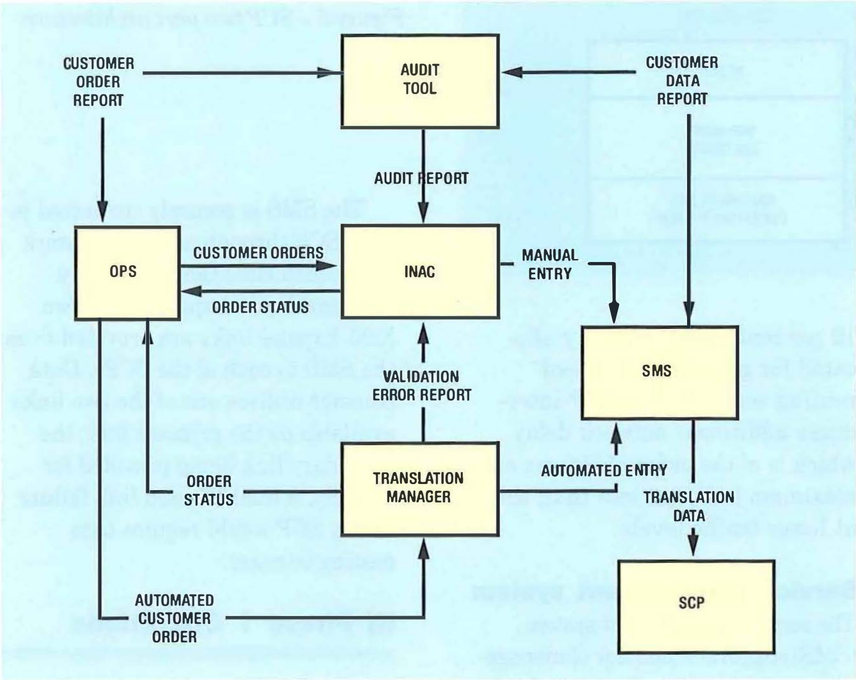


Figure 6 – Schematic for service provision

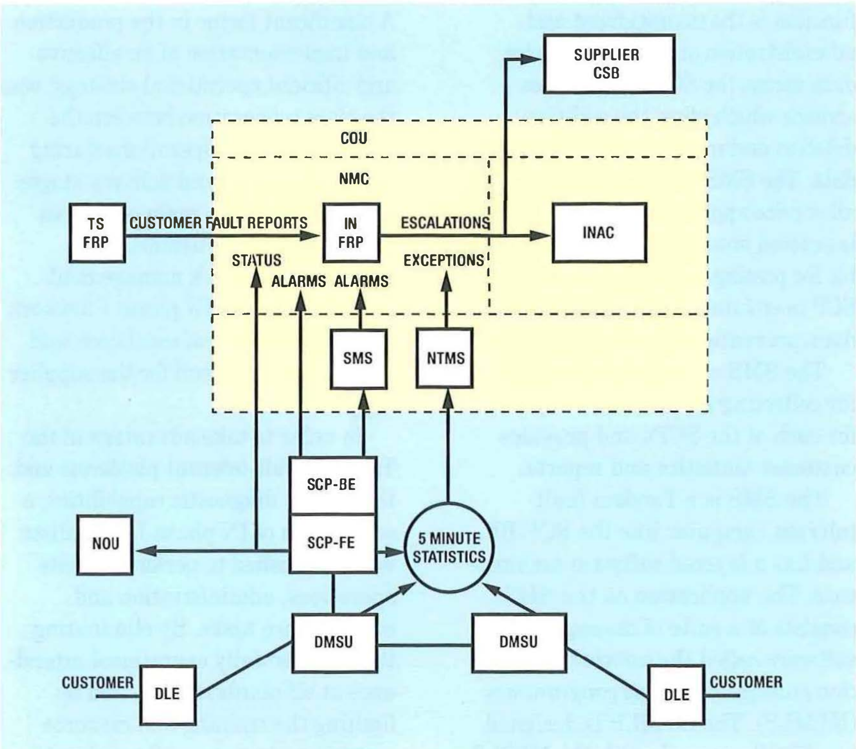


Figure 7 – Schematic of network management

required, the provision of new PSTN lines for the delivery of NTS calls is handled by normal business processes. The order to provide, modify or cease the translation is presented to the IN administration centre (INAC) via a dedicated NTS order processing system (OPS). INAC staff are responsible for implementing translations, via the SMS, at the SCPs. Both the INAC and SMS are located at the central operations unit (COU).

Most orders are implemented automatically via the translation manager (TM), a BT developed application. Any orders failing data entry validation checks performed by the SMS are reported to the INAC who resolve any problems and manually implement the translation via the SMS (Figure 6). Orders requiring coordinated implementation to meet a customer's specific needs (for example, change of answering location at a specific time), are also handled in this way. The completion of orders is notified to the OPS by the INAC or automatically by the TM.

Data audits are performed and results handled by the INAC staff on a monthly basis using a BT developed audit tool. A report is generated on the OPS for all IN phase 1 based services and a similar report generated from the SMS; both are downloaded to the audit tool, which compares them and generates an audit report.

Network management, alarm handling, fault management and escalation and support

The network management function for IN phase 1 is performed by staff within the network management centre (NMC), located at the COU. Data is collected every 5 minutes from the DMSUs for calls attempting to access the SCPs and is analysed/displayed by the network traffic management system (NTMS). Processor-occupancy information is also provided from the DMSUs and SCP-FEs. Exceptions to pre-set thresholds will identify any traffic handling problems on the virtual routes to the SCPs or processor overloads, and enable the NMC to investigate and take action to limit the impact of any incidents on the NTS.

Alarms and event or status messages from the SMS and SCP-BEs are also presented, via craft work stations (CWS) to the NMC staff. Each alarm condition indicates the nature and priority of the alarm with more detailed information on the generating event and action to be taken being available from the system.

24-hour alarm handling for the SCP-FEs is performed by the individual SCP zone network operations unit (NOU). Escalations for support are passed to the supplier's customer support bureau (CSB) via the IN fault reporting point (INFRP) in the NMC. The INFRP also has visibility of the SCP-FE alarm status and controls any maintenance or repair work taking place on the SCPs. See Figure 7.

Customer-reported faults are handled centrally by the telemarketing services fault reporting point (TS FRP). The TS FRP ensures that the PSTN service to which calls are directed is working correctly. All network faults for IN phase 1 supported services are passed to the INFRP via the TS FRP. The INFRP checks that the translation data held on the SMS is correct and, if necessary, escalates the fault to the INAC to determine its location and expedite a repair via the network operations units (NOUs). When a fault cannot be located by the INAC it will be escalated to the supplier's CSB via the INFRP. Customers are informed by the TS FRP once the fault is cleared.

Under the control of the INFRP, the supplier's CSB has remote access to IN phase 1 for remote diagnostics and repair. Should a supplier site visit be required, this is organised by the INFRP via the appropriate NOU. No site spares are held for the Tandem equipment and therefore, when required, this must be replaced by the supplier.

A fallback site is provided in case of emergencies where the NMC and INFRP are able to continue, among others, their IN phase 1 activities.

Operations, administration and maintenance (OA&M)

IN phase 1 operations, administration and maintenance are the responsibility of the INAC team during normal business hours, with callout via the INFRP at all other times. The INAC has remote access to the SMS and the SCPs.

The OA&M functions include service provision and the management and implementation of customer's large orders and timed customer data changes. The INAC is responsible for the data integrity and the running of data audits. It also takes a lead role in the migration of NTS to and from the IN phase 1 platform and the control of IN phase 1 upgrades with the support of the NOUs.

The INAC performs first-line maintenance for the SMS and the SCP-BE and runs limited routines on the SCP-FE. First-line maintenance on the SCP-FEs is the responsibility of the NOUs. The INAC also deals with application- and communication-related escalations from the INFRP. All support functions for IN phase 1 are undertaken by the supplier's CSB via the INFRP.

The computing operations group in the COU performs all daily audit trails and weekly backups for the SMS and SCP-BEs and assists the INAC with various housekeeping functions. A full system archive of the SMS and SCP-BEs is carried out six monthly. The supplier carries out preventative maintenance site visits on a monthly basis. Any data entered automatically on to the SMS is retained in the TM and a record of any manually entered data is retained by the INAC between daily archives.

In the event of a failure requiring recovery of the data, the weekly backup and daily archives would be loaded followed by re-entry of the data retained in the TM and any manually entered data. In this way, all data can be recovered up to the time of the failure. Complete loss of any system would require a reload of the full system archives followed by the data. The supplier's CSB carries out recovery procedures under the control of the INAC.

The INAC carries out performance and capacity management for IN phase 1 via the generation and interpretation of statistical reports from the SCPs and the SMS. This activity is supported by the COU-based capacity-management group who are responsible for the capacity management of all DMSU-to-SCP virtual circuits/routes.

The system access security manager (SASM) function for the Tandem systems also resides within the INAC. This includes the generation of user templates, user identities and passwords and user monitoring. The zone SASMs carry out this role for the SCP-FEs.

The launch of new products and services to be delivered via IN phase 1, through feasibility, definition, trial and national launch is also supported by the INAC. This includes the production of process and procedural documentation and participation in the operational readiness testing prior to launch.

Growth and evolution of IN phase 1

Since its inception, the deployment of IN phase 1 in BT's network has been seen as an interim step, until a fully flexible IN with an extensive SSP call model, non-circuit related signalling using TC/SCCP, could be built. In terms of network evolution, IN phase 1 delivered the embryonic SSP in the core network switches, which are now being enhanced to provide world beating, full IN Capability Set 1[2] and ITU[3] and ETSI core INAP infrastructure[4]. These developments are only now reaching fruition in BT's network, but in the future will enable the rapid introduction of new services and features in conjunction with new IN platforms.

Discussion and Conclusions

A review of the initial objectives set for the project shows that IN phase 1 achieved all and more than was envisaged at its inception. The operational experience gained has enabled BT to be in a more informed position for purchasing and operating future IN platforms. It has helped to clarify operational requirements for IN platforms and enabled these to be fed into future developments. The project has confirmed that standard, albeit fault-tolerant computing technology can be used and provides the operational capability needed to support real-time call processing. The grade of service offered and the resilience of the platform demonstrate in clear terms that SCP technology and IN are suitable for supporting basic mass-market telephony.

The IN phase 1 project has been invaluable in meeting BT's needs in the number-translation marketplace, and the initial capacity ordered is now fully utilised. The architecture of IN phase 1 has considerably reduced the costs of supporting number translation services, as the additional overheads of switching and transmission using overlay networks are minimised.

A lesson that this project has taught BT and the industry is that development of IN, however 'simple it may appear', is a complex task and should not be underestimated. To achieve a working IN solution requires a careful blend of the right skills from the traditional telecommunications and computing industries, together with a carefully controlled design methodology to ensure defined interfaces and strong integration teams.

References

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2 ITU Capability Set 1 Q121x.

3 ITU INAP Q1218.

4 ETSI 300 374-1 Core INAP.

Glossary

CLI	Calling line identity
CDBM	Call dropback message
COU	Central operations unit
CWS	Craft work stations
CSB	Customer support bureau
DSN	Derived services network
DDSN	Digital derived services network
DMSU	Digital main switching unit
GBR	Geographical based routing
IFAM	Initial/final address message
IN	Intelligent network
INAC	Intelligent network administration centre
INFRP	Intelligent network fault reporting point
NMC	Network management centre
NOU	Network operations unit
NTMS	Network traffic management system
NTS	Number translation service
NTMLP	Number translation management logic pro grams
NTSLP	Number translation service logic program
NUP(BT)	National user part (BT)
OA&M	Operations, administration and maintenance
OPS	Order processing system
SCP	Service control point
SMS	Service management system
SPN	Service provider number
SSP	Service switching point
SCU	Signalling concentrator units
SCCP	Signalling connection control part
SASM	System access security manager
TAD	Translated address destination
TM	Translation manager
TS FRP	Telemarketing services fault reporting point

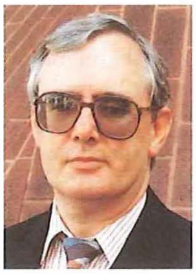
Biographies

Trevor Wyatt
BT Networks and Systems

Trevor Wyatt graduated from Keele university with a B.Sc. Honours degree in Electronic Engineering in 1981. From University, he joined BT where he worked in System X development for several years. This included periods working in a laboratory environment, integrating and testing the first digital System X exchanges. In 1988, he became manager of the IN team that was responsible for the specification, development and implementation of IN phase 1. He has recently been responsible for BT's strategic IN developments in the core network.

Deborah Gozal
BT Networks and Systems

Deborah Gozal joined BT in 1987, working on the digital derived services network, initially in operations and support, and later in the area of contract management. More recently, she joined the IN features team with technical specification and design authority responsibility for both the IN phase 1 platform and the tactical IN SCP. She obtained an M.Sc. in Computer Science from Hatfield Polytechnic in 1984.



Jim Hancock
BT Networks and Systems

Jim Hancock joined BT in 1965 and spent the following 15 years on various transmission and exchange maintenance duties in the Liverpool telephone area. After a short period in headquarters service and performance division, he joined the transit network management group at Oswestry in 1982. From 1984 to 1990, he worked on the specification, development, implementation and operation of the derived services network (DSN), including analogue DSN, digital DSN and advanced services platforms. He has worked in the IN operations group since 1990 and is currently the IN policy, process and strategy manager within the COU.

Andrew Catchpole

Computer Telephony Integration

The Meridian Norstar

PBX vendors, computer companies and innovative software companies are cooperating to realise computer-supported telephony solutions. The Meridian Norstar† business telephone system can already support such applications. One of the most innovative features of the Norstar system is the PC interface board, which provides the interface between the Norstar system and a desktop computer.

Introduction

In the July 1995 issue of *British Telecommunications Engineering*, a new theme on computer telephony integration (CTI) was introduced[1]. CTI was defined as a technique that enables the functional merging of telephony and data processing services in order to add benefits to business applications. More specifically, CTI enables command and status information to be passed between the voice and data processing environments. The telephony system could be a PBX, or a CTI-enabled telephone for a single-line business or domestic customer. The data processing system could range from a large mainframe computer to the small, but comparatively powerful, desktop personal computer (PC). There are currently two main approaches to CTI: *desktop integration* and *PBX-based integration*. There is also an opportunity for the telcos to offer CTI on the public network that could be used to cooperate with or even replace the private telephone networks.

Desktop integration applies when a computer application is linked via a physical interface at the desktop to a single telephone and/or line. The computer application can then manipulate that telephone/line; for example, to make and receive calls. The application can generally perform the same functions as the telephone/line itself—it knows what the telephone/line knows and its view of the telephony world is limited to the view from that telephone/line; this view is known as *first-party CTI*. For small installations, this approach to CTI is normally the simplest and cheapest method to achieve functional integration between the telephone and the computer.

PBX-based integration, also known as *third-party CTI*, applies when a common CTI channel is provided between the computer system and the PBX telephone system. Each workstation or client still has desktop CTI functionality, but in this case there is normally no physical connection between individual computers or workstations and the telephone. Instead, the client computers communicate via a computer network to a telephony server which has a common CTI link into the PBX. With PBX-based integration, the computer application(s) can generally perform the same functions as the PBX—it knows what the PBX knows and its perspective of the telephony world is extended to that of the PBX telephone network. As the PBX can manipulate a collection of telephone sets and lines, so can the computer application. The PBX-based CTI approach is normally a more complex method to achieve integration between the telephone and the computer, and for small numbers of users can be considerably more expensive than desktop integration. However, for a complex call centre application, a desktop CTI solution would not normally be a cost-effective or practical proposition.

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

Continuing on the computer telephony integration theme, this article concentrates on one specific telephone switching platform—the Meridian Norstar business telephone system. The Norstar offers some unique features as far as CTI is concerned as will be revealed in greater detail within this article.

Figure 1—Norstar M7310 digital feature telephone

Meridian Norstar Key Telephone System

The Meridian Norstar is a fully digital business communications system manufactured by Northern Telecom (NorTel). The Norstar Modular is the market-leading telephone system for small-to-medium-sized businesses. It is reported that, since its launch in 1988, over 425 000 Norstar systems[2] have been installed in over 65 countries. In the UK, where BT is the only supplier of the Norstar, sales have exceeded 60 000 installations since its launch in 1991.

The Norstar is a hybrid telephone system which can be configured as a traditional PBX with one or more answering points or switchboards. Alternatively, the Norstar can be configured for key system working, similiar to the popular key-and-lamp units, whereby terminals have multiple line buttons and displays to indicate line status.

Meridian Norstar design

The development of Norstar was market-driven through extensive customer research. Three major design objectives emerged[3] for the Norstar system:

- ***Cost-effectiveness***—to deliver a business telephone system at an appropriate price. The Norstar Modular system has been designed to grow as required as businesses expand, thus reducing the need for expensive new systems and retraining.
- ***Simplicity in operation***—to simplify every aspect of manufacturing, distributing, selling, installing and using a business telephone system. Extensive research resulted in system features designed specifically for ease of use. For example, all Norstar terminals have liquid crystal displays (LCDs) to guide the user in a context-related fashion when using the system features such as transferring calls, conferencing etc. (See Figure 1.)
- ***Level of functionality***—to increase radically the functionality offered by a business telephone system relative to previous electronic analogue key systems. As well as having in excess of 80 system facilities, the Norstar allows software developers to create additional functionality using interactive applications; for example, voice mail systems and desktop applications. The Norstar architecture is based on the ISDN interface; therefore, as well as voice, the Norstar can potentially carry data simultaneously at speeds up to 64 kbit/s but only requires a single pair of wires between each terminal and the Norstar central control unit (CCU)—which again increases simplicity and reliability.

In the UK, BT offers two models of the Norstar telephone system depending on the current and projected size of company:

- Compact 6 × 16 with 6 exchange lines and 16 extensions;
- Modular 32 with up to 188 exchange line/extension port combinations.

The recently launched Norstar Modular 32 supports up to two ISDN30 digital connections from the public exchange with a total number of ports of up to 188 analogue exchange lines, digital exchange lines and extension ports. The Norstar has its own range of digital telephones; however, the Modular 32 will be developed to support I.420 standard terminals. ISDN services, that is, two 64 kbit/s channels, will therefore be available to every desktop. This will potentially allow connection of BT's DP2000 digital telephones, VC8000 videoconferencing, Group 4 fax etc., as well as other I.420-compatible terminals behind a business telephone system. The new Modular 32 also has new features such as direct dialling in (DDI), calling line identification (CLI) and call charge indication.

Norstar Computer Telephony Integration

PC interface board

One of the most innovative features of the system is the PC interface board (PCIB)[4], which provides a physical interface between the Norstar CCU and an IBM-compatible PC. (See Figure 2.) This CTI link gives a PC application program access to the Norstar's signalling system and a data communications channel for transfer of data between computers. Signalling and data messages received on the Norstar's extension ports are transferred by the PCIB on to the PC's data bus, and messages from the PC are transferred by the PCIB to the Norstar's extension port. The data and signalling channels of a Norstar extension port are time-division multiplexed (TDM) in a similar way to ISDN; that is, 64 kbit/s for a voice channel (B1-channel), 64 kbit/s for a data channel (B2-channel) and 16 kbit/s for the signalling channel (D-channel). The Norstar is cabled in a star topology and only one terminal is permitted at each port. The major difference between ISDN and the Norstar system is that the D-channel signalling information is broadcast to all extension ports. Therefore, a signalling message for one extension terminal is always seen by all extension terminals. Effectively, each computer with a PCIB card has the functionality of third-party CTI although still using a first-party CTI connection model. This is a particularly important feature which allows extremely flexible CTI capabilities.

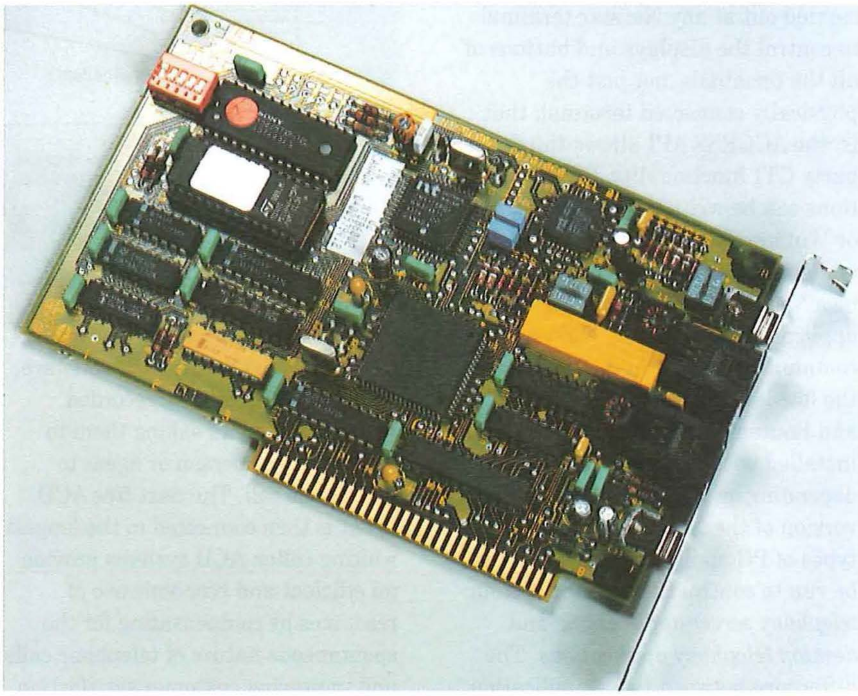


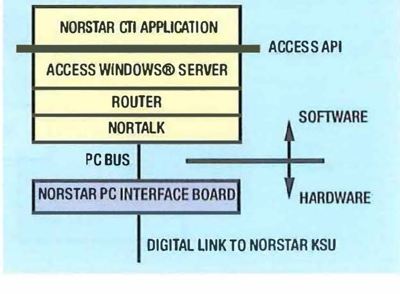
Figure 2—Norstar PC interface board (PCIB)

The CTI capability for the Norstar is cost efficient. However, the one-off ACCESS software development licence is required from NorTel and run-time licence royalties are payable to NorTel for every application using the CTI capability.

Software drivers

In order to make use of this PCIB interface, the appropriate software drivers must be installed into the host PC. (See Figure 3.) The *Nortalk* driver is a TSR (terminate and stay resident) program which is executed only once during the PC boot-up procedures. Nortalk runs in background and provides a logical message link between the PC application program and the PCIB. Up to 16 application programs can be running in a single host PC at the same time; therefore, another TSR called *Router* allows the messages to be delivered to and from each application to the PCIB via the Nortalk TSR program. As stated earlier, only one Norstar terminal can be connected to each extension port. However, the PCIB hosted in a PC can be connected in place of the terminal and, if required, a terminal can be connected to the secondary port of the PCIB. The number of PCIBs that can be installed on a Norstar system is not limited; therefore, it is possible for every Norstar terminal to be connected to a PC.

Figure 3—Software interface to the Norstar PCIB



Norstar ACCESS toolkit

The Norstar ACCESS application development toolkit is a 'C' language application programming interface (API) that allows PC-based applications to communicate with the Norstar system and its terminals. Monitoring and/or control can be

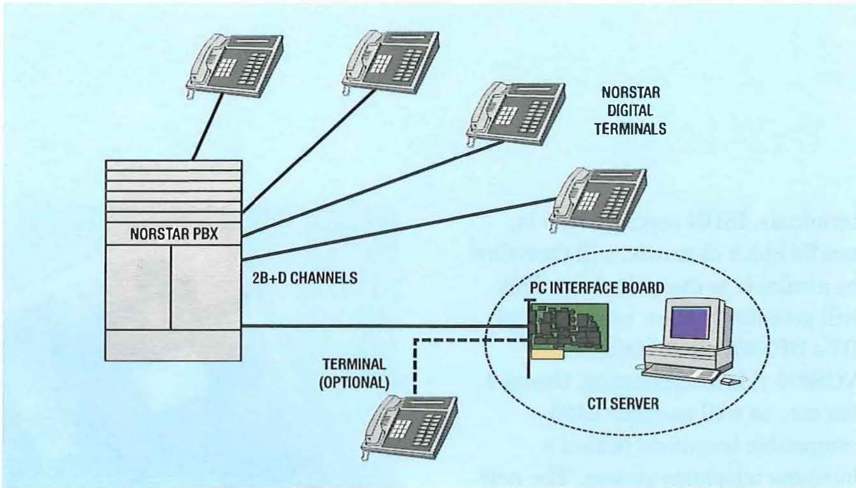


Figure 4—Norstar CTI architecture with server-based PC application

carried out at any Norstar terminal to control the displays and buttons of all the terminals, not just the physically connected terminal; that is, the ACCESS API allows third-party CTI functionality. PC applications can be written for either DOS or Windows® operating systems, while a new OS/2 PCIB driver will be available during 1995. The PC application uses the ACCESS API to communicate with the PCIB through the low-level DOS drivers—Nortalk and Router. ACCESS must be installed with appropriate files depending on the specific software version of the Norstar CCU. Two types of PC application program can be run to control the Norstar system: *telephony server applications* and *desktop telephony applications*. The difference between these application types is explained below.

Norstar Telephony Server Applications

A telephony server application is a computer program running on a single PC for the benefit of a group of Norstar terminal users. The server application can interact with the terminal users by displaying messages on the LCD screen of the Norstar terminal, and users can respond by pressing the terminal's soft-keys or the programmable feature buttons. (Soft-keys are buttons positioned just below the LCD screen (see Figure 1) which are dynamically changed by the software application(s)). The CTI server application is able to monitor the activity of all the system's devices such as terminals and lines. It can also initiate new calls and change the state of existing calls. Effectively, each computer with a PCIB card has the functionality of third-party CTI although still using a first-party CTI connection model (see Figure 4).

ACD for Norstar

An example of a Norstar telephony server application is the Norstar automatic call distribution (ACD)[5] system. Incoming calls are automatically answered by the ACD software, which plays a digitally recorded message to callers asking them to wait for a free person or agent to handle the call. The next free ACD agent is then connected to the longest waiting caller. ACD systems provide an efficient and economic use of resources by compensating for the spontaneous nature of telephone calls and improving customer satisfaction by always answering the longest waiting call first. ACD for Norstar also provides statistical management reports to allow the system configuration to be monitored and refined.

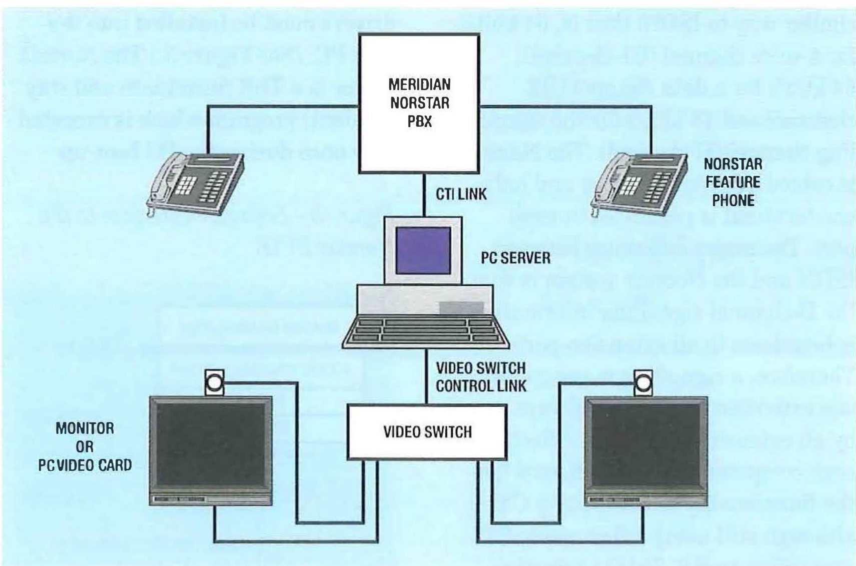
StarTalk Mini

StarTalk Mini is a voice processing system which uses the Norstar's CTI capabilities to answer calls automatically and take messages or route callers through a number of options known as *custom call routing* (CCR).

Norstar VideoPBX

The Norstar VideoPBX is a prototype system that was designed and built by using the CTI capabilities of the Meridian Norstar telephone system. CTI allows calls on the Norstar to be shadowed by a video switch which connects appropriate cameras and TV monitors together so that the users enjoy both audio and video communications (see Figure 5). 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 capture card so that the video is displayed on the PC screen. Normal Norstar system functionality such as call holding, transfer and conferencing is maintained for the voice and video parts of the call. Internal video calls on the Norstar VideoPBX enjoy television-quality pictures, while off-premises calls use

Figure 5—Norstar prototype VideoPBX system using server-based CTI architecture



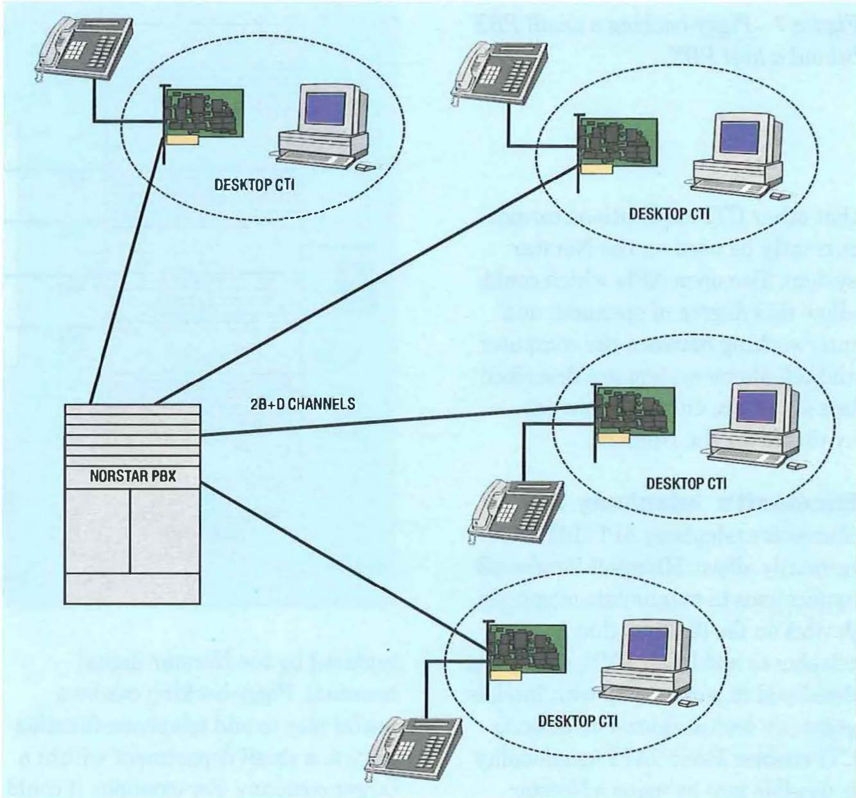


Figure 6—Norstar CTI architecture with multiple third-party desktop CTI

a VC7000 gateway to route calls over ISDN2. Additional applications have also been identified for the Norstar VideoPBX system, one of which is the distribution of business TV channels to the desktop using the VideoPBX system. Business TV or broadcast channels can be selected by pressing buttons on the Norstar terminals which connect the required programme to the monitor.

The Norstar VideoPBX telephone system has features available that are not yet supported by existing video-telephony products. In particular, the system allows full PBX functionality and television quality pictures when calls are made within the same building. With this system, 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 prototype was to develop an **easy-to-use** video communications system which anyone could and would use.

The VideoPBX concept offers an alternative to state-of-the-art technology and prepares customers for future desktop multimedia services and applications. By using system integration and CTI it has been shown that an economic and high-quality video-telephone system can be built today by using off-the-shelf hardware.

Norstar Desktop Telephony Applications

Desktop telephony applications are executed in a PC that is physically connected to a Norstar extension port and Norstar terminal (see Figure 6). Generally, the application will only monitor and control the single collocated terminal, but this is not a restriction of the Norstar system because the PCIB uniquely allows full third-party CTI at **every** desk. There are no commercial desktop telephony applications available for the Norstar system. Indeed no known applications are available worldwide and it is a market that has yet to be exploited. Personal telephone directory applications which automatically make calls to the selected number are the most common examples given for desktop telephony applications, but these are fairly mundane tasks for CTI. A more novel example could be a telephony workgroup application whereby a PC application could allow screen-based control of a programmable group of users' telephone lines; for example, to answer a colleague's ringing telephone. Integration into existing applications such as Microsoft Mail and Schedule+ could provide a much more powerful method of dealing with colleague's calls; for example, to find out when someone will be returning to the office, to book a meeting, to send a telephone message. These types of CTI application are commonly known as *personal productivity applications*.

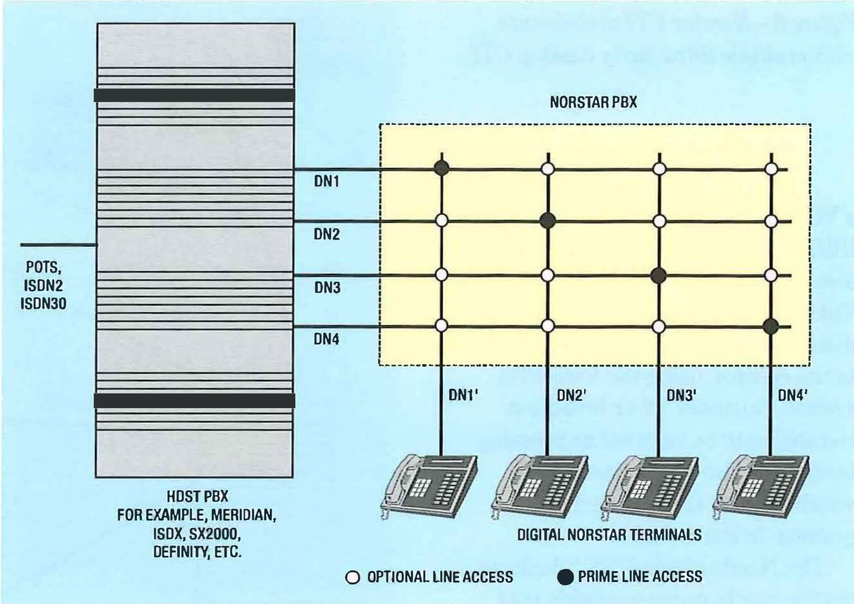
Dialogic Voice Processing Cards

An independently produced CTI card is also available from Dialogic[6] which is primarily aimed at the voice processing market, although it does have advantages in other CTI applications areas. In addition to its own hardware and software, the Dialogic platform has many supporting tools and applications support from third-party companies. Current and future CTI applications using the Dialogic platform could potentially be moved to the Norstar platform with the minimum of software modifications. Possible CTI features using the Dialogic board include outbound dialling, audio recording and play-back, speech recognition, text to speech, facsimile etc. Each Dialogic board has four independent Norstar digital terminal interfaces, which replaces the need for the Norstar terminals. The PC board can handle all the normal telephony signalling including DTMF as well as access to called number identification for calls transferred within the system, access trunk identification for calls originating outside the system, and control message waiting notification. Uniquely, the board also provides real-time digital audio recording and play-back which removes the need for digital-to-analogue conversions for voice processing applications.

Other Application Programming Interfaces (APIs)

Norstar ACCESS is a proprietary API, which means that a CTI application must be specifically developed for use on the Norstar system and therefore cannot be reused on any other non-Norstar telephone system. This also means

Figure 7—Piggy-backing a small PBX behind a host PBX



that other CTI applications cannot currently be used on the Norstar system. Two open APIs which could allow this degree of openness and interworking between the computer and telephone system are described below, but are currently not yet available for the Norstar.

Microsoft's telephony API

Microsoft's telephony API (TAPI)[1] primarily allows Microsoft Windows® applications to manipulate telephony devices on the desktop; that is, telephones and lines. TAPI, which was developed in partnership with Intel, is generally seen as a low-end desktop CTI enabler. Basic TAPI functionality is possible now by using a Norstar analogue terminal adaptor (ATA) and a POTS computer telephony interface[1]. However, for full PBX functionality, specialised hardware and software will require development.

Novell's telephony services API (TSAPI)

TSAPI, which was developed jointly between Novell and AT&T, is aimed primarily at the PBX market rather than for physical desktop integration. Most of the major PBX vendors, including NorTel, have agreed to provide PBX drivers to support TSAPI by the end of 1995. Once a PBX is linked to a TSAPI server then the customer will be at liberty to buy and operate **any** number of value-adding CTI applications.

Piggy-Backing

It is not unusual for a PBX in the Norstar's class to be deployed behind a host PBX; this is sometimes referred to as *piggy-backing*. When piggy-backed, the Norstar is usually configured in a square arrangement whereby each Norstar terminal has one (or sometimes multiple) directory numbers (DNs) from the host PBX (see Figure 7). Also, originating calls from a Norstar terminal have prime access to its associated DN. In effect, the Norstar becomes transparent except that the original telephone is replaced by the Norstar digital terminal. Piggy-backing can be a useful way to add telephone functionality to a small department within a larger company. For example, it could be used to offer:

- digital telephones,
- key-and-lamp facilities,
- automatic call distribution, and
- voice mail.

Another important reason why piggy-backing could be useful is for providing cost-effective CTI solutions. This is a particularly attractive proposition when a CTI solution is required exclusively within a small department of the company. The advantages of a piggy-backed CTI solution are:

- ***Cost-efficient CTI solution***—CTI solutions to date have often concentrated on the large call centre markets with large PBXs. Desktop integration will offer much cheaper CTI applications but these are often not scaleable and the CTI functionality is not as rich as with PBX-based CTI. Norstar CTI allows cost-effective PBX-based CTI at every desktop without expensive new PBX replacements.
- ***Department-wide deployment rather than big-bang approach***—Often a CTI solution, for example, a technical help desk, will only be required in a small department, which could easily have an autonomous telephone system behind the much larger company-wide PBX.
- ***PBX independent***—Piggy-backing should be possible on almost all PBX telephone systems. Normally, where a PBX has been supplied by a company other than BT, then it would be commercially impossible to gain access, if it existed, to the CTI link. Piggy-backing would resolve this problem allowing the host PBX's CTI link to be by-passed.
- ***Single API***—There would be no need to write specific versions of the application software for every different type of PBX system; the application software would always be written by using the Norstar's ACCESS API.
- ***Potential for shrink-wrapped CTI***—There is potential for marketing a complete one-box solution that would include all the necessary application software and CTI connections (which just happens to include a Norstar system for piggy-backing on the host PBX!).

The Norstar VideoPBX prototype system, as described in this article, is a good example of piggy-backing the Norstar to achieve a cost-effective solution that is independent from the underlying host PBX.

Acknowledgements

The author would like to thank the BT Norstar product line managers and NorTel for their help in completing this article.

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6 Dialogic products and services guide—D/42-NS™ voice board.

Glossary

ACCESS Norstar's application programming interface
ACD Automatic call distribution
API Application programming interface
CCU Central control unit
CLI Calling line identity
CPE Customer premises equipment
CTI Computer telephony integration
DDI Direct dialling in
DN Directory number
LCD Liquid crystal display
PBX Private branch exchange
PC Personal computer
PCIB Personal computer interface board
POTS Plain old telephone service
TAPI Telephony application programming interface
TSAPI Telephony services application programming interface

Biography

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 as a Technical Officer working in a group developing a facsimile transmission testing system. He was then promoted into his current position in the Network Intelligence Engineering Centre at BT Laboratories where he works in the Customer Premises Equipment and Peripheral Intelligence group. His main work is investigating computer telephony integration technology for the desktop and the Meridian Norstar. 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 a video telephone system using CTI.

Stanley Chia

Global System for Mobile Communications

Radio Coverage Design and Planning

The radio coverage of a GSM system is dependent on network dimensioning, cell architecture design and frequency planning. It is further affected by the base site aquisition and implementation as well as the switch parameters design. The objective is to construct a quality network with an optimal investment through efficient utilisation of the network infrastructure and spectrum. This article provides an overview of the design and planning process for achieving good radio coverage and examines the many trade-offs involved.

Introduction

Good radio coverage is frequently perceived to be the key quality of service measure for a cellular network. This is no exception for the Global System for Mobile Communications (GSM). Similar to any cellular network, the planning of radio coverage for a GSM system is based on the optimisation of many interrelated factors including the traffic distribution, spectrum allocation and characteristics of base station equipment. An effective radio plan for a GSM network must satisfy simultaneously several operational criteria, including a high user capacity, a large geographical footprint, a good quality of service and an efficient utilisation of network infrastructure. Radio-coverage planning is further influenced by many external factors such as regulatory and environmental constraints as well as user behaviour. In general, the prime objectives are to provide extensive radio coverage and to achieve a high user capacity for minimum investment.

As a first step in producing a radio plan for a GSM network, the national spectrum allocation plan and the spectrum migration plan for both the servicing country as well as the neighbouring countries have to be considered. In addition, detailed terrain features, morphology characteristics and demographic data have to be evaluated. While computer-based engineering tools are useful to assist radio coverage planning, the accuracy is frequently dependent on the topology of the country and the radiowave propagation model employed. For hostile terrain or heavily urbanised cities, extensive calibration of the engineering tool will normally be required to achieve statistical accuracy. The primary output of the radio coverage planning is to generate search circles for acquiring base sites as well as to produce frequency plans for radio-frequency (RF) channel assignment. In order to validate the plan, field measurements of the footprint and interference level of each individual base site have to be conducted to confirm their feasibility before implementation. Network optimisation has to be carried out once the base sites are launched into service in order to fine tune their performance.

The principle of 'frequency reuse' was introduced in an earlier article in this series on GSM[1]. In that article the concept was illustrated using a mosaic of polygons. In practice, the coverage area will be far from regular, and a highly complex planning function is needed. To this end, this article addresses the key considerations essential for ensuring good radio coverage as well as providing insights into the practicalities of the planning process.

Spectrum Management

The success of a GSM cellular network is critically dependent on the allocation of sufficient radio spectrum. More spectrum would generally imply less-expensive network infrastructure and better operational efficiency. While it is true that by reducing the cell size, a denser frequency reuse pattern and hence a higher user capacity can be achieved, in reality this may have a profound impact on the network quality if not designed correctly. Thus it is important that the amount of radio spectrum allocated is identified before the design of a GSM radio network is commenced. Together with other system features to be adopted, such as full-rate or half-rate speech coding, and the requirements for data transmission, the quantity of radio network equipment can also be determined.

In order to facilitate international roaming and the utilisation of standard GSM equipment, the GSM spectrum allocation is standardised across Europe and among many countries adopting the GSM system. The GSM spectrum allocation at 900 MHz is divided into the primary GSM band and the extended GSM band. Both bands support full duplex transmission using two sub-bands spaced 45 MHz apart. The primary GSM band runs from 890–915 MHz for mobile-to-base transmission (up-link) and 935–960 MHz for base-to-mobile transmission (down-link). The extended GSM band runs from 880–915 MHz for the up-link and 925–960 MHz for the down-link. This is summarised in Table 1.

In some countries, for historical reasons, part of the GSM spectrum allocation is assigned for use by the analogue Total Access Communication System (TACS) and extended TACS (E-TACS) networks. This will result in the subdivision of the primary GSM band into a TACS sub-band and a GSM sub-band. The former normally occupies the lower 15 MHz of the 25 MHz duplex allocation, while the latter occupies the upper 10 MHz of the duplex band. As the GSM networks mature, spectrum migration will take place to phase out the analogue networks, returning more spectrum for GSM operations. For GSM, the RF channels (n) are numbered from 1–124 and the corresponding centre frequencies can be calculated from the following equations:

mobile station transmit:

$$F_{up}(n) = 890{\cdot}2 + 0{\cdot}2\,(n - 1)\ \text{MHz}.$$

base station transmit:

$$F_{down}(n) = F_{up}(n) + 45\ \text{MHz}.$$

For a start-up GSM network, a minimum of 12 carriers is normally assigned in order to adopt the reuse pattern needed to meet the minimum carrier-to-interference ratio (CIR) requirement for satisfactory network operations. However, most regulators allocate 24 or more carriers to an operator so that two carriers can be assigned to each cell.

If two operators are assigned to adjacent bands, one RF channel is normally the minimum guard band required to avoid interference between them. International coordination of the frequency allocation is also required at national borders. This should normally conform to CEPT TR 20/08 and CEPT TR 25/04, which provide guidelines for the harmonisation of frequency usage and planning at international boundaries. Specifically, CEPT TR 20/08[2] states that the frequency coordination at national borders should be based on the following principle: preferential frequencies or preferential frequency bands (that is, the frequencies or frequency bands which are not allocated simultaneously at the border of a neighbouring country) may be used without coordination with a neighbouring country, if the field strength of each RF carrier produced by the base site does not exceed 19 dBμV/m, at a height of 3 m above ground, at a distance of 15 km inside the neighbouring country. All other frequencies are subject to coordination between administrations if the interfering field strength produced by the base sites exceeds 19 dBμV/m, at a height of 3 m above ground, at the border between two countries.

Table 1 GSM Spectrum Allocation

	Extended GSM Up-link	Extended GSM Down-link	Primary GSM Up-link	Primary GSM Down-link
Start	880 MHz	925 MHz	890 MHz	935 MHz
Stop	915 MHz	960 MHz	915 MHz	960 MHz

Spectrum Efficiency

GSM adopts a spectrally-efficient Gaussian minimum shift-keying modulation scheme. Nevertheless, radio spectrum is a scarce resource, and therefore it must be used efficiently in the design of the network. In practice, greater spectrum efficiency in a GSM cellular network can be achieved in three ways: better trunking efficiency, a higher density of base sites and tighter frequency reuse distance. In the following, these approaches are discussed in more detail. It is, however, important to note that the effectiveness of these techniques is limited in an already congested high-capacity network. The efficiency of a GSM network is ultimately dependent on the availability of sufficient spectrum allocation.

Trunking efficiency

As a general principle, a higher user capacity can be achieved by improving the trunking efficiency of the radio network. This can be achieved through an increase in the spectrum allocation and the introduction of low-rate speech coding.

Spectrum allocation

When more spectrum is available, more RF channels can be assigned to individual base sites. An increase in the number of RF channels per base site implies that a better trunking efficiency can be achieved. Moreover, in accordance with traffic theory, the gain of capacity through better trunking efficiency is in excess of the increase in spectrum; that is, the process is a non-linear relationship.

Half-rate coding
While half-rate coding doubles the number of voice circuits for a transceiver, the overall gain in network capacity may not always be fully achieved. The reason for this is that the utilisation of half-rate coding within a network is also determined by the number of full-rate users (such as roamers and early subscribers) and the amount of 9·6 kbit/s and 4·8 kbit/s data transmissions, as well as fax transmissions, within the network. All these users will require full-rate channels. In addition, as customers continue to demand a better quality of service, there is a general concern that the penalty on speech quality may outweigh the gain in user capacity.

Cell radius reduction

Increasing the number of base sites per unit area will result in a reduction in the cell radius. This can lead to a more efficient reuse of the spectrum allocation and hence a higher user capacity. However, there are penalties and limitations as explained below:

Increase in infrastructure
An increase in infrastructure will increase the capital and the operating cost of the network. Also, more antenna structures will need to be placed within the area. There will also be greater challenges on environmental issues and difficulties in acquiring base sites.

Quality of service
While GSM requires a handover success probability of 99%, this only holds true under 'low traffic conditions', as suggested in GSM ETR 02/08 Section 3. Degradation is, therefore, expected to increase for congested base sites. If the cell radius is reduced, and the average mean call-holding time remains unchanged, it is likely that the number of handovers per call will increase. In particular, in areas where the cell radius has to be decreased, the volume of traffic is expected to be high and congestion is more likely to occur. In this case, the cumulative handover success probability will be severely compromised leading to a general degradation in the quality of service for the network.

Handover delay
GSM adopts a mobile-assisted handover scheme. After each handover, mobile stations have to reconstruct their neighbour cell list before a further handover can be initiated. Performing the necessary measurements requires a finite time, and there could be a problem if the cell radius is reduced below a critical value. In these circumstances, mobile stations may not be able to initiate a further handover in time for connection to the best server site, with consequent deterioration of the overall CIR of the network.

Frequency reuse

The minimum frequency reuse pattern is dependent on the CIR which a system can tolerate. For a GSM system without slow frequency hopping, a 4 × 3 (four base sites each with three cells) reuse pattern is required for satisfactory operation in an ideal environment. This is why a minimum of 12 RF channels are normally allocated by the regulator for GSM network start-up. Insufficient spectrum allocation could lead to problems with frequency planning.

Slow frequency hopping
In theory, the introduction of slow frequency hopping could lead to additional gain in the link-budget in situations limited by noise and interference. However, the gain is dependent on the environment and the speed of the mobile station. The highest gain is seen in an urban environment with the mobile station either stationary or moving very slowly. Even then, the gain is only a few decibels. For this reason, it is unacceptable for a GSM radio planner to assume automatically that with slow frequency hopping, a 3 × 3 reuse pattern could be adopted. For a good-quality network, it is necessary to design the network based on a nominal 4 × 3 reuse pattern until the system aspect of slow frequency hopping is fully resolved.

Interference management
It is not always practicable to implement a regular 4 × 3 frequency plan by using a minimum of 12 frequency groups. This is especially difficult in areas where a base site or a group of base sites is missing in the re-use pattern owing to difficulties in acquiring a site, or in areas where there is a change in cell size. Extra frequency groups have to be implemented in order to maintain the CIR. For coastal regions and bay areas, where the base sites are exposed to each other via a path over water, extra frequency groups are usually required to ensure the overall quality of the network. Without adequate spectrum allocation, a high quality of service will be difficult to attain in areas where a regular reuse pattern is disturbed.

Radio Network Architecture

The architecture of the radio network in a GSM network is determined by the user capacity to be delivered by a given spectrum allocation as well as the target quality of service. At service launch, the primary objective of a GSM network is to maximise the radio coverage footprint, thereby extending service to as wide a geographical area, and to reach as many customers, as possible. As the network evolves, more base sites are added to increase the capacity and to enhance coverage to selected areas.

Reusing an identical RF carrier in different cells is limited by co-channel interference between cells. In order to ensure that the CIR is met, the nominal reuse distance employed must be sufficiently large. By contrast, the smaller the reuse distance, the higher the traffic capacity. A trade-off has to be made between these two requirements. For a practical network, a mixture of single-cell (omnidirectional) base sites or multiple-cell (sectorised) base sites will be deployed. A single-cell base site is fed from a single group of transceivers into one set of transceiving omnidirectional antennas, while a multiple-cell base site has more than one group of transceivers at the same base site each with their own transceiving antennas.

For GSM implementation, several possible cell repeat patterns can be adopted. If 12 frequency groups are available, a co-channel reuse distance of 12 would ensure a 12 dB location reliability over at least 90% of the service area. For multi-cell base site implementation, a reuse pattern of 4 × 3 or a reuse pattern of 3 × 3 may be selected. In general, a 4 × 3 reuse pattern is recommended since the overall CIR location reliability is better.

Reducing the reuse pattern from 4 × 3 to 3 × 3 would increase the user capacity. It is possible, potentially, to implement a 3 × 3 configuration for GSM. However, in order to achieve an acceptable quality of service, sufficient carriers must be available at each cell for the implementation of slow frequency hopping. In addition, power control and discontinuous transmission will also have to be implemented and optimised. It can be seen that the co-channel reuse distance is dependent upon the number of frequency groups, N. The larger the frequency group, the greater is the co-channel reuse distance, D. If R is the radius of the cells, simple hexagonal geometry of the cells gives the following relationship:

$$D/R = \sqrt{3N}.$$

Two typical reuse patterns for GSM are shown in Figures 1 and 2.

For GSM systems, cells can generally be classified into *large* cells and *small* cells. In large cells, the base-station antennas are installed at prominent positions on top of tall buildings or towers and the path loss is determined mainly by diffraction and scattering at roof tops in the vicinity of the mobile station. The nominal cell radius could be well in excess of 3 km, especially in rural areas. For urban areas, small cell

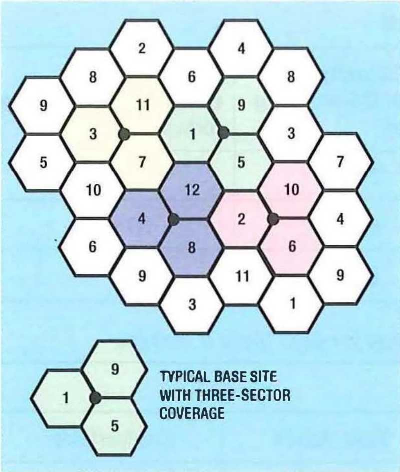

Figure 1—Frequency plan for a 4 × 3 reuse pattern

coverage is normally adopted. The antenna elevation in this situation is normally above the median but below the maximum height of the surrounding roof tops. The cell radius implemented may be less than 1 km. In addition, microcells with the base station antenna mounted below the city sky line can also be implemented[3]. Micro-base station classes are defined in GSM Technical Specification 05.05. The cell radius is in the region of 200–300 m. The implementation of a micro-base station has to take into account the minimum coupling loss between the mobile station and the base station. This is determined by the relative antenna positioning, gain and height. A typical example is shown in Figure 3.

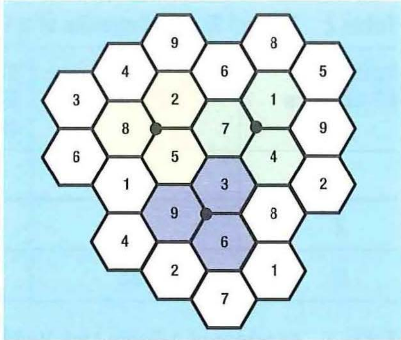

Figure 2—Frequency plan for a 3 × 3 reuse pattern

Network Dimensioning

With a knowledge of the spectrum allocation and the radio network architecture, network dimensioning for a GSM network can be performed. This requires an understanding of the traffic distribution across the whole network. Both the amount of traffic to be generated by each customer and the distribution are key marketing inputs. To decide the number of channels required by a GSM network, two traffic engineering models are widely adopted: Erlang B and Erlang C. The former represents the situation where blocked calls are cleared, while the latter represents the situation where blocked calls are queued for an indefinite duration until a channel is obtained.

When calculating the required number of channels based on the amount of offered traffic, the blocking

Figure 3—A mixed cell architecture

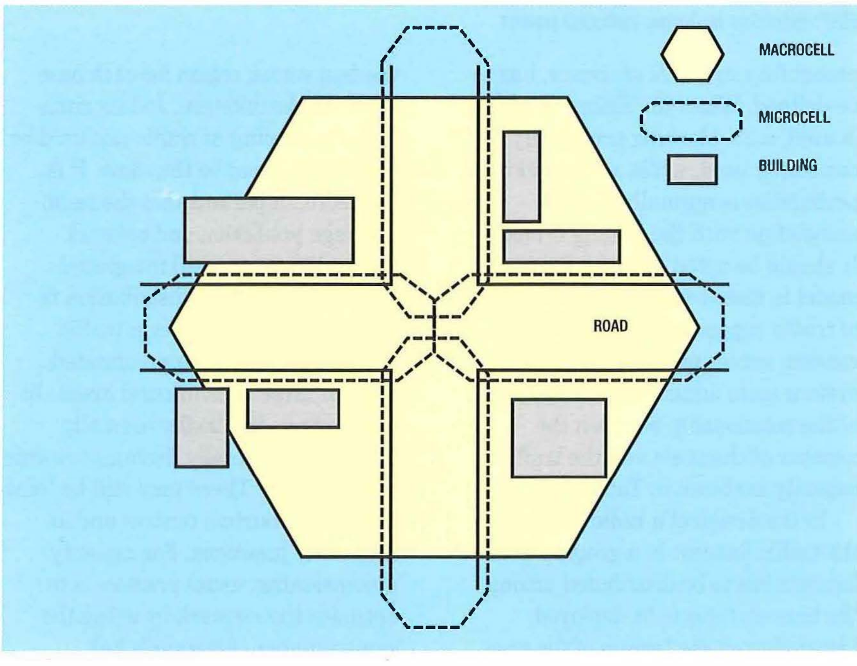

Table 2 Typical Traffic Capacity of a GSM Cell

Number of RF Carriers	No. of Channels Channels	Traffic Capacity Erlang B, 2% blocking (erlangs)	Traffic Capacity Erlang C, 1% blocking (erlangs)
1	6	2·28	1·76
2	14	8·20	6·71
3	22	14·0	12·5

Table 3 Example of a Radio Link Budget Design for GSM Class 4 Mobiles

	Units		
Receiving end		Base station	Handportable
Transmitting		Handportable	Base station
Reference sensitivity	dBm	–104	–102
Interference degradation margin	dB	3	3
Cable/connector loss	dB	4	0
Receive antenna gain	dBi	12	0
Lognormal margin	dB	5	5
Isotropic power	dBm	–104	–94
Transmitting end		Handportable	Base station
Receiving		Base station	Handportable
Transmit power	dBm	33	38
Combiner loss	dB	0	3
Cable loss	dB	0	4
Transmit antenna gain	dBi	0	12
Peak EIRP	dBm	33	43
Isotropic path loss	dB	137	137

EIRP: Effective isotropic radiated power

probability, or *grade of service*, has to be defined. When the Erlang B model is used, a 2% blocking probability is commonly used, while a 1% blocking probability is normally used in association with the Erlang C model. It should be noted that the Erlang C model is more conservative in terms of traffic capacity, but it represents random access process of a GSM system more accurately. An example of the relationship between the number of channels and the traffic capacity is shown in Table 2.

In the design of a radio network, the traffic forecast in a geographical location has to be distributed among the base stations to be deployed. Depending on the terrain of the area, the best server region for each base site could be different. In this situation, the amount of traffic captured by each cell will not be the same. It is, therefore, important that the radio coverage prediction and network dimensioning are well integrated.

In reality, traffic distribution is rarely uniform. A uniform traffic distribution can be approximated only for large cells in rural areas. In city centres, the traffic normally peaks and gradually declines towards the outskirts. There may still be local peaks in suburban centres and at motorway junctions. For capacity dimensioning, usual practice is to optimise the network by using the same number of channels but changing the cell coverage area so that the traffic carried per cell is kept constant with the traffic density. This optimisation and traffic rebalancing can normally be achieved by controlling the base station transmit power, antenna footprint and up-link/down-link balance parameters.

For microcell implementation, a split band arrangement may be necessary such that the microcells and the overlaying macrocells can operate in different sub-bands. This is beneficial from the frequency management point of view but will reduce the trunking efficiency of the radio network. It is, therefore, important that sufficient channels are provided to both the macrocell layers and the microcell layers in order to avoid congestion. These channels can be provided through correct balancing of the spectrum allocation and by introducing the appropriate density of base sites.

Link-Budget Design

The radio link between the mobile station and the base station is best described by a *link budget*. This link budget shows the system gain and loss and is determined by many factors which include:

- base station transmit power;
- base station receive power (base station reference sensitivity);
- mobile transmit power;
- mobile receive power (mobile reference sensitivity);
- base station antenna gain;
- mobile station antenna gain;
- base station diversity reception gain;
- path loss;
- base station combiner loss;
- base station feeder/connector loss;
- frequency hopping gain;
- building/vehicle penetration loss (for in-building/in-vehicle coverage);
- operating margins.

An example of a simplified link budget[4] for a GSM network is presented in Table 3.

As GSM requires a full duplex communication link between the base station and the mobile station, the maximum transmission distance is always determined by the weakest link. For handportables (Class 4), the output power is 2 W. A base station can, however, operate at a power level an order of magnitude higher. For this reason, the up-link transmission budget must be balanced with that for the down-link. This is particularly important for two-way communication near the cell edge. As the same type of antenna is used for both the transmit and receive paths, and they are installed close to each other, the antenna gain, cable and connector losses and the path loss are the same for the up-link and the down-link directions. The transmit power levels and the receive reference sensitivity are however different. In addition, on the down-link, there is typically a disadvantage of combiner loss if more than one transceiver is used. In the up-link direction, the output power of the mobile station is limited to 2 W for handportables for safety and battery life considerations. There are, however, advantages in terms of diversity gain in the up-link owing to the implementation of base station spatial antenna diversity. For a balanced up- and down-link, we can write:

Base station transmit power
– combiner loss
– mobile receiver sensitivity =
mobile transmit power
+ diversity gain
– base station receiver sensitivity.

As the physical configuration at different base stations may be different and the mobile station transmit power is constant, it can be concluded that the base station effective radiated power will be different for each base site. This is somewhat in contradiction with the requirement of equal effective radiated power for each base site in order to enable path loss handover implementation. It is therefore important to realise that perfect link-budget balancing could only be achieved in an ideal world.

Finally, it should be noted that link-budget balancing is achieved only for a specific power class of mobile station. When more than one power class of mobile station exists in the same network, link-budget imbalance is taken care of in cell selection in idle mode and in the handover decision algorithms in most situations.

Radio-Coverage Planning

Radio coverage is frequently perceived to be the most important measure for network quality. Clearly the extent of the coverage footprint is directly proportional to the size of the network infrastructure investment[5]. As for any quality-of-service requirements, the coverage requirement for any network is a marketing decision. For GSM application, one of the fundamental criteria is that the network is to provide adequate service to handportables.

From an operator's point of view, the primary goal of providing radio coverage for a GSM network is to achieve a high traffic capacity while maintaining an acceptable quality of service. The provision of radio coverage to remote areas where the traffic is minimal is frequently seen to be a poor investment and is provided purely for strategic reasons.

The design criterion used for radio coverage of a cell is to meet a 90% location probability within the service area. The signal levels received at both the mobile stations and the base station have to meet the threshold specified in GSM Technical Specification 05.05. These levels are referred to as the *reference sensitivity.* For the base transceiver station this is –104 dBm, while for the mobile station it is –102 dBm. In order to ensure reliable communication, the planning figures used for radio planning have to include an extra margin to account for the shadow fading. The margin is dependent on the standard deviation of the received signal level and the path loss characteristic. In addition, depending on the coverage objective, a suitable building loss margin will also be required. This margin is highly dependent on the type of building material and the orientation of the building relative to the base station. For on-street coverage, a margin is again required for vehicle penetration. This varies with the type of vehicle as well as with the orientation of the vehicle relative to the base station. An in-vehicle booster may be installed to compensate for the loss in some cases.

For designing radio coverage to special areas such as tunnels, underground railway systems, city underpasses, etc., the dimensions of the environment must be considered. In particular, it is important to decide if dedicated equipment, including repeaters or dedicated base stations, have to be implemented. In some extreme cases such as in train tunnels, leaky coaxial cable must be used to provide adequate radio coverage. On-frequency repeaters are frequently used in GSM systems in order to provide adequate signal for strategic coverage. These repeaters are essentially bi-directional amplifiers which extend the footprint of the service area by amplifying the up-link and the down-link simultaneously. High-power repeaters are used in rural areas, while low-power repeaters are mainly for indoor applications. In real-life implementation, there are many planning considerations, including coordination among operators, as well as RF engineering issues such as the derating of the repeater gain to meet the GSM intermodulation specification.

Frequency Planning

Channel allocation is normally made on a frequency-division basis. A group of neighbouring cells (a *cluster*) uses the same set of RF carriers but there is no reuse within the same cluster. Owing to the CIR requirement, the number of frequency groups for a cluster in a GSM implementation is either 9 or 12. Channel allocation for uniform traffic distribution may follow one of the well-known reuse patterns depending on CIR requirements. By contrast, channel allocation for non-uniform traffic distribution can be optimised using graph colouring heuristics. Furthermore, for irregular terrain and highly built-up areas, non-standard frequency assignment may have to be made. It should, however, be noted that irregular frequency planning could lead to severe problems when a new base site is inserted into the existing network. The affected areas, and hence the number of base sites involved, could be quite extensive.

Adjacent channel interference is an additional consideration in the frequency assignment. According to GSM technical specifications, the adjacent channel suppression should be -9 dB. This implies that the first adjacent channel should not be used in the same cell or the same base site. It should be noted that when a 3 × 3 reuse pattern is used, it may not be possible to avoid adjacent channel interference as it is impossible to avoid assigning adjacent RF channels in neighbouring cells.

As an example of the channel allocation for a 3 × 3 reuse pattern, consider the assignment as shown in Table 4. With this assignment, it can be seen that the RF carriers in the same frequency group are always nine channels apart and adjacent channel interference by RF carriers within the same cell is thus avoided. The same principle applies to other regular reuse patterns.

As said previously, the traffic density across the network is rarely uniform—it is not uncommon for cells of different sizes to be used in different parts of a network (through cell splitting). This will impose difficulties in radio planning as the co-channel-reuse distance will be dissimilar for different cell sizes. A buffer zone has to be created between cells of different cell radius in order to avoid severe co-channel interference, see Figure 4. If the spectrum allocation is limited and additional buffer frequency groups are not available, a degradation in the network quality of service is to be expected. A mixture of omnidirectional and multi-base transceiver station base sites and a random orientation of antennas should also be avoided to ease the difficulties in frequency planning[6].

In addition to the assignment of a frequency group to a cell, a base station identity code (BSIC) must be assigned in association with the frequency group. This will eliminate the possibility of incorrect cell identification and will allow the evolution to future cell architectures. The BSIC is a six-bit colour code consisting of a three-bit network colour code and a three-bit base station colour code. The principle for allocation of the base station colour code is the same for the RF carriers but at cluster level rather than cell level.

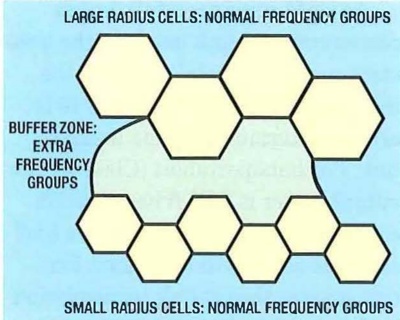

Figure 4—A buffer zone to reduce co-channel interference

Site Implementation Considerations

As part of the radio-coverage planning process, several base site implementation issues must be considered. These include the selection of antenna, the adoption of diversity reception, the use of frequency hopping and the method of minimising time-dispersion impairment.

Antenna beam-width

For urban environments, it is common to use directional antennas. For a narrow-beam directional antenna, the gain at the bore sight is higher than for a wider beam directional antenna. This has a number of advantages in terms of better building penetration and a faster signal roll-off at the cell boundary relative to the bore sight. This will generally help to maintain a better CIR for the network. The downside is that at the cell edge the signal level could be lower than the design level if a cell-radius based on an omnidirectional base site is used as a basis. For this reason, the inter-site distance has to be reduced in order to compensate for the coverage gap between sectors.

For rural areas, if directional antennas are used, the requirement for interference protection is less stringent. A wide beam directional antenna can be used. This will generally improve the footprint of the base station. In practice, there is very little change in the CIR in a network if 85°, 105° or 120° antennas are used.

It should be noted that the antenna-mounting structure could significantly distort the free space measured radiation pattern. Sufficient margins should be built into the radio network design in order to compensate for the imperfection.

Diversity reception

Horizontal spatial diversity is frequently employed in GSM networks for signal reception at the base station. Diversity reception is used to combat the fast fading caused by

Table 4 Frequency allocation for a 3 x 3 reuse pattern

Frequency group	A1	B1	C1	A2	B2	C2	A3	B3	C3
Channel Number	1 10	2 11	3 12	4 13	5 14	6 15	7 16	8 17	9 18

multi-path propagation. The improvement varies with different radio environments. The basic principle for achieving improvement is to exploit the decorrelation of the signal path when the reception source is spaced sufficiently far apart. In open environments, the diversity gain is generally very low, while in dense urban environments, the diversity gain could be significant.

In real-life implementations, horizontal spatial diversity reception is simple to install for a sectored base site but it will be difficult to achieve the same gain in certain azimuthal orientations for an omnidirectional base site. It should also be noted that horizontal diversity is normally preferred compared to vertical diversity as the spatial decorrelation for the former is much faster than the latter.

Downtilt

Downtilting the base station antenna is an effective technique for controlling the radiation pattern and hence the footprint or interference level of a base station. This is commonly used to control co-channel interference by pointing either the first null of the base site antenna to the co-channel cell or by pointing the upper 3 dB point of the antenna radiation pattern to the cell edge. The amount of downtilt is dependent on the height of the building and the cell radius.

In practice, three-dimensional antenna radiation patterns are difficult to obtain and the effect of antenna downtilt cannot always be certain in a real environment. Downtilting an antenna has an equivalent effect of widening the beam-width of an antenna. To avoid this, electrically tilted antennas are available in the market which have either tuneable tilt angles or predetermined tilt angles. Mechanical tilt brackets generally allow for much greater downtilt angles, however.

Slow frequency hopping

Slow frequency hopping is a special feature of GSM which is designed for improving the radio performance in both noise and interference conditions. Unlike spatial diversity, which takes advantage of the decorrelation of the signal in the spatial domain, slow frequency hopping exploits the decorrelation of the signal in the frequency domain. This feature is available for both the up-link and the down-link but is optionally implemented by vendors. Frequency hopping has two benefits:

- In noise-limited systems, frequency hopping helps to average out the effects of fast fading and is particularly useful at low signal levels.
- It provides interference diversity which is obtained when hopping between time slots that have different interference levels. This feature is especially useful for slow moving mobiles when the interleaving and channel coding capability is inadequate to deal with the channel errors.

It should be noted that the broadcast control channel (BCCH) carrier does not support any frequency hopping. In other words, omnidirectional base sites with only a single transceiver do not permit the implementation of slow frequency hopping.

Time dispersion

For digital transmission, time dispersion is potentially a problem. For GSM, the time dispersion is controlled by the implementation of an equaliser with an equalisation window of 14·6 microseconds. When this is exceeded, degradation is to be expected which is dependent on the relative amount of energy between the dominant signal path and the reflected signal path. From the radio-planning point of view, the problem can be resolved by either positioning the base sites close to the reflector or by implementing more base sites in order to ensure that handover can occur when the quality of the call degrades.

Parameter Planning

The number of parameters residing in the base station controller (BSC) database for a GSM network is far in excess of any analogue network. These parameters control the exact algorithm for network access, power control, handover, location updating as well as the utilisation of other radio features of the system[7,8]. The implementation of these control parameters is vendor dependent. As part of the radio-planning process, the values for all the parameters have to be determined and eventually optimised once the network is operational. This could be particularly complex for a multi-vendor network on the base station system. Frequently, manufacturers have their own interpretation of the GSM technical specification and the handover algorithms are always proprietary.

For GSM networks which support both speech and data delivery, the radio parameters optimised for the former service may not be sufficiently robust for the latter. This is especially evident in a slow-moving urban environment. The impact will become acute for prolonged data transfer at a high transmission rate using a transparent data delivery mode. Even if a non-transparent data delivery mode is adopted, the throughput could still be severely hampered. However, for short data transfer, a successful call set-up will almost guarantee an acceptable data transmission session.

Network Optimisation

The goal of network optimisation is to fine tune the performance of a network after the completion of the build process. In a way, this is an ongoing process as the network evolves. New base sites are built and terrain features may vary over time. The optimisation process is aimed at adjusting the network parameters and the physical configuration of base-site antennas in order to achieve the designed service quality. For a complex and hostile environment some of the detailed terrain features may be overlooked during the planning phase. Initial field trials prior to the base site construction may only give an indication of the coverage performance.

Other dynamic behaviours of a network such as call set-up success rate are difficult to predict until the base station is finally commissioned and integrated into the network. Furthermore, during the construction phase, the final positioning of the base site antenna may be compromised owing to physical limitations in the construction process. For these reasons, the performance of a network can be verified only after the base sites are fully operational. Indeed the cell data describing the operation of each base site cannot be optimised until the base site equipment is fully functional. At the first stage, only default and best-guess cell data are loaded into the BSC database in order to enable the base station to operate nominally.

The optimisation process mainly consists of a two-step iterative process: validation and implementing corrective actions. The validation part of the process is to validate the existing physical configuration and the parameter settings. If the performance is found to be unsatisfactory, corrective actions have to be proposed and implemented. Further validation takes place as a consequence. The process continues iteratively until either the performance can no longer be improved or a satisfactory level of service has been achieved.

Conclusion

This article has highlighted the salient points of the radio-coverage design and planning process. An insight into the actual implementation of a radio-coverage plan and a frequency plan has also been provided. It is important to realise that spectrum allocation is of fundamental importance to the radio-planning process and interference management. In addition, the user capacity and the quality of service are also directly affected. Inevitably, the investment in the network infrastructure will ultimately be a limitation on the radio-coverage footprint. A large coverage footprint is frequently perceived by users as one of the most important measures for comparing the merit of competitive networks in a particular country. Finally, when a network is launched, continuous optimisation of the infrastructure and the database is required to achieve the best results and to cope with the forever-evolving environment.

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Biography

Stanley Chia
BT Networks and Systems

Stanley Chia graduated from the University of Warwick with a B.Sc. in Engineering Electronics in 1983 and gained a Ph.D. in Microcellular Radio Propagation from the University of Southampton in 1987. He joined BT Laboratories in 1988 and has worked extensively on both radio and network aspects of digital cellular radio systems. In 1989, he became the cellular coverage core task leader of the European RACE mobile project, leading an international team on third-generation mobile system research. During 1992, he was seconded to head the Radio Engineering Department of SmarTone Mobile Communications Ltd., providing the first GSM service in the Asia Pacific region. In 1994, he was appointed to serve as Technical Director of AirTel, the BT Spanish GSM consortium. He is currently leading a multi-discipline team responsible for improving the Cellnet transmission network. He is a Member of the IEE and IEEE and is a Chartered Engineer.

Peter Cochrane, David Heatley, Ian Pearson

Who Cares?

Future of Telemedical Technology

The first world is moving towards higher concentrations of older people and fewer carers. Just 20 years ago there were 30 potential carers for each person needing care. By 2010 this will have reduced to only three potential carers. National economies will not be able to sustain the levels of care enjoyed to date and a potential crisis looms. Fortunately, the technological advances that have extended lifetimes are also spawning the means of caring through information technology (IT). The demands placed on telecommunications networks will dictate wide-band services, with human-scale delays and interfaces.

An Ageing Local Population

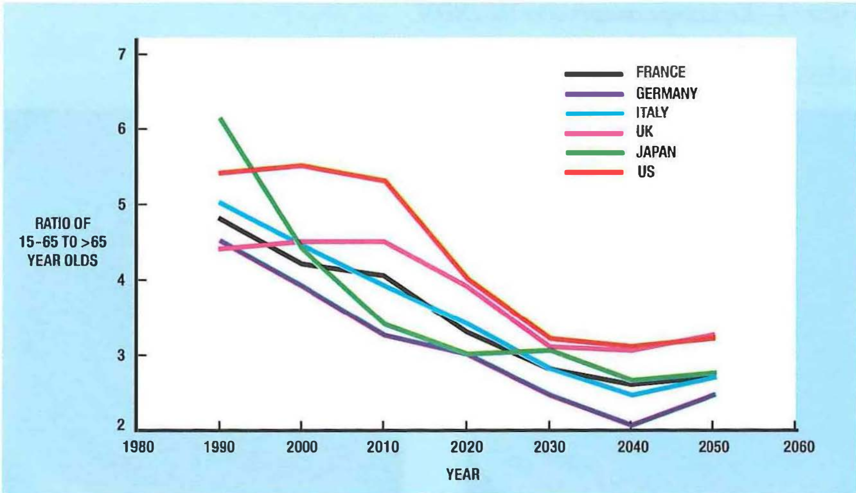
The population of the developed world is ageing rapidly with people's life expectancy now approaching 80. At the same time, the birth rate is declining and the number of people available to support this ageing population is decreasing (Figure 1); a critical imbalance is rapidly developing. In some parts of the world, this imbalance is expected to reach the point where there is only one supporter for every two adults needing care. Japan is already addressing this dilemma by developing robots to undertake basic care and rehabilitation. Interestingly, the opposite trend is evident in much of the less developed world, there being a relative abundance of young people to take on the role of carers. Information technology (IT) and telecommunications offer a potential solution to this geographical anomaly by teleporting expertise, experience and presence. Indeed, technologies are already available that allow surgeons at remote locations to 'be' with, or even inside, a patient's body. Similarly, robots are already being used in hip replacement, brain and eye surgery. Before long we will see surgical operations performed remotely with telerobotics, so that a surgeon in California can operate on a patient in London.

Further developments include the remote monitoring of patients through electronic interfaces mounted on, and in, the body. It is already possible for diabetics and other drug-dependent people to be monitored by remote computers that administer and optimise dosage. So far, experiments have been confined to hospital wards, but there is no reason why this cannot be realised globally via telecommunications. The ultimate goal is that the trip to a doctor's surgery or the hospital outpatient's department, and other routine care activities, become an automated and remote activity.

Info-medical Advances

While IT can be used to give people independence for as long as possible, and informal health care can be transformed to self-care, the question

Figure 1 – Ratio of 15–64 year olds to over 65s (source: Financial Times, *8 Mar. 1994)*



nevertheless arises: is it possible to utilise finite medical resources more effectively? For example:

- Can nurse practitioners take some of the load off GPs?
- Can GPs and nurse practitioners work together more effectively?
- Can consultants and specialists be more accessible?
- Could the social services be more effective?
- Could help be on tap when required?

These are all feasible through the use of networked personal computers (PCs) equipped with video cameras and high-resolution displays. Consultants, GPs and nurse practitioners can then share images and data via fixed and mobile communications, and thus assist in remote diagnosis and treatment (Figure 2). The PC that will achieve this might seem fanciful today, but it will be available in only a few years at a cost of less than £500. They will also function as an integrated entertainment and management centre for business and home use.

With such technology, perhaps the smart patients will choose to access medical care and help directly by themselves? And perhaps the really smart patients will access the same

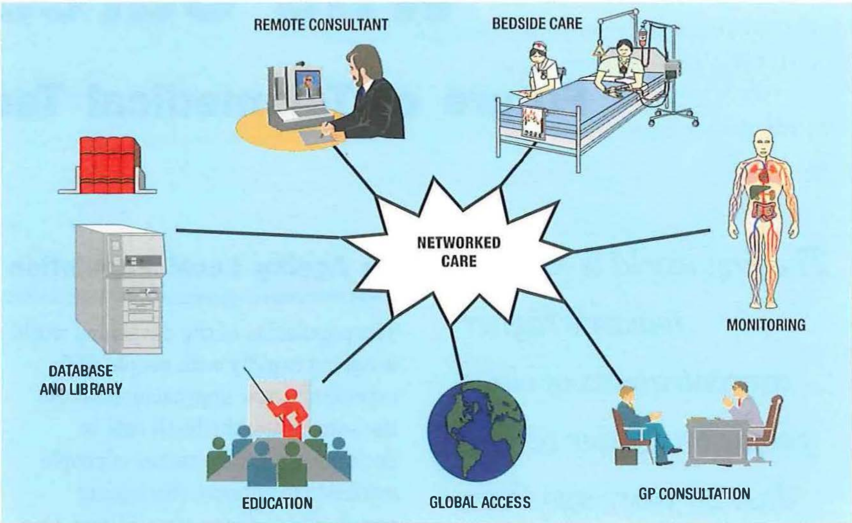


Figure 2 – Networked medical care

Figure 3 – Tele-endoscopy over ISDN2. Remote consultation

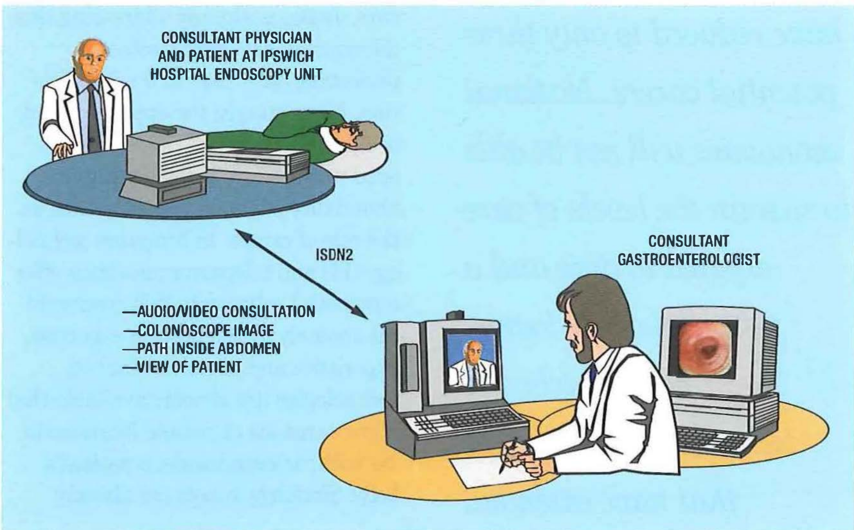


Figure 4 – Endoscope images over the ISDN

ISDN2 *ISDN6* *Original*

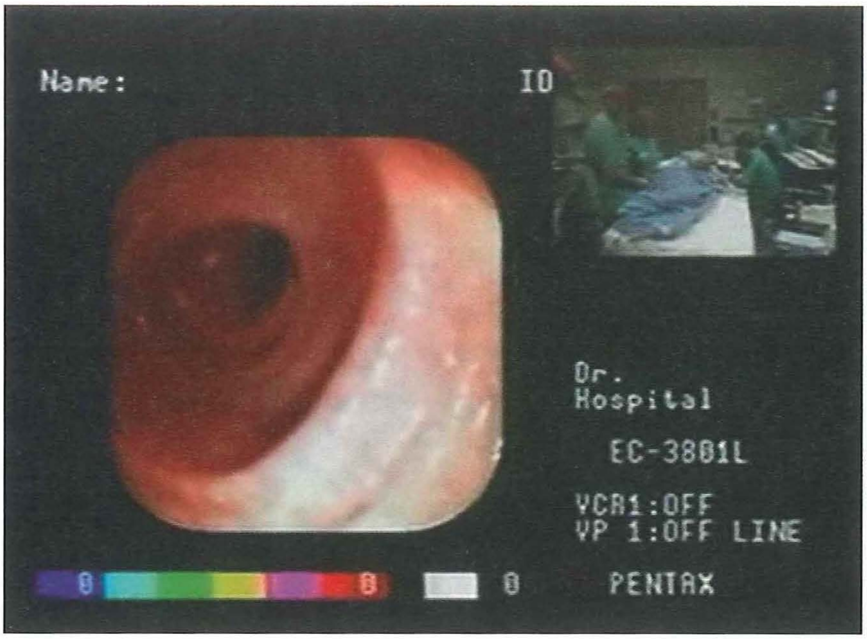


Figure 5 – Endoscope display with inserted view of examination room

information as the medical professionals!

Networked Medicine Future

When doctor and patient meet, in the flesh or on-line, medical records could be instantly accessed. Symptoms could be recorded, and the computer could despatch intelligent software agents to identify a range of causes and treatments. At the point when a doctor might normally decide to refer a patient to a specialist, remote access to the specialist's own expert system may prove sufficient. If the diagnosis is still unclear, agents could search databases worldwide for a match to the symptoms. By allowing such agents to carry diagnostic and visual information, doctors will be able to get help from any medical facility connected to the network. In essence, the doctors will become cybernauts. If a consultant proves necessary, telepresence technology will allow a doctor to act as the consultant's eyes and ears and examine the patient under remote guidance.

In theory, the data and images produced by any form of electronic diagnostic equipment can be conveyed over a network and viewed in as many locations as necessary. In certain medical fields this is already being trialled with notable success. For example, patients receiving endoscopic examinations have benefited from the participation of a consultant at a remote location (Figure 3). Images from the endoscope (Figures 4 and 5), as well as audio/visual commentary from the attending medical staff, are conveyed to the consultant over the ISDN, who in turn is able to offer advice on treatment. Medical training is also benefiting from such technology (Figure 6).

Orthopaedic surgery is also benefiting from networking. During a recent knee operation (Figure 7), the attending surgeons were linked with a consultant at a remote location

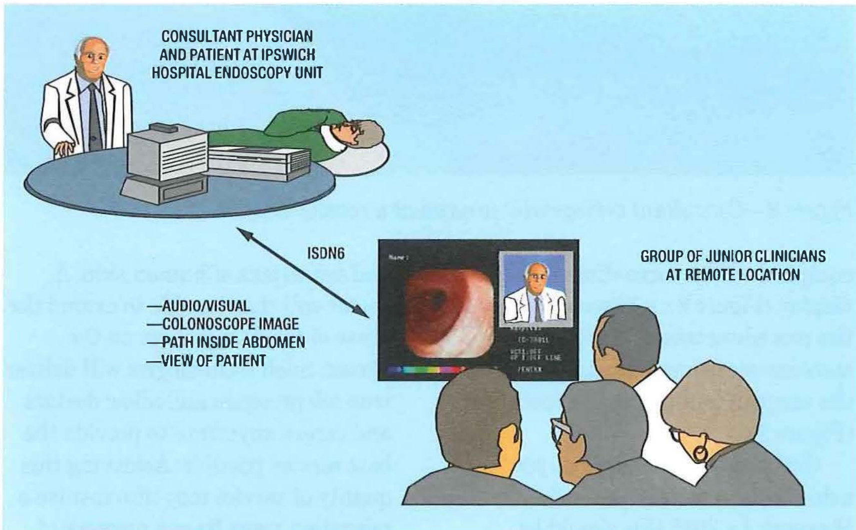


Figure 6 – Tele-endoscopy over ISDN6. Remote education and training

Figure 7 – Camera view of knee operation

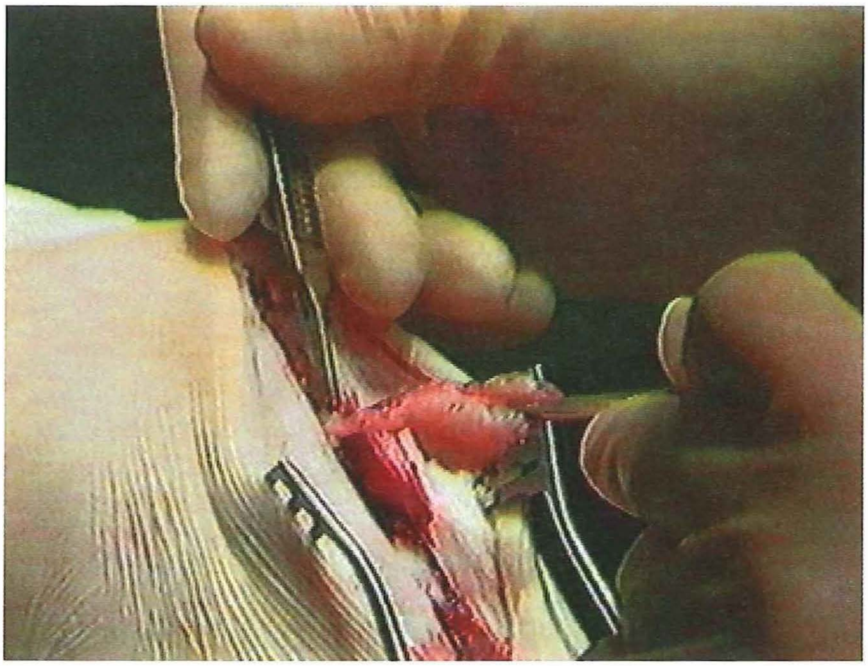


Figure 8—Consultant orthopaedic surgeon at a remote location

equipped with a three-dimensional display (Figure 8). A binocular view of the procedure was delivered by a stereoscopic camera headset worn by the surgeon conducting the operation (Figure 9).

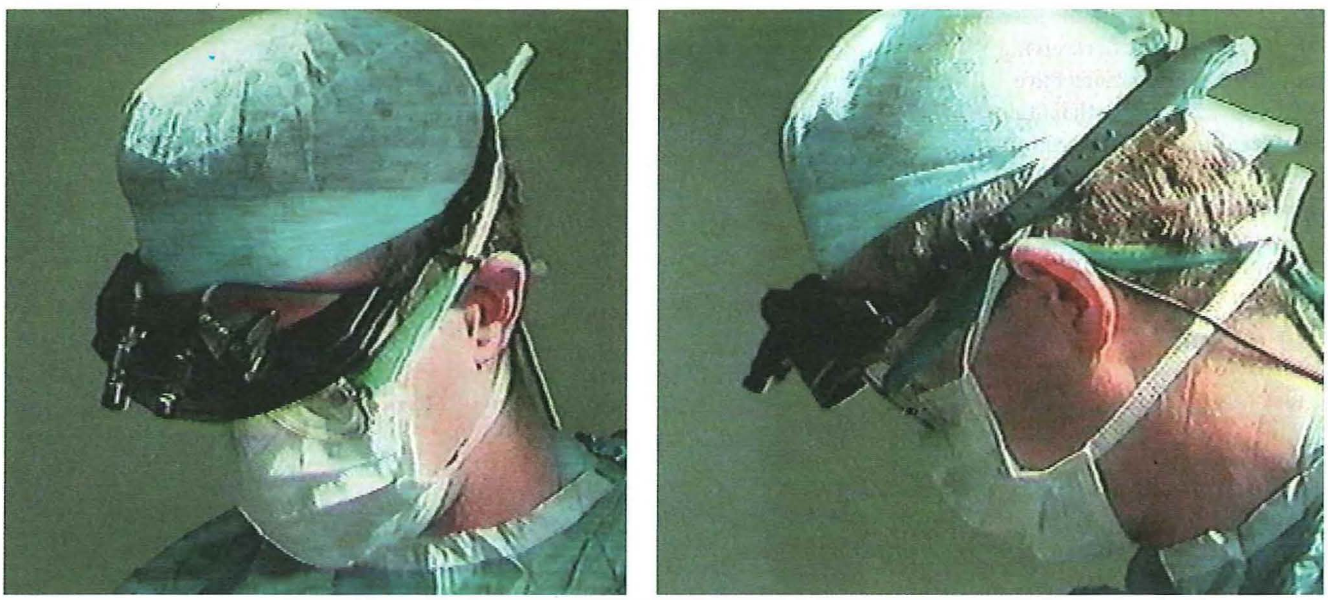
One diagnostic ability not yet achievable remotely is touch. However, by 2015 this should be possible through the use of synthetic skin that has all the tactile qualities and sensations of human skin. A doctor will then be able to extend the sense of touch anywhere on the planet. Such technologies will deliver true telepresence and allow doctors and carers anywhere to provide the best service possible. Achieving this quality of service may also involve a migration away from a network of GPs supported by a large general hospital, to a series of 'smart' cottage hospitals supported by advanced facilities dispersed across the globe.

Telepresence will allow a surgeon anywhere in the world to oversee, and eventually perform, an operation anywhere in the world. For example, it is already possible to operate remotely using crude 'remote hands' and robots. Experimental robots are now being used in certain operations in a supporting role. Early experiments have involved robots controlled by tomographic scanners to remove brain tumours with a precision higher than that of surgeons. A further success is in stapedotomy operations, where the surgical robot has demonstrated a performance superior to that of humans when drilling bone. Robots are now being introduced into retinal and joint-replacement surgery.

Information Access

Medicine as a science is characterised by the amount of analysis based on subjective data. This, and the breadth of the data, has in turn bred the 'specialist', many of whom, of necessity, are involved at some stage in the care of an individual patient (Figure 10). (Contrast this with the 'font of all knowledge' that characterised

Figure 9—Stereoscopic camera headset worn by attending surgeon



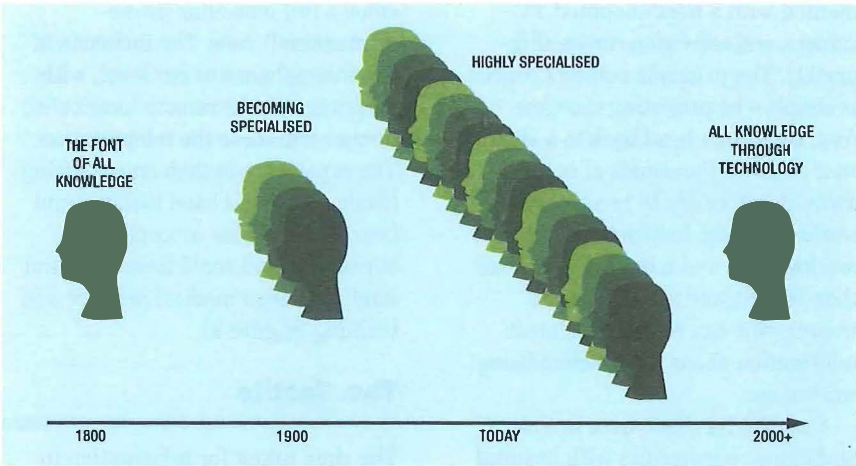


Figure 10—Knowledge trend in recent society

medics in early society.) The diagnostic process can therefore be long and complex, needing many referrals and tests which may result in uncertain conclusions by a process of elimination. In many professions, it is not unusual to spend up to 85% of your time trying to find information, 10% putting it into the right format, and only 5% making the critical decision. Help is required to navigate through the growing field of information, find, access and manipulate data, and finally get down to the kernel—decision and action! The necessary technologies are all under development and use a combination of artificial intelligence (AI) for navigation and location, Hebbian decay filing, and automatic text summarisation. However, there are still significant problems associated with the complexity and size of systems, databases and connectivity expected by the year 2000.

What improvements could be made to this process?

Searching for information is extremely wasteful in terms of human time and effort. Software 'agents' working on our behalf are now able to roam networks and electronic libraries across the planet, find data and retrieve it in a mater of minutes. The next step is to educate them to format the data for the human users and their particular applications.

The single biggest impediment to realising an effective system is the huge legacy of patient data, case histories, techniques and information recorded in paper form. If all of this was available electronically, access to the global experience would be possible. Furthermore, trend data could be produced and made available on a continuous basis. Critical features such as hot spots, errors, corrections, new correlations and effects, new diseases, and outbreaks could then be detected and acted upon within hours rather than months or years.

Smart Copier—Dumb Pacemaker

Smart copiers and fax machines are now common in offices. When they break down they automatically log the failure, call the service engineer, and present a readout of likely causes. The same technology is finding its way into food and drink vending machines, garage forecourts, automatic bank tellers and telephone kiosks. Soon it will reside in your washing machine, tumble-drier, microwave oven, hi-fi, TV, and computer. None of these directly affect life and death—but the faltering pacemaker does, and yet at present it is dumb by comparison! As the number and use of artificial body parts increases there will be a logical and necessary need to monitor both the outside and inside of humans, with the wide variety of operational parameters being relayed to a 'caring computer'. Preventative maintenance is always preferable to curative medicine!

Real-Time Drugs Administration

Vast amounts of time and hospital space are currently taken up by people who merely require continual or periodic monitoring, or basic medication to be administered. Today, the administration of everything from insulin to steroids requires the involvement of trained medical staff. A modest level of instrumentation and AI could obviate this. For example, prototype technology already exists to monitor and administer the correct dosage of a drug, optimised through real-time biofeedback, to match an individual's body mass and metabolism. To take a specific example: an artificial pancreas is already at the research stage, and some hospitals in the USA are experimenting with the dispensing of drugs by such mechanisms. The next step is obvious—the patients remain at home and are remotely monitored and advised over the telecommunications network.

The Machine as Doctor

There is some evidence that patients prefer an impersonal, inanimate questioner at the initial stage of the diagnostic process. Talking to a computer about personal issues may be less embarrassing and more acceptable, and the patient can be more candid, thus improving the quality of information and subsequent diagnosis. Furthermore, it has now been demonstrated that machines are often more accurate than human doctors in the preliminary diagnostic phase. It is likely that such machines will outpace humans as the amount of information increases through the use of improved biometrics. In this situation, AI could be a means of reducing diagnostic uncertainty as it has the potential to consider all previous case histories and diagnoses on a global scale.

Real-Time Monitoring

Other advances will change the mode of home care from passive to active. The technology used in wrist-sized computing will also generate diagnostic information and location detection. People who elect to wear such devices will benefit from round-the-clock monitoring. Similarly, a PC in the home can learn the wearer's preferences and daily routine, and thus recognise when medication has been missed or the possibility of an accident and raise the necessary alarms. Combining these may allow the onset of sickness to be detected earlier and provide the means for timely treatment. Using location detectors, people who go missing or get ill could be rapidly found and treated.

CamNet-Based Telepresence

In this system, an operator utilises a conventional audio headset augmented with a head-mounted TV camera and television screen (Figure 11). The principle behind CamNet is simple—by projecting the view from someone's head back to a site that could be thousands of miles away, it is possible to perceive their world remotely. Instructions, schematics, fixed and moving images can then be transmitted back to the wearer, who can receive the latest information about the problem being worked on.

CamNet has been used to link ambulance paramedics with hospital specialists so that care can be administered during transit, and the necessary hospital facilities prepared (Figure 12). The addition of tactile and prosthetic transmission, plus remote instrumentation, would create the ultimate teleportation of human abilities. Expertise on demand, anywhere, any time!

Surrogate Head

An obvious extension of CamNet is to place two cameras at eye level on the wearer, and at the remote location to a virtual reality style of headset. People at a remote location (or locations) can then effectively sit behind the eyes of the wearer and enjoy a full binocular (three-diemnsional) view. The inclusion of two microphones at ear level, with earphones at the remote location(s), further enhances the teleportation. The experience is then one of sitting inside someone's head looking (and hearing) out! This concept of a surrogate head could have profound implications in medical practice and training (Figure 9).

The Tactile

The time taken for information to travel from our fingertips to our brain is of the same order as the time taken for a single photon to travel from the UK to the USA on an optical fibre (about 30 ms). Given that the delay with touch is dominated by synaptic processing, an extended hand across the Atlantic is feasible. The 'feely gloves' and 'prosthetic arms' now being developed will allow the virtual reality participant to reach out and not only grab virtual entities, but also feel and react to their tactile qualities. Leading on from this, data suits would allow sensory information to be communicated for the whole body. Current research suggests that direct sensory stimulation will be

Figure 11 – The CamNet headset in field use

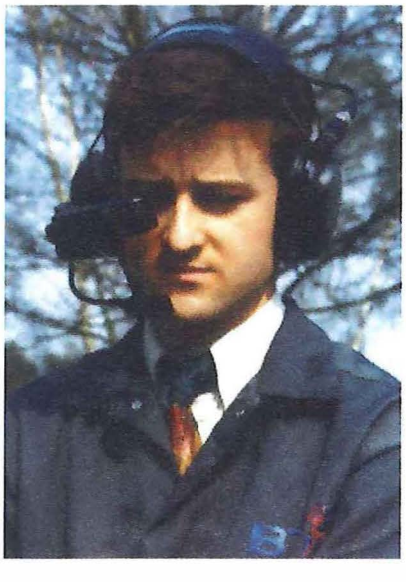


Figure 12 – CamNet at a road traffic accident

practical in the next decade or two, which should eventually improve the feeling of teleportation. These developments will also aid the development of full-sense prostheses.

Decision Support (AI)

Medical research is generating new information at an exponential rate. To benefit from this information explosion, doctors must be able to find the facts that are relevant to the case in hand. Since the early days of computing, expert systems for medical diagnosis have been a target for AI researchers. While the early systems proved as accurate as human doctors, they suffered from a lack of confidence and accountability in the medical community. However, the growth in information and recent improvements in AI techniques, such as knowledge elicitation and representation, has seen systems surpass their human creators in accuracy. While it may be some time before automatic diagnosis is the preferred option, such systems will at least give doctors decision support and on-line reassurance in diagnosis and treatment.

Criticalities

While our society will become much older, the technologies to help the older members are already being developed. Travel substitution will allow us to work, play and socialise from anywhere. Telemedicine will revolutionise the way doctors work and communicate with each other and their patients. The same technology will allow experts in all fields to share expertise worldwide without having to travel.

Experiments with delay introduced into a communication channel have highlighted how human coordination can be critically affected. For example, with a delay of only a fraction of a second between hand and eye, we have trouble writing. With a mere 200 ms delay between lips and voice, we behave like a talking mannequin. At 300 ms we can experience severe coordination problems and confusion. Generally speaking, a delay exceeding 100 ms between sight, sound and touch will unacceptably degrade our ability to communicate effectively and safely. A telecare system capable of meeting the future needs of society can therefore only be realised with delays and interfaces matched to our inherent capabilities. Optical fibre networks offer the ideal bearer for such a future with their massive bandwidth and delays of only 30 ms between London and New York. Signal coding and software, however, need critical attention. A new attitude is required and so the developmental trend is aimed at greater efficiency and minimum delay rather than size and proliferation. We need to trade bandwidth, processing power and memory capacity for human effectiveness, which, after all, is our most precious commodity.

Probably the greatest challenge will be the design and engineering of interfaces that can be successfully mastered by an old, infirm, and sometimes confused population. The emphasis has to be a human one as increasingly it will be the machines that care!

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Biographies

Peter Cochrane
BT Networks and Systems

Peter Cochrane joined the British Post Office in 1962 and is a graduate of Trent Polytechnic and Essex University. He is a fellow of the IEE, IEEE, and Royal Academy of Engineering, a visiting professor to Essex, Kent and University College London. He joined BT Laboratories in 1973 and has worked on a variety of analogue and digital switching and transmission studies. He has been a consultant to numerous international companies on projects concerned with systems, networks and test equipment development. In 1978, he became manager of the Long Lines Division and directed the development of optical-fibre systems, photonic amplifiers and wavelength-routed networks for terrestrial and undersea applications. His team received the Queen's Award for Technology in 1990 for the production of optical receivers for TAT-8 and the PTAT-1 undersea cable systems. In 1991, he was appointed to head the Systems Research Division at BT Laboratories, which is concerned with future computing and communications developments. He was further promoted in 1993 to head the Advanced Applications and Technologies Department with 620 staff.

David Heatley
BT Networks and Systems

David Heatley obtained B.Sc. and M.Sc. degrees in electronics in 1978 and 1981 respectively, and a doctorate in Optical Communications Systems in 1989. He joined BT Laboratories in 1978 to work on the development of analogue and digital optical-fibre systems designed for video and broadband services. In 1985 he was appointed to head a group responsible for the development of optical receivers for terrestrial and undersea fibre systems. In this capacity he was a member of the team that received the Queen's Award for Technology in 1990. He is presently with the Advanced Media Unit and heads a team with special responsibility for mobile telecommunications, future studies and telemedicine. During his career he has published widely on telecommunications, ranging from discrete components, through to systems, networks and services. He is a Member of the IEE and a Chartered Engineer.

Ian Pearson
BT Networks and Systems

Ian Pearson graduated in 1981 in Applied Mathematics and Theoretical Physics from Queens University, Belfast. He spent four years in the defence industry and joined BT Laboratories in 1986, analysing the performance of computer networks and protocols and helped to develop asynchronous transfer mode (ATM) transmission over optical networks. He has periodically worked on broadband networks and services, but now mainly focuses on mapping the progress of new developments throughout information technology, considering both technological and social implications. He currently works in the Centre for Human Communications. He has received five awards for papers, including the Best Paper award at the 1993 FITCE Conference, and the IEEE Benefactors premium in 1994.

Bill Whyte

The World at Work and Play

By the 21st century, many new environments will emerge to change the way we work and play. They will be made possible by evolving technologies that realise massive computing power, very wideband transmission, humanised interfaces, multimedia, and artificial intelligence.

The World at Work

The role of telecommunications is to dissolve distance and distort time. By removing the tyranny of travel or the lost opportunity of time constraints, it can eliminate our suffering of traffic jams, public transport delays or jet lag, and can transport us effortlessly and instantly to virtual shops and cinemas.

Even now, telephony has made many business journeys unnecessary, while television and the video store have brought the cinema into our homes. However, they are only partial substitutes for the real thing: face-to-face full sensory contact.

Imagine what it could be like in a couple of decades:

'In the future, reality and its virtual image will merge. At first our offices will disappear and we will work from home, surrounded by virtual walls that change colour, image and texture as we wish. We will have access, instantly, to all and only the information we require to do our job. We will meet our colleagues only virtually; their voices and faces, and thus personalities will be modified to make them appear more in tune to our preferences whilst also exhibiting improved management style...'

Bill Whyte
Computers in the city, 1992

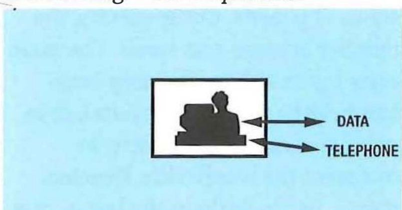
Underlying this apparent science fiction is a serious proposition: three of the major technological challenges of the next few years—cheap bandwidth, multimedia and intelligent processing of data—will offer radical changes to the way we work and play. Implicit in the statement is the need to accept that major social and organisational changes will also happen. Thus, technology, people and organisations must move forward together.

The disappearing office

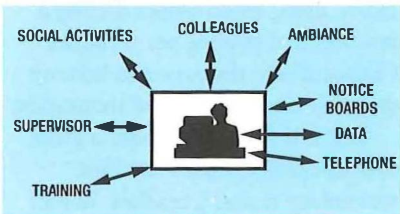
Teleworking, *remote working*, and the *virtual office* are just some of the names used to describe a vision of a fully dispersed company, perhaps working on a number of sites around the world, or even from the homes of its employees. If people were machines, all we would require is a distributed operating system and a reliable interconnecting network to make many of the reasons for the existence of a headquarters disappear at a stroke.

Take a fairly structured task: the telephone enquiry agent. From a simple view, all that is required is to answer a call from the customer, check the database for the right information, and feed the information back to that customer. However, we know from everyday experience, and from properly quantified studies, that this description is totally inadequate for describing the real job. There are a large number of job-related interactions such as logging on at the beginning of the shift, or going sick, face-to-face briefings on current issues, discussions of performance, training, problem handling etc. plus a number of informal activities such as swapping shifts, gossip and mutual help.

Teleworking—the simple view



Teleworking—the realistic view



BT's teleworking experiment at Inverness involved directory assistance operators working from home over the integrated services digital network (ISDN).

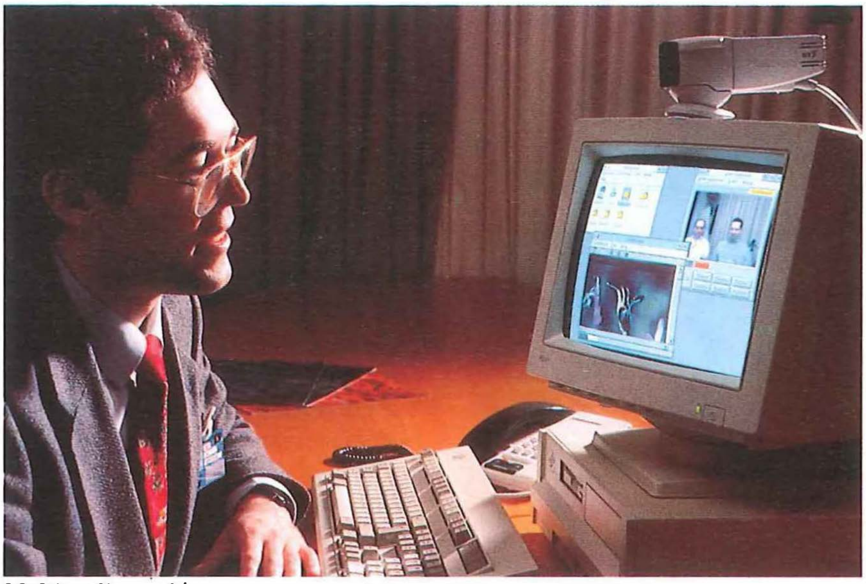
The directory enquiry operator's task is straightforward and highly-structured but by no means intensely interactive between members of the team. By contrast, managerial and professional activities often require the examination of large amounts of unstructured input, together with a high degree of personal interaction. This is clearly a more complex task requiring multi-point desk-top videoconferencing.

Within 2 to 3 years, a field repair centre will be able to transmit images of faulty equipment to a designer and product manager, anywhere in the world, so that they can collectively view and discuss components and circuit diagrams, run simulations, and agree and sign-off changes electronically. Projects underway today include linking a fashion buyer with a garment house so they can jointly view, modify, and discuss a three-dimensional visualisation of a garment. Further work includes designing the clothes on computer-generated models that can move to display the clothes realistically.

The word 'affordable' is significant: how does something become 'affordable'?

Multi-party videoconferencing has been available for a very long time but at a cost of hundreds of thousands of pounds. Consequently, the number of users was small. The main costs lay in either providing large bandwidths (tens of megabits), or in expensive coding equipment to compress the bandwidth. Developments, particularly in the latter, now make it possible to provide multi-point conferencing, over basic-rate ISDN, using video codecs costing a few hundred pounds per terminal. Consequently, the expected take up may run into hundreds of thousands.

But it is false, or at least a gross over-simplification, to say that technology makes a market. In fact



Multimedia working

the take-up of the desktop office will need to run into hundreds of thousands just to pay for the development of the large-scale integrated circuits that make data compression possible. It would be at least as fair to say that, in many cases, markets make technology. Perhaps a more instructive way to put it would be: 'An attractive market will exist when an **adequate** solution can be found for an **affordable** price.'

What is the 'adequate' standard required from multimedia? Some interesting answers are beginning to emerge. At first thought, one would imagine that the 'serious' or 'objective' design tasks of distributed project management or engineering inspection would require the widest bandwidth and the 'frivolous' or 'subjective' uses, such as fashion shows, the least. However, the reverse is probably true: the videophone provided as part of the Inverness experiment really came into its own when a reorganisation issue arose and the operators wanted to 'look the supervisor in the eyes'.

Almost without fail, the most critical of observers of picture quality are retailers, the entertainment industry, and individuals as purchasers of goods or entertainment. The 'emotional needs' of the multimedia experience will demand the most from the image coding and transmission specifications.

Working on the move

Currently, we are all cocooned in our offices surrounded by a supportive infrastructure with familiar landmarks sign-posted in our own language, people who understand half-formed requests, using communications and computing services, tailored to our corporate needs, which are supported by local service management.

Out in the world it is all harshly different: the language is difficult, the people are far away, the interfaces to the services are unfamiliar. You are alone and cut off. You may not even know where you are, or how to get to where you want to be. What you need is a reliable servant.

What you will get is a pocket-sized, always accessible, two-way communicator. It will know where it is by taking its position from satellites or terrestrial beacons, and be able to instruct the communications network to send you messages securely and without failure. By knowing where you are and the current state of the road network, from information taken from a variety of sensors on all major routes, it will be able to pilot you around traffic jams, find you a parking space

The portable videophone

and, if you are unlucky enough to have an accident, alert the emergency services to get them to you as quickly as possible.

Much of the technology for this already exists. It merely requires that the parties concerned—car manufacturers, telecommunications authorities, local and government bodies—move their business cases forward at the appropriate pace. This will happen sooner or later because, despite other 'greener' alternatives, most market predictions place the automobile as the dominant and growing means of transport well into the next century.

There will probably always be two problems associated with mobile equipment: reliable signal propagation and battery life. Tunnels, deep cuttings, metal loading bays, ferry car-decks etc. all threaten the reliable transmission of the vital message. Even if we can develop batteries that work at the limits of physical and chemical laws, they will never be enough because they will always be chasing new functionality (three-dimensional multimedia, global range, printing, screen size).

Imagine, in the future, I am sitting in the departure lounge of an airport. Having decided to reschedule some of my meetings, I need to find transport at my destination, book a hotel and possibly send out a number of memos requiring replies. I can do this on my portable unit and then, without wires, perhaps by radio or infra-red link connected to a payphone, simply log the instructions into the network and travel wherever I want, knowing that I will receive confirmation that the tasks have been carried out when I next switch on my communicator.

One way to do this is to make use of a *remote software agent* in the form of a sophisticated message which does not just carry text, but also carries computer code that can run on the machines it is addressed to. For instance, my travel requirement would be sent to the travel company that I normally deal with. The small program would run on the company's computer and select a number of options. At the same time, the diary scheduler in my office would be interrogated by the program, which I had sent there, to find out whether the dates I had asked for were suitable. These two software agents (one I sent to the travel company's computer and the other I sent to my office) would communicate by sending each other intelligent messages and, in the end, put together a consistent diary and travel package for me.

Machines that understand

Today we proudly talk about the integration of multimedia—the combination of speech, image and text—but the integration is only in transmission and storage, and not in information processing. The main difference between 'data' and 'information' is that the latter 'means' something to a human or a machine in the sense that an action or emotion results; for example, to feel fear and run away at the cry of 'fire!' or to connect two parties on receipt of a telephone number.

The main difference between text and the rest is that computers do make a reasonably good job of understanding text. Databases can be searched for key words and fairly complicated relationships set up by using relatively simple combinations of logical ANDs and ORs. Synonyms and antonyms can be looked for, and the joint probabilities of occurrences in the database can lead to fairly complicated inferences being drawn. The same is barely true for speech and hardly at all for image.

It is true that useful, practical systems for interpreting speech sounds are available. Telephone access to ordering systems where you speak isolated numbers or spell individual items are becoming highly accurate, but we are still a very long way from developing machines that can accurately understand continuous speech in an unconstrained environment. Even these limited efforts, however, are significantly greater than our ability to develop computers that can automatically look at pictures and determine what is going on. But suppose we could do it. An early use might be in the office of the future. Every time you conversed on your multimedia office automation system, the speech- and image-understanding computer in the background was able to extract key words and, for example, identify the caller from their videophone image.

the bandwidth requirements for any part of the network cannot be predicted with any degree of certainty or permanence

The entire call would be automatically tagged, by the computer, with information on the content and imagery then stored in the virtually infinite database. When you wanted to track down previous conversations, you could simply ask the system, through voice or keyboard, to find material relevant to any set of subjects. Of course, we do not need to stop there. The reason that you are involved at all is that you are being asked to make a decision or take an action. If the computer can understand what the request is, then it can, presumably, carry it out itself.

This has implications for telecommunications. Consider, for example, a distributed trial. The prisoner is in the dock, with the jury members, in the comfort of their own homes, observing the production of evidence, the behaviour of witnesses, and the physical appearance of expert material. The bandwidth to carry all of this, faultlessly, is enormous. The verdict is only one bit of information: 'guilty' or 'not guilty'. The decision process (the 'intelligence') has collapsed terabits of data into a single bit. As was the case with signal compression and bandwidth, intelligence and bandwidth are, if not enemies, then at least alternatives. Almost always, conversion of raw data into intelligently processed form produces a major reduction in the information rate and storage required. Is this then bad news for the telecommunication companies? Probably not.

A previous article* demonstrated the cyclical trends in analogue versus digital transmission. However, the need for both has not really declined. Similarly, speech and image coding have tried to reduce the need for bandwidth, but worldwide bandwidth requirements have continued to grow at exponential rates brought about by an increase in affordable applications and a demand for higher and higher quality images.

There is one very simple but profound consequence that emerges from the example above: because the capability of artificial intelligence is continuously expanding and, in general, can produce a massive (downwards) change in bandwidth requirements, the bandwidth requirements for any part of the network cannot be predicted with any degree of certainty or permanence. Consequently, networks must be built that are flexible and cost insensitive to bandwidth fluctuations. This is a clear message that emerges from studies of future enabling technologies: **plan for uncertainty!**

The World at Play

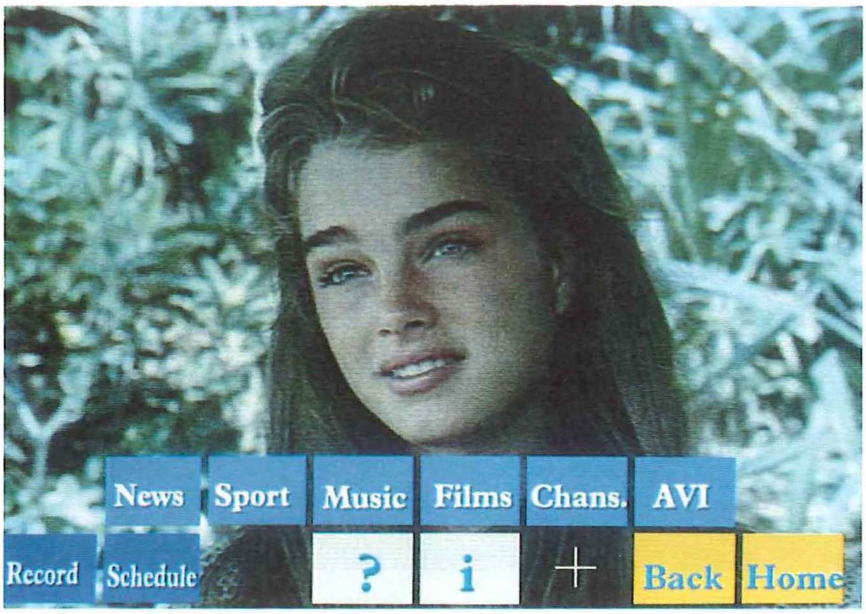
Imagine a morning sometime before the end of this century. Normally, you will get out of bed, perhaps reluctantly, to go downstairs to your den where you work on your teleworking terminal. But not today—it's the weekend.

There is no robot to dress you or bring you tea, but a lot has happened overnight to make your morning agreeable and free from nasty surprises. Your home control unit (which lives under the stairs next to the gas meter) has discovered that the dishwasher was developing an intermittent fault, and has already sent a message to the repair company who will call to remedy the problem before it becomes permanent. Downstairs in the kitchen you will still have to get your own breakfast, but you can be assured that you will not run out of cornflakes because the management system in your interactive shopping service detects when you are running short and orders replacements in time. It may have done this in a number of ways. Active tags on packet goods could be read by an intelligent cupboard or your cupboard may be equipped with dispensing machines that know how much you have used or, more simply, your consumption pattern for staple goods could have been monitored by your interactive shopping service which will then be able to anticipate your needs.

Your kitchen, like most of the rooms in the house, is provided with flat-screen television. Picture quality will be very good, and the living room TV set may be wall-sized and three dimensional. You switch it on and it plays music it has selected to meet your taste. Then a persona, perhaps the image of a real person or an

The virtual supermarket

* Cochrane, Peter. Copper Mind-Sets. *Br. Telecommun. Eng.*, Apr. 1994, **13**, p. 10.



Personal programming

animated character in a style that you like, speaks to you.

'Good morning. Today I have your horoscope for the week ahead, the weather and what to wear. Have you got an hour to spare? I know you like knitwear and there is an exhibition downtown with crèche facilities for your toddlers. I think you will like the stall I have added to your shopping arcade.

'For the rest of the day, I have prepared a new *personal programme* including the Stones' last concert, the Archers' omnibus for May and the latest from the City Council on the playground provision you asked me to keep you up to date on.

'The Vehicle Licensing Office want to know whether to debit your bank account for the Rover's licence and the Electricity Board have remotely read your meter and e-mailed your bill.

'Don't forget the global link-up on your Open World University course at 5 o'clock!

'If you have a moment, I would like to tidy up a few of the services I am providing to make sure they are properly tailored to your needs. It will take less than 2 minutes.'

The service waits a few seconds to see if you want to play with it or not. If you don't turn the set off, it begins the *personal programme* until you give some reaction. As the programme progresses, it displays a log of what has been played to allow you to ask for repeats of bits that you missed or to add them to your home library.

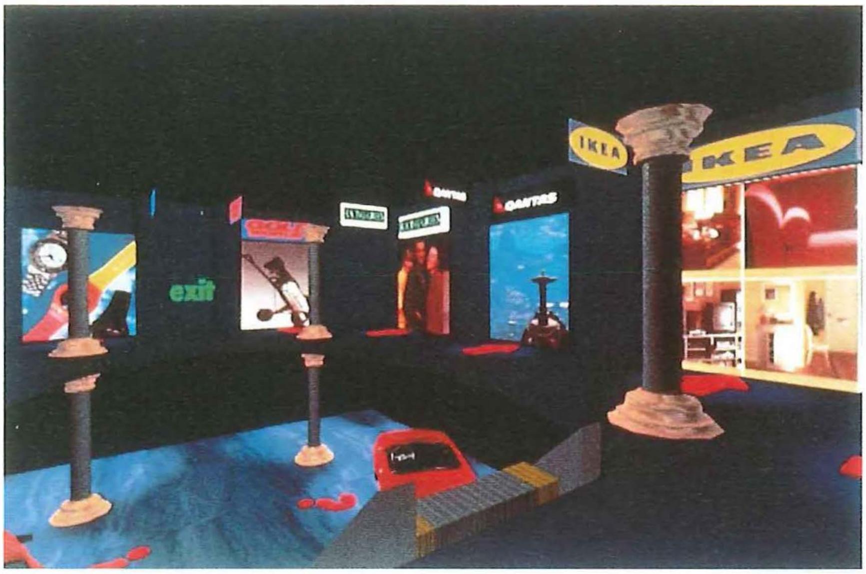
This is only one of the ways in which you can interact with your home service; however, it illustrates several issues. For instance, there will be access to a vast amount of information. Hundreds, or even thousands, of entertainment and information channels will be broadcasting but you are not, necessarily, going to know them as channels because they are likely to be accessed under topics of interest; for example, sport, news, fashion, music. In fact, our example demonstrates a fairly complicated personal magazine that has been put together using an artificial intelligence editor that gradually acquires an understanding of your interests. The 'tidy up' activity mentioned would include asking you to say which parts of the programme you liked and didn't like. It isn't science fiction to suggest that this could be done by monitoring skin resistance, iris dilation or other non-voluntary nervous system reactions, but it won't happen for some time.

In the meantime, new jobs will have grown up for composers who are talented in editing magazines for enjoyment, instruction or shopping. Much of the audio-visual content of these magazines will be reused. You may want to look at Australia from an information or interest point of view or you may want to buy a holiday there. In both cases, the travelogue material will be the same but surrounded by an appropriate dialogue intended to inform you or to sell to you. The editors of the magazine will survive by their ability to make the best guesses on the subject matter which forms the most seductive collage of material. All the audio-visual material will be accessed over a multi-megabit network, and stored on multimedia computer files. Some of the files will be associated with the network and run by BT, others will be provided by individual retailers, while the remainder will belong to information providers who collect and sell material.

All of this means that it is wrong to talk about the electronic village or the electronic highway. These are geographical terms that have less significance now information can be delivered anywhere at almost the speed of light. For instance, today we visit shops. In the future, the shop will not simply come to us; instead our needs and desires for goods will be satisfied. This is a subtle but important distinction. We usually want to go on a holiday rather than shop for one. Shopping for a holiday is a fairly complex process: we need to buy the package from the travel agent, arrange for appropriate clothes, get information on places of interest and so on.

At present, we do this by visiting (either physically or by telephone) a number of individual shops—the travel agent, the department store and the book shop. In future, we may browse through the holiday experience that has been put together by a broker (either a human being or an intelligent agent) to view the places, the hotels, the local delicacies and the loan we are going to need to pay for it all. At first sight, the broker may look like an extra step in the supply chain, but is, in fact, merely a very thin facilitation layer which allows you to deal directly with a large number of suppliers without having to travel to a shop.

In general, the electronic multimedia service will allow shopping to become much more customer-centred and less driven by the physical limitations of a shopping mall. This isn't all bad news for the shops. People will still go shopping but the shopping experience may be very



The virtual mall

different and probably much more enjoyable. Going shopping may become more like taking a holiday than doing a chore

Because an electronic shopping mall can in principle capture all your purchasing behaviour, (and your browsing that does not lead to a purchase), the retailers will have achieved their long-felt dream of being able to target individuals precisely through knowledge of their personal likes and dislikes. This will have to be handled carefully. I, for one, am not sure that I would like to be so blatantly manipulated. In fact, there is only one place that I can think of where I would really like to be treated this way—in the pub!

'The usual?' One of the attractive features of the pub (or church or social club) is the feeling of belonging. To belong, you must be understood by people who should know something of your likes and dislikes. This is why, among other reasons of course, these organisations have survived so successfully down the years (and are likely to continue to do so). Virtual beer on the electronic highway will not displace the real thing. The 'traditional local' is vanishing, but people are seeking out 'themed pubs' which provide them with a range of entertainment to suit their taste.

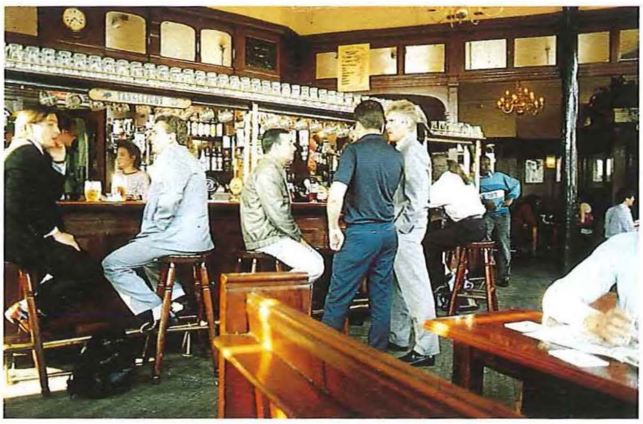
Publicans are trying to cut costs, fight off the problem of crime, and diversify into a market not solely reliant upon alcohol but still different from dance halls and traditional restaurants. One way they can do this is to trade on customer loyalty. An electronic means of achieving this could be some form of smart card. Perhaps, it could be plugged in to the table you sit at: it tells the bar staff who you are and what you like to drink. It may remind them it is about time they gave you your 21st birthday 'one on the house'. It could also be used as a credit or debit card to avoid the need for bars to manage large amounts of money and change. When you go on holiday, both you and the smart card will be accepted at all outlets in the chain. You may well have charged it with prepayment cash from your home phone—or your parents may have done so and set a cash limit!

Of course there will also be pub games: these will be much more elaborate than at present. Perhaps they will use virtual reality and allow inter-pub competitions in a 'realistic' environment by using wideband circuits and sophisticated computing power. Many of the games that will eventually migrate to our homes, to be played on cheaper equipment with smaller screens, may well have started life in the pub of the future. Some of the games may even be played worldwide. While we are discussing worldwide links, what about sitting down to celebrate Christmas at a table with a three-dimensional screen that gives you full-size images and realistic two-way conversations with your relatives in Australia? The pub will be quite happy to let you do this. During the day it will be providing videoconferencing services for businessmen using exactly the same technology.

Alas, there is always a time to pay and you can be assured that electronic methods of payment, either through the loyalty card or through an electronic purse and payment network (built to an International Standard) will ensure that your account is debited faster than ever. At least you should be reasonably confident that it is your account being debited and that you are the person who is authorising it. Developments

The real mall

A very real pub



it is customer benefit, particularly the subjective components, that will determine the success or otherwise of a technology

in biometrics, which will begin to emerge around the turn of the century, will allow cost-effective ways of checking your finger prints or your retina patterns to reduce the possibility of fraud. In any case, don't forget the application of real intelligence rather than the artificial kind. The increased penetration of videophones will make it much easier for people handling accounts to be able to check the person, requesting the financial transfer, against a database of photographs.

We pay for our pleasures in other ways too. Although the danger of everyone becoming a couch potato is probably more imaginary than real, labour-saving devices may give us more time to lie around and vegetate. However, illness comes to us all whether we exercise or not and our first medical assistance may be by a remote house call. BT Laboratories is already participating in experiments with British and Australian medical units to perform remote sensing and diagnostics. Although it is unlikely that we will suffer remote surgery on the kitchen table, there are real possibilities for remote diagnosis. Low-cost sensors and standard network interfacing equipment which will allow remote measurement of blood pressure, pulse, electrocardiograph etc. are under development. The possibility of an affordable health check without leaving home is real.

Collectively we are an ageing population and care of the aged is becoming a significant problem. Apart from being very costly, it can be upsetting for old people to be taken into care. Remote sensing, obviously on a voluntary basis, of any change in their use of cooking or personal care facilities or even changes to patterns of moving about the house can raise alarms in care centres and help prolong their independence. Cheap video telephones and communal videoconferencing may help to remove the feeling of isolation. In fact, much of this technology is available today and, although pricey, will become much cheaper in a mass market.

It is customer benefit, particularly the subjective components, that will determine the success or otherwise of a technology. Unfortunately, there is no technology or crystal ball that can reliably pick winners. Not even the potential consumers know what they will want. Because we are offering radically new visions of the future, it is unrealistic to expect people to know which they will prefer from the outset.

The trick to master is the ability to detect the early possibility of a market, rapidly prototype, trial, and evaluate an acceptable first offering, drop the losers, and quickly roll-out the winners.

Biography

Bill Whyte
BT Networks and Systems

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Speech Technology

It's good to talk

Speech is the easiest, most expressive and natural means that people have for communicating with each other. This article reviews the key speech technologies and discusses the associated commercial applications and challenges. It concludes with some personal predictions about future trends and opportunities in this important, exciting and far-reaching field.

Introduction

As people have been communicating with each other with some form of speech for at least 50 000 years, it is not surprising that most of us take it for granted. Speech is a highly complex process, and even the simplest sentence contains a world of information besides its literal content. It is more than just a way of saying words or ideas—it conveys the essence of human emotion, mood, and personality. Getting a machine to generate such subtle speech is somewhat of a challenge; making machines which can fully comprehend speech is even more daunting.

Despite these challenges, worldwide interest in speech technology is growing at an unprecedented rate. The reason for this interest is simple to understand: speech is BT's core business, accounting for over 90% of current revenues. It is also the primary access point to 26 million customers in the UK telephone network, and to potential revenue growth opportunities from a base of around a half a billion telephone users worldwide. With effective voice processing, a range of advanced services, such as ordering items and accessing data 24 hours per day, 7 days per week, can be added to the network. By investigating voice processing at an elementary level, the goal is to develop the technologies that differentiate BT's products and services from those of its competitors.

Many factors contribute to the growing interest in speech processing—technical, commercial and regulatory[1,2,3]. But it was the advent, in the late 1970s, of the single-chip digital signal processing microcomputer which helped to convert research into practical cost-effective systems. This has resulted in the current upsurge of interest in new telecommunications applications of speech technology. Since the advent of the transistor, device complexity has been doubling on average every two years. If aeronautical engineering had progressed at the same pace as device technology, then it would now take under a minute to travel across the Atlantic!

Speech processing applications are today in the vanguard of this revolution, just as on a lesser scale modems were a few years ago. The latest generation of mobile telephones, aeronautical and multimedia terminals depend on speech coding. The recently launched BT intelligent network answering service, Call Minder™, uses speech recognition to enable customers without a touch-tone telephone to access the service, as well as speech coding to store efficiently the vast amounts of data generated. Speech echo cancellers are regularly used on international calls to facilitate two-way simultaneous speech conversations. Synthesised speech is 'the voice of BT' for services ranging from the speaking clock to operator services and reading e-mails over the telephone.

Speech technology is an amalgam of many broadly-based disciplines (Figure 1); this article provides an overview of the key enabling technologies that underpin the subject. To conclude, some predictions are made on future trends and applications in this exciting and far-reaching field.

Challenges and Opportunities

Although the public imagination has been fired with images like 'HAL' in

In telephony, speech technology provides significant opportunities for generating revenues and cost saving through the introduction of new speech-processing services

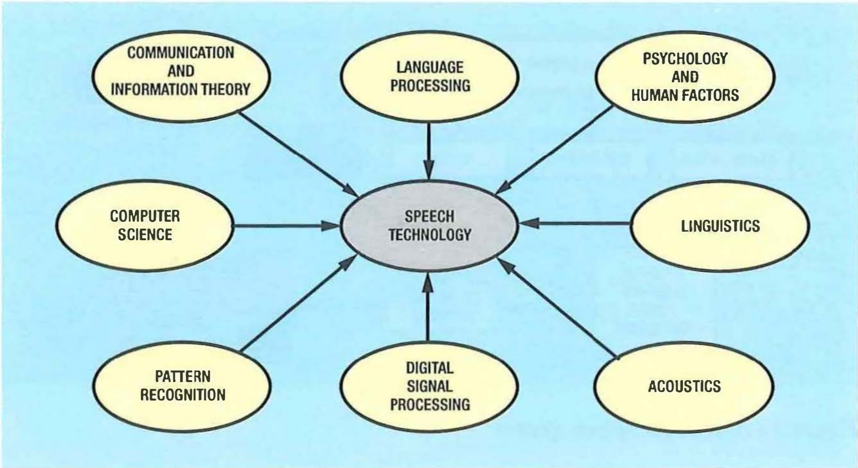


Figure 1—Speech technology disciplines

Stanley Kubrick's '2001—A Space Odyssey' and the robot C-3PO in George Lucas's 'Star Wars', the goal of producing completely natural language interfaces between humans and machines is still some way off. The main difficulties arise because of the variability in factors that dictate performance:

- the great variety in the signal characteristics of human speech, when the word or phrase is uttered by different speakers and even when repeated by the same speaker;
- the wide variety of channel characteristics through which the speech signals are sent; and
- the nature of the accompanying background noise.

This mutable behaviour is unavoidable and must be accommodated by a speech processing system which aims to provide a seamless and natural interface between people and machines. Above the level of the acoustic signal, ambiguities can occur at a higher level of linguistic abstraction. The phrase 'it's easy to recognise speech' could be interpreted as 'it's easy to wreck a nice beach' at a conference of surfers!

In telephony, speech technology provides significant opportunities for generating revenues and cost saving through the introduction of new speech-processing services which can be accessed easily over the telephone 24 hours per day, 7 days per week. Specifically, speech processing adds value, for example:

- by stimulating additional call revenues (for example, the BT network-based call answering service, Call Minder™);
- by creating new speech services (for example, Skyphone™ aeronautical telephony, talking e-mails);
- by providing differentiation in existing services (for example, speech enhancement, noise control);
- by reducing operating costs (for example, by partial or full automation of operator services and call centres);
- by allowing control of systems by voice to make them easier to use and hence improving customer satisfaction;
- by extending system usage to areas where other digit entry systems fail, where it would be dangerous to use hands, or where users require easily remembered access codes (for example, names); and
- by providing a simple means of getting large amounts of variable text data to users over the telephone (for example, text-to-speech).

Interactive Voice Systems

Developments in speech technology now enable a new generation of services operating over the telephone network (see Table 1). These services range from telco-type services, such as automation of directory enquiries, to customer handling and information retrieval applications which can offer commercial opportunities for major businesses[2].

Table 1 New Services Enabled by Voice Technology

Voice store and forward —Call Minder™	Telemarketing —promotions
Finance —banking —stocks and shares —insurance quotations —credit card transactions	Teleshopping/reservations —theatres —airlines —catalogue shopping
Entertainment —betting —horoscopes —games	Field operations —data operation and retrieval —field personnel job dispatch —voice access to electronic mail
Information services —timetables —Yellow Pages™ —news	Automatic operator —network services —call centres

Typically, such applications require the integration of speech technology with existing databases, information technology processes and call-centre capabilities. Additionally, they can vary in scale from small bespoke systems to large applications which can significantly alter the way in which customers interact with providers of information, goods and services.

A typical interactive speech system is shown in Figure 2. The user aims to extract information from the system database (or voice store) by means of spoken commands. Speech input is achieved via the recogniser (which can be touch-tone, dial-pulse or speech-based), and speech output is by means of the synthesiser (which can be based on stored concatenated speech or text-to-speech). For a network-based application serving thousands of customers, a speech coder may be necessary in order to make efficient use of expensive storage media.

The dialogue controller ensures that the system recovers from any errors that may occur in the speech recognition either by asking the user to repeat, or by modifying the dialogue to obtain the required information by re-phrasing the question. From the user's point of view, the system should be friendly, reliable and comfortable to use. To achieve this, each component of the system must perform adequately, and align with the customer's expectations. Orchestrating all the constituent speech technologies to meet the expectations of the whole user population under all operating conditions is a considerable challenge.

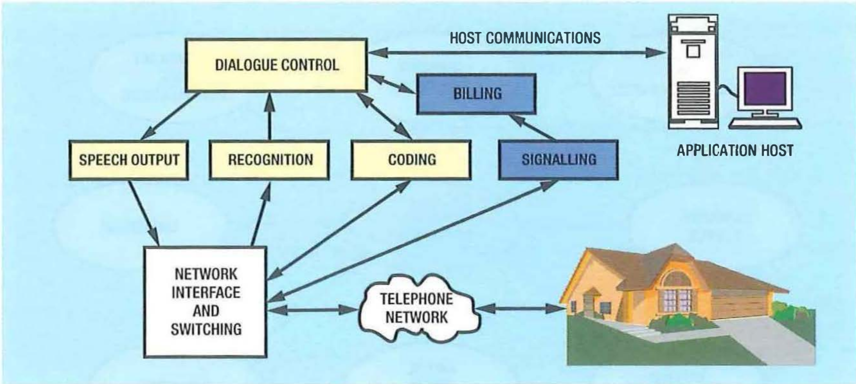


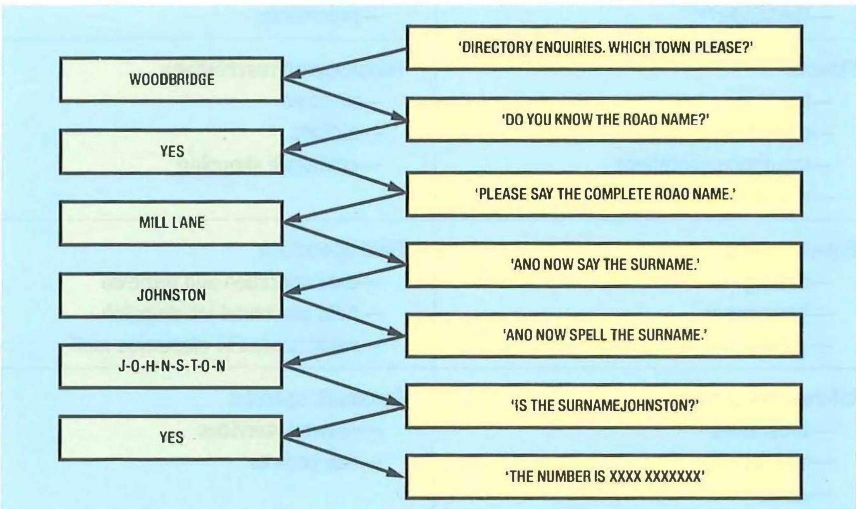
Figure 2 – Interactive speech system

An example of a dialogue for an experimental directory enquiries application is shown in Figure 3. Note that, to overcome deficiencies in the speech recogniser, the system asks the user to spell the surname, thereby adding an extra level of confidence in identifying the correct piece of information.

To address network-based applications for interactive voice systems, BT in conjunction with Ericsson has developed the speech application platform (SAP)[4], a modular system based on industry standards for hardware, software, interfaces and protocols. The SAP can be scaled from single-line systems to large embedded network and intelligent network installations and supports a range of exchange signalling and network integration options. The SAP provides a wide variety of speech and signal processing facilities such as speech recognition, text-to-speech synthesis, speech coding, touch-tone and dial-pulse recognition. Dynamic allocation of individual speech functions at the start of the call ensures that efficient use is made of available resources, and that these are made available to other telephone channels when no longer in use. Figure 4(*a*) shows an SAP rack installation at a telephone exchange, and Figure 4(*b*), the SAP speech processing card.

The key underlying speech technologies are reviewed next, starting with the most mature of the technologies—speech coding.

Figure 3 – Example of a voice response interaction



Speech Technologies

Speech coding

Speech coding exploits redundancy in the speech signal to reduce the transmitted bit rate. At the same time, it exploits the known properties of human speech perception to reduce the coding distortion to acceptable levels. Speech coders for particular applications are selected according to a trade-off between coder complexity, bit-rate, and signal

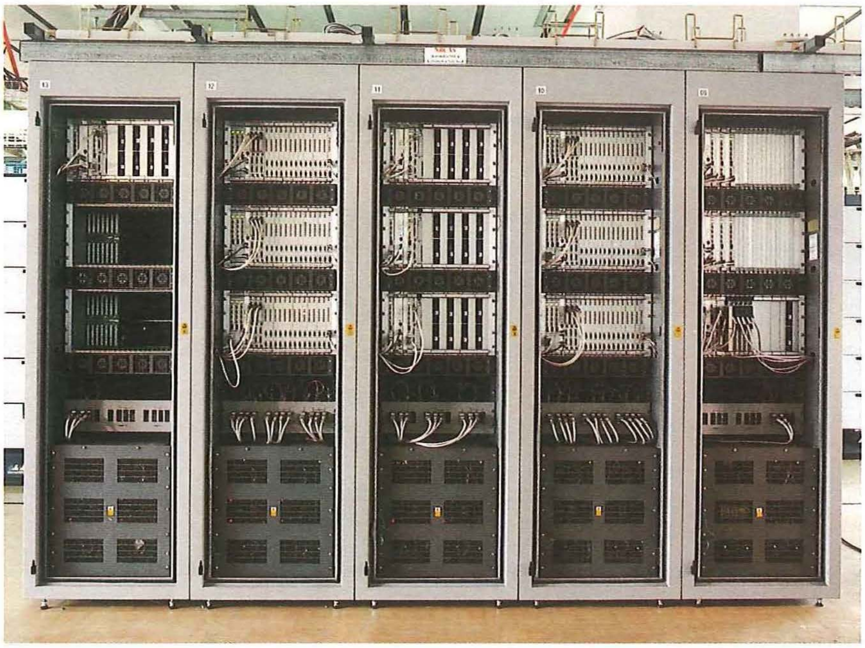


Figure 4(a) – SAP rack

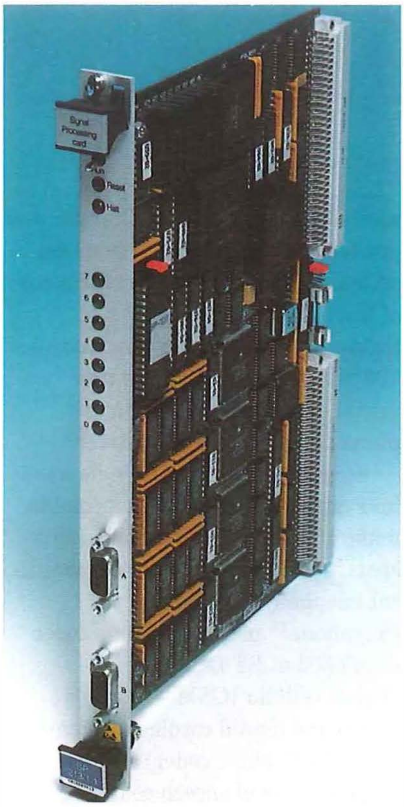


Figure 4(b) – SAP speech processing card

quality. This basic design trade-off is further complicated in practice by the need to take additional factors into account such as codec delay (which affects customer perception of echo), transparency (which affects the ability of the codec to pass non-speech signals), coder tolerance to transmission errors and tandeming ability (or the ability to mix different coders in a transmission path without the accumulation of distortion to unacceptable levels).

Current speech coding algorithms can be broadly classified into the following three types:

- waveform coding,
- vocoding, and
- hybrid and perceptual coding.

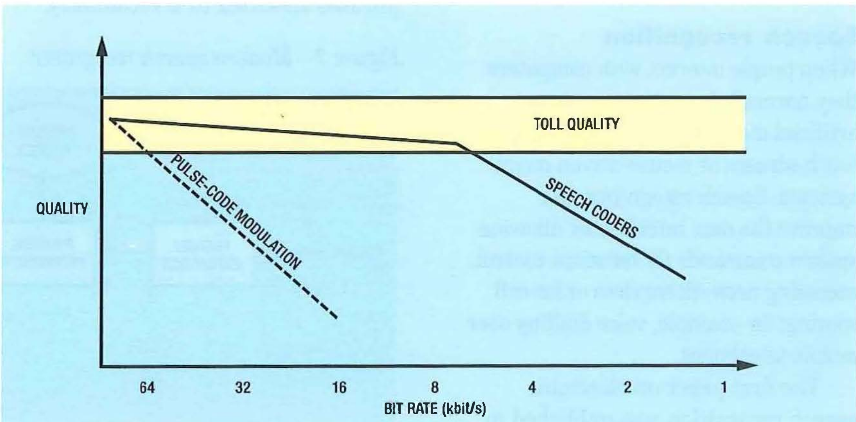
The aim of waveform coders, as the name implies, is to reproduce the original waveform as accurately as possible. As these coders are not speech specific, they can cater for many non-speech signals, background noise and multiple speakers without difficulty. The penalty of a relatively high bit rate, however, must be paid for this acoustic robustness. Examples are pulse-code modulation (PCM), adaptive differential PCM (ADPCM) and sub-band coding.

In contrast, vocoders (voice + coders) make no attempt to reproduce the original waveform but instead derive a set of parameters at the encoder which can be used to control a synthesiser based on an assumed model of speech production. The resultant speech quality tends to be synthetic or variable between speakers, and hence is not used for public telephone network applications. However, vocoders have been applied extensively in military applications, an example being the US Department of Defense LPC-10 system operating at 2·4 kbit/s.

Hybrid coders combine features from both waveform coders and vocoders to form coding schemes that provide good-quality efficient speech coding. At rates between about 16 kbit/s and 4 kbit/s, good-quality coding is achieved using *analysis-by-synthesis* techniques. They may also exploit the psycho-acoustics of human hearing to conceal coding distortion. A good description of the operation of the basic analysis-by-synthesis technique is given in Reference 5. This technique is the basis of the coding schemes used for Skyphone™, the International Telecommunications Union (ITU) 'low-delay' 16 kbit/s standard, and the recently announced ITU proposed standard for toll-quality coding at about 8 kbit/s.

Currently 'toll' or telephony-quality coders operate down to bit rates of around 8 kbit/s (see Figure 5), with the prospect in sight within a few years of rates down to 4 kbit/s and below. In the longer term, more significant gains are theoretically possible if one considers that the maximum rate of articulatory movement is limited by inertia of the

Figure 5 – State of the art in speech coding



physiological structures of tongue and jaw to about 10 discrete sounds per second. Given the 40 or so phonemes of English (6 bits), this gives a theoretical minimum of less than 100 bit/s (even allowing for non-verbal cues such as emotion and phrase emphasis to be included).

Speech coders are still in demand for systems where there is a need to make efficient use of precious radio spectrum; for example, for aeronautical telephony via satellite (Skyphone™ uses a 9·6 kbit/s coder developed at BT Laboratories). Digital cellular (GSM—13 kbit/s coder) and digital cordless systems (DECT—32 kbit/s coder) also make extensive use of speech coding.

Speech coders have also been applied in customers' private network applications (for example, for speech-and-data multiplexers); in public switched telephone network (PSTN) and integrated services digital network (ISDN) videophone applications for the audio channel (for example, VC8000™); and in interactive network-based voice messaging applications (for example, Call Minder™), where cost of storage is still a critical factor. There is also worldwide interest in coding enhanced-quality wideband speech (typically between 7 kHz and 20 kHz bandwidth) at rates of around 1 bit/sample for speech and 2 bit/sample for audio (including music); for ISDN applications such as teleconferencing, CD audio compression (MPEG-audio) and for commentary channel transmission.

Figure 6—Skyphone™ satellite aerial at the Goonhilly ground earth station

Speech recognition

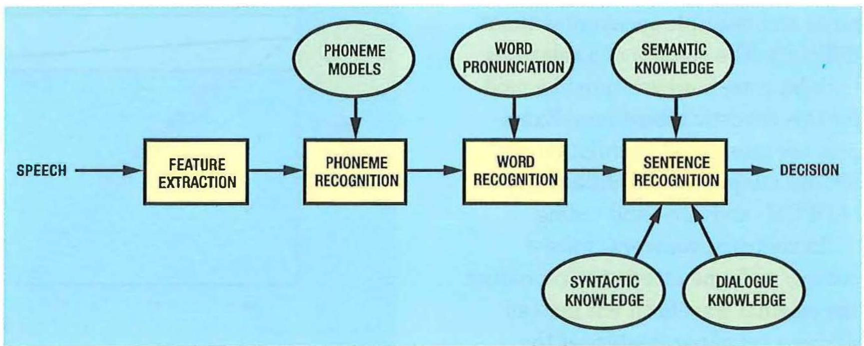
When people interact with computers they normally have to resort to artificial methods: keyboards, tonepads, touch-screens or mouse-driven menu systems. Speech recognition can improve the user interface by allowing spoken commands for terminal control, accessing network services or for call routing; for example, voice dialling over mobile telephones.

The first paper on electronic speech recognition was published in 1952 (AT&T's 'Audrey' system) and described a system which could recognise single-digit utterances spoken in isolation by a single speaker. BT began work on speech recognition in the early 1980s, and this resulted in Topaz, the first repertory dialler for hands-free voice dialling in cars, in 1986. Early small-vocabulary speaker-independent recognisers were also deployed in the pioneering trial of automated banking in 1988, which at its peak involved some 400 Royal Bank of Scotland employees in using an interactive banking system. More recently, the latest large-vocabulary recognition system has been implemented on the network-based speech application platform[4].

A speech recogniser is designed to recognise one of a set of words or phrases specified in a vocabulary. Because of the variability inherent in a speech signal, speech recognition is difficult, and no speech recogniser (not even a person!) is 100% accurate. For example, the person speaking may have an accent on which the recogniser has not been trained; or there may be a lot of background noise from a busy office or a radio so that the recogniser is unable to distinguish between the person's speech and the background noise.

Figure 7 shows the components of a speech-recognition system. The front-end stage performs feature extraction on the sampled speech signal. It takes segments of the speech at regular intervals and transforms them to facilitate pattern recognition by converting the unwieldy time-domain signal into a more compact and consistent representation. These frames of features

Figure 7—Modern speech recogniser



are then processed either to identify words or parts of words (phonemes). In a more complex scenario, knowledge of the words that are likely to follow each other can be used to advantage by exploiting semantic (meaning), syntactic (grammar) and dialogue (discourse) contraints to help recognise sentences.

Many current speech recognisers use the technique of *hidden Markov modelling* (HMM) to represent the vocabulary. An HMM is a type of model based on a statistical representation, and this helps the recogniser to cope with some of the uncertainties in the way people speak, including coping with variations in the shape of the vocal apparatus and temporal variations brought about by speaking at different rates. Each HMM usually represents either a word or a sub-word unit (for example, phoneme) to be recognised, and is constructed using statistics calculated from examples of the spoken word or sub-word. The recogniser aims to identify, from observing a sequence of speech features (feature extraction), which of the stored Markov models is most likely to have produced these observations. A good 'layman' description of HMMs can be found in Reference 6.

A connected word recogniser is able to recognise 'phrases' consisting of strings of words (for example, telephone numbers). Because the largest units modelled are usually words, the recogniser has to be capable of matching utterances to strings rather than to single models only. This is usually achieved by constructing a finite-state network of models to represent the whole vocabulary. The task of the recogniser is then to find the path (or paths) through the network that most closely matches the utterance.

The performance of a speech recogniser is dependent on such factors as the size of the vocabulary and the number of users. A business dictation system can recognise a large vocabulary (typically 20 000 to 30 000 words), but is trained to a particular speaker and exploits tight constraints on language and word statistics. In contrast, speech recognition across a telephone network is likely to use only a small vocabulary since the recognition task is far more challenging: the speech of all telephone users needs to be recognised (speaker independence) across the channel vagaries of the telephone network. Also, application-domain and grammatical constraints tend to be weaker, as with surname and address recognition. As an example of the state of the art, BT's latest speaker-independent recogniser is capable of identifying more than 2000 words and any connected grammar over the telephone network.

In the past, the production of new vocabularies required a laborious process of recording many examples of the words from perhaps a hundred or more native speakers. The whole process could take several months, with the added complication of having to redo the exercise if a change or addition to the vocabulary was needed. However, a valuable method has recently been developed which enables new vocabularies to be generated very quickly, within a matter of minutes, by simply typing the words to be recognised. The phonetic transcription of the word is obtained from either a dictionary or a set of letter-to-sound rules, and the word model is then built up from the individual models for the sub-word units (which typically correspond to phonemes). Because of the various approximations in this process, recognition scores for text-generated vocabularies are generally inferior to those which have been trained on actual speech utterances.

Currently, telecommunications provides one of the largest market sectors for speech recognition, with applications as diverse as automation of operator and directory assistance (using whole word or spelt input recognition), voice dialling services, validation of credit card sales, voice banking (for example, the NTT ANSER system) and access by voice to information services (such as sports, weather forecasts and theatre bookings).

telecommunications provides one of the largest market sectors for speech recognition

Speaker verification

Speaker verification can be used to validate the claimed identity of a person from his or her voice-print. Typically, this technology is combined with a general-purpose connected speech-recognition system to recognise a spoken personal identification number (PIN), and then to check that the PIN was spoken by the authorised person. Speaker identification can be used to recognise a member of a closed user group (for example, a family) directly from a known spoken word (text dependent) or from any spoken utterance (text independent).

The first paper on speaker recognition was by Pruzansky of Bell Labs in the 1960s. From then until the early 1970s, speaker-recognition research commenced at several laboratories, including IBM, TI and NTT, and both text-dependent and text-independent methods were investigated. The first network-based use of speech verification by BT was as part of a trial of automated banking with the Royal Bank of Scotland in 1988.

Typical current applications include secure access control to information, banking (often combined with auto teller machines and smart cards), computer networks, PBXs and work areas. The technology can also be used to provide access to a range of network services according to customer profiles (for example, name dialling and travel information).

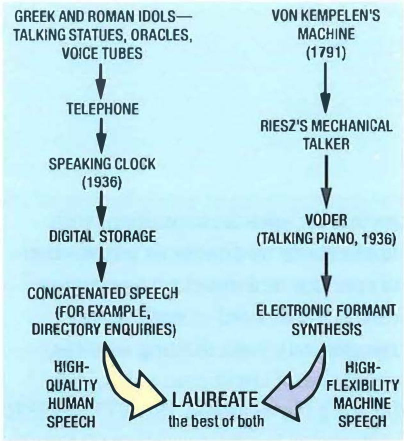


Figure 8 – Evolution of speech synthesis

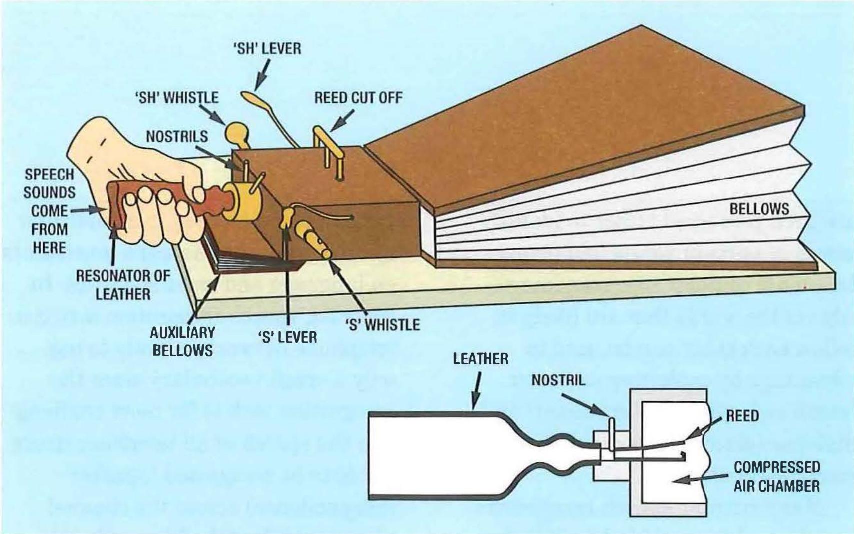


Figure 9 – Wheatstone's replica of Von Kempelen's machine

Speech synthesis

The evolution of speech synthesis technology is illustrated in Figure 8.

In 1791, Von Kempelen constructed a talking machine (Figure 9); it consisted of a bellows, a mouth shape, nostrils and whistles. The machine included a compressible leather tube and an air chamber equipped with a reed leading to a soft leather resonator which could be manually shaped for the formation of the vowel sounds. Consonants were created by holes which the 'player' closed by movement of the fingers. The Von Kempelen machine could produce about 20 different sounds!

The earliest electronic synthesis of speech was achieved by Dudley in 1939 when he demonstrated a manually controlled speech synthesiser known as *VODER* (voice operated demonstrator) at the New York World Fair.

Speech output from computer-based equipment has commonly been achieved by storing whole messages in digitised form (as with the BT speaking clock). These messages require recording by a speaker and, although a natural sounding voice output is achieved, significant amounts of data storage are required. An additional constraint on system design and extension arises when the messages need to be changed or updated if the original speaker is not available. There are many applications where the quantity of information that needs to be accessed or the rapidly changing nature of the information is such that the versatility of a full text-to-speech system is the only practical solution.

BT's synthesis system, known as *Laureate*, is designed to convert unrestricted textual input into speech. Laureate differs from conventional speech synthesis systems in that it does not attempt to generate sounds artificially to mimic human utterances. Rather, it constructs the voice from elemental components of a person's recorded speech. The result is more natural sounding speech which can be easily modified (by recording suitable speakers) to effect local accents, and other languages (requiring additional changes to the system's language rules). The system has been engineered to commercial software standards, is portable between different platforms and is designed for multichannel operation.

In Laureate, the speech output is derived directly from an unconstrained textual input and the first stage of processing involves expanding the text by a normalisation stage which deals with abbreviations and acronyms. As an example 'St John St' becomes 'Saint John Street'. This is followed by a stage of syntactic parsing which aims to resolve ambiguities between words such as 'lives' or 'convict', which have both a verb and a noun form. A semantic analysis may also be carried out which provides a representation of the meaning of text as an aid to word pronunciation. Next, a phonological analysis of the words is made to derive an appropriate word pronunciation based on both a large dictionary and a set of letter-to-sound rules, where the dictionary look-up fails (for example, for proper nouns). The prosody rules are then applied to provide the required emphasis on duration, intonation and major word stress. Finally, the speech is synthesised by looking up the appropriate speech segments which are combinations of phonemes, and then by concatenating them in as seamless a fashion as possible.

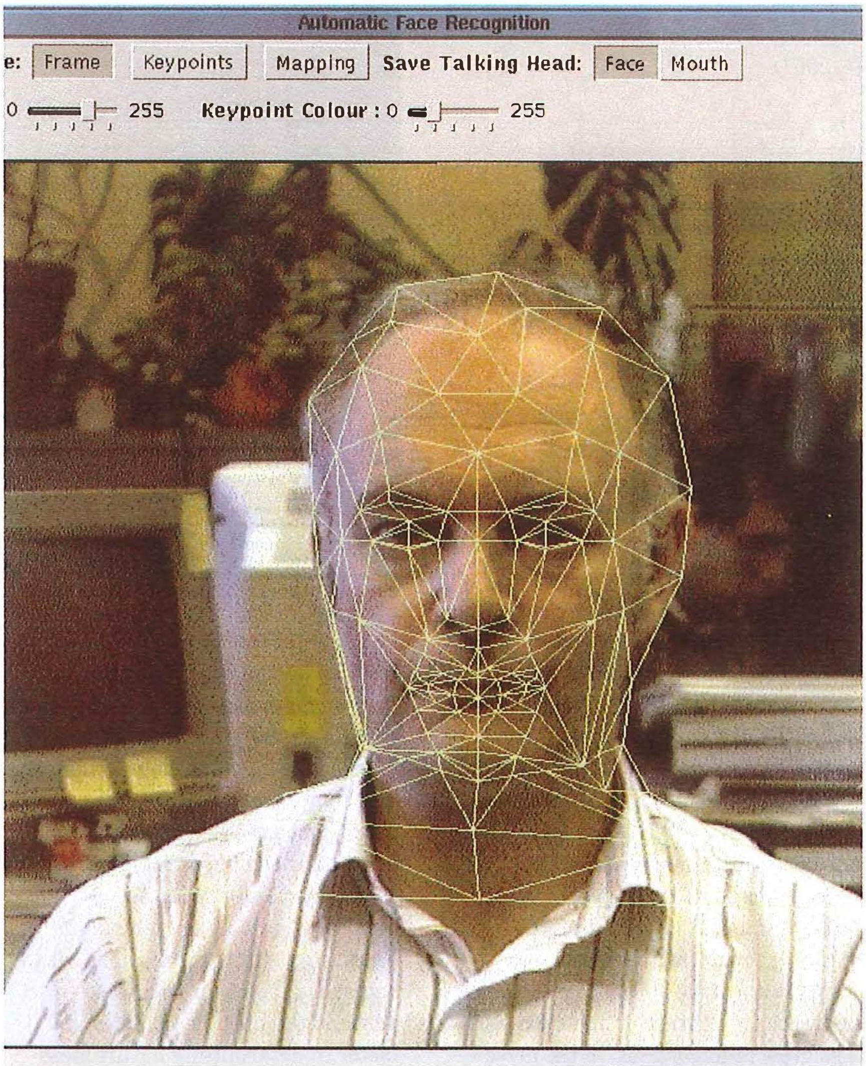
An example of an application for a text-to-speech system is a telephone-based catalogue ordering service, where the system can respond with a full description of the item being ordered as well as being able to say the name and address of where the item is to be sent. Here, the quantity of information would be too large to record directly any average-sized catalogue. A good example of a system where the output information changes rapidly is access to news information. Here large amounts of text can be updated regularly and be available over the telephone with no manual intervention apart from the original typing. The ability to speak e-mail over the telephone is another important application, enabling people to check their electronic messages when away from a computer terminal.

Speech enhancement

Speech enhancement is the process of enhancing the perceived quality of a speech signal received over a telephone link. An example is the cancellation of echoes on long international circuits to enable simultaneous two-way speech communications.

Echoes occur when signals undergo delayed reflections, and can affect both talkers and listeners on a call. In telecommunications, signals can be reflected from one direction of transmission into the other, either at the electrical interface between 2-wire and 4-wire circuits or by acoustic coupling at the handset. The

Figure 10—Synthetic persona (talking head)



effects of telephony echo on customers are complex, depending on electric and acoustic factors as well as the motivation of both customers.

Echo suppressors have been used for many years and conceal echo by detecting when the distant customer is speaking and the near customer is silent. Satisfactory operation depends on accurate speech detection to avoid syllable clipping and utterance blocking, and can be difficult on circuits with high levels of noise and echo. The alternative of echo cancellation was first proposed by Sondhi of AT&T Bell Labs, and the first single-chip custom very large-scale integration (VLSI) implementation appeared in 1969. A replica of the echo signal is synthesised by an adaptive filter which models the echo path and is subtracted from the send signal. In this normal mode of use, the echo canceller is required only to model the relatively short-duration echoes returned by the national network. In general, it is desirable to cancel echoes as close to their source as possible. Cancellers offer somewhat better quality than suppressors on long delay circuits, because they have greater signal transparency and less intrusive speech-clipping effects.

Adaptive noise suppression can be employed for applications where the speech and noise typically have overlapping spectra. In such a system, adequate performance is dependent on obtaining a good estimate of the noise spectrum either from a separate reference microphone, or from noise-only periods in the incoming speech (obtained using a voice activity detector). Applications include very noisy environments where the signal-to-noise ratio is low such as telephone kiosks in busy concourses or in financial dealer rooms.

To improve the naturalness of interactions in hands-free conferencing systems, interest is being shown in using acoustic echo cancellation and adaptive beam-stearing (and talker location) to remove reverberation and noise. Early work in this area at BT Laboratories has shown the potential of this technology to provide improved naturalness and utility for loudspeaking telephones[7].

Future Directions

Optical-fibre systems provide virtually limitless bandwidth in terrestrial telecommunications networks; the need for speech coding may therefore diminish on circuit-switched point-to-point connections. However, with the growth in corporate 'virtual' networking and wideband packet networks, the added flexibility afforded by variable-rate speech coding will be in demand for competitive bandwidth-management schemes.

Bandwidth will also remain under pressure in mobile and personal communication systems. In such areas, the demand for speech coding will continue to grow strongly over the next decade. This demand will be driven by rising customer expectations on quality, international standardisation, and technical advances in the on-chip integration of digital and analogue functionality.

The current drive to improve the naturalness of text-to-speech systems will continue with the emphasis in areas such as:

- improving the 'natural rhythm' of speech;
- allowing more choice in selecting the 'personality' of the speaker (current systems tend to adopt a single monotonous speaking style); and
- providing more choice of language and accent and the associated tools to provide such flexibility in text-to-speech systems.

Current work on combining visual and speech modelling systems (synthetic persona) shows promise for new services such as customised database access systems, 'continuous presence' conferencing and to provide a framework for studying fundamental mixed-mode signal interactions. In such a system (Figure 10), a wire-frame model of the person's head is

Figure 11—Natural teleconferencing (c. 2001)

created from photographs and a synthesised voice is synchronised to the lips of the model. By typing in text, the synthetic persona can be made to 'speak'.

The future direction of research in speech recognition is less clear. Undoubtedly, the current emphasis on large-vocabulary speaker-independent systems will continue for telephony applications. To make such systems scalable to national network applications, more work is needed on improving noise robustness and out-of-vocabulary rejection (the ability of the system to reject words that are not in the current vocabulary). There is also interest in developing recognition systems that can adapt to the characteristics of the user's voice and the transmission environment. Techniques such as 'barge-in' (the ability for a user to interrupt an outgoing prompt with speech) and wordspotting (the ability to pick out a key word in a phrase or sentence) will also grow in importance in the drive to make speech systems more natural, and hence more acceptable, for customers.

However, to enhance significantly the basic performance of recognisers, more basic knowledge will be needed in areas such as feature extraction, building in more knowledge as it becomes available of the physiology of the ear and brain as a coupled 'system'. Recent work on time-frequency representations of speech (for example, wavelets) shows some promise in this area. Improvements to modelling of speech can be expected in a drive to remove the limitations of the existing statistical (HMM) based approaches. New paradigms based on mixed mode (that is, acoustic, speech and visual) cues may offer one way forward. Although a good appreciation of human factors and the psychology of dialogue design as it relates to natural human interaction is essential, they are not, in themselves, a substitute for inadequate underlying recognition performance.

Although much of the discussion so far has focussed on man-to-machine interaction, speech processing also has an important role to play in person-to-person communication. To improve the naturalness of 'hands and eyes free' interaction, it will be necessary to develop improved acoustic ('last metre') processing such as intelligent louspeaker and adaptive microphones. Also in such systems the processing and transmission delays between people can be critical—perhaps the most critical design factor in determining naturalness and user acceptability.

Spoken language will be an essential vehicle for searching and retrieving information. For example, a personal communications device designed to fit in a pocket will be too small to support a keyboard. Also information must be accessible to all users, of all ages and not just the computer literate. Much of the information will be multimedia and multilingual, and much will contain unstructured prose. For such applications, interactive dialogue-based systems will increasingly demand both high-performance speech recognition and language understanding in order to identify and respond properly to users' requests[8].

Herein lies the destiny of speech processing—not just one mode of communications, speech, but all the senses orchestrated to meet the real underlying communication needs of people. A business conference of the future might be as easy to use and natural as indicated in Figure 11.

Spoken language will be an essential vehicle for searching and retrieving information.

Conclusions

Speech processing is a dynamic, exciting and commercially relevant field, overlapping the traditional subjects of mathematics, electronics and computer science.

Despite the enormous effort expended on speech technology research over the last few decades, still surprisingly little is known about signals, or rather how humans perceive and interact using them. For example, in areas like speech recognition, much more fundamental knowledge is needed to allow machines to be made that approach the capability of humans. Arguably, there has been too much emphasis recently in the digital signal processing (DSP) community on solving the problems of *digital processing* and not enough on understanding the subtlety of *signals* and human perception.

Real-world speech applications will increasingly require a broader based, more holistic, approach to realise systems that are acceptable to the public at large. Engineering and computing skills will need to be complemented by skills in man–machine interaction, human perception, psychology, acoustics, linguistics, natural language processing, and many others. The academic community has a key role to play in helping industry to develop this broader perspective.

As speech technologies are commercially exploited, different skills and expertise will be required at different stages in their evolution, from research/prototyping in the early stages to downstreaming and support of real-world applications in the later stages. The effective coupling of research to delivery into applications is critical. In particular, the problem of scalability, from laboratory demonstrator to national network service is fundamental, and one in which BT can be expected to play a key role.

Speech communications is and will continue to be key to the use of the network, currently accounting for well over 90% of revenue. Speech is the most natural way for users to communicate from person to person and in the future, where appropriate, from person to system. Having the right applications and services is key to revenue generation. Understanding the technology behind them is vital to designing and operating the network efficiently, to the future of network intelligence and operational support systems, and to reducing costs, while presenting BT as a technologically-advanced service provider.

Speech technology is well poised to affect dramatically the way we all communicate and interact in the 21st century.

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Biography

Fred Westall
BT Networks and Systems

Fred Westall received a B.Sc.(Eng.) in Electrical and Electronic Engineering from University College London and an M.Sc. in Communication Engineering from the University of Manchester Institute of Science and Technology in 1973 and 1975 respectively. After graduate training and a spell as a microwave development engineer, he joined BT Laboratories in 1975 to undertake research and development of speech-band modems for the public switched telephone network. He has been closely associated with digital signal processing ever since. In 1982 he became head of the Speech Coding Applications Group with specific responsibility for the development of novel speech-and-data multiplexers, which incorporated low bit-rate and high-quality (7 kHz) speech codecs. In 1986, he was appointed to manage the Data Products Development Section where he was responsible for packet terminals development and high-speed modem research and development. He is currently responsible for downstreaming speech-band applications onto speech platforms and for signal processing research and development, notably in the fields of speech recognition, coding, analysis and synthesis. He is a Fellow of the IEE and Senior Member of the IEEE.

Fraser Burton

Residential Broadband Services: A European Study

The next few years will see interactive broadband services such as telegames, teleshopping and teleworking offered across Europe. These services will not be restricted by today's national borders and will connect European homes to a revolutionary new type of European market place. BT is involved in collaborative work with European counterparts to understand the network requirements of these new services.

Introduction

Europe is one of the most densely populated regions of the world and is also one of the most diverse in geography, culture and language. The International Telecommunication Union (ITU) identified 47 separate countries in Europe in 1992, with a total population of nearly 800 million people[1], therefore the European residential market provides a significant opportunity for telecommunications network operators. The potentially fast-growing market for video services, entertainment and information services is also driving innovation in the infrastructure needed to carry these new services to the mass market; for example in the development of asymmetric digital subscriber line (ADSL) access and large-scale video servers.

Video-on-demand (VoD) and interactive video services are being investigated over trial networks worldwide[2,3,4,5] and a number of European collaborative projects are studying these services. This article looks at some of the work that BT is involved with as part of the Europe-wide organisation, EURESCOM[6], and the European Commission's RACE programme[7]. EURESCOM is the European institute for research and strategic studies in telecommunications, and has been in existence since 1991. In 1994, EURESCOM included 25 public network operators from 21 European countries, all co-operating to carry out pre-competitive research and development in their core business of telecommunications. RACE is a European Commission programme 'Research and development in advanced communications technologies in Europe' performing specific research and development in the field of communication technologies. This article features some of the ideas that have sprung from BT's involvement in the EURESCOM project 'Broadband Services for Residential Users', and the RACE project 'Multi-Wavelength Transport Networks'.

The next section gives a brief overview of the broad range of new services together with evidence for the potential popularity. After this, there is a section on customer demographics followed by a discussion about traffic scenarios. The results presented here are essentially technology-independent and further work will be needed to map the offered traffic on to a network for any given choice of technologies.

The Services and Their Markets

The range of services offered over a broadband network of interest to a residential user will include at least these general types of activity:

- entertainment;
- purchasing;
- information gathering; and
- communications (for social interaction or teleworking).

A residential user will wish to perform these activities in an intuitive fashion without concern for the underlying technology. Numerous services can be placed under each major heading, and

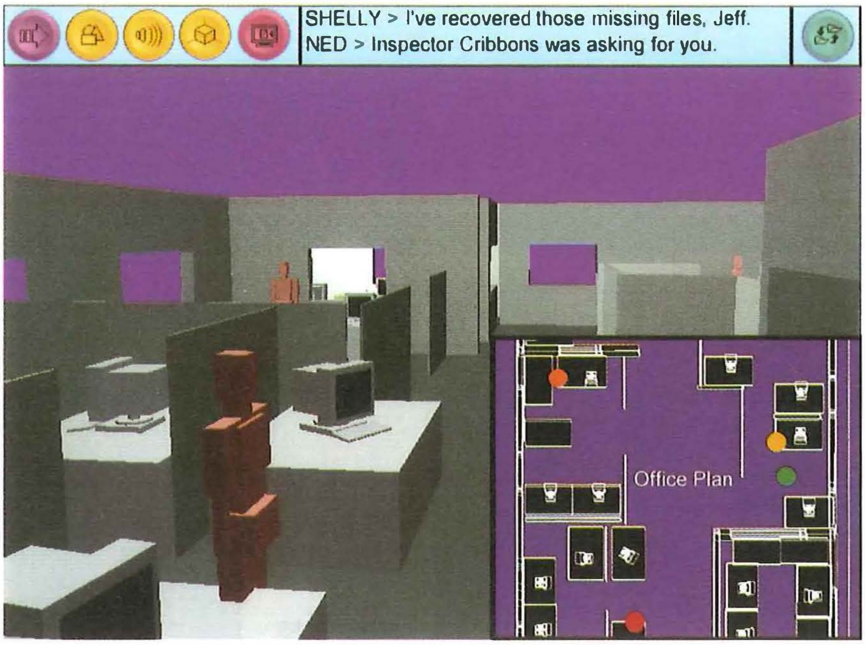


Figure 1 – The user's view of a games environment, interacting with objects and other players in a virtual world

excellent articles have already discussed some of the possibilities[8,9]. An example is given below for each heading together with estimates for the potential market.

Entertainment: Games

Videogames was a $6·5 billion per year business in the USA in 1993[10] and is predicted to grow to $7·5 billion this year[11]. The USA has a population of approximately 260 million and Western Europe has a population of greater than 400 million, so scaling the market to Europe, and assuming telegames take 50 per cent of the stand-alone market, results in a $5 billion annual market. Numerous major high-technology companies are actively involved in producing games, including AT&T, Matsushita, Paramount, Viacom, Blockbuster, IBM, Silicon Graphics, Time Warner, Philips and Sony. By 1993, over 64 million games machines had been sold in the USA by Sega and Nintendo alone. The market is strongly fashion-oriented since most users are young. Users respond to high levels of advertising and require a constant supply of new products in order to retain their interest. Software sales drive the profits for games manufacturers, and the short lifetime and popularity of individual games are clearly beneficial to a network operator, as new software needs to be downloaded regularly.

The continual need for large software file exchanges to a widely distributed customer base demonstrates the possible opportunities to telecommunications network operators. A multi-user game service distributed across Europe could connect users 1000 km apart, so offering the fast response times that players demand will be a considerable technical challenge. Figure 1 shows one possible form for an interactive games environment, where users can explore a virtual space and interact with other users and virtual objects.

Purchasing: Home shopping

In the US in 1993, direct marketing accounted for a $60 billion turnover[11]. Scaling to Europe and assuming teleshopping can take just 10 per cent of the catalogue market results in a $9 billion annual market. Telecommunications providers will take only a small share of this market, since other companies are involved in the production and retail of consumer goods. Social factors are significant to the popularity of the service; for example, the involvement of advertisers, retailers and delivery firms. Secure fund transfer and billing are essential. The interface to the service is also important (for example, how products are displayed). A key requirement will be data security and this is the subject of on-going research, standardisation and legislation[12]. Users must feel confident that the identification and password procedures can be trusted, since they will be at considerable financial risk if fraud or accidental misuse takes place. A European shopping service must offer products in the language and currency of the target audience, so automatic translation servers will be needed.

Information gathering: Multimedia newspaper

Newspapers and magazines accounted for £2·3 billion of UK consumers' expenditure in 1992[13]. Scaling to Europe, converting to US dollars and assuming an on-line service can take 25 per cent of the paper-based market, results in a $6 billion annual market. An electronic newspaper may be based upon an audio-visual archive service, where the contents are frequently updated and linked to information providers' databases across the world. The service would resemble a broadcast television news programme where users can enter their own profile of interests and can interrogate the service for more information. For instance, a user watching a general news programme may be interested in a short item on the electronics industry, and can request more detailed textual or audio information on that subject to be provided. User profiles may be held in the terminal (for personal information) and in the server (for public-domain information). The quantity and quality of this customer information have the potential to radically alter advertising and retailing, and could be a genuine benefit to users when filtering the enormous amount of on-line information. For example, NASA mission images and Olympic medal results have been provided in real-time over Internet, faster than any mass-distribution news service.

Communications: Videophone

Videophone has wide ranging appeal and applicability to all residential users and is being defined by international standards bodies[14]. Given the choice of a high-quality

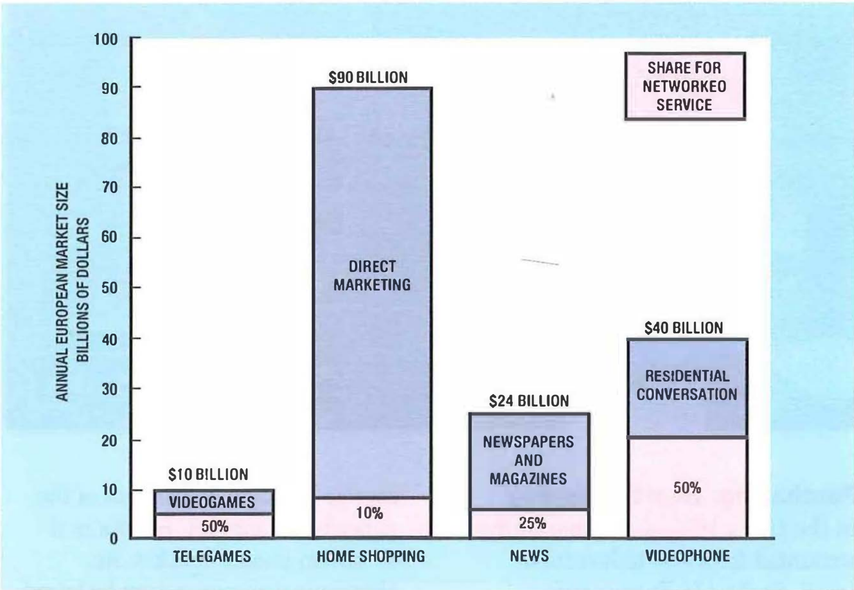


Figure 2—Potential European markets for new services

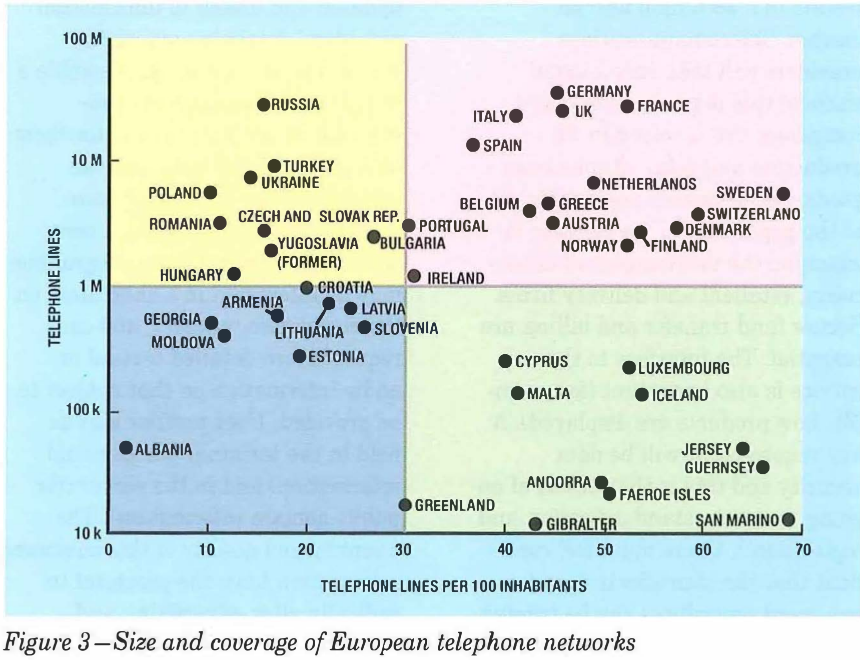


Figure 3—Size and coverage of European telephone networks

video conversation or a standard voice-only telephone call at the same price, a large proportion of residential calls will migrate to video. If as much as 50 per cent of European residential call revenue moves over to videophone, an annual market of greater than $20 billion would result and this market needs to be retained by network operators. The delay requirement for the videophone service is an important quality-of-service parameter, in addition to picture and sound quality, and the European Telecommunications Standards Institute (ETSI) notes that lip synchronisation must be supported so that users do not discern any difference between speech and video signals. As with telegames, keeping delay within acceptable limits across 1000 km or more of Europe will be a challenge for communication engineers.

In summary, it is clear that if network operators can provide the infrastructure, new services will provide multi-billion dollar annual revenues as shown in Figure 2. Enormous potential exists and experience with the World Wide Web and the Internet shows that users want new services now!

Where are the Customers?

A telecommunications market may be characterised in many different ways depending on the product or service to be offered. The first task is to identify where the customers are located.

Geographical spread

The current size of telephone networks in European countries varies widely, as does the coverage these networks provide their populations. Figure 3 shows ITU data[1] plotting the size of the network (in terms of the number of telephone lines) against the density of the network (in terms of the number of lines per 100 inhabitants) for each European country in 1992.

A convenient grouping of countries may be achieved by placing the countries in quadrants as shown. A country may be classed as possessing a *large* network if it has over one million lines, and a *small* network if there are less. Similarly, a network may be classed as *dense* if there are greater than 30 lines per 100 inhabitants, and *sparse* if there are less. It may be seen that many of the Eastern European countries have sparse networks, though these may often be fairly large. Small islands and city states frequently have excellent telephone coverage, and Monaco is off the scale with 97 lines per 100 inhabitants! For convenience we shall restrict attention to the 16 largest and most dense national networks shown in the top right-hand quadrant of Figure 3. However, it should be remembered that many of the Eastern European networks are growing rapidly and may soon be comparable to the established networks of the West.

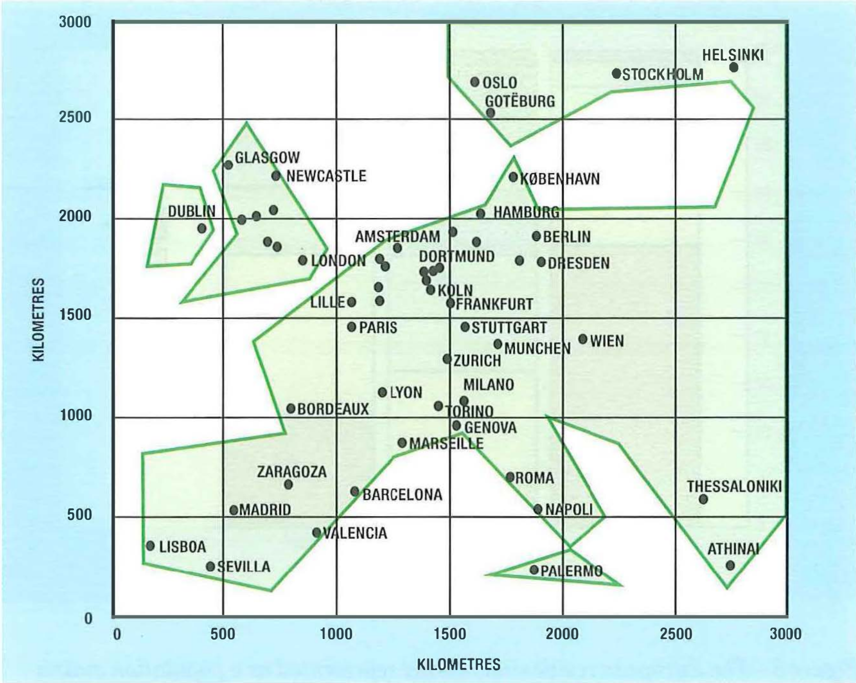


Figure 4—Some of the major European cities with a population greater than half a million

Figure 5—Population distributions in different countries

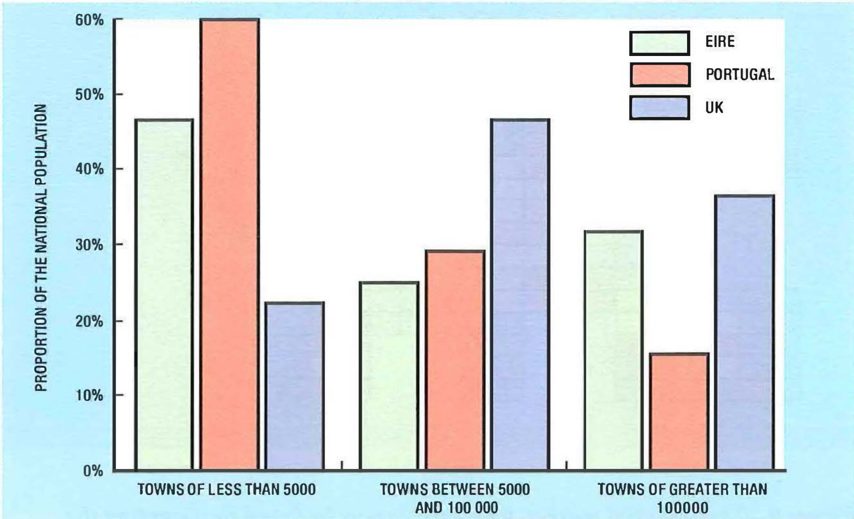
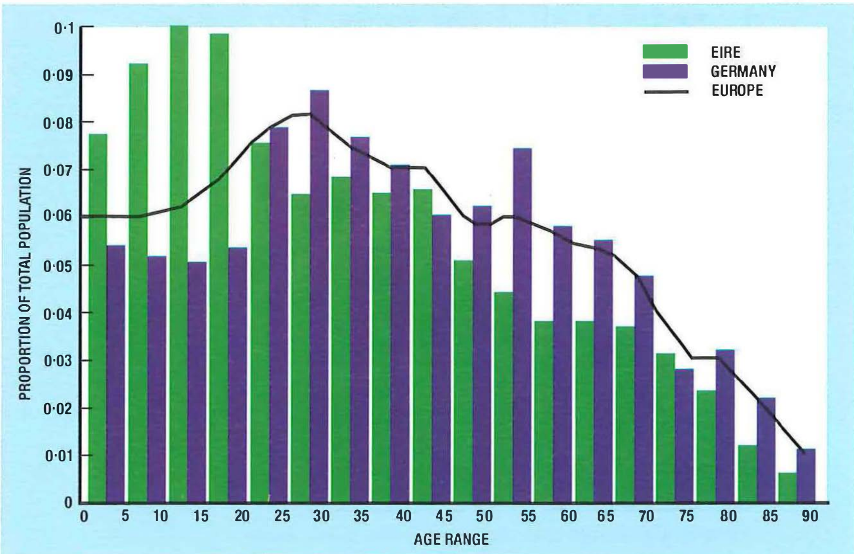


Figure 6—National age distributions compared with the European average



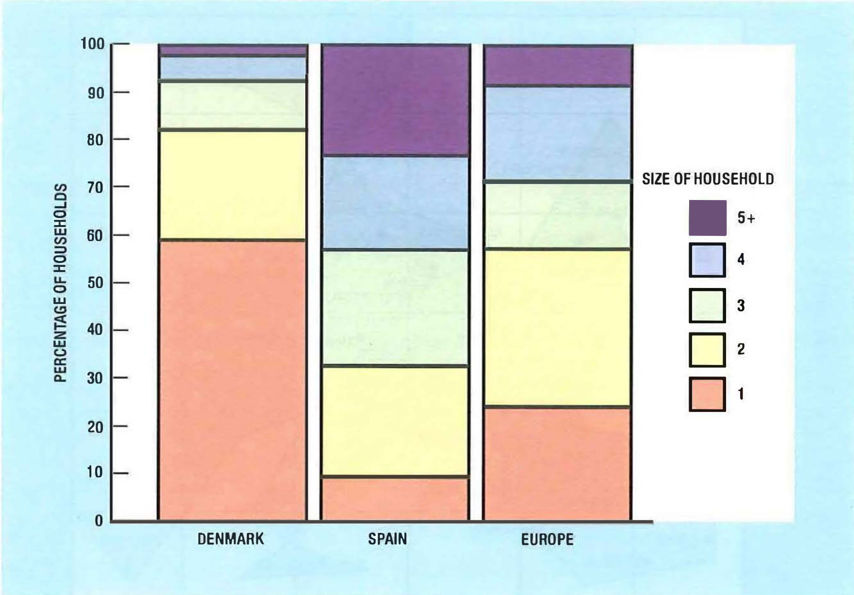
The 16 large/dense national networks of Europe provide 170 million lines, serving a total population of 380 million people over a land area of 3·9 million square kilometres. Figure 4 shows a schematic map with 55 of the major cities, each with a population greater than half a million. These cities account for about 20 per cent of the total population of these countries.

This population distribution can be used as the basis for producing traffic estimates, but it is also important to consider the different patterns of population within each country since these can vary widely. Figure 5 shows how population is clustered in three different countries. In Eire, the population is largely located in either very small rural communities or large cities, with few medium-sized towns in existence. In Portugal, there are few large cities with most of the population in the countryside and small towns. In the United Kingdom, the rural population is small and most people live in medium-sized towns and cities. These national differences must be included in assessing the market for distance-dependent services. For example, a Video-on-Demand (VoD) service carried over copper pairs is restricted in range by the attenuation of the final drop, and so can be economically deployed only in densely populated areas. Conversely, a telemedicine service will be attractive to remote communities without local medical centres.

Demographics

Having located your customers, the next step is to classify them. The age, gender, number of children, and expendable-income will all be key factors in whether an individual is likely to be a customer for a particular service. Figure 6 compares the age distributions in Eire and Germany against the European average. It can be seen that Eire has a significantly higher proportion of under 20 year olds, whereas Germany has an above-average

Figure 7 – Household size is dependent on cultural and economic factors unique to each country



proportion of over 50 year olds. An age-specific service such as tele-games would therefore be a sensible choice for the young Irish population, and teleshopping would be suitable for the older German population.

Cultural differences between countries can have an affect on how the average household is composed. Figure 7 shows how household size varies for two particular countries compared to the European average. It is found that Denmark, Norway and Sweden have a high proportion of single-person households, while Spain, Portugal and Eire have a high proportion of households with five or more people.

It can be seen that there is no such thing as a 'representative' country in Europe, and any method of characterising the European market must allow for considerable regional variations. One method to tackle this problem is to describe the European market as a matrix, M[x,y], as shown schematically in Figure 8.

Each element of the matrix would be a vector of the key metrics needed for estimating demand (for example, total population, age distribution, household distribution, expendable income distribution). The choice of metric and the size of each grid square will be dependent on the quality of data that is available.

Having identified the nature and distribution of your customers as an input matrix M, the next task is to convert this into potential demand, taking all of these factors into account.

Estimating demand

It may be assumed that the market potential for a particular service is some function of the market metrics, so that

Potential Market P[x,y] = f(Market Matrix M[x,y])

To further simplify the problem, it is useful to assume that the depend-

Figure 8 – The European residential market represented as a population matrix

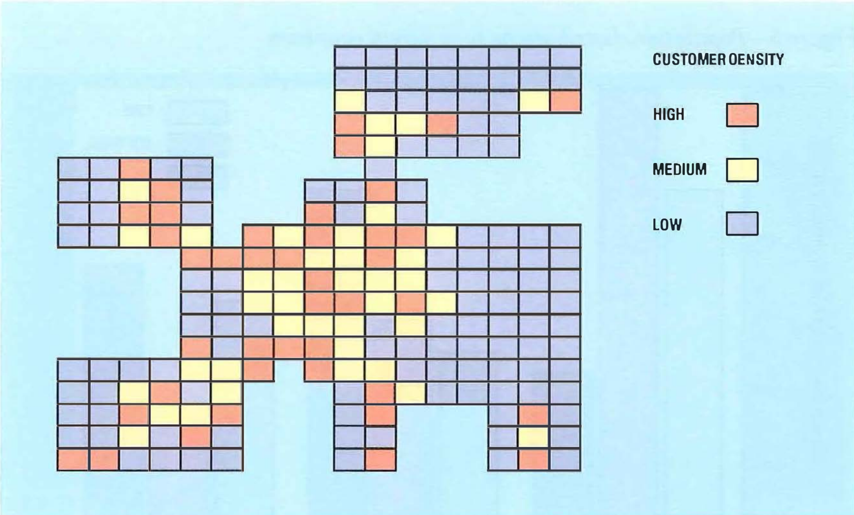


Figure 9 – The potential market for a service may be found by weighting the market metrics

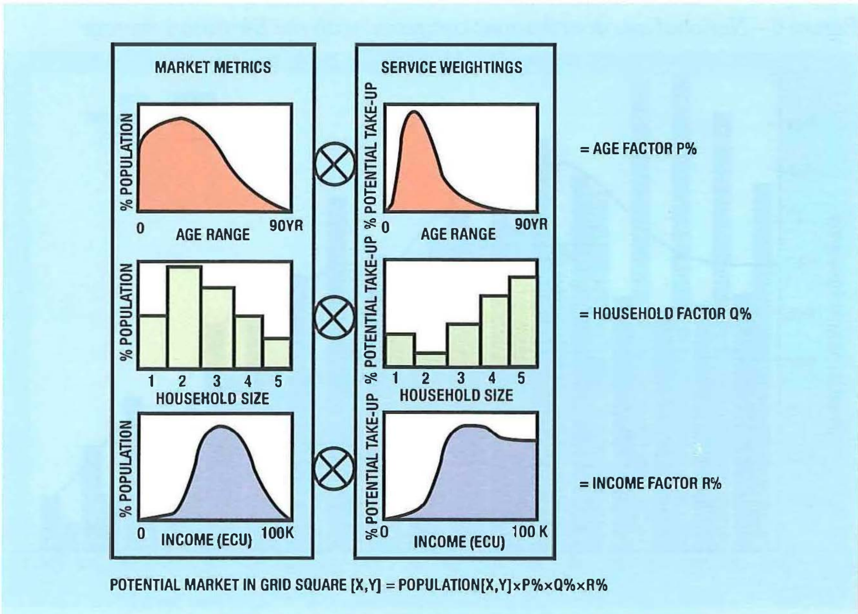
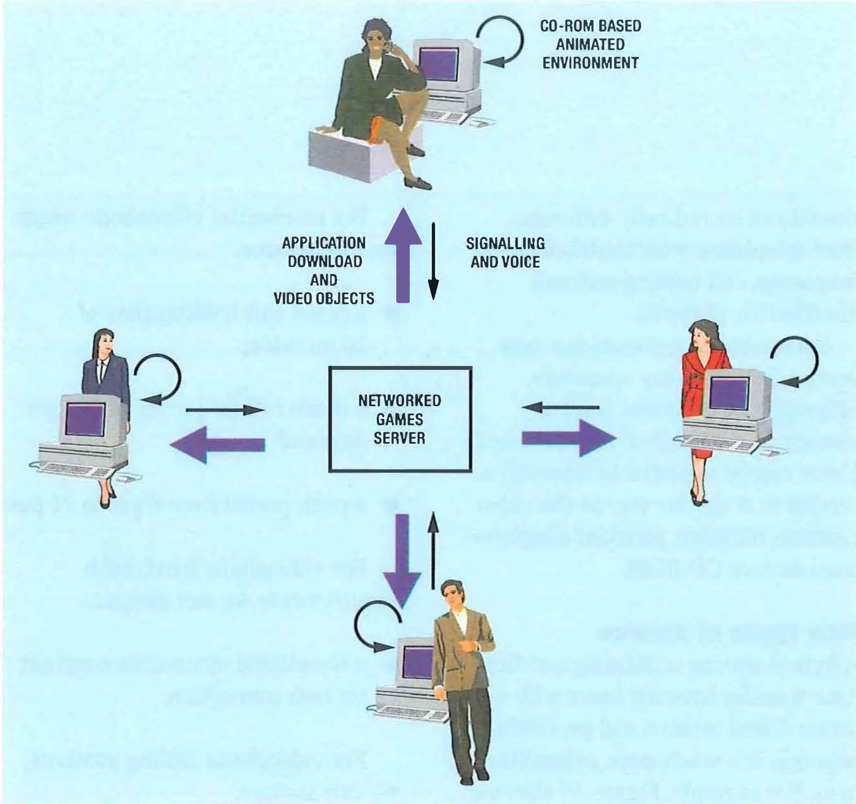


Figure 10—A possible implementation of a games service



ence on each metric can be dealt with separately, so that

$$P[x,y] = Population \times f_1(Age) \times f_2(Household\ size) \times f_3(Income)$$

This approach ignores the fact that there may be correlations between metrics. For instance, if a region has a high average income and a large average household size, this may suggest a large potential market exists. In reality, it may be the case that the larger households have a much lower income and the potential market is small. By choosing the size of the grid square used in the market matrix M to be sufficiently small, this effect can be reduced.

Figure 9 shows how this method could be used in practice. The market matrix element M[x,y] gives the age, household and income distributions in a region as three vectors.

A particular service, such as telegames, will have three associated weighting vectors. For example, a games service will be most popular with younger people, so the age-weighting is strongly peaked around 16 year olds. Similarly a games service will be popular in households with many children, so the household-weighting increases with household size. Finally, service take-up requires a certain level of income, though high-income households may prefer other pastimes. By forming the scalar product of a market metric vector with its associated service weighting vector, and forming the product for all metrics, the potential market for a service in that region may be calculated. Repeating this procedure for all elements of M[x,y] will yield the potential market distribution that needs to be served across Europe.

How Much Traffic?

Having identified what services are to be offered and which customers are likely to make use of them, the next task is to calculate what this means in terms of the network requirements. Whereas bandwidth is not the only network resource new services will demand, and may not even be the most important, it is certainly the simplest to understand for network operators with a history in telephony. It is important to distinguish between the *offered* traffic (produced by customers and servers) and the *carried* traffic (after routing, storing and processing).

Characterising services

In principle, calculating the offered traffic matrix is quite straightforward. In the last two sections, it was shown how the European population could be expressed as a matrix of market metrics, M[x,y], and that a particular new service could be represented by a set of weighting vectors, such that a suitable product of these two would yield the potential number of customers requiring the service at each grid location across Europe, P[x,y]. If a particular service connection is now characterised as a traffic source/sink with characteristic properties, then applying simple rule sets to the customer matrix will result in an offered traffic matrix for that service. Repeating this procedure for all services and summing the traffic matrices will then produce the traffic requirements to be carried by the network.

Uncertainty can arise for two reasons; firstly, the same service (as perceived by a user) can be implemented by the network in a variety of ways, and secondly, the behaviour of the user is difficult to estimate for new types of service.

The network implementation of the new services mentioned in the previous section can be grouped into (at least) three broad types:

- *user-to-user conversational*, with minimal server functionality (for example, videophone);
- *user-to-server retrieval/delivery*, with high server functionality (for example, multimedia archive); and
- *hybrid* (for example, multiplayer game environment).

For conversational services, such as videophone, it should be possible to draw analogies with the conventional telephony implementation and simply scale up bandwidth, delay and synchronisation requirements. User behaviour of videophones should not be radically different from telephony, with modified call frequency, call holding and call distribution patterns.

Server-based retrieval is a new service for telephony operators, although the computer industry already has considerable experience. Users can be expected to use such a service in a similar way to the video cassette recorder, personal computer hard disk or CD-ROM.

New types of service

A hybrid service combining real-time data transfer between users with a server-based archive and processing resource is a much more unfamiliar idea. For example, Figure 10 shows a schematic for implementing a games environment. The home terminal presents a virtual reality environment to the user (for example, a medieval castle), where the environment data is locally stored on CD-ROM. The environment data could have been purchased from a high street store or downloaded from the network server in advance. The users will be represented in the virtual environment by their own video characters (for example, wizards and dragons). The network server receives signalling data from all players and continually updates all the home terminals on the actions of the other characters. As new players join a games session, their video character and objects (for example, swords and potions) will be downloaded to the other players' terminals from the server. As players 'meet' in the virtual space they will be able to talk to each other, with voice paths broadcast to the relevant players by the server. The traffic sources and user behaviour patterns for such a service are immensely complex.

Calculating traffic

For simplicity we shall briefly outline how offered traffic may be calculated for just the conversational videophone service. A limited set of assumptions and rules is sufficient to start generating traffic matrices:

For residential videophone usage we can assume:

- a mean call-holding time of 15 minutes;
- a mean call frequency of one per day; and
- a peak period from 6 pm to 11 pm.

For videophone bandwidth requirements we can assume:

- a broadband symmetric constant bit rate connection.

For videophone calling patterns, we can assume:

- all calls are terminated within Europe;
- a connection is equally likely to originate or receive a call;
- the probability of a call being set up between two users decays with the distance between them; and
- the rate of decay with distance is a constant for all users.

These assumptions imply a five per cent peak utilisation of a customer's connection, so assuming the customer distribution shown in Figure 4, accounting for 170 million telephone lines, and a 50 per cent videophone take-up, this implies a total offered videophone traffic of 4·25 million videophone channels during European peak period. Most of the offered traffic consists of local calls, so if the traffic patterns are normalised such that 80 per cent of all calls are under 40 km, this results in a characteristic decay length of 72 km with 77 per cent of calls remaining within major cities' catchment areas. Inter-city links of 10 000 channels are common. If broadband video services are to be offered across Europe, the traffic on European networks is likely to increase significantly and the underlying infrastructure will have to change dramatically to be able to carry this.

Conclusion

Collaborative projects with BT's European counterparts offer an opportunity to establish a common framework for describing and studying the revolutionary changes within the telecommunications industry. The diversity of new services, and uncertainty about their potential demand, can make the design and implementation of new network infrastructure an exceedingly difficult task. However, by using a methodical approach it is possible to study each separate aspect, so that, starting with the users, a clear statement of design requirements can be achieved. The new generation of broadband interactive services will have profound effects on European life and the collaborative work with European operators and suppliers continues to ensure that the dream of the 'Information SuperHighway' soon becomes a reality.

Acknowledgements

This article has resulted from the author's involvement with the EURESCOM and RACE collaborative projects. Particular thanks to colleagues in Telenor, as well as the telecommunications operators of Finland, Ireland, Italy, Portugal and the Netherlands for many interesting discussions. Thanks also to the Human Factors Centre at BT Laboratories for their help with the games interface.

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Biography

Fraser Burton
BT Networks and Systems

Fraser Burton graduated from Oxford University and joined BT Labs where where he initially worked on modelling optical waveguides, and later the simulation of chaotic queuing systems. After this, he moved to a business systems group, where he provided consultancy to Cellnet on the dimensioning of its new core network. Fraser is currently part of a network modelling group where he leads a small team of people looking at the economic and design aspects of new network services. He is currently working with strategy units on demand modelling and business modelling projects. Fraser is a task leader on a European collaborative project with 16 other telecommunications companies studying advanced services for residential users.

Leo Brome

Managing a Joint Venture Network

This article discusses experience from BT Telecomunicaciones, the joint venture between BT and Banco Santander in Spain. Conflicting needs and constraints had to be balanced in moving a private network operator in Spain to be a major public operator offering global services.

Introduction

BT Telecomunicaciones is a joint venture between BT and Banco Santander currently offering public data services throughout Spain. The venture was launched in April 1994 and is formed from BT Spain and MegaRed, the bank's wholly-owned network operator.

BT was looking for a partner with existing infrastructure to allow fast access to the Spanish market. Banco Santander was looking for investment opportunities in the telecommunications arena, effective telecommunications being fundamental to its banking operations. The synergistic effects of a partnership could also reduce its network operations costs and enhance its capabilities.

The venture supplies a mix of national services tailored to local requirements and homogeneous global services. This mix is reflected in the management systems and operations structure. The joint venture is operated by nationals, with BT providing consultancy as required. The venture is managed and operated from Madrid.

Existing Network

Historically, the MegaRed subsidiary of Banco Santander provided data services to link branches throughout Spain. Digital lines were leased from Telefonica for access and links. Although there were numerous branches to handle, effectively there was only one customer. Branch data managers were technically aware and able to deal directly with MegaRed's operations staff for support. A branch number provided the key for identification of configurations or problems. The bank financed the operation as a single cost centre; that is, no charges were directly allocated to a branch. The network used Hughes equipment and element management systems. In addition, a PC inventory system was developed in-house to assist with planning and evolution activities. (See Figure 1.)

This article is based on a paper presented by the author at the FITCE Congress, Bologna, Italy, 10–16 September 1995. The paper won the Best Paper award.

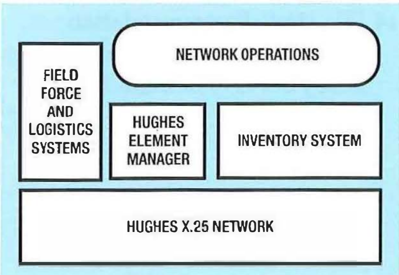
The views expressed are those of the author, and do not necessarily represent BT's or BT Telecomunicaciones' policy on the topics discussed.

Private to Public

How do you move from being a successful private operator to being a successful public one? The main factors are:

- ***Network growth*** The roll-out and extension of the network to new customers introduces a significant change of scale, and it becomes necessary to introduce

Figure 1—MegaRed private network functions and systems



functional departments specialising in technical and management areas. This enables the large-scale operation to be managed effectively; however, it creates a greater need for cross-department liaison.

- ***Public operator status*** Offering a commercial service in a competitive market requires more stringent non-functional requirements. These include resilience, fall-back centre, out-of-hours cover, stand-by power, node accommodation (these were previously on bank premises), and system resilience. Compliance with a number of detailed commercial and legal factors is also necessary.

- ***Customer facing activities*** Apart from moving from one to hundreds of customers, the nature of the customers and the support they require is radically different. The concept of 'service' and product differentiation also has to be introduced. End users of services have changed from being individually-known and technically-aware bank data managers to little-known, and possibly technically-naïve, general business customers. Marketing, sales, and customer-handling functions have to be established, along with appropriate support systems. Customer-handling functions cover service provision, invoicing, problem handling, and customer reports.

- ***Company support functions*** Financial management systems and processes have to be established, and a management information system (MIS) function is necessary to provide office automation and internal data communication services.

In short, a whole company has to be formed, integrated, and motivated within a very short timescale.

Systems selection

Systems are needed to operate and maintain the network, to support customer service (for order handling, billing and problem handling), to provide operational statistics and company support systems. The functions and processes that these systems have to automate are well understood within the industry. How they should be physically realised is less clear. The issues are:

- Which processes should be automated and to what extent?

- How much integration is necessary?

- Should the management systems be made, bought or borrowed?

- How can a relevant effective solution be achieved that has a practical evolution strategy?

A single-vendor one-platform multi-service vertical management solution can be used or an integrated multi-vendor architecture using standard interfaces. Neither of these options is entirely practicable, so the reality becomes a heterogeneous mix of different, even competing, technologies which reflect the business drivers and history of a particular operation or organisation. The answer to these questions is only achieved by understanding and reacting to the key drivers and working effectively within existing constraints.

Key drivers are the major influences that steer the decision process. Different drivers will apply depending on the scope of the decision area. For example, the drivers for selecting which products to offer are not the same ones that influence how the product is supplied.

Some examples of key drivers and constraints are used to illustrate how BT Telecomunicaciones decided on systems philosophy and integration issues to meet public operator status.

Drivers

Initial product set

What are we selling, how much of it, where and to what quality-of-service targets?

The products were domestic and global X.25 and frame relay services, available throughout Spain, but with the main traffic density in Madrid and Barcelona. In detail, this driver would include service definitions, market forecasts and roll-out plans, how the products would be offered and specific quality-of-service targets for each service.

Revenue source

Where is the major source of revenue? What is the split between international and in-country? Is business or domestic the main source?

Within Spain, the in-country market generates the largest proportion of revenue, which comes from medium and large businesses. By allocating the major cost items to the revenue stream, and taking into account profit targets, priorities become clearer: the emphasis must be on systems focused on the in-country market.

Dimensioning information

What are the volumes and rate of churn? How many customer interactions daily, monthly, weekly? Are on-request invoices required, and if so how often? How many interactions with the field force? What are the response times required for customer-facing and internal operations?

The figures for Spain showed that existing PC systems needed to be re-engineered onto larger platforms using a client server architecture. Dimensioning information tends to influence design considerably more than the application requirements.

Constraints

Infrastructure

Any existing network, buildings, management systems, processes and personnel.

The pre-existing bank network was based on the Hughes platform, an excellent product but different from BT's global platform. All nodes were on bank premises. Hughes element managers, an in-house inventory system, and many small-scale tools were in use. The MegaRed personnel moved across *en bloc* to the joint venture.

Local and transnational regulations

Regulations that affect the business of providing public telecommunications.

Liberalisation: Telefonica must be used for access and backbone links; public voice is not allowed until at least 1998. EU approval has to be obtained to act as a provider.

Homologation: All network elements and platforms for interconnection must be homologated (approval obtained for interconnection from public utilities; that is, Telefonica and the power supply company).

Legal issues

Pre-existing contracts, personnel or other obligations, intellectual property ownership.

There were existing contracts with third-party maintainers (TPM) to be honoured.

Interconnect

Any need to interface to other carriers, both domestic and global.

BT Telecomunicaciones has to interface with Telefonica for IBERPAC services and Concert for BT's global services.

Stakeholders

Other key considerations are the functional areas within the company: their needs have to be considered and their buy-in obtained, if any system is to be successfully implemented. These managers and users are referred to as *stakeholders*.

Each stakeholder considers that their needs are essential to the success of the business and must have priority over other stakeholders requirements! (See Table 1.)

Decision framework

All of the above factors give the framework within which the selection or design of management systems can take place. By analysing and debating all the drivers and constraints with the stakeholders, an optimum solution can be obtained. This is an ongoing process as the drivers and stakeholders are subject to change, and technology costs fall and functionality increases at a rapid rate.

Table 1 Stakeholders' Requirements

Stakeholder	Example of Unconstrained Requirement
Marketing	Proactive product capability, short product launch timescale, full availability
Technical	Accurate forecasts, single platform, early accommodation requirements, reference model for network and systems testing
Operations	Automated systems, fast response times, single consoles, full control of network and systems, network modelling for planning and evolution, excellent third-party maintainers
Customer service	Instant visibility of customer data, network configuration and order and fault progress, immediate notification of service-affecting problems
Finance	Revenue and cost tracking, asset management, control of development expenditure
Management information systems	Integrated systems with automated report generation, client server architecture, single logical database. Owners for systems and data
Sales	Product availability; accurate up-to-date product and cost information

Decision making in most companies is made up of a mix of objective and subjective criteria. The subjective areas of values, feelings and status are often not addressed, although they are usually the main factors behind decisions.

Differing cultures can also hinder understanding. Extra emphasis is needed on communication and consensus reaching. For example, in some cultures, time is seen as being of paramount importance; in others, it is not a key factor. These different approaches can cause conflict unless they are understood and worked around.

This process of analysing drivers, constraints and stakeholders' needs was used to decide on systems integration, platform and data ownership issues within BT Telecomunicaciones. To obtain consensus decisions from all the relevant stakeholders a workshop technique was utilised†. This technique, with its clear procedural rules, worked well in a multi-cultural environment.

Outcomes

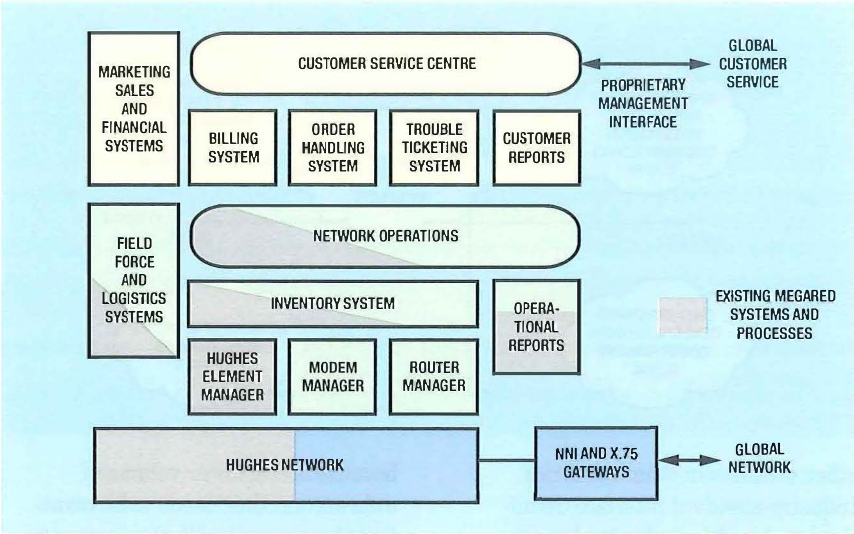
The process produced a top-level data model, and identified key interfaces that would be automated, ownership of key workstrings, and a platform policy.

Data model

Prior to the workshop, each system and process owner was responsible for their own data. This meant that common data was not necessarily common. Customers were referred to

† The workshop technique utilised for systems selection is a part of the Dynamic Systems Development Method (DSDM). DSDM is a European-wide software development approach adopted by many major companies. Its workshop stage is useful for obtaining consensus from stakeholders with differing requirements and opinions, by the use of an impartial leader.

Figure 2 – BT Telecomunicaciones functions and systems



differently on different systems. An output of the analysis was a table indicating who could create, read, delete or update data items. This is an essential precursor to solving the interface problem.

Key interfaces

The volumes, response times and criticality of data, and cost of manual activity are key factors in identifying which interfaces to automate.

A lesson learnt is that the whole process must be automated, not just the linkage between two automated systems. For instance, operations staff perform additional validation and auditing functions before committing configuration data. Simply automating the manual interface between an inventory model and the element management system is not sufficient.

Workstrings

A major factor in the success of operations and maintenance is the ownership of the billing, service provision, problem handling and reporting workstrings. Appointing an owner responsible for coordination of all 'vertical' activity ensures that processes and systems work together across all levels. It removes the artificial organisational barriers where people, quite rightly, focus on their tasks at their own level, without always being aware of the broader picture.

Platforms

A client server architecture with an underlying Oracle database was utilised for all new systems to meet the in-country operations requirements.

Figure 2 shows the key functions and systems.

Public to Global

With the emphasis on in-country service, how can a high-quality end-to-end global service be provided? At the two extremes of possible solutions are the single-network, and 'network-of-networks' scenarios.

Single-network scenario

The easiest way to provide an integrated global service is by using a single vendor and its vertically integrated management product set. (See Figure 3.)

However, this approach will not meet in-country requirements unless the joint venture or alliance has the same product set, platforms, management systems and processes.

Network-of-networks scenario

For a global network formed by a joint venture or alliance with a partner with existing infrastructure, as is the case of Spain, then a 'network-of-networks' approach appears valid. (See Figure 4.) However, the technology is unlikely to be compatible with

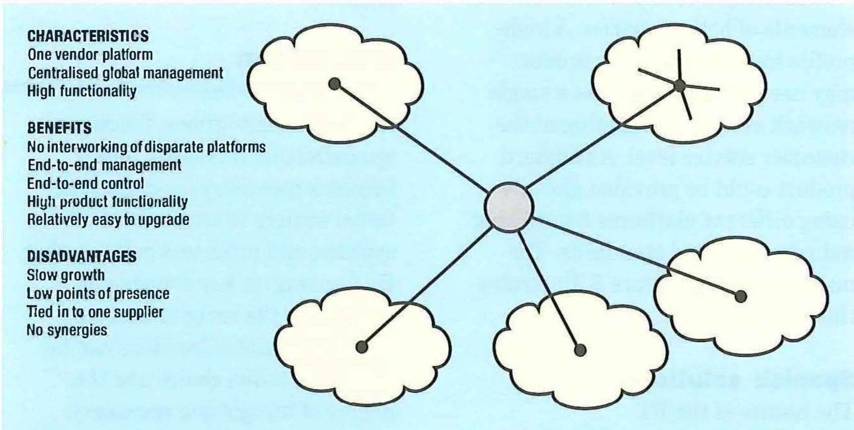
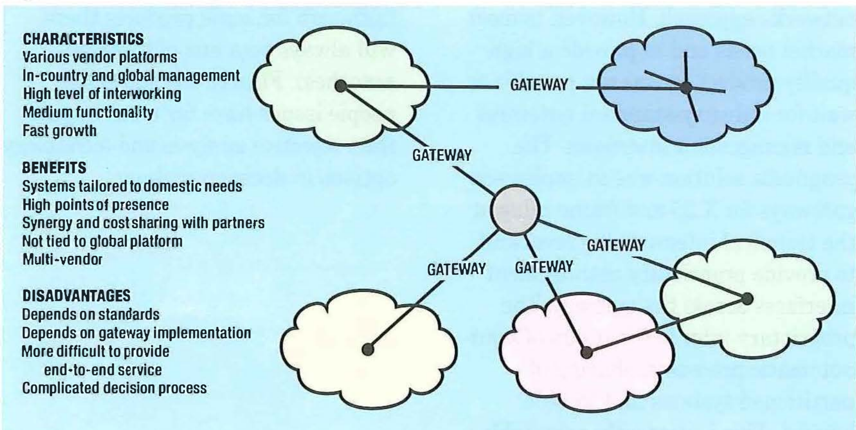


Figure 3 – Single global network

Figure 4 – Network of networks



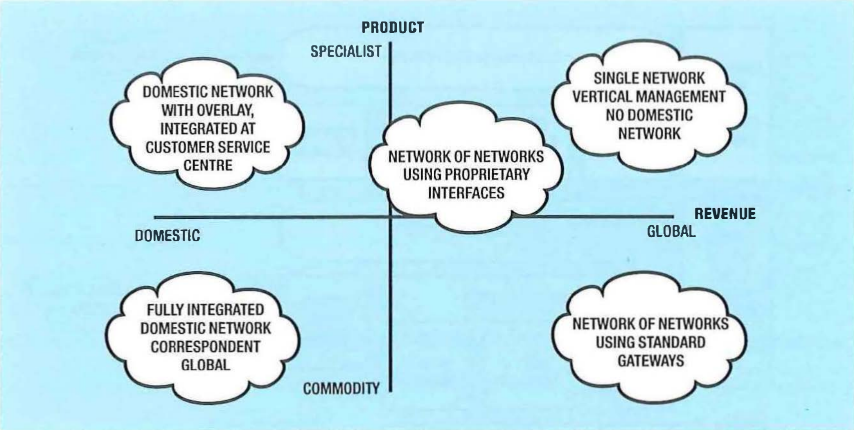


Figure 5 – Network options

other ventures in other countries. Industry-standard interface definitions and multi-vendor implementation of them are required to establish a global network. By the time standards have been implemented, the technology is usually becoming a commodity, and any state-of-the-art functionality lead over competitors is lost.

Given that neither of the above scenarios meets global and domestic requirements, what can be done? A compromise is needed but not one that reduces service excellence or increases costs. There is no simple answer.

Generally, a solution could contain elements of both scenarios. A high-profile high-functionality product may need to be provided as a single network overlay, integrating at the customer service level. A standard product could be provided globally using different platforms by utilising industry-accepted standards. The matrix shown in Figure 5 illustrates this mix of options.

Spanish solution

The nature of the BT Telecomunicaciones market places the emphasis on in-country needs, but with global interoperability, which suggests the network-of-networks approach. However, to meet market needs and to provide a high quality product, it was not possible to wait for industry-standard gateways and management interfaces. The pragmatic solution was to implement gateways for X.25 and frame relay at the technical interworking level and to provide proprietary management interfaces across the gateway. The proprietary interface is a mix of semi-automatic processes, sharing of partitioned systems and 'double keying'. This is currently acceptable because of the lower volume of information that needs to be transferred compared with the in-country activity. Both the joint venture and BT Global Communications worked closely together on formulating interworking processes for order handling, cost accreditation, and problem handling between disparate systems. When the volumes dictate, these interfaces will probably be automated or standardised. The telecommunications management network (TMN) standards are being contributed to and closely monitored for sufficient maturity for this purpose.

Conclusion

As the business grows, functional specialisation increases, and it becomes necessary for cross-functional owners to ensure that all systems and processes pull together. By focusing on key drivers and examining the revenue and cost chain, pragmatic decisions can be made on system choice and the degree of integration necessary.
The in-country/international revenue split drives the emphasis on whether to go for a 'network of networks' approach or a single-platform overlay (although for some products there will always be a mix of these approaches). Finally, the subjective people issues have far more impact than objective analysis and technology options in decision making.

Acknowledgements

The author is grateful for the contributions from the following: Rafael Conejos, Technical Director, BT Telecomunicaciones; Juan Jose Gilsanz, MIS Manager, BT Telecomunicaciones; and Malcolm Barnes, BT Global Networks.

Biography

Leo Brome
BT Networks and Systems

Leo Brome delivers outline management system solutions for BT's global joint ventures and alliances. These solutions include systems selection, processes and interoperability. His current role follows a broad career in BT Laboratories including telecommunications engineering, software engineering, project management, software marketing and consultancy. Leo is also a council member of the Institute of Management.

Journal Awards for 1994/95

Introduction

British Telecommunications Engineering is an important record by which the membership of the Institution of British Telecommunications Engineers (IBTE) and others can keep abreast of various items of interest in telecommunications.

To encourage readers in furthering the role of the *Journal*, and to give authors due recognition for outstanding contributions, the Board of Editors operates an annual award scheme. Prizes are awarded to the authors of articles which, in the opinion of the Board, demonstrate excellence in content and presentation and which enhance the quality and range of contributions published.

Each year, a prize is awarded for the best article published in the four issues of a complete volume, together with a number of prizes for runners-up. The Board also selects highly-commended articles. This year, for the first time, the *Journal* awards were extended to include the *Structured Information Programme*, the quarterly supplement to the *Journal* which has been steadily building into a valuable comprehensive reference on telecommunications.

At a special awards dinner held on HMS Belfast in London on 4 October 1995, IBTE President Dr. Alan Rudge presented the prizes for the Best Article and runners-up for Volume 13 (April 1994-January 1995) of the *Journal*, and the prizes for issues 12–15 of the *Structured Information Programme*.

Top Award for 'Phone-ins'

The prize for the best article from Volume 13 went to a team of three authors—Colin Tuerena, Peter Mabey and Neil Barnes for their article 'Phone-ins: Their Impact and Management' published in the January 1995 edition. They each received a crystal bowl inscribed with the IBTE's insignia, a cheque and a certificate.

At one time or other, many of us have been urged to telephone this programme or that, but perhaps not giving a second thought to the effect this has on the telephone network. The numbers of calls stimulated by phone-ins can be enormous and various measures have to be put in place to prevent severe disruption to the network. In this highly readable article, the authors describe the development of phone-ins in recent times and the techniques used to manage them. The article also looks at phone-ins as products, describing some of the events that will be familiar with many of us, and looks to some possible future developments.

Journal Best Article award winners with Alan Rudge. Left to right: Neil Barnes, Peter Mabey, Alan Rudge and Colin Tuerena

Journal Runners-Up

The Board of Editors awarded two runner-up prizes. Each author received a crystal goblet, a cheque and a certificate.

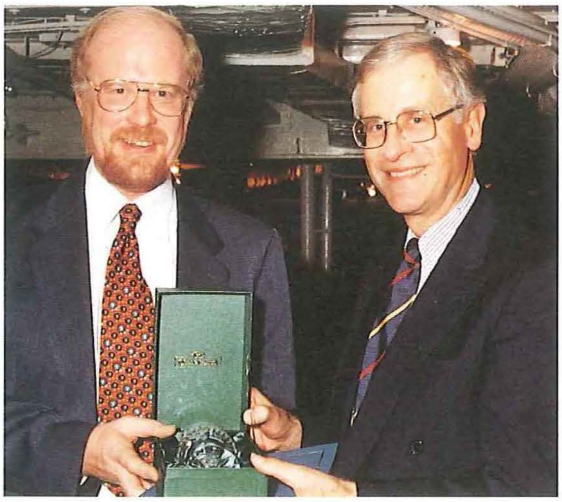
Speech Recognition for Speech Services

The first runner-up prize went to Denis Johnston (pictured overleaf) for his article 'Speech Recognition for Speech Services' published in the July 1994 edition.

The benefits of machines able to recognise and understand speech are enormous. While speech and language processing are not at the stage where we can have a casual conversation with a computer, there has been an increase in systems which use simple speech recognition, and in particular in telecommunications. In his article, Denis provides a background to the technology of speech recognition, looking in particular at how it is used in telephony applications and where it may appear in the future.

A New Structure for London's Public Switched Telephone Network

Simon Wood and Roger Winterton (pictured overleaf) were awarded the second runner-up prize for their article 'A New Structure for London's Public Switched Telephone Network' published in the October 1994 edition.



Denis Johnston receives his Journal runner-up award

Runners-up Simon Wood (left) and Roger Winterton (right)

Optimising the structure of the public switched telephone network to provide the required performance and functionality at lowest practical cost has long been a key goal. In their article, the authors describe a new, radically simplified structure for the London network, which promises significant savings in operating costs and paves the way for the future. It describes the difficulties with the existing structure and explains the improvements the new structure will bring about. In addition, it considers the interconnection implications of such change for the ever-increasing number of other licensed operators.

Highly Commended

The Board of Editors nominated seven articles as highly commended. Each author was sent a certificate. The highly-commended articles were:

- 'Electronic Trading: BT's Commitment to Changing the Way We All Do Business' by David J. Brunnen and Eric Wyllie (April 1994);
- 'Telecommunications Quality of Service: Principles and Management' by Tony Mullee and Antony Oodan (April 1994);
- 'Human Factors in Telecommunications Engineering' by Martin Cooper (July 1994);
- 'A Natural Solution to the Travelling Salesman Problem' by Shara Amin, José-Luis Fernández-Villacañas Martín and Peter Cochrane (July 1994);
- 'Building on the Architectural Framework' by Hill Stewart (October 1995);
- 'The "Value" of the Telecommunications Engineer in Eastern and Western Europe' by David Corrie (October 1995); and
- '200 Futures for 2020' by Ian Pearson and Peter Cochrane (January 1995).

Prize for 'Benchmarking'

The articles in the *Structured Information Programme* are more familiarly known as *units*; the Board of Editors selected two units for the 1994/95 awards.

The prize for the Best Unit went to Paul Cherrett for his unit 'Benchmarking...Here to Stay'. He received a crystal bowl inscribed with the IBTE's ensignia, a cheque and a certificate.

Competition demands that companies continue to reduce costs and enhance their performance if they are to grow or even maintain market share. Traditional year-on-year incremental improvements are unlikely to deliver against accelerating customer expectation. In the drive for 'best practice', benchmarking can be a formidable tool. In his unit, Paul gives a step-by-step guide showing the practical elements necessary for a successful benchmarking programme. It includes a few gems of wisdom from other companies convinced of the benchmarking process.

SIP Runner-Up

The Board of Editors awarded one runner-up prize for the *Structured Information Programme*. This went to Peter McKenzie for his unit on 'Project Management'. He received a crystal goblet, a cheque and a certificate.

Change has become an increasing part of everyday life. The management of change through projects in business is proving ever more necessary. Project management is a skill that all managers need to add to their more traditional skills. In his unit, Peter introduces the principles of project management and, in particular, shows how its application within BT has enabled better control of projects and has led to the successful achievement of business objectives.

Structured Information Programme award winners. Left: Paul Cherrett, Best Unit award; right: Peter McKenzie (runner-up)

Call for Enforcement of EU Telecommunications Liberation Rules

On 14 September, Sir Iain Vallance, Chairman of BT, spelt out his vision for the creation of a free and open global telecommunications market, which, he said, was essential for the development of world trade.

Speaking to the American-European Community Association in Brussels, Sir Iain said that the long awaited US Telecommunications Bill was likely to introduce sweeping deregulation designed to promote greater competition. In Europe, the situation might be better described as 'poised' ready for takeoff.

He said that a critical issue for Europe was the need for adequate enforcement and implementation of European Union telecommunications liberalisation and competition decisions.

While he welcomed the three proposed EU directives relating to the liberalisation of cable TV and mobile markets by 1996, and to voice telephony services and infrastructure by 1998, he said: 'Liberalisation and competition decisions are worthless without adequate enforcement and implementation. The history of the much less radical telecommunications legislation of 1990 gives little ground for confidence, since five years later it remains poorly and patchily implemented.'

Sir Iain said that the 1996 Inter-Governmental Conference (IGC) has a key role to play in consolidating the single market. It must debate the mechanisms for achieving adequate enforcement and needs to consider whether a pan-European regulatory body could accelerate the harmonisation of natural regulatory systems across Europe.

'In these debates, we must guard against those who appear to be seeking to use the IGC to turn the clock back and bolster monopoly rather than competition in utility sectors.'

Of the proposed France Telecom and Deutsche Telekom Alliance, Sir Iain said: 'I strongly believe that approval of this alliance, without rigorous conditions, could well render the potential benefits of liberalisation for Europe null and void, since the partners have substantially closed and ineffectively regulated home markets. The right conditions, on the other hand, would help open markets faster. But national change must be real and practical, not abstract and legal.'

New BT Discount Scheme for Businesses

BT has announced a new discount scheme for business customers that cuts the cost of many calls by another five per cent, enabling companies to make savings of up to 26 per cent on call charges.

The scheme, called *BT Business Connections* and launched on 1 October 1995, gives a five per cent discount on direct-dialled calls made to 10 other numbers. It can be added to the discounts of up to 21 per cent available on BT's Business Choices Levels 1–5 schemes, to provide a maximum possible 26 per cent saving on the qualifying calls.

A BT spokesman said: 'Business Connections will provide valuable savings for most companies, whatever line of business they are in. Up to 30 per cent of a company's phone bill can be spent making frequent calls to the same 10 numbers.'

There is a single joining fee of £10, excluding VAT, for each site covered, and customers nominate which 10 numbers they wish to be included for Business Connections discounts. Two of these numbers can be international numbers.

Discounts also apply to calls made from a BT Chargecard, but do not apply to operator-connected calls, calls to information and entertainment services on numbers such as 0891 and 0894, mobile telephones or calls that are billed to credit cards.

BT also revised the terms of its Business Choices, PremierLine and Option 15 schemes from 1 October 1995. Discounts on calls made to information and entertainment services, and to mobile phones, will be at a universal rate of five per cent for all the schemes. This recognises that BT retains only part of the revenue from these calls and passes a substantial portion on to the other companies which provide these services.

BT's Family and Friends scheme, which gives residential customers five per cent savings on calls to five nominated numbers, and its Business Choices 2000 Series for large corporate customers, were improved on the same date.

For the first time, Friends and Family customers can include a mobile telephone as one of their five nominated numbers. This enables customers to enjoy a total discount of 15 per cent on calls to that number if they are on BT's Option 15 scheme, and 20 per cent if they are on BT's PremierLine.

All Business Choices 2000 Series discounts are being increased by one per cent, to give a maximum discount of 21 per cent on regional, national and international calls on the highest level of the scheme.

Express Delivery-Packet Routeing at the Speed of Light

Researchers at BT Laboratories have demonstrated a world-first in an optical packet router that sorts information by its destination address at the speed of light. The router is a key building block of a futuristic 100 gigabits per second (10^{10} bits per second) optical datapacket network, which could lead the lead the way to a new form of communications network—with the ultra-high capacity and flexibility necessary to meet the demands of future growth in computing power and multimedia.

Each packet is a burst of optical pulses encoded with a destination address and data payload. The optical packet router reads the address of each incoming packet and switches the packet onto the output path that takes it towards its destination.

In describing the invention, Dave Cotter of BT Laboratories said: 'What is unique about this demonstration is that the router reads the packet address optically rather than electronically. This greatly simplifies the design of the router and allows us to use a packet bit rate of 100 gigabits per second in the demonstration. This is 100 times faster than in any existing packet network.'

The ability to read the address optically also allows the packets to pass through the router at the speed of light, rather than being delayed by electronic processing bottlenecks. This means that a network based on these routers would have very low end-to-end delay. A packet could be sent across the globe in less time than it would take to pass through a single present-day electronic router.

As well as the feature of low end-to-end delay, a network of optical packet routers would allow data sources to send packets when they require without having to set up an end-to-end circuit across the network. This connectionless approach is the most flexible way of networking and is highly suited to computer-to-computer communications.

More Service Options for BT*net*

BT is responding to the commercial world's growing confidence in the Internet as a new way to do business by adding more options to its connection service.

Launched last year to give both large and small business customers access to the Internet, BT*net* includes higher access speeds, a number of enhanced facilities, and a migration tariff. The introduction of these new services should eliminate some of the barriers preventing companies realising the many benefits of the Internet which can be used for e-mail, on-line ordering and market research, and as a promotional tool.

According to Adrian Edwards, BT*net* product marketing manager, companies who find the Internet paralysingly slow will welcome BT's increase in the range of access speeds of up to 2 Mbit/s, a level of bandwidth necessary for companies looking to run multimedia applications over the Internet and wanting to take full advantage of some of the more interactive pages stored on the World Wide Web.

While the US maintains an annual growth rate of 115 per cent with 70 per cent new subscriptions from companies, the UK and Europe are somewhat more hesitant, representing around 6 per cent and 30 per cent of the total Internet user base respectively.

BT and LACOTS Revolutionise Local Government

BT and the Local Authorities Coordinating Body on Food and Trading Standards (LACOTS) have successfully completed a pilot project in the use of electronic data interchange (EDI) in the government sector. The new initiative has radically changed the transfer of administrative and statistical information between local and central government departments and can be regarded as one of the most innovative uses of EDI to emerge this decade.

Following the successful outcome of recent trials, the complete EDI package, to be known as ***perform***, including BT EDI*Net access and EDI software developed by Kewill-Xetal Systems Ltd., is now being made available to all local authorities in the United Kingdom—establishing itself as the biggest single takeup of EDI in the government sector.

Dave Phillips, project consultant for LACOTS. Commented that unless management reports are automated, administration would become a huge cost burden and a significant resource factor. Administrative costs have been reduced by about 76 per cent when ***perform*** has been used. Using EDI as a means of transferring administrative and statistical information has also reduced the error rate from around 70 per cent in some cases to 0 per cent.

The trial has proved that EDI not only can be used nationwide in local authority and government departments, but also is a viable solution for organisations across the whole of western Europe. It has the potential to reduce large volumes of paperwork and form filling, and has demonstrated the ability to transfer large volumes of statistical information.

BT and LACOTS have recognised the benefit of developing EDI systems to cover all the routine statistical reports that flow from local to central government departments.

The project marks a significant departure from the traditional use of EDI for procurement and is an excellent example of how electronic commerce can be used to benefit an entire organisation. The EDI Business Team, which includes BT and Kewill-Xetal Systems Ltd., provided a flexible and tailored solution which was essential to the success of the pilot scheme.

EDI services will be rolled-out to around 600 local authorities over the next three years. This may also be extended to Europe as local authorities liaise regularly with their European counterparts.

Remote Surveillance Catches a Million Pounds

Remote Video Applications has earned more then one million pounds for BT thanks to recent account wins.

Doncaster Council, Newcastle City Council and Breckland Council have signed up BT to supply the transmission links for their new closed-circuit television (CCTV) scheme covering nearly 500 square miles—an area as large as the counties of Berkshire and Bedfordshire combined.

All the schemes will be using the RS1000 Remote Surveillance Cable Service, which connects the cameras with the control room by analogue cables. These offer one of the most cost-effective methods of transmitting real-time pictures.

Alan Smith, BT's Remote Video Applications marketing manager said that the new contracts were a great boost for BT and underlined the quality transmission service that BT could provide. The Breckland Council contract will be the largest

CCTV system, geographically, in the country.

BT Helps 1·6 Million Victims of Malicious Calls

BT has revealed that over 1·6 million customers have asked for help in the battle against malicious calls since the company launched a national network of specialist bureaux, three years ago.

The number of cases reported to BT reached a peak during 1994, with some 60 000 new requests for help each month. However, since the introduction of Caller Display and Call Return services in November 1994, this figure has dropped by 20 per cent with a corresponding reduction in the number of malicious and hoax calls made to emergency services.

About 10 per cent of cases lead to police involvement. In the past, more than one million individual calls made to some 65 000 customers were traced successfully at the request of the police.

Making malicious calls is a criminal offence under Section 43 of the Telecommunications Act (1984); the maximum fine was raised earlier this year to £5000 and a custodial sentence of up to six months was introduced for the first time.

In the past, there have also been a number of cases in which the offender has been charged with causing either grievous or actually bodily harm on psychological grounds; both these offences can be tried in the Crown Court and carry a penalty of up to five years imprisonment.

BT Lift the Lid on the Secrets of Cyberspace at Live '95

BT's 20-strong team of specially recruited cyber-surfers served up simple suggestions for navigating the 'net' at the BT Internet Cafe, which was part of this year's Live '95 exhibition at Earls Court.

Forty terminals, all with free access and expert tuition, made this the largest single opportunity yet for people in the UK to cruise the contents of the information superhighway.

The Internet Cafe also featured easy-to-follow interactive tutorials and some new products from BT which were on show for the first time and will be launched at the end of the year. Visitors were also able to try out electronic shopping, check out the Live '95 information pages or simply sail around the World Wide Web at their leisure.

They also had access to Campus-World, BT's new on-line home information service for school students, which is an ideal reference tool for helping out with homework and group projects.

Also on the main BT stand was 'Talk Live'—a series of exciting, nonstop shows, games, celebrity competitions, big prizes and give-aways galore. A series of fun presentations featured some of BT's latest products, including Call Minder (the invisible answering machine and Caller Display (the system that identifies incoming calls).

'This is Your Electronic PA Speaking ....'

Calling the office to have a short, accurate summary of the lengthy report read over the telephone to you, instantly and automatically, will soon be possible thanks to a new development from BT Laboratories.

BT has successfully combined its automatic text summariser and the Laureate text-to-voice software. The summariser scans text stored on a computer and is able to produce an accurate précis of a document to any length desired by the operator. Tests have shown that a one-twentieth abridgement will still retain three-quarters of the important information. Laureate, the computer-generated human voice system developed by BT Laboratories, translates text on a computer screen into recognisably human speech. Together, they open up exciting possibilities for human-to-computer interaction using ordinary telephones.

This means that it will be possible to call a computer by telephone and it will 'talk back' with the required information. One possible application is to access e-mail and getting an executive summary of the messages.

Once connected to the database the user will respond to prompts, asking how short or long a summary is wanted, by using the telephone keypad to instruct the remote computer. The text can be shortened by any amount down to 2 per cent of the original length. Turning this information into speech which can be received on an ordinary telephone is where Laureate comes in. The system uses the various elements of human speech, taken from a recording, and synthesises these to recreate the words in text to audible speech. It has been 'taught' to recognise many intricacies of the language including abbreviations; for example, according to context, 'St.' comes out correctly as 'street' or 'saint'. Laureate is a real voice recorded, dissected, analysed and reconstructed.

BT and NIS Provide Global Connection

BT and Network Information Services (NIS) have announced a deal that will extend Internet access to Japan.

NIS is the first on-line service provider to utilise BT's global network to set up its own Internet access service. NIS Internet Network (NISnet) will be used primarily by business customers and individual users, and offers both direct and dial-up access. NIS offers community services (access to mailing lists and newgroups) and consulting services. The service is provided from Tokyo to London.

The customary group of Internet applications is being offered by NIS, including e-mail, a World Wide Web server resource service, telnet and ftp.

BT is also providing a connection between NISnet and EuropaNet, Europe's largest academic and research network. BT has also used its partnership with MCI to create a transpacific backup transit route between the US, Japan and Europe using BT*net* over the CONCERT Frame Relay service.

AT&T to Separate into Three Companies

On 20 September 1995, AT&T Chairman, Robert E. Allen, announced plans for a strategic restructuring that will separate AT&T into three publicly traded, global companies.

Allen said the company was taking this bold step to capitalise on the opportunities in each business' segment of the global information industry—communications services, communications equipment, and transaction-intensive computing.

Under the plan, AT&T shareholders would hold shares in each company. A fourth business—AT&T Capital Corporation—would be sold. AT&T hopes to complete all transactions by the end of 1996.

'Changes in customer needs, technology and public policy are radically transforming our industry,' said Allen. 'We now see this restructuring as the next logical turn in AT&T's journey since divestiture. It will make AT&T's businesses more valuable to our shareholders, even more responsive to their customers, and better able to focus on the growth opportunities in their individual markets. Under the plan, one of the new companies would focus on providing the world's best "anytime, anywhere" communications and information services.'

Operating under the AT&T brand name, the services company would consist of AT&T's current Communications Services Group, the AT&T Universal Card Services Corporation, the newly established AT&T Solutions consulting and systems-integration organisation, and AT&T Wireless Services (formerly McCaw Cellular Communications).

The company also plans to create an AT&T Laboratories unit around the core of Bell Laboratories people dedicated to research and development in communications services. In 1994, AT&T Global Information Solutions would be launched as an independent company by spinning it off to AT&T shareholders, following an aggressive turnaround effort.

In addition, AT&T plans to sell its remaining interest in AT&T Capital Corporation to the general public or to another company. AT&T holds in excess of 80 per cent of Capital Corporation shares, having sold a minority interest to the general public in 1993. Capital Corporation is already one of the largest leasing and financing companies in the United States. In 1994, it had revenues of approximately $1·4 billion. Proceeds from the sale, and from the initial public offering of the new equipment business, will be used to retire current AT&T debt, giving each of the new businesses balance sheets appropriate to its industry.

AT&T said that each of the businesses it is establishing will have everything it needs to meet customers' needs. Each already has seasoned management and a productive workforce and each has significant global operations. The service, equipment and computer businesses each has the sophisticated system-integration capabilities necessary to provide complete solutions to its set of customers.

OFTEL Rules on Telephone Equipment Pricing

Don Cruickshank, Director General of Telecommunications, has directed BT to cease unfair subsidies of its telephone equipment supply business.

Don Cruickshank said: 'OFTEL has been investigating complaints from a number of BT's competitors about the supply of telephones, answering machines and fax machines in the domestic and small business market. I have concluded that BT's supply of such equipment in the wholesale market and from BT shops and other retail channels is unfairly subsidised, and this is harming or likely to harm BT's competitors. I have therefore made a direction requiring BT:

- to eliminate the subsidies so that the relevant BT businesses make an adequate return in the last quarter of the calendar year 1995 and subsequent quarters; and

- to provide financial and other information to allow me to judge whether the relevant BT businesses are subsidised in the future.

'The complaints received by OFTEL also raised various other issues, including an allegation that BT unfairly refused to stock its competitors' products in its shops and a complaint about BT's use of its telephone call bills to advertise BT branded telephone equipment.

'BT now proposes to introduce a wider range of equipment in its shops. I have decided to take no action in relation to these aspects of the complaint for the time being'.

New Director of Services Competition and International Affairs at OFTEL

Don Cruickshank, Director General of Telecommunications, announced that he has appointed Caroline Varley to be Director of Services and Competition and International Affairs at OFTEL. This is a new post within OFTEL and Ms. Varley took up her duties on 25 September 1995.

Caroline has joined OFTEL from the DTI where she has been responsible for negotiating UK interests across a range of issues, including IT research, financial services regulation and telecommunications policy. She played a leading role in negotiating European legisation on network and terminal equipment liberalisation.

Don Cruickshank Speaks Out on Telecommunications Regulation

Don Cruickshank said, on 11 September 1995, that halfway through his five year term as Director General of Telecommunications was an appropriate point to stand back from detailed issues and take stock of the debate about regulation and regulators.

Speaking at the Financial Times Telecommunications Conference held at the Landmark London Hotel he said: 'I suggest that there are three questions of substance which must be tackled for regulation of recently privatised monopolies: what are the objectives to be met, does the regulator have the appropriate tools, and does the regulator have sufficient independence from the Government of the day? Answer these three questions and the framework is set for dealing with secondary issues such as the appropriate degree of discretion for the regulator, checks and balances, etc.

'Two things are certain in an industry such as telecommunications —there needs to be someone with the duty of promoting effective competition, and the public interest must be protected on a full-time basis. There has to be a consumers' champion.

'The UK framework raises arguments over the discretion of the regulator. I have found it very important for discretionary powers to be both flexible and widely drawn. The only alternative to this is, in effect, to leave this discretion in the hands of the regulated company. Over the last 11 years, this has become the standard pattern—increasing scope for the dominant company to fetter the regulator's exercise of discretion. This is particularly striking in the post duopoly licence conditions. The effect is to defer the impact of effective competition by limiting and slowing the regulator's discretion to act. And yet it is me that stands accused of intrusive and detailed regulation.

'My proposal to introduce into telecommunications licences, a general condition on the maintenance of effective competition aims to achieve the right balance of discretion. This is, I believe, the single most useful change I can do to achieve effective competition, which everyone—Government, BT and BT's competitors—all say they want.

'The response from BT, so far, has been to say that the regulator cannot be prosecutor, judge and jury and ask for an appeals procedure. But there are already avenues for appeal through the MMC and by review by the courts. Beyond that, the insertion of a further body could only lead to delay and confusion. In a world where there are no sanctions for breach of licence condition: in which there are already ample opportunities for the dominant operator to indulge in delaying tactics and where delay only serves the dominant operator at the expense of customers and competitors, such a move would be a retrograde step. I am, in reality, more in the position of a probation officer saying "don't do that again or there may be trouble"—hardly a role that in practice needs a separate prosecutor, judge and jury, as BT argues.'

Turning to the question of accountability, the Director General said: 'Accountability is a word which means many things to many people. It is often coined by those who wish to see the independence of the regulator diminished or who would wish to instruct the regulator on how he or she should act. That's what they mean by accountability. What I mean by accountability is how I, as the independent regulator, can properly and openly demonstrate that I have acted out Parliament's will.'

After discussing how accountability is achieved, and how it might be improved, including the setting up of commissions and proposals for more open processes, the Director General summed up by saying: 'We have watered down the powers of the regulator too much already. I am determined to right the balance and make the pleas that we must not let the current debate take us in the wrong direction—anti-competition and harmful to consumers. We would cherish the independence of our regulators and not allow them to become the agents of government. The present system of accountability is relatively strong—not weak. But let us consider strengthening it further by more openness and by possibly replacing individual regulators with voting commissions.'

TAT-12 Enters Service

A consortium of more than 50 telecommunications operators from 38 countries has announced that the TAT-12 submarine cable link is now in service. TAT-12 consists of the first three segments of the TAT-12/TAT-13 network and links landing points at Shirley, Long Island, New York (US), Green Hill, Rhode Island (US), Land's End (UK) and Penmarc'h (France).

Stretching a total of 6500 km, TAT-12 contains two fibre-optic pairs, one for service and one reserved for self recovery. The system uses optical amplifiers to reamplify the optical signal all along the cable. This optical amplification gives the link significantly greater capacity than the previous generation of undersea lightware systems. This means that TAT-12 can transmit some 300 000 simultaneous two-way telephone conversations, or any other combination of voice, video and data transmissions.

In October 1996, another transatlantic cable, TAT-13, will enter service between Shirley, Long Island, New York (US), and Penmarc'h (France), completing the loop begun with TAT-12. The TAT-12/TAT-13 system will constitute a 13 000 km telecommunications network featuring 'self-healing' for internal system recovery in the event of a fault, without any loss of voice traffic. The total cost of the TAT-12/TAT-13 system will reach $700 million.

Atlas and Phoenix Ventures Agreement

At a pivotal meeting in Brussels, the European Union (EU) Competition Commissioner, Karel Van Miert; Deutsche Telekom's Chairman, Ron Sommer; and France Telecom's Chairman, Michel Bon, achieved agreement on the conditions for the approval of the Atlas and Phoenix joint ventures. The meeting included French Telecommunications Minister, F. Fillion, and Mr. Scheurle representing the German Telecommunications Minister, who affirmed their governments' commitments to get parliamentary approval to liberalise alternative networks in Germany and France no later than 1 July 1996.

This breakthrough will allow the parties to obtain EU clearance for their Atlas venture and their Global

Phoenix venture with the Sprint Corporation.

Phoenix still requires the approval of the US Federal Communications Commission, which is expected to consider the matter in December of this year. The parties have already agreed on a proposed consent decree with the US Department of Justice for antitrust approval in the US. The parties intend to commence providing seamless telecommunications to customers worldwide by 1 January 1996.

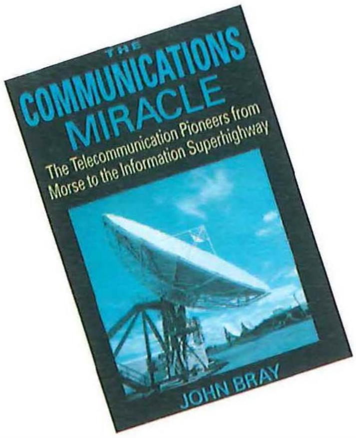
Michel Bon said, 'The customers and Europe are the real winners today. Our global joint venture with Deutsche Telekom and Sprint will, by the beginning of 1996, deliver an offer which, I am convinced, will play an outstanding role in the development of the truly pan-European and global services demanded by the market.'

Ron Summer said, 'We have achieved a fair agreement for all sides. Atlas, joined with Sprint in our global partnership Phoenix, will be able to begin business as planned, entering the market as a pan-European and global competitor. At the same time, we have accepted undertakings which address the Commission's concerns under EU law.'

In addition to the planned liberalisation of alternative networks by 1 July 1996, agreement in principle was reached on the following key points:

- The parties will be allowed to merge their domestic public-switched data services, Datex-P and Transpac in France, into the Atlas venture on 1 January 1998.
- Both France Telecom and Deutsche Telekom will ensure nondiscriminatory access to their domestic public data networks and separate accounting of Atlas and Phoenix joint ventures.
- Info AG, a German-based data services subsidiary of France Telecom, will be divested.

The Communications Miracle: The Telecommunication Pioneers from Morse to the Information Superhighway
by John Bray



The global telecommunications network is arguably the most complex technical creation of mankind. It is the product of discoveries and inventions that have occurred mostly since the middle of the last century. The impact on modern day society is immense and with continuing advances in information technology (IT) they promise to transform the very nature of our society. It is interesting that, while today's networks and systems are the product of huge development teams, each stage of advance can be traced to the seminal ideas and work of a few key individuals. In the early years, the impact of Faraday, Maxwell and Hertz are well appreciated but also, more recently, key individuals have been responsible for pivotal advances in telecommunications. John Bray has chosen the almost impossible task of chronicling the history of communications from its early days to its present state by reference to the activities of these key individuals. In dealing with history in this manner he has managed to produce not only an essentially human story of the development of modern communications but also a most interesting and readable account.

Dr. Bray is, of course, eminently qualified to chronicle the developments in telecommunications. He has been associated with the field from 1935 when he joined the (then) Post Office as an Assistant Engineer. In much of his career he was not only associated with radio and satellite developments, but also a key player whose personal contributions helped advance these areas of telecommunications. He was, at one time, the holder of a Harkness Foundation Fellowship at the Bell Telephone Laboratories and, from 1966 to 1975, was Director of Research at what is now BT Laboratories at Martlesham Heath. John is particularly well qualified to take on the monumental task of writing a history of communications.

The book starts with a review of the early creators of the mathematical and scientific foundations and proceeds to the early advances in telegraph cables, telephone engineering and thermionic electronics. Aspects of development in areas such as radio, TV, and transatlantic cable systems are then dealt with. The developments which have arisen from advances in microelectronics are then covered with chapters on pulse code modulation (PCM), stored program control (SPC) switching, waveguides and visual communications. The book concludes its technical coverage with chapters on IT, mobile radio and future developments.

The book, which is essentially a human-related story, appropriately ends with a final chapter entitled 'A Part of Which I Was' which proves to be an interesting recollection of John Bray's own experiences over his long and eventful career in telecommunications.

Although prominence is given to British innovations and inventions there is good coverage of the essential developments elsewhere, notably the United States, Germany, France, Austria and, more recently, Japan. Its British flavour is, however, its strength, and its reference to the important role played by BT Laboratories (and its antecedents) in the key developments of communications is a fitting and worthy acknowledgement to these contributions over the years.

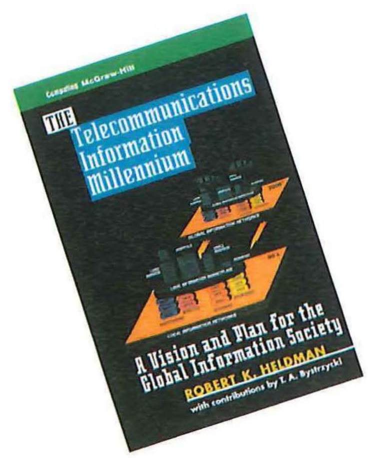
The book is recommended to those interested in the history of telecommunications but especially to those with a special interest in BT's contribution to that history.

Published by
Plenum Publishing Company Limited
£23·00, 350 pp.
ISBN 0-306-45042-9

Reviewed by Gerry White

The Telecommunications Millenium: A Vision and Plan for the Global Information Society

by Robert K. Heldman



This is an ambitious and very pertinent book, which anyone who is interested in the technology development of the global information society should read. It is also perhaps fortuitous that this book should become available as the IBTE *Journal* launches its new theme on the 'Information Industry and its Key Technologies'. The perspective, not surprisingly, is very American orientated and the book is of a semi-technical nature. But this should not deter people with either technical or commercial backgrounds from finding many useful ideas in it. I suspect over the next few months we will be seeing many more books appearing on a similar theme.

Much has been written about the information revolution and the development of the information society. What Heldman has attempted is to explore this vision in a very pragmatic way. He asks some fundamental questions concerning the technology evolution of today's telecommunication networks to the new information networks of tomorrow. Unlike many writers, he does not get caught up in the hype of cyberspace, virtual reality and such like. This does not mean he does not share these visions but rather his focus is on how can we start to make them happen.

The book is generally well thought out, although in places I feel Heldman stumbles at the large task he has set himself. The book is structured into three parts. The first provides an 'outlook for the future'. After revisiting the future information society vision, Heldman reviews the infrastructure development options for narrowband, wideband, broadband and wireless services. He examines the users' needs of each type of service, how they are provided today and what the options are for tomorrow.

A strong theme, not surprisingly, running throughout is the integration of voice, data and image into a sensible architecture for future networks. Heldman's pragmatic approach is also reflected in his strong focus on the use of today's technologies such as ISDN to offer early access to the new information environment and its applications. He argues that this new environment, which he calls the *information market-place*, will offer many new exciting market opportunities to both network providers and service providers. But he also warns that new highly stringent performance criteria will have to be met by the networks, in particular on reliability and security. With new technologies such as ATM we have to expect that there will be very different types of public network environments than those that exist today.

The second part of the book is about 'planning for the future'. Here Heldman explores the issues of complexity, uncertainty, cost, long-term revenues and risks that are involved with the change to a new network paradigm. He identifies 12 challenges that network operators face. These include the establishment of ISDN access interfaces to numerous information providers, a ubiquitous public data network and support for the development of value-added applications. These challenges are then developed into 10 specific strategies for network operators to adopt. These include strategies on information pricing, access, regulation and service management. Finally, Heldman recommends a 10-layer model of the network and its services to support the global information society.

It is in the third part of the book that Heldman's patriotic Americanism comes forth. He proposes, for the US telecommunications industry, a 'plan of action' that would correctly position the USA to take a leadership role in the development of the global information infrastructure. He asks how, without such a plan of action, can we play the information game and provide customers with the new services and applications? His plan of action includes the US taking appropriate regularity, market and management perspective on the new technology. In his conclusions, Heldman develops marketing and technology strategies to drive the new services and features to the customer.

The third part of the book is the weakest, but this is overcome by some good appendices covering a range of issues concerned with global information telecommunications. As mentioned earlier, Heldman has taken a pragmatic approach which will appeal to many readers. There are some very glaring gaps, most notably the lack of any real thought on the information industry roles and structures. Heldman has assumed that the cosy world of today's telecommunications companies will continue. I think he will be in for a shock.

So, overall it is an excellent book, with lots of thought-provoking ideas and good reference material, but there is room for many more ideas and material to be put into print.

Published by
McGraw-Hill Book Company Europe
£21·95. xxviii + 250 pp.
ISBN 0-07-028106-8

Reviewed by David Greenop

BRITISH TELECOMMUNICATIONS ENGINEERING ISSN 0262-401X

Published in April, July, October and January by *British Telecommunications Engineering Journal*, 2–12 Gresham Street, London, EC2V 7AG. (Formerly *The Post Office Electrical Engineers' Journal* Vols. 1–74: April 1908–January 1982.)

British Telecommunications Engineering is printed in Great Britain by Headley Brothers Ltd., and the *Structured Information Programme* is printed in Great Britain by Staples Printers.

Subscriptions and Back Numbers
Price: Single copy—companies, universities, libraries and other bodies £9·25 (£10 including postage UK, £11·25 including postage overseas); private individuals (paid by personal cheque) £5·00 (£5·75 including postage UK, £7·00 including postage overseas). Annual subscriptions (including postage)—companies etc. £40·00 UK, £45·00 overseas; private individuals (paid by personal cheque) £23·00 UK, £28·00 overseas.

Overseas customers can pay by sterling drafts drawn on London banks or by sterling Eurocheques.

Price to BT staff: £2·25 per copy.

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Communications
All communications should be addressed to the Editorial Office, *British Telecommunications Engineering Journal*, PP: G012, 2–12 Gresham Street, London EC2V 7AG. (Telephone: +44171 356 8050. Fax: +44 171 356 7942.)

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FEDERATION OF TELECOMMUNICATIONS ENGINEERS
OF THE EUROPEAN COMMUNITY (FITCE)

35th European Telecommunications Congress

CALL FOR PAPERS

Multimedia is the new buzzword in telecommunications. Its roots are in computers, telecommunications and information providers. All three areas are now converging into a single market. Personal computers become TV sets and play audio compact disks; telephones include video cameras and modems; broadcasting is evolving to video on demand and becoming interactive. The digital coding of video signals is allowing bandwidth to be reduced and new applications to be created.

What is multimedia really, and where is it heading? Who needs multimedia, who makes it, who controls and influences it, and who is influenced by it? Is it really the growing market for the future? Which standards will succeed? What is the content that will determine the new services?

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FITCE is inviting papers on this topic, covering one or more of the following aspects:

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- multimedia standardisation (B-ISDN, MPEG, MHEG, ODA, etc.);
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If you are interested in submitting a presentation, please prepare an abstract, which should be in English, giving a clear indication of the theme and coverage of the proposed paper. The abstract, which should be prepared on the standard FITCE form, should be sent before **13 February 1996** to:

Paul Nichols, FITCE UK Papers Coordinator, Post Point G012, 2–12 Gresham Street, London EC2V 7AG (Telephone: (0171) 356 8022; Facsimile: (0171) 356 7942).

Copies of the FITCE standard form are available from the above address, and will be sent on request. Papers should be unpublished. The abstracts will be reviewed by the International Papers Selection Committee for relevance, technical content and originality. Authors will be informed by 15 April 1996 whether their proposed paper has been selected for presentation. The full text of the selected papers, in English, is required by 15 June 1996 and should allow for a 25 minute presentation, which should be supported by slides. Requirements for special presentation equipment should be indicated in the abstract.

FITCE

OLUME 14 PART 3 OCTOBER 1995

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