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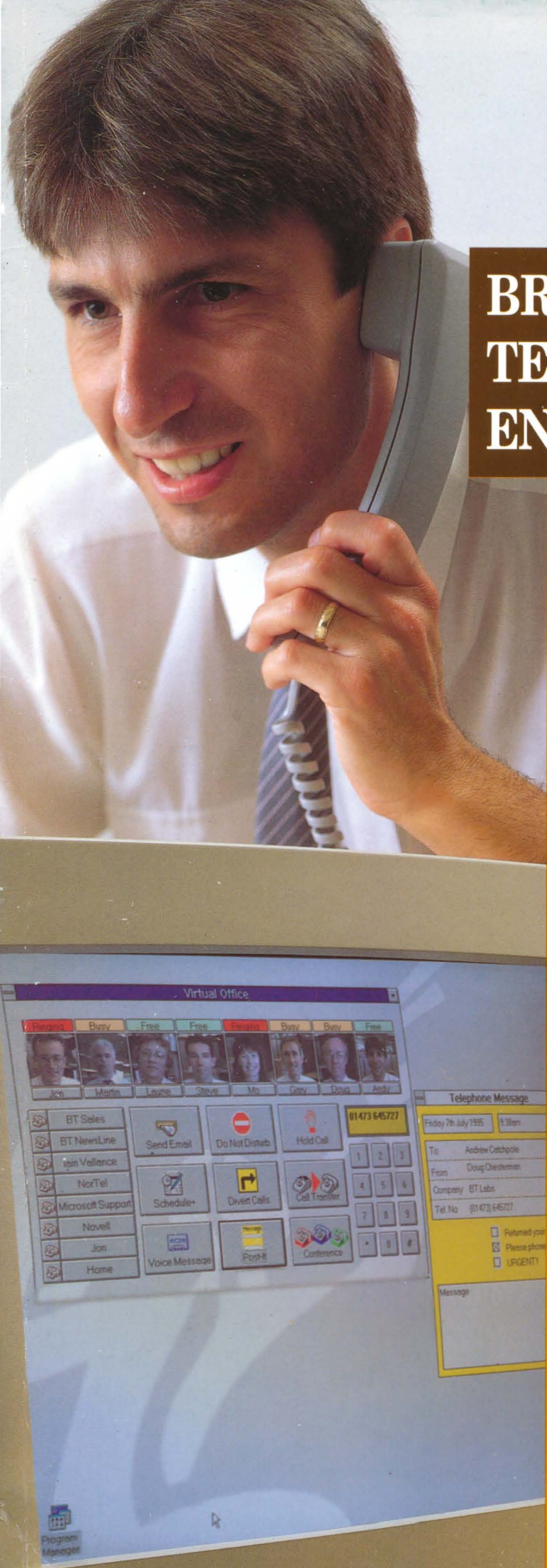

BRITISH TELECOMMUNICATIONS ENGINEERING

Included in this Issue

Computer Telephony Integration

NOMS2 and WORK MANAGER™

Cooling Network Equipment

The Journal of The Institution of British Telecommunications Engineers

BRITISH TELECOMMUNICATIONS ENGINEERING

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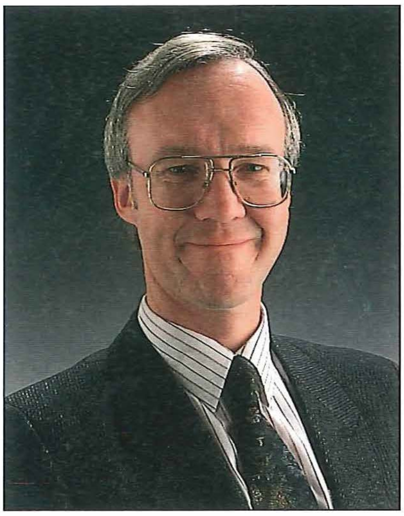
Doug Chesterman

A Revolution on the Desktop



Computer telephony integration (CTI) is the convergence of computing and communications applications. Developed originally for telemarketing services, CTI is rapidly making an impact on the user's desktop.

Since the early experiments with stored program control (SPC) on telephony switches more than two decades ago, computers have played an increasingly significant part in the delivery of new systems and facilities. Today, all but the most humble telephone has the ubiquitous microcontroller at its heart, and yet despite this massive increase in intelligence and capabilities, there has been little change in the usage of the telephone. Few can remember the access codes for more than a small percentage of the available facilities, and few have the need to do so.

Computer telephony integration (CTI) is a technology which is set to change this. It is much more than the embedding of call control software in telecommunications systems as described above. It is the convergence of computing and communications applications particularly on the user's desktop. It opens up a wide variety of new capabilities, examples of which include context-sensitive access to the telephone system's facilities through a Windows™ environment, point-and-click call set-up from screen-based directories, integrated mail, voice and fax messaging systems, systems which access electronic diaries to determine the current destination for incoming calls, teleworking, hot-desking and multimedia communications. In the fast-growing world of telemarketing, it allows calling line identity to be used to access customer records before the call is presented to an operator, the integration of voice response systems, and the simultaneous transfer of calls and their associated data between operators.

CTI is not new. At BT Laboratories at Martlesham Heath, the technology and its applications have been researched for more than a decade. As it moves into its maturity, large numbers of new players are appearing on the stage, alliances are being formed, and proprietary interfaces and international standards battle for supremacy. The inclusion of the Telephony Applications Programming Interface as a standard feature of Microsoft's Windows™ 95 must surely signify its movement to the mass market. However, its progression from the laboratory to the users' desktops is not fuelled solely by supplier and media hype. The increased efficiency and user satisfaction which have been experienced through its application in telemarketing operations are ensuring an increasing customer demand for the wide variety of user applications which CTI enables.

A very few years ago, few had heard of the CD ROM and those who had saw little relevance to their own requirements. Today, more than 70% of new PCs are shipped with a CD drive. If we are to believe the pundits, then it may not be long before a telephony handset hanging on the side of a computer monitor is as common a sight as the CD ROM is today. In anticipation of such a future, this issue of the *Journal* contains the first of a series of articles which will seek to explain CTI technology, its applications and its implications on users, suppliers and network operators.

Doug Chesterman
Network Intelligence Engineering Centre
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Andrew Catchpole, Gary Crook and Doug Chesterman

Introduction to Computer Telephony Integration

An office desk without a telephone or computer is a rarity nowadays. However, without computer telephony integration these two essential business tools cannot be linked together. Cooperation between the telecommunications and computer industries will see the emergence of new computer-supported telephony applications, not only for large call centres but for office workgroups. In the future, the distinction between the telephone and computer will disappear.

Introduction

This article is the first in a series which discusses the integration of the telephone and the computer. This technology has become known as *computer telephony integration* (CTI). In this first article, CTI is defined and briefly described—further information will be given in later articles.

What is CTI?

Computer telephony integration could be 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, it allows a method of passing command and status information between the voice and data processing environments. The telephony system could be a private branch exchange (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).

Integration of the computer and telephone essentially starts when, for example, a modem or fax card is connected to a computer. But these simple cases are not normally recognised as CTI. Instead, CTI is normally associated with the functional, rather than physical, integration of the two technologies. This is because each has different design requirements and user expectations; for example, telephone systems must have a high degree of reliability and availability—not many businesses would trust a desktop computer to be a PBX—well not yet anyway! Looking to the future, as asynchronous transfer mode (ATM) technology is developed, the traditional boundaries between the telephone and data networks and the associated paraphernalia will quickly dissolve.

Early Examples of CTI

In the late 1980s, BT was at the leading edge of developing products that integrated the computer and telephone into a single terminal. The Merlin Tonto[1] was the first customer terminal to combine desktop computing and telephony services. At the time, the concept of converging voice services, data services and computing was the cornerstone to BT's drive towards office automation. The QWERTYphone[2] was developed as a low-cost integrated voice and data terminal which could be used on the public switched telephone network (PSTN) or behind PBXs. The BT Mezza system[3] combined digital telephony, voice, text messaging and

It is interesting to note that computer systems may no longer be integrated into telephone systems but telephone systems are now being integrated into computers!

UNIX computing in a single highly-integrated product that was compatible with most PBXs. However, all these products were soon out-dated by faster computers, better office applications and new digital telephone systems. At the time, physical integration of the computer and telephone caused constraints on each that provided no real benefit. This is still true in the larger CTI installations as there is little perceived benefit, at present, for physical integration.

It is interesting to note that computer systems may no longer be integrated into telephone systems but telephone systems are now being integrated into computers! The computer industry is now progressively pushing towards physical integration of the telephone into the computer, particularly for small and desktop CTI systems.

Merging of Computing and Telephony

Technology

Since the 1970s, three technology advances have brought the telephone and computer closer together. Firstly, engineers started to look for ways of controlling telephone systems using stored-program control (SPC) to provide flexible call routing and enhanced customer features. In both public and private telephone exchanges, SPC was used to improve the reliability, performance and cost of telephone switching. Secondly, in the modern telephone network, the voice is converted to a digital signal so that switching and transmission can be done more efficiently; the digital network can thus easily carry voice and data in the same network. Thirdly, there was a need for telephone switching nodes to communicate with each other and so there has been a requirement to design fast and reliable inter-processor signalling and control systems between public telephone exchanges, as well as from public to private and from private to private telephone exchanges. However, these factors alone have not driven the CTI market.

Market drivers

High investment costs in CTI have restricted the take-up in proprietary CTI systems except in large call centres where there are potentially many benefits to be gained by a company and its customers. The following market drivers are responsible for the rapidly expanding CTI market.

1. New CTI suppliers

The merging of computing and telephony has also meant the distinction between the computer and telecommunications industries has blurred. Companies from the computer hardware and software worlds have now become key players in the telecommunications market.

2. Business awareness

A significant lack of CTI awareness is being reversed by software companies such as Microsoft who will be putting CTI capability in every computer running the soon-to-be-launched Windows™ 95 operating system.

3. Business expectations

The merging of the computer and telephone worlds has also been driven by new expectations and demands from the business community. In the increasingly competitive markets (where some traditional businesses have moved away from the high street to a telephone-based service (for example, financial services)), it has been imperative to increase efficiency by handling more telephone calls in shorter times with the same or fewer human resources.

4. Business solutions

Business applications no longer care about voice and data separation—computing and telecommunications contribute to a 'business solution'.

5. Large and small CTI solutions

CTI capabilities are now available for large call centre operations right down to desktop CTI systems.

6. Off-the-shelf CTI solutions

Low-cost CTI solutions can easily be achieved through standardisation and 'shrink wrapped' applications that open up new market opportunities aimed at both large and small companies considering CTI.

7. Standards

Cooperation between the computer and telecommunications industries has resulted in a new openness to CTI and the adoption of recognised standards.

CTI Players

PBX suppliers

Until now, PBX suppliers have largely differentiated their products through functionality and price. CTI now offers PBX suppliers a new opportunity to differentiate their products. Most of the larger PBXs have, for several years now, offered a limited CTI capability, but these have often been based on closed interfaces and have been relatively expensive. CTI applications from PBX suppliers are few and far between.

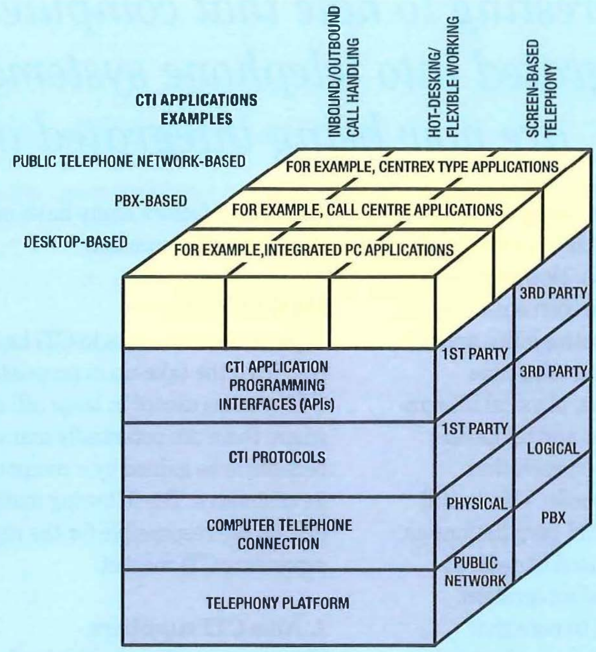
Computer suppliers

Some of the largest computer suppliers have been very active in the CTI call centre market. IBM, for example, is able to integrate all its existing computer platforms using its CallPath™ application programming interface. CallPath™ allows integration with most major PBX platforms such as Northern Telecom, Ericsson, AT&T, Siemens and Aspect. Other well-known computer suppliers in the CTI market include Hewlett-Packard and Tandem—but Digital, one of the original players, has sold off its CTI interests to the voice-processing giant Dialogic.

Telcos

CTI offers opportunities for generating more network revenue; for example, improved inbound call handling using calling line identity (CLI) and outbound call generators.

Figure 1—CTI cube model



Not only can CTI be offered on PBXs but also on public networks to exploit the extended capabilities of the public telephone network; for example, FeatureNet. In the future, network-based CTI could cooperate with or even replace traditional private telephone systems (PBXs). Telcos are well placed to take advantage of CTI technology particularly in North America where Centrex is more popular than in Europe, which has a small but growing customer base.

Independent software vendors (ISVs)

Independent software vendors, including many new and small companies, have much to gain from a rapidly growing CTI market. ISVs are generally very good at rapidly producing attractive, shrink-wrapped and cost-effective products in a fast-moving computer software market. To access a large customer base and to gain credibility, it is probable that an ISV will look to form strategic alliances with larger CTI players.

Alliances

Alliances between the CTI players will be critical to the success of CTI solutions. This is because the business application, rather than the underlying CTI technology, will be seen as core business need. ISVs will provide many of the shrink-wrapped CTI applications but will rely on alliances between themselves and the well known CTI players such as PBX and computer suppliers. Notable CTI alliances to date include Microsoft and Intel who have developed Windows Telephony Application Programming Interface (TAPI); Novell and AT&T who have released the Telephony Services Application Programming Interface (TSAPI); and the 'Versit' partners Apple, AT&T, Siemens and IBM. PBX suppliers will also benefit from alliances with ISVs who will be able to provide a diverse range of CTI applications that can be offered alongside their existing PBX product line. These can be used as a key marketing advantage. In fact, it is a major disadvantage if a PBX does not offer CTI applications or at least a CTI capability.

Interactive voice response (IVR) vendors

IVR systems are used mainly for home banking and voice mail systems as well as in auto-attendant systems which attempt to replace the need for PBX operators. The IVR industry is normally independent, but closely associated, to the CTI industry (telecommunications and computing) and in a lot of business solutions both CTI and IVR technologies will be employed. IVR vendors are therefore also seen as key players in the CTI market.

Company Organisation

Another possible reason for the slow up-take of CTI lies in the way in which companies are organised. Many have separate telecommunications and information technology (IT) departments. The telecommunications department will deliver a company telephone system and the IT department the computer infrastructure and business applications. Not only are these two functions carried out within separate departments, they also have separate budgets, employ people with different skill sets and have different working practices. To some extent, this is now being addressed in higher education where telecommunications students study both telecommunications engineering and computer engineering.

The current outsourcing trend can also complicate matters still further. For a company to successfully implement a CTI business application, the technology and organisational challenges need addressing. Minimum requirements include a compatible telephone and computer system, software and hardware upgrades to one or both systems and sufficient deployment budget in both departments. The working relationship between the IT and telecommunications departments needs to be developed, faults need to be reported to a single contact point and new skills will be required to allow the different types of engineers and managers to communicate.

CTI Architectures

CTI is a complex combination of both hardware and software systems. The CTI cube model, see Figure 1, is an attempt to show the main component parts. In the following sections the layers of the cube are introduced, but more detail will be given in future articles. 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

The term *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. There are several ways in which computers and telephones can be physically connected (Figure 2):

- telephone interface unit,
- PC-hosted telephony card,
- a data connection from the telephone or PBX feature phone, and
- complete system intercept.

PC telephony equipment can now be bought and connected to computers (internally and externally) that offer services such as telephone, fax, modem, voice recording, voice playback and even voice recognition. BT's VC8000 videophone, among others, also allows video communications as well as voice and data. As with CD-ROM drives, telephone, fax and data capabilities will probably become standard hardware on a PC within a year or two. Effectively, these are all examples of CTI but are usually supplied with applications specific to the telephony hardware.

One company has recently launched an enhanced telephone with a computer interface that supports CTI applications.

A CTI system using complete system intercept will normally terminate all PSTN or PBX extension lines and so effectively has a view of the whole telephony domain; this is effectively *third-party CTI* (see below) but without a direct CTI link to the PBX.

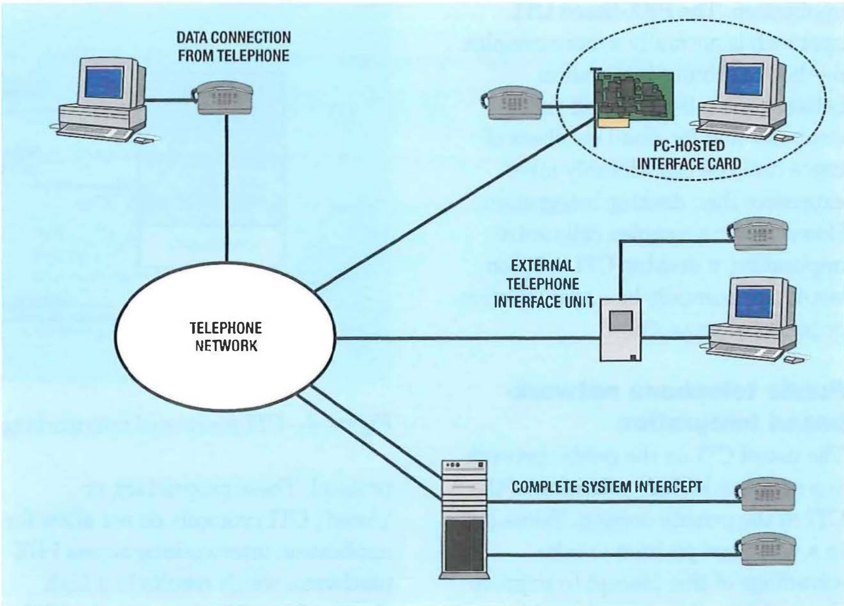
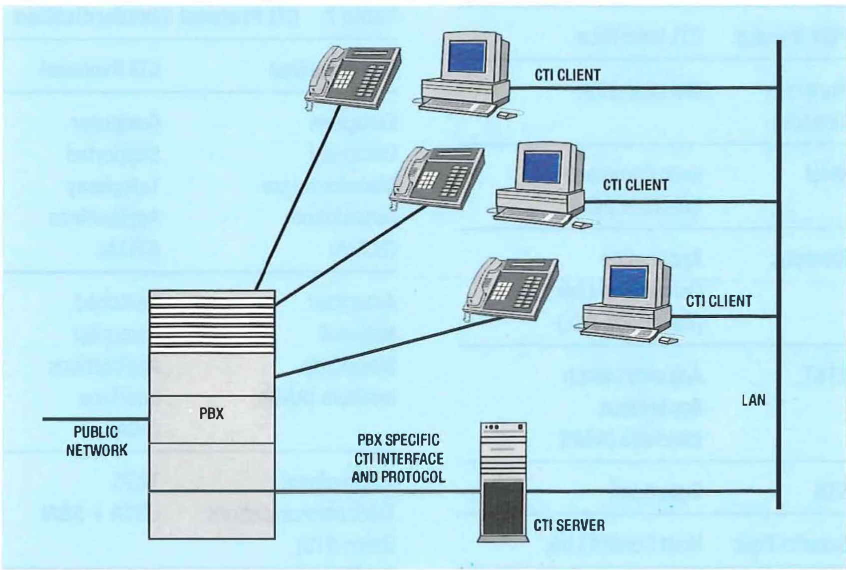


Figure 2—Methods of physically connecting computers and telephones.

PBX-based integration

The term *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 (see Figure 3). Each workstation or client still has desktop CTI functionality, but in this case there is no physical connection between individual computers or workstations and the telephone. 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 now extended to that of the PBX telephone network. As the PBX can manipulate a collection of telephone sets and lines, so can the computer

Figure 3—PBX-based computer telephony integration



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 could 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.

Public telephone network-based integration

The use of CTI on the public network is a new, but logical, extension of the CTI in the private domain. Telcos are in a very good position to take advantage of this concept to improve the usability of network-based services such as FeatureNet.

CTI Protocols

A CTI protocol is a set of messages and associated sequencing rules for the communications, at layer 7 of the Open Systems Interconnection (OSI) model, between the computer and telephone system (see Figure 4). Each PBX offering CTI has its own unique protocol and set of telephony services which it can offer. Table 1 gives examples of CTI protocols.

Most PBX suppliers have their own published CTI interface and protocol. These proprietary, or 'closed', CTI protocols do not allow for application interworking across PBX platforms, which results in a high degree of coupling between the PBX platform, the computer platform and the CTI application. However, in most cases, proprietary protocols do enable the CTI applications designed by the PBX vendor to exploit the full potential of a single PBX platform.

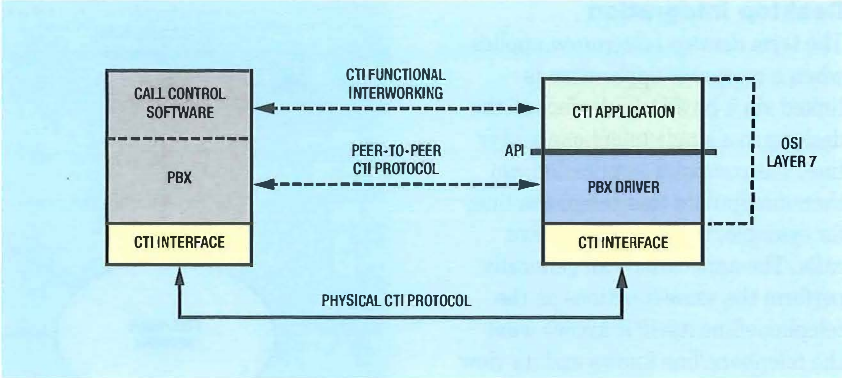


Figure 4—CTI functional interworking

Table 1 Examples of CTI Protocols

PBX Vendor	CTI Interface
Northern Telecom	Meridian Link
Mitel	Host Command Interface (HCI)
Siemens	Application Connection Link (Callbridge ACL)
AT&T	Adjunct/Switch Application Interface (ASAI)
STS	SuperLink
Summa Four	Host Control Link

Open CTI protocols

Three organisations have attempted to standardise the CTI interface (see Table 2). The most successful is the European Computer Manufacturers Association (ECMA), which has defined the Computer Supported Telephony Applications (CSTA) protocol. CSTA defines an 'open' CTI protocol to allow interworking between compliant computers and PBXs. In theory, PBXs and applications from one vendor, which adhere to this standard, can be used interchangeably with PBXs and applications from other vendors. The PBX vendors that actively support the CSTA protocol are:

- Alcatel
- AT&T
- Ericsson
- GPT
- Philips
- Rolm
- Siemens
- Tadiran
- Telenorma

Table 2 CTI Protocol Standardisation

Organisation	CTI Protocol
European Computer Manufacturers Association (ECMA)	Computer Supported Telephony Applications (CSTA)
American National Standards Institute (ANSI)	Switched Computer Applications Interface (SCAI)
International Telecommunications Union (ITU)	TASC CSTA + SCAI

The Switched Computer Applications Interface (SCAI) standard tended to be favoured by companies within North America but has now more or less been abandoned. In an attempt to bring the work of the ECMA and ANSI together into a single standard, the ITU initiated the TASC standard that attempts to combine CSTA and SCAI. However, although the first issue of TASC is being ratified, interest in this standard has diminished.

Application Programming Interfaces

In the CTI environment, an application programming interface (API) provides the communications mechanism between application software running in the host computer and the telephone system hardware. It is normally the responsibility of the API vendor to provide the physical interconnections required between the telephone and computing equipment as well as the PBX specific software 'drivers' that are installed in the computer. In theory, an API isolates an application programmer from the underlying CTI technology enabling the application to make and receive relatively high-level service requests and responses between the computer application and the telephone system. CTI APIs can be classed as one of the following:

PBX proprietary APIs

In the few cases where PBX vendors do offer APIs, these are exclusive to their PBXs, which has generally kept the price of CTI high. However, pressure from the more 'open' computer industry has meant the development of new open APIs. Because no two APIs are the same, CTI applications written using proprietary APIs are specific to a PBX and are not easily modified for other vendors' PBXs. Mitel was one of the earliest suppliers to release an API for its SX-2000 range PBX.

Computer vendors' APIs

These APIs have been developed by the computer vendors so that they have a common interface to heterogeneous PBX platforms. An example of such a computer vendor's API is IBM's CallPath™ services architecture which functions across its range of computing platforms and a wide range of PBX platforms.

Independent third-party APIs

APIs available from independent third-parties (that is, neither the PBX nor computer vendor) have arisen from the need for applications to function across many heterogeneous computer and PBX telephone systems. The advantage is that an application developer can write a single version of a CTI application with minimal knowledge of the telephone system that it will be used on. It is the responsibility of the API to communicate with the PBX using the appropriate command protocol for that PBX. An example of third-party APIs is T-Server from Genesys. Third-party APIs are sold on a commercial basis and are only available from a single vendor; also they do not conform to any standard and so can not be classed as open.

Open APIs

There are no truly 'open' standards for a CTI API—indeed the ECMA, which did start work in this area, has now dropped plans to standardise an API based on the CSTA protocol.

Novell's Telephony Services API

The closest to an 'open' API is offered by the partnership between Novell and AT&T who, in 1994, released Telephony Services API (TSAPI). TSAPI is an API, which is based on the CSTA protocol standard, offers full PBX-based CTI—but only on Novell's networks! TSAPI is aimed primarily at the PBX market rather than desktop integration. Most of the world's major PBX vendors have agreed to provide CTI drivers to support TSAPI by the end of 1995.

Microsoft's Telephony API

Another important API is Microsoft's Telephony API (TAPI) which primarily allows Microsoft Windows applications to manipulate telephony devices on the desktop; that is, telephones and lines. TAPI capability will be included with Windows™ 95, the new Windows operating system, but owing to its delayed launch, the number of TAPI-compliant applications and telephony devices has been very limited to date. TAPI, which was developed in partnership with Intel, is generally seen as a low-end desktop CTI enabler offering a de facto standard for desktop CTI.

CTI Applications

CTI applications enable computers to manipulate the telephone domain as well as manipulating the data/computer domain, and for telephone systems to make more efficient use of the data held within the computers. In its simplest form, a CTI application could be a telephone directory application that maintains a catalogue of names, addresses, company details and telephone numbers. Such applications are relatively common, but without CTI it is not possible for the numbers to be automatically dialled under the control of the computer. At a higher level, CTI applications can be used in call centres[4] to route efficiently large numbers of telephone calls to telephone agents based on data held in a computer. Call centre applications can bring many benefits to the company, such as reducing costs and improving customer satisfaction, but only if the CTI solution is properly specified and implemented. Except for a few emerging desktop applications, most CTI system users to date are employed in call centre activities. A few generic examples of CTI applications are given below:

Inbound call handling

Inbound call handling is the most popular application area for CTI; for example, automatic routing of calls to free telephone agents with automatic pop-up of customers' records based on calling line identity (CLI) information.

Outbound call generators

Potential customers are called automatically by the outbound call generator from a database of existing customers' contact numbers; this method is quicker, more reliable and a more efficient use of the human resources.

Hot-desking/flexible working

Each telephone system user is given number portability so that he or she is allowed the flexibility and mobility to commute between shared office desks, mobile telephones and even the home, but without losing any telephony or computing functionality normally available in the office.

Screen-based telephony

Screen-based telephony moves the functionality and features of the telephone into a computer application so that, for example, calls can be made by clicking names on the computer screen or to improve usability of *# codes used in network 'Star' Services.

Intelligent scripting

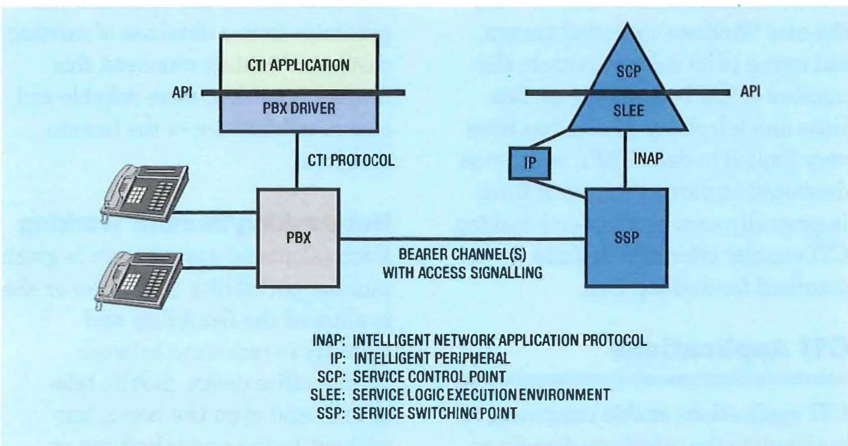
Intelligent scripting is used in both inbound and outbound applications to help the telephone agent through a pre-written script that varies depending on the customer's data and verbal responses.

Relationship to Intelligent Network

CTI protocols are generic enough to be able to build a private equivalent of many intelligent network (IN) call handling services[5]. The removal of restrictions on network-to-network calls also means that such services are not necessarily restricted to the private network domain, and there are examples of independent service providers using CPE to deliver facilities which would normally be considered to be in the domain of the telco. A comparison of the CTI and IN capabilities indicates the similarities in the functionality offered in both environments. However, CTI in its various proprietary forms is a more mature technology. Also, it will not be easy for IN to close the gap on CTI, since the CPE environment is one in which responsiveness and innovation are easy to achieve. This environment is largely unregulated, is not constrained by licence restrictions, is fiercely competitive, does not incur the availability, process, billing and security overheads which apply to a network operator, uses cheap technology, and is very easy to develop in.

However, the CPE and network environments should not be regarded as competitive, and a closer examination of the CTI and IN protocols shows that they have been specified with entirely different objectives. The role of the network is to **deliver** calls, and the role of CPE is to **handle** them efficiently and in a user-friendly way at the network termination point. Thus a protocol like INAP does not assume capabilities such as transfer, call distribution, predictive dialling, etc. within the switching fabric, since these are in themselves IN services. On the other hand, while CTI provides a pragmatic interface to a switch or network which is already highly featured, it lacks the range of security, charging and other features required for control of a public network. By contrast, the IN has a range of functionality essential to the service provider (operations and maintenance, mobility, charging, etc.) which is either poorly specified, or non-existent, in CTI. CTI and IN technologies may therefore be considered to present orthogonal control views onto the public network with IN presenting a 'vertical' view for call delivery services and CTI presenting a 'horizontal' view for post call delivery call handling applications. It is apparent from a consideration of the architectures of both CTI and IN systems (see Figure 5) that there are considerable similarities between the major elements of each architecture. At a simplistic level, each architecture comprises a switching system which is controlled by an external computing platform. To this may be added a number of supporting resources such as communications peripherals (interactive voice response (IVR) units, facsimile modems, etc.) and database systems. It is therefore possible to consider a CTI environment as being a 'private' IN.

Figure 5—Comparison of CTI and public IN architectures



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Biographies

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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 (CPE) and Peripheral Intelligence group. His main work is investigating CTI technology for the desktop and the Meridian Norstar PBX. 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 PBX telephone system using CTI.

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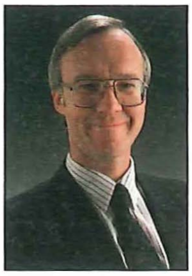
Gary Crook joined BT as an apprentice in 1981 within the Oxford Telephone Area. After graduating from Essex University with a B.Sc in Electronics and Communications, he joined the London Software Engineering Centre where he worked on PBX systems integration and radiopaging call control development. He joined his present team, the CPE and Peripheral Intelligence group, in 1990 specialising in the applications, architectures, capabilities and standards for CTI. He also has a Diploma in Management Studies.



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BT Networks and Systems

Doug Chesterman joined BT in 1973, after graduating from the University of Kent at Canterbury with an honours degree in Electronics. After a 5 year period in which he contributed to the Network Planning department's early strategies for the introduction of digital switching systems, he moved to BT Laboratories and joined the System X development project. Here he took a leading role in the design and implementation of a new call processing architecture, which was subsequently adopted by the System X prime contractor. He currently leads a group which specialises in intelligent CPE and access systems, and in understanding the relationships between these and core network intelligence.

Glossary

API Application programming interface
ATM Asynchronous transfer mode
CPE Customer premises equipment
CSTA Computer Supported Telecommunications Application
CTI Computer telephony integration
ECMA European Computer Manufacturers Association
ISV Independent software vendor
IVR Integrated voice response
OSI Open Systems Interconnection
PBX Private branch exchange
PC Personal computer
POTS Plain old telephone service
SCAI Switch Computer Applications Interface
SPC Stored-program control
TAPI Telephony Application Programming Interface
TASC CSTA + SCAI
TSAPI Telephony Services Application Programming Interface

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Workforce Allocation in the Core Network: NOMS2 and WORK MANAGER™

This article describes the history and current status of systems designed to manage and allocate work to the core network workforce. It explains the early days of the NOMS2 system, the development and introduction of WORK MANAGER within the core network and likely future system evolution. It gives an overview of the technology and system architecture, the implementation and project management aspects needed for the successful launch and an early view of the benefits derived.

Introduction

A key aspect of BT's network administration implementation programme (NAIP) was that minimal manual involvement would be required for either provision of service or maintenance. To deliver this vision a task had to be allocated to an individual technician with the appropriate skills who would attend the correct location and complete that task within the target time. This concept was widened to ensure that:

- the technician's travelling time (and hence the cost) is minimised,
- a (correct) spare item is collected and taken to site, and
- test equipment or, indeed, keys to the building are collected.

The Early Days—NOMS2

NOMS2 arose initially from BT Development and Procurement (D&P) who, after requests from field people for assistance with work control, began to define a system. It was realised that there should be close synergy with the NAIP activity and there was a clear need to ensure that a uniform system was developed. A centre team was formed to control the overall development and implementation. The result was the Network Operations Management System No. 2 (NOMS2)—(NOMS1 is an alarm collection system).

NOMS2 Overview

NOMS2 was a decision support system; based upon stored data concerning individuals, locations and tasks, it would offer a list of suitable people for manual selection. This selection would be performed by the task allocation duty (TAD) in the network operations units (NOU). The TAD would issue tasks for all NAIP platform technology real-time fault repair and routines. The method of transmitting the task to the selected individual varied: terminals, pagers or the telephone were used. Where terminal access was possible, the field technician could read all the information pertinent to the task and enter data (clear code, time completed and/or problems arising causing delay). In all other cases, the technician would ring the control, be given the task over the telephone and would report task completion back in a similar manner (the TAD would then input the completion on the system). NOMS2 included a facility for the TAD to page the field technician automatically from the screen.

NOMS2 Deployment

System deployment started with a pilot in North West Zone in June 1991. Deployment was reasonably straightforward with digital switch work, but TXE4 and transmission proved difficult to implement. Power routines were attempted, unsuccessfully, and real-time power faults were never tried. The reasons for the failures were various—lack of clear processes, non-standard procedures, limited system functionality, and unacceptable operational constraints imposed upon field users. Nevertheless, with system enhancements, sign-off was gained for exchange aspects and national roll-out began. Perhaps the greatest benefits from this system were from enabling managers to see the advantages in the use of such a system, formulating the processes that were needed to underpin its effective use and the pointers it gave for defining a new and more powerful successor.

NOMS2 Extension

Major improvements were made to the system after it had been in service for about 2 years:

- Capacity was enhanced (CPU and memory) to widen the scope. This followed an idea originated in the Midlands that benefit could be derived from extending the technique to cover the analogue exchange maintenance workforce and frames people. Knowledge of the whereabouts of frames people would enable tasking for non-frames work, for which they had the appropriate skill (or could acquire easily, such as changing a line card). This was called the *analogue and frames* (A&F) project and was an early example of common skilling.

- A limited management information system (MIS) was provided. This followed complaints from field managers that they were unable to derive information from the system that would enable them to manage their workforce better. Some simple statistics were developed, based upon the data stored and created in the system, about the tasks and the people who had dealt with them.

Impact of NOMS2 System Failures

A major weakness of NOMS2 was the vulnerability of a Zone to a catastrophic failure of the system. Whether through software or hardware failure, once a Zone managed its workforce via NOMS2, fallback to old paper-based systems was painful and unsatisfactorily. Many system teething troubles gave serious performance problems and outages—causes ranged from incorrect packet length on LANs to lack of routine maintenance in purging obsolete records. The business case did not include a fallback machine as this was not then considered necessary. As part of the A&F upgrade, two features were added to enhance resilience:

- The new PTX operating system provided the Sequent 'high availability' facility which enabled a Zone whose machine had failed to share another machine in the same NACC and carry on under restricted operating conditions. It was far from ideal and was not applicable to all Zones, but it was an improvement.

- Sequent machines could have part of their hardware disabled remotely and continue working with reduced capacity. By over-provision of hardware (CPU, RAM and power supplies) it was possible, for example, to dimension machines to 115% of required capacity such that a hardware failure could be tolerated by remote busying of the failed component and operation continued at 90% of original capacity.

NOMS2 Technology

NOMS2 used Sequent computers and their version of the Unix operating system (Dynix), together with the Oracle database system and application software developed by D&P. Based in network administration computing centres (NACCs) located in Bristol (serving Wales and the West), Woking (Southern and Northern Home Counties), Walsall (Midlands), Manchester (NE, NW and NI), Glasgow (Scotland) and Ealing (London). Essentially each Zone had its own machine.

As Zones discovered the capabilities of the system, they began to load it up in ways not envisaged—such as to give the whereabouts of provision and construction people—and derive further benefits. This had exceeded the capacity and the A&F upgrade was desperately needed. At the same time as the A&F upgrade, a new operating system from Sequent (PTX) was loaded which gave a number of improved housekeeping features.

Shortfalls of NOMS2

It was realised that NOMS2 had a limited life. The demands being made on the system were too great for its design; network operations and the demands of the business had moved forward during the life of the system and a replacement with greater functionality was required. The shortcomings could be summarised as:

- Insufficient capacity for the requirement and the need to move to a larger platform would necessitate a new business case which would require fresh benefits unlikely to arise from extending NOMS2.

- A rudimentary MIS which was not easy to access.

- Manual allocation of tasks was inefficient, selection was biased towards individuals that the TAD knew from experience could do the task (thus they kept getting the work). Inequitable distribution of tasks, atrophying of skills and excessive travel costs resulted.

- Provision for terminals and connection to a network was excluded from the original business case. Zones which had provided terminals via other projects were at a great advantage. To implement a terminal network would have been costly.

- The hardware platform was relatively old technology and incapable of further enhancement; replacement was required.

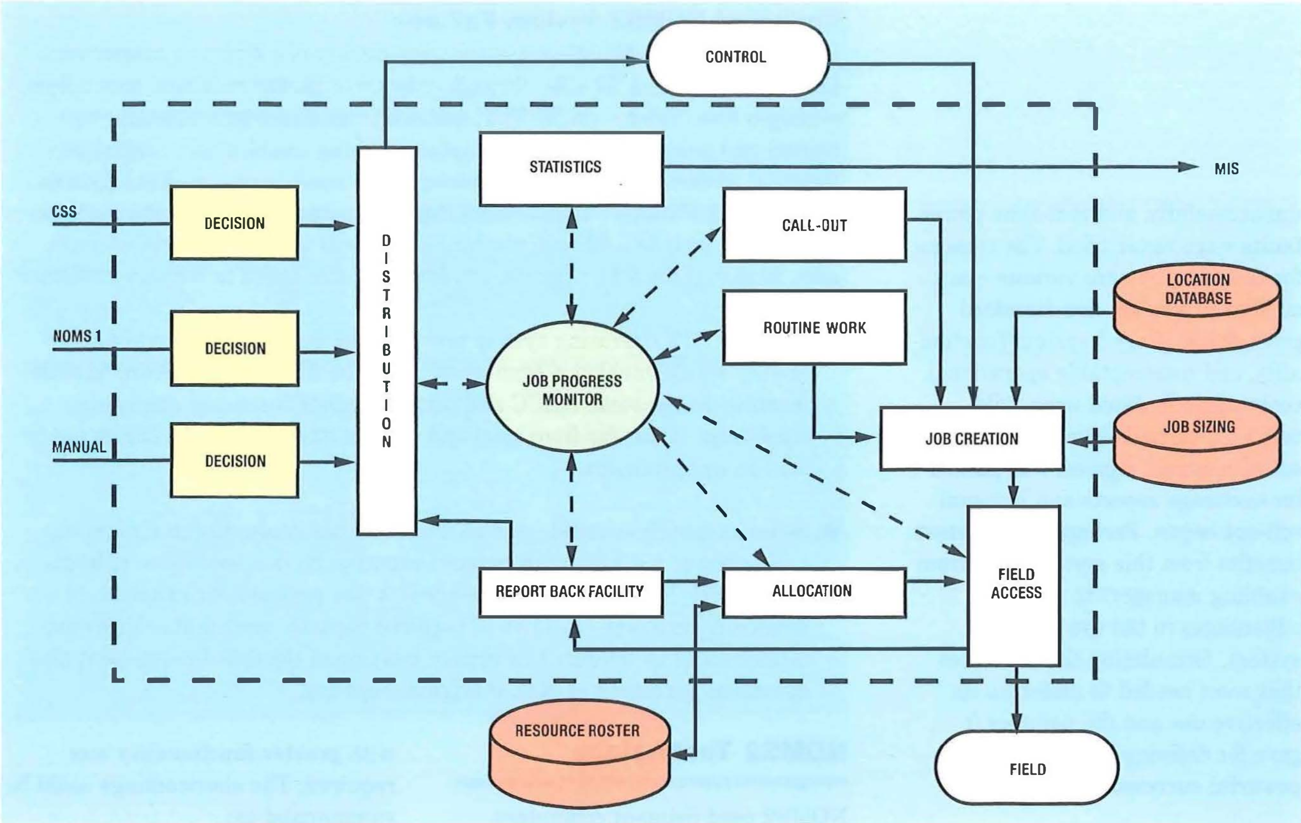


Figure 1—WORK MANAGER functional diagram

WORK MANAGER—Outline Concepts

Business process improvement studies in the late 1980s had suggested that improvements in cost effectiveness of over 30% were likely from a properly controlled workforce. These gains were too significant to ignore for the Personal Communications (PC) field force and the work management programme was started. Worldwide Networks (WN) was invited to join the programme and thus produce a single pan-BT work management system to allocate and monitor all work. This was attractive as a replacement for NOMS2. The new system was to be evolved from NOMS2 and developed in-house, but the NOMS2 architecture was inappropriate and a new start had to be made. The fundamental differences in process and work type between PC and WN meant that two variants would be needed, referred to as *work management system network* (WMS(N)) and *WMS customer* (WMS(C)). Development of the two major variants (while sharing a common core) gave rise to contention for development resource and the end result was delay to the project.

WORK MANAGER—Approach with Core Network

The overall plan for implementation within the WN core network was to operate a three-phase project, each phase being sequential in its field launch.

NOMS2 replacement

The first phase was *NOMS2 replacement*, replacing NOMS2 and enabling the Sequent machines to be recovered. All NAIP platform work was undertaken by WMS(N), using the Version 2 software. Existing NOMS2 functionality either continued or was improved. In particular:

- *Routine tasks*—an improved generator was introduced for routine tasks which overcame the limitations found with NOMS2, particularly in the power area.
- *CSS downlink*—all repair tasks originating on the customer service system (CSS) are transferred into WMS(N) automatically via an electronic interface to CSS.
- *Messaging and broadcast*—the capability exists to send a message to individuals or to a selected group (for example, by occupational unit code (OUC) or by skill set) such that at next log-on they will see the message. This is useful for announcing team brief sessions, or in conjunction with the 'routines tool', to issue a task which is to be performed at many sites; for example, a safety check.

Automated process workflow

The automated process workflow phase enhances the system capabilities and provides interfaces to other support systems to give automatic flow-through of work, obviating manual input to the system (Figure 1). This is particularly important for provision work, but also improves transmission repair (for example, by interfacing to the transmission domain surveillance (TDS) and computer-aided maintenance for special services (CAMSS)).

Control of all work

This phase extends the coverage so that all work currently undertaken (excluding construction) is covered by WMS(N). It includes the capability to monitor dwell times

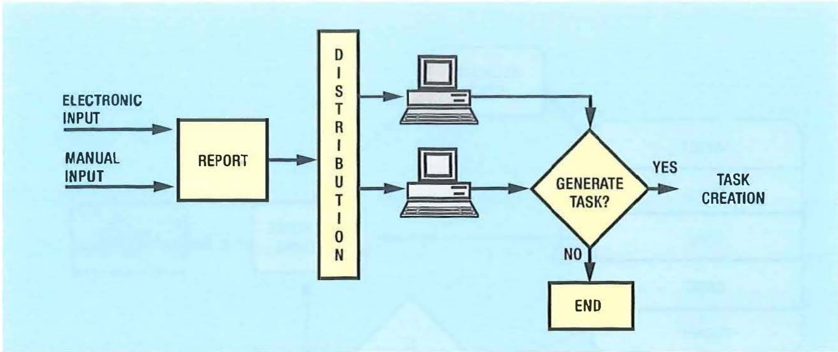


Figure 2—Input and handling of work

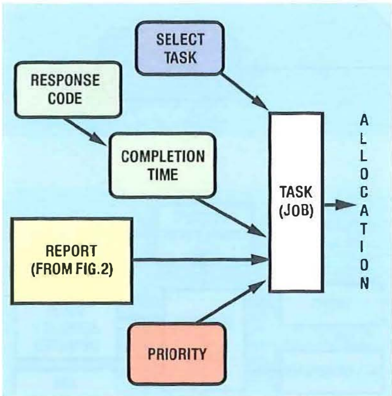


Figure 3—Task creation

within the various areas of the NOU and enable process improvement.

The System and How it Works

Figure 1 shows the overall system functional diagram. The system has four main purposes:

Input and handling of work

The objective is to allocate and issue tasks† to the most appropriate skilled technician, as far as possible automatically. A request for new work may be received electronically from CSS or NOMS1 (and, in the future, from other systems such as TDS) or created manually (Figure 2). It is input and may be displayed on the screen, enabling the control technician to relate it to other requests in the system. Reports contain details of what and where the problem is and each report can be directed to a specific control position dependent upon type (for example, for switching, transmission, customer or network). When it has been established that field technician involvement is needed, it is turned into one or more tasks by adding attributes (Figure 3) including:

- standard task type,
- service contract or agreement that applies,
- priority of the work (which has a default value per task type), and
- any notes to assist the technician.

Sufficient information now exists to package and allocate the task to a suitable technician. In some circumstances (for example, where a certain field technician has previous site or job knowledge) it may be preferable to allocate the work to a specific individual. This may be achieved by *pre-pinning* the job which overrides the automatic allocation. Such tasks should form only a small percentage of jobs as this technique limits the efficiency of the overall system allocation.

The task is now placed in a pool of unallocated work. Automatic checks are made to detect if the task is unlikely to be completed by the commitment time and if so it is flagged to the control technician who may then take action to ensure it is so completed.

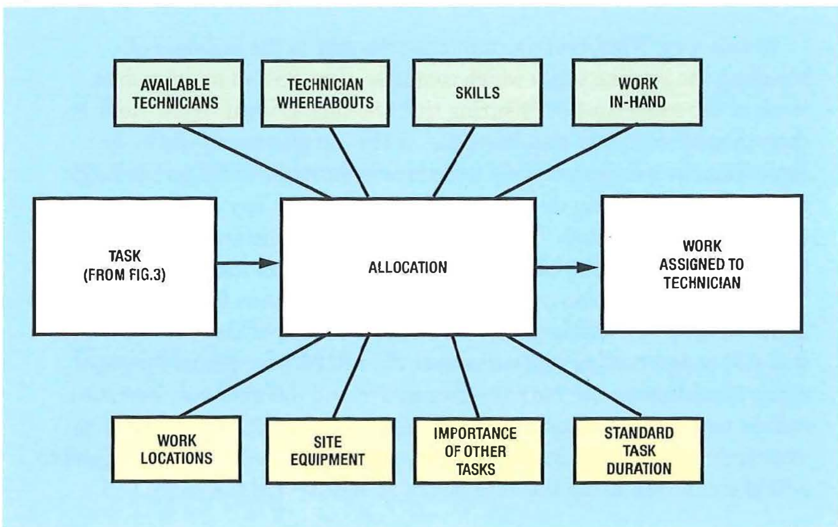
Automatic allocation—the algorithm (Figure 4)

This is the most important part of WMS and distinguishes it from NOMS2. The database holds details of:

- all technicians, who may be called upon to carry out work,
- scheduled hours of attendance for each technician,
- whereabouts of each technician and capability to travel,
- technician skills of each technician (defined by consultation between the line manager and each technician),
- work in-hand for each technician,
- listing of all work possible on the network divided into task types, and

†The term *task* refers to the lowest level into which work can be divided for allocation to an individual. The term *job* is in common-sense use and this causes confusion as *job* is the standard term for a collection of related tasks; for example, a job to provide a circuit may require several jumpering tasks and a line-up task.

Figure 4—The allocation algorithm



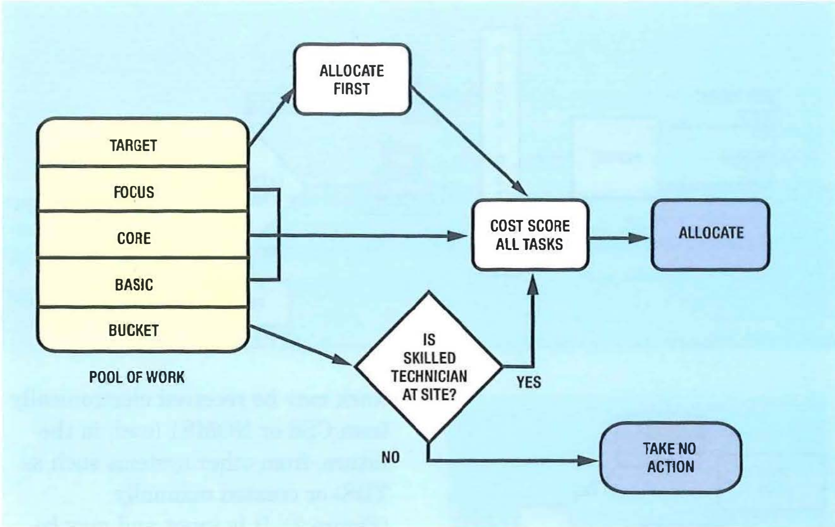


Figure 5—Task 'costing'

- listing of all network sites and systems located there.

The multi-stage real-time algorithm (RTA) accesses this data and automatically allocates the work. Most tasks are allocated to give a job start time that will ensure completion by the commitment with the customer; this is known as the *commitment time*. To do this a task is 'costed' (Figure 5) to take account of the many attributes, including relative importance to the business, availability and whereabouts of technicians with the required skills. Some tasks such as *co-op* work (where the task requires the assistance of another BT person—not necessarily at the same site) are treated as appointments and allocated at a specific time. Tasks with a contractual completion date sit in a pool of work and their priority is automatically raised as commitment time approaches, thus increasing the probability of allocation.

Work control

(Figure 6) WMS monitors all tasks through to completion. A *jeopardy monitor* displays this progress and shows as tasks change status and/or move into jeopardy. Warning messages (*alerts*) are also routed to the control technician if problems are detected which affect a task.

Routine tasks

These tasks are automatically generated and issued on a daily, weekly etc., basis and calendarisation may be down to a specific set time. The routines generator logs progress and if work is slipping, it updates the next routine in the cycle. Similarly it suppresses a routine when it detects work is ahead of schedule.

Management information

WMS produces management information in real-time and historical statistics, which can be used by managers to improve process efficiency and, hence, the standard of service to customers. The statistics include simple totals, such as number of tasks of a given type at a given location and averages such as the average time taken for a particular task type at a given location. Many reports are standard on the system but each Zone may customise its own reports.

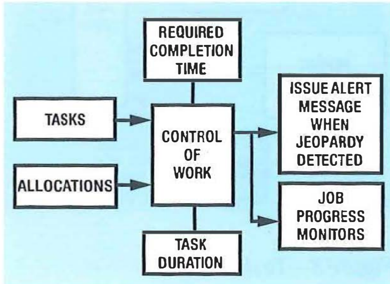


Figure 6—Work control

WMS work categories and allocation

WMS categories work as:

- *Target*—allocated first; very important work including some customer aspects.
- *Focus*—provision work and appointments.
- *Core*—the bulk of network tasks.
- *Basic*—unimportant work; travel to site if not completed by a given date and no other work available.
- *Bucket*—only allocated when the technician is already at the site.

In this way, WMS seeks to minimise the cost to the business of handling the routine tasks which comprise some 85% of maintenance work at the same time as ensuring that the time-critical repair work is done to meet customer requirements. WMS can also bundle tasks and issue them as a *Superjob*. This technique is designed to fill up the field technicians' remaining duty time up to a maximum (say two hours—set in the system parameters). This also means that technicians are not required to log-on and off continually to receive short duration tasks.

Automatic allocation is nominally available between 0600 and 2200, to allow for system housekeeping and back-up outside of these times. WMS will still accept reports and tasks over the full 24 hour period for automatic allocation on the next working period and the manually operated *callout* tool is also available day and night. As with NOMS2 there is an *automatic paging* facility. Additionally, urgent tasks may also be flagged to a field technician using the *auto-interrupt* facility and the pager tool.

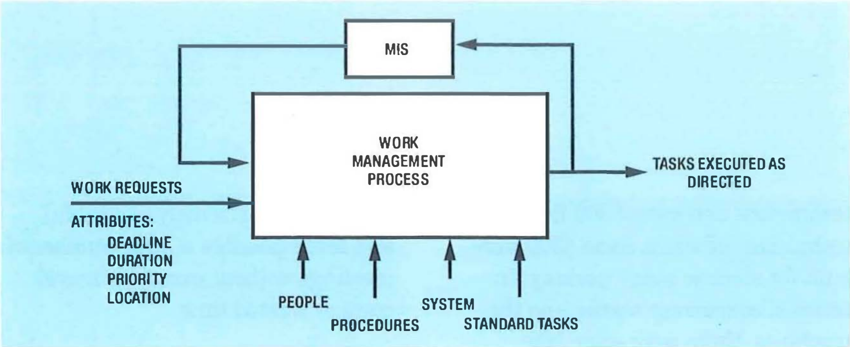


Figure 7—A single work management process

Making It Happen

Pilots

A complex support system is subject to pilot trial to test functionality in a live environment and to verify the integration with the processes it supports. WMS was piloted in 1993 and found to be inadequate. There were considerable process and cultural problems, and a serious number of system functionality defects. One of the major reasons for the latter was the time that had elapsed between original requirement capture and pilot launch. During this time, practices in the field had evolved and the system was no longer aligned with those revised practices. This was particularly noticeable in respect of NOMS2 Replacement. NOMS2 was a simple system and could be modified easily to cope with changing circumstances by changing data. WMS was highly inflexible and the field changes that had taken NOMS2 to cover more than NAIP platform maintenance could not easily be handled by WMS.

After further development, the system was relaunched as a pilot in the East Midlands in early 1994. Sustained work by field and centre people (concentrating on 'tuning' the algorithm, establishing lower-level processes and procedures and thorough 'war-gaming†') began to demonstrate the capabilities of the system.

The system was next used in London on the AXE10 area. Again, after bedding-in, the system was successfully operated and this became the start of a series of mini-pilots in different functional areas within London. The feedback from these pilots was incorporated into training, databuild, system changes and implementation briefings. The pilots must take considerable credit for breaking the ground and enabling a better overall launch for the system.

MIS

Zones had started to operate the NOMS2 MIS in July–October 1993 and were, together with local PC-based spreadsheet and database systems, starting to derive useful measures. WMS(N) had the capability to produce many statistics but these were not in a readily usable nor useful form. Fortunately this was realised early in a pilot and remedial action was taken. A pan-Zone project was established which built upon the NOMS2 experience and redefined the WMS(N) package for MIS. This is being developed to give an easy-to-use set of meaningful management statistics. In parallel, the capabilities of the system have been exploited and selected Zone people have been trained in the use of data-query language which enables them to write their own bespoke reports.

Operational process

The operational process of 'how we manage, allocate, control and do work in the field' has been the most vital yet complex area. Historically, processes were devised at District and/or Zone level and have never been standardised. The advent of a support system which underpins a 'standard process' (see Figure 7) for allocating and controlling work precipitates difficulty—the lack of a standard process.

In pilot trials, the system generally proved satisfactory but some Zones raised questions over the system functionality.

'Local' practices further complicated the issue. Additionally the component processes of maintain, provide etc., and lower-level procedures which run through the *allocate and control work* process—were also non-standard and caused problems.

Resolving such problems, involving data capture, analysis of root causes, and devising and trialling solutions has occupied both manager and technician effort in each Zone. The by-product was a standard set of processes—forced by the use of the system. These lessons were circulated via the project control forums and disseminated to each Zone as the intelligence was gained.

WMS(N) is able to support a multi-skilled 'patch' or geographic area. This can be any combination of existing field forces, depending how the data is built; for example, a combination of TXD maintenance and TXE4 maintenance, transmission maintenance and transmission works, all maintenance or all operations. The use of zones‡ allows the organisational structure to be reflected in the system, ensuring a particular field force undertakes work in a specific geographical or functional area.

WMS Technology

Hardware

A competitive tendering exercise operated jointly with the WMS(C) project resulted in the contract for the supply of hardware being awarded to Hewlett Packard (HP). For the core network the machines are installed in three NACCs (Croydon, Bristol and Manchester), each NACC housing a cluster of up to four processors. Each Zone has a dedicated processor and there is an additional stand-by machine per cluster. This machine

†War-gaming is the use of the system (with either dummy or previously-gathered 'live' data) where the user fully exercises all the system and process functions.

‡The term 'zone' refers to a geographic sub-division of the WN Zone, (which, for clarity, uses a capital 'Z' throughout this article).

can be brought into rapid operation should one of the working machines fail. Additionally it may (when not required for fallback operation) be utilised to provide a training instance for Zone-based training or scenario testing. A future use may be to run MIS tasks in background, say producing overnight statistics runs. The overall configuration includes mirrored disks per Zone (the stand-by machine can access any pair of disks) and management tools for system control and diagnostics.

Communications

Network communications are provided under the communications infrastructure programme (CIP). CIP provides X.25 communications to each exchange where a WMS terminal is located. The terminal traffic is then routed via the multi-protocol router network (MPRN) to the NACC. Terminals are provided as part of the roll-out programme for WMS and this is closely aligned to the user access programme, geared to delivering a variety of services (WMS, OMC, databases etc.) to the same terminal. The lessons learned under NOMS2 were fully taken on board.

Software

The WMS software was specially developed by D&P. The system makes use of the latest version of the Oracle database and associated query tools. The Unix-based operating system and management tools are HP proprietary.

The system is of a considerable size in terms of systems operating on minicomputers. At the end of December 1994, the system comprised 163 data-tables, which contained a total of some 1040 data items. It contained data built for over 3100 control technicians and some 8300 field technicians of which some 4300 were built for shadow zone† working. In terms of concurrent sessions on the machines, there were some 560 control technicians and some 770 field technicians, including some 130 in the shadow zone.

†Shadow zone working allows technicians to be logged onto the system for whereabouts information (analogous to the NOMS2 A&F situation) but does not issue work to them automatically.

Launch and Roll-out

Project management

Roll-out of the system involved co-ordination between other centre units (concerned with CIP and user access), computer service operations (providing the communications and MPRN), D&P (installing the software and configuring the hardware), training course designers, the video production company (who produced the training videos), HP and of course the Zones. The Zones were not only rolling out the system to managers and technicians but also implementing the communications, NACC work and process design. The coordination was performed by the centre programme team in operational policy and support.

From the start, extensive use was made of Zone forums. A steering group chaired by a Zone General Manager operated to give overall direction and field focus to the programme. A process and system meeting involving NOU and NFU managers met to oversee the roll-out, agree priorities, establish responsibilities for undertaking process design and system proving and to provide an escalation point for field people within their Zone. Finally, each Zone appointed an implementation manager (IM) and project team. These IMs met regularly and worked to a national template plan. The key to successful implementation within such a short timeframe (approximately six months) was the IM forum and the extensive use of teleconferencing with IMs prior to and after any Zone *go-live*—both for control and problem solving and to disseminate lessons learned. This method was extremely successful and made possible a large number of meetings without excessive travel costs or wasted time.

Training

A major lesson learned from NOMS2 was that, although technician training was adequate, there was no specific management training. For WMS, specific courses were designed for control technicians and field technicians. NACC people attended system-specific courses supplied by HP. However it was in the management training that new ground was explored. The approach was a top-down cascade starting from senior Zone managers and courses operated as workshops to examine the people and process issues. They were not detailed system courses but aimed to equip managers to handle concerns and problems from their people and manage the introduction of the system smoothly. This was aided by use of a video compiled from pilot trial locations, to promote discussion.

War-gaming

It was realised from the early pilot phase that the complexity of the system and the need to adhere to processes required more than just a system training course. To further this, each Zone was provided with training instances to permit selected groups of technicians to war-game based upon their own patch and with data captured from NOMS2 or WMS in an earlier week. These sessions lasted about a week each and served to consolidate or refresh people who, as part of a Zone roll-out plan, had attended courses some time prior to their Zone going live. It also helped considerably in process design and practice. Each Zone will have a training capability for the future to permit testing of new facilities, train new people or undertake refresher training locally.

Databuild

The building of the data on the system was a considerable task for each Zone. The mass of data for people, sites and tasks was enormous. For Zones which had NOMS2 in use, a 'data-cleanse' and 'porting tool' was developed but many Zones chose to rework their data. Final testing and live use threw up many examples of incorrect data which led to task failures and rework costs.

Progress to date

Roll-out started with the Southern Home Counties Zone at the end of July 1994. Considerable thought, by both the centre and zone project teams, was given to the selection of the launch methodology. It was finally concluded that the most effective method for SHC was the simultaneous transfer of all network maintenance (digital local exchanges, DMSU, power and transmission) in addition to private circuits and PSTN repair. This was successful but revealed a number of system and process issues which were quickly resolved by the combined centre, D&P and Zone team. This was followed Zone by Zone, some using the simultaneous approach and others on a more gradual patch-by-patch basis. By the end of January 1994, only parts of London remained to be completed and NOMS2 had been closed.

Benefits

At the time of writing, core network rollout has just been completed and it is too early to analyse fully the benefits. However, some early indications are most promising. Routines are being discharged without failure and economically; service level agreement (SLA) targets are coming into line as processes improve; bundling of tasks is showing real gains in efficiency; there are times when there is no work as it has either all been allocated or it is of low priority and will wait until later.

Automatic allocation—the problems

With NOMS2, the basic approach was to issue the job as soon as possible to the selected technician such that the work could then proceed. WORK MANAGER does not do this—knowing the expected task duration, it calculates the job start time. Then, knowing the current locations of the available suitably-qualified technicians and the estimated time to complete current work, it calculates the travel times and the time at which it will then inform the selected technician. This is often referred to as the just-in-time (JIT) approach and is a radical departure from the earlier method. By suitable adaptation, it can be made to behave in an 'as soon as possible' manner, but the most efficient way is JIT—for the same reasons as in production line work. This method requires a change of approach and the system requires fine tuning. SLA target jobs have failed and careful analysis has shown that these are due to such reasons as incorrect categorisation of task type priority and inadequate data collection/building (that is, personal, travel times and task types). However, there are still some system problems which will be addressed in the future—such as raising the rate of increase with time of the importance of a job, greater granularity of task categories and giving some additional float on commitment time.

The Future

Interfaces

With roll-out completed, the next emphasis is the completion of the automated process workflow project and the realisation of the interfaces between WMS and other systems. The resource needed to define a comprehensive interface is considerable and it is a difficult task. Work is in hand to deliver a generic WMS interface but the definition of this will take time and needs to be exact to prevent expensive failure. To aid definition and to gain early benefits, the idea of tactical interfaces arose (compared with the longer term strategic or generic). These systems use PC and Visual Basic and Team Talk programs running under Windows to perform 'screen scraping' and permit the bi-directional transfer of data with manual involvement where necessary. These interfaces are successful in proving the concept, permitting early process definition and development and enabling detailed generic intake definition to be started. However, they require manual effort and careful build control to cope with upgrades of either system. Current tactical interfaces include CAMSS, TDS and CSS (provision).

Resource management

An area of current investigation is the use of either WMS or the addition of a separate system to undertake resource management. WMS is essentially a real-time job allocation tool. It lacks the ability to do predictive work which might enable management action to ensure the real-time allocation has a high success rate—such aspects as skills mix and training levels, attendance during peak load times, longer-range future appointment conflicts, prediction of workload volumes and available resource.

This leads to the concept of business modelling whereby future events may be modelled and the impact on both the workforce and the budget investigated. This may involve the launch of a new product or service, the impact of altering an SLA target or the capability to withstand a reduction in people.

National job recording

Currently field technicians enter their time spent on work on a weekly basis into CSS job recording. This takes time, requires the technician to note the work and to know the relevant classes of work. This information is either available within WMS or could be made so. WMS(C) currently passes all such time-related job data automatically into CSS job

Bringing it together

Since January 1995, the WMS(N) and WMS(C) project teams have been combined. This will give the benefit of pooled experience, economies of scale and greatly harmonise the development prioritisation. It will pave the way for more detailed system integration downstream and the possible joining of the current physically diverse platforms.

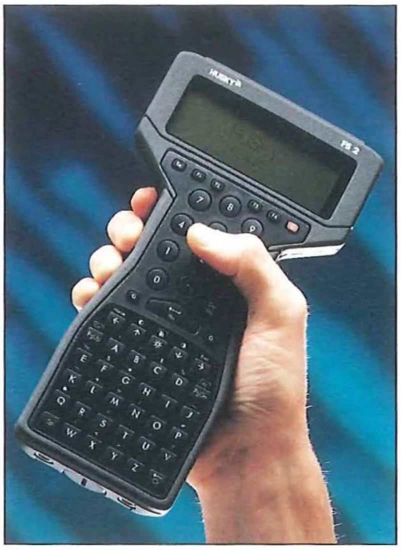
Networks people currently use fixed terminals and customer-facing the hand-held *Husky*. This latter is not considered suitable for Networks owing to the amount of data to be displayed on the screen. However, it is possible that in the future networks technicians will be equipped with portable PCs which they will take home and use to get the first job of the day or the complete day's work via an overnight download. Alternatively a voice-response system may give an abbreviated message such as the location of the first task.

Outline plans exist to give terminals a multi-session capability which will enable them to gain access to WMS, CSS, databases and other documentation retrieval.

recording and has removed the need for separate entry. The WN route is somewhat more complex with financial and budget process aspects to be resolved, but the future points towards the automatic uplift of data from WMS to CSS job recording with no further need for the technician to remember classes of work. The benefits here will be saving in time for technicians and managers, better quality of input data and the probable disappearance of classes of work in their current form.

Extending coverage and scope

Outline plans exist to extend coverage to the provision-of-service workforce, the first step beyond NAIP platform maintenance. Work has started to extend a pilot trial to international operations (aligning with NAIP). The issue of construction work has not yet been approached as process issues are a great concern—can we divert a person concerned with construction to



The Husky hand-held computer, used by customer facing people

do a series of maintenance tasks with-out prejudicing the construction project.

In theory, there is no reason why planning people should not be issued tasks via WMS—which will give managers immediate visibility of resource usage. Managers themselves could use WMS—for example, to prompt them for certain 'routine' tasks such as safety checks.

Conclusion

Although the first steps in delivering workforce management to BT have been taken and the large step increase in capability from NOMS2 to WMS is now apparent in the field, there is a considerable future ahead. The goals of reducing costs/increasing performance, satisfying ever increasing customer requirements for service and the operational management of a smaller, more mobile workforce have guaranteed the worthwhile nature of the programme. The delivery of WMS has demonstrated that although system issues may preoccupy people at the outset, the real challenge in delivery of such systems lies in the process and people areas. The successful roll-out of the system was due to excellent team working between centre and field and involving field colleagues at an early stage and throughout the launch.

Acknowledgements

Colleagues of the authors in centre, field and D&P, who defined, developed and implemented both the NOMS2 and WORK MANAGER systems, are gratefully thanked for their assistance and contribution to this achievement.

Biographies

Bill Morris
BT Networks and Systems

Bill Morris joined Post Office Telecommunications in 1974 and held a number of posts including KiloStream network planning and works, customer private network planning and MegaStream definition and development, becoming Private Circuit Programme Manager. A move to Network Operational Support was followed by attendance on the BT Master's Programme. He then led a unit responsible for the development and deployment of NOMS2 and WORK MANAGER. Currently he is responsible for International Switching projects and their support systems and Special Investigations. He is a Chartered Engineer, a Member of the Institution of Electrical Engineers and a Fellow of the BT Staff College.

Liam Kelly
BT Networks and Systems

Liam Kelly joined the Post Office in 1966 as an apprentice. At the time of Project Sovereign he moved from Head of Network Operations in the former North Downs District to become the Network Operations unit manager in the Southern Home Counties Zone. Currently, in the Sigma Organisation, Liam is responsible for Customer and Network Controls in Southern Home Counties.

David Smith and David Tidswell

Tail Management

The ability to manage performance is more than ever the key to delivering first-class customer service and secure a profitable future for the company. New approaches to monitor performance were needed. This article describes one such approach and explores a methodology to manage the opportunities exposed by a range of measures while avoiding growth in performance-analysis resource. It shows how a focused approach to poor performance using exception reporting can be used to drive up customer satisfaction. Although the measures described are predominantly network based, this methodology can be applied to any cost or quality measure.

Introduction

Measurement of quality of service has been carried out for many years but recently its importance has increased as a means of improving customer perception of a telco. Indeed there have been a number of related articles in this *Journal*[1,2]. However, the general method of measurement involves consideration of the average number of failures or faults.

From a customer's viewpoint, the interest is in an improved level of service which involves fewer faults and speedier response times. Telco measures involve an average number of faults per line or average response time, and there is a growing requirement to publish these results to demonstrate the improvements. As the quality of service improves, the management of improvements using average performance becomes more difficult. The question must be asked: if 90 per cent of customers are receiving a satisfactory level of service, what service do the other 10 per cent of customers receive? Is it marginally worse or considerably worse? It is also possible that some customers may be receiving a considerably better than average level of service. It was as a result of asking these fundamental questions that led BT Worldwide Networks to create a set of *tail measures* that closely monitored performance and set targets for improvement to customers not experiencing average performance (the 10 per cent referred to above).

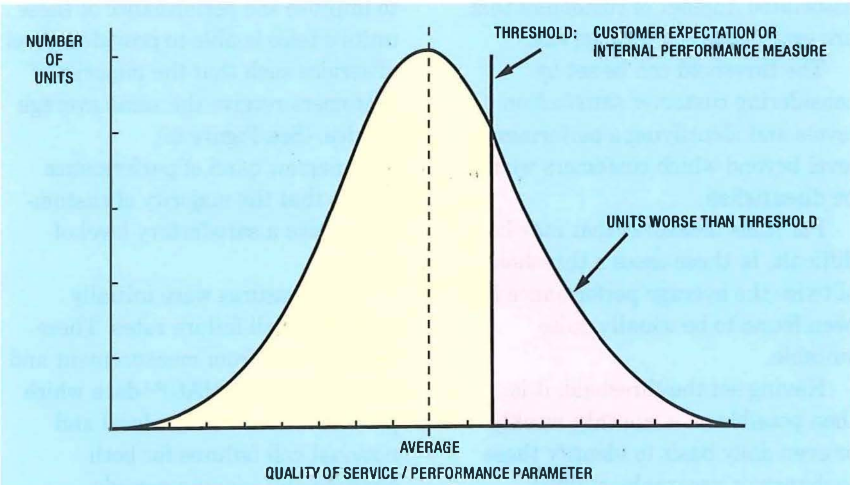
Concepts of Tail Management

The tail threshold concept

Traditionally, performance measures are reported at various management levels as an average. This approach is only satisfactory when the spread of performance is within acceptable limits; if it is not, the poorer performing areas will be masked by the better performing ones.

Performance is usually measured for a particular geographic area, for example a telephone exchange area. The object of tail measures is to identify those exchange units that are under-performing. This is achieved by setting a threshold which indicates the start of the tail (Figure 1), and therefore the

Figure 1—Threshold with a large proportion of customers in the tail



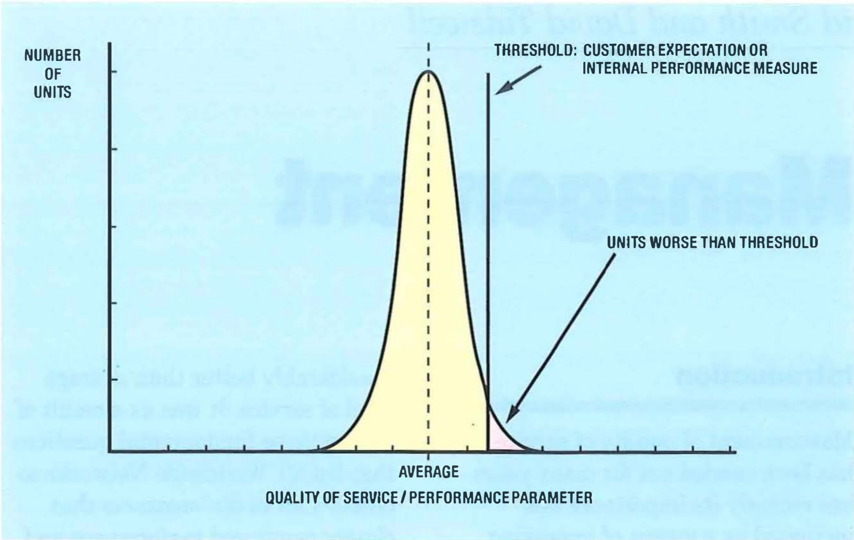


Figure 2—The same threshold with few customers in tail

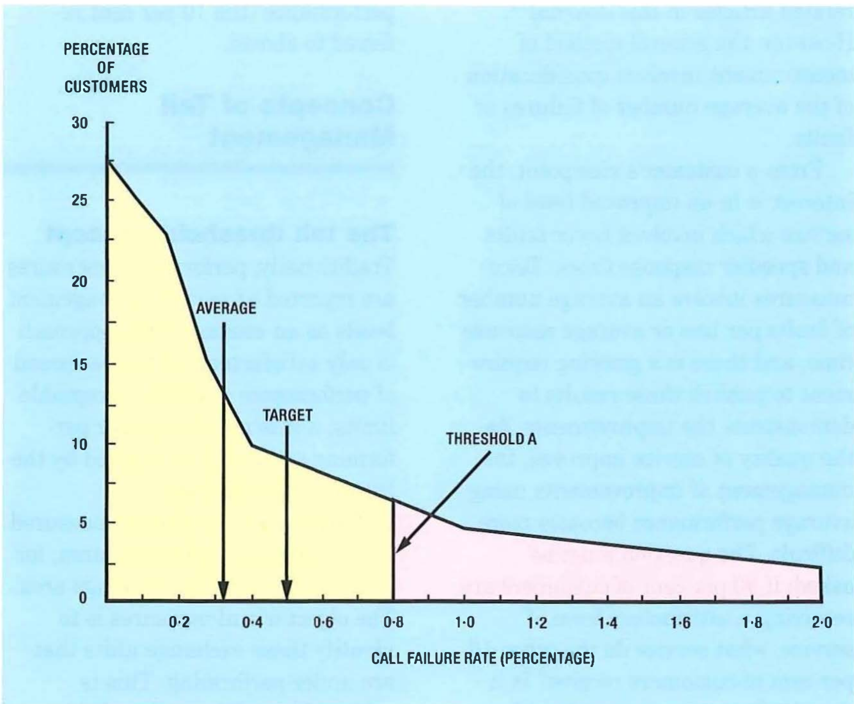


Figure 3—Call failures: tail performance showing threshold A

company can identify the number of exchange units, and hence the associated number of customers that are experiencing a poor service.

The threshold can be set by considering customer satisfaction levels and identifying a performance level beyond which customers would be dissatisfied.

For some measures that may be difficult. In these cases a threshold of twice the average performance has been found to be usually quite suitable.

Having set the threshold, it is then possible on a monthly, weekly or even daily basis to identify those exchange or geographical units whose performance is worse than the threshold. By taking positive action to improve the performance of these units a telco is able to provide a level of service such that the majority of customers receive the same average service. (See Figure 2.)

A narrow band of performance means that the majority of customers receive a satisfactory level of service.

Tail measures were initially applied to call failure rates. These were derived from measurement and analysis centre (MAC)[3,4] data which provided measures for local and national call failures for both daytime and evening periods.

By taking exchange connection information from the A51 fault reporting system it was possible to produce a tail measure showing not only the number of exchange units performing worse than the threshold, but also the number of customers that are likely to experience poor service. This assumes that any unit with a performance level worse than threshold will be deemed to offer all customers on that unit a similar quality of service. The spread of performance for call failure performance is shown in Figure 3.

This shows that although the average performance is better than target the length of the tail was considerable. It has been determined from market analysis that customers were satisfied with a 0·5 per cent call failure rate but, because of the length of the tail, it was decided to set the threshold at 0·8 per cent with a view to eliminating the tail over a period of time. Then the threshold could be reset to a lower value.

After some experience with this type of tail measure and in consultation with operational managers the concept was further refined with the introduction of two thresholds A and B. The 'A' threshold was similar to that previously described, but the 'B' threshold was introduced to indicate immediate action was necessary. Thus it was an operational imperative to eliminate any performance worse than threshold 'B' (Figure 4).

Tail performance analysis is a means of focusing attention on those areas of performance which might indicate a service, either in terms of cost or quality, that falls outside normal customer acceptable expectations.

An example of the application of threshold A is in the area of network call failure performance. The stated target is virtually to eliminate the tail over a period of approximately five years. Threshold B (or the maximum permitted performance) applied to the same measurement indicates action to be taken to meet this threshold over a much shorter term.

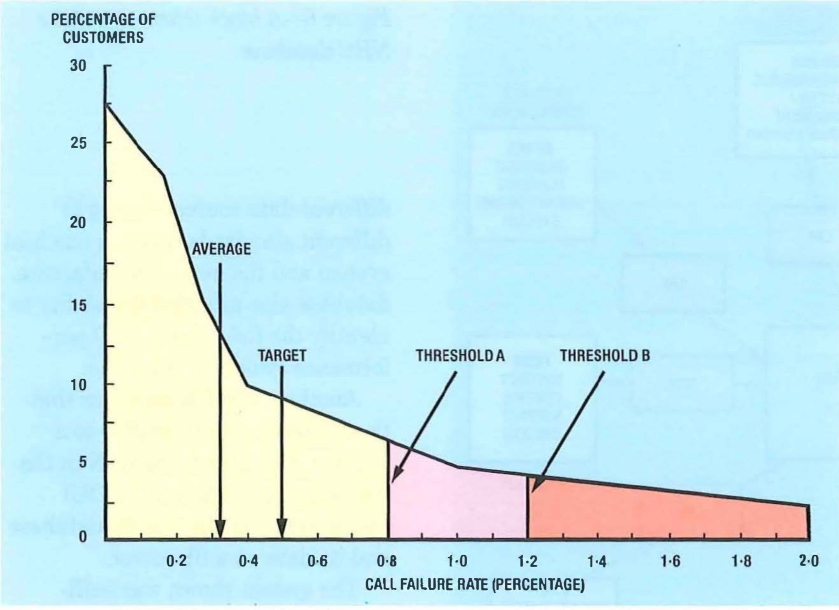


Figure 4—Call failures: tail performance showing thresholds A and B

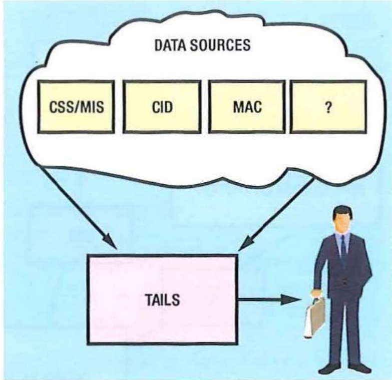


Figure 5—Vision of TAILS data capture

This process is not necessarily designed to improve the overall performance of the network although this may happen by default. However, it is designed to bring up the performance of network operations (both cost and quality) to an acceptable customer standard irrespective of where the customer is within the network.

Although the tail measure principles were first applied to call failure measures, they were quickly applied to other network measures.

Management information System (MIS) for Tails Management

In early 1992, the operational part of the Network Directorate, then called Worldwide Networks UK Operations (WN Ops), commissioned a project team to implement a management information system (MIS) primarily to take the tail management concept and apply it across a wide range of measures, both network and non-network.

WN Ops consisted of nine geographical zones which were responsible for operating and maintaining the UK network. As an example, North East Zone covers the north east of England from the Scottish Borders to the Wash, and from the Pennines to the East Coast, with a customer base approaching two million network connections.

The project team consisted of people from the network performance management teams and field managers from each zone and from Headquarters responsible for operating policy. The aim of the team was to accelerate and share the work done on this initiative and to determine a cost-effective MIS which would be implemented in all zones.

The objective was to develop a system that automatically produced tail performance reports, on an exchange unit (or functional area) basis and to use a 'management by exceptions' approach to direct corrective actions (only those areas in the tail would be reported). This was to ensure that only the tail was focused on for action.

The system was to be engineered to adopt new measures with a minimum of redesign to ensure that the system was quickly upgraded to keep pace with changing requirements. Also, wherever possible, measurement data would be collected electronically and outputs delivered automatically to minimise the manual resource needed to run the system.

The output of the MIS was to be designed to address the needs of appropriate managers at all levels, from the Director to first line managers.

The main areas of performance to be tackled first were call failures, network switch major service outages, and customer process service delivery and productivity.

The team started work in June 1992 and delivered two major releases of the MIS by October 1993.

System design

To enable the selection and design of the tail analysis and information listing system (TAILS) database, an early task was to declare an overall vision for data capture as shown in Figure 5.

This depicts a number of possible data sources including the customer service system (CSS) MIS for access to customer delivery and service level agreement (SLA) measures (definitions of inter-divisional performance standards), central information database (CID) for access to financial data and MAC for network performance data. The TAILS would then manipulate this data and output any suitable tail measurement exceptions to the end user.

Once the requirements of the MIS were understood, the task of assessing possible suitable database systems in the field could be undertaken. This was a necessary task since the only way to deliver the MIS within the timescales would be to adapt a database that had the majority of the necessary elements already developed and proven. The development task would then be to modify the database to deliver the required tail performance data.

Initially, the plans included the incorporation of an action plan generator, with associated procedures for action tracking, but it was decided that this was too ambitious. Instead each operational user would have to determine the appropriate action to be taken following receipt of a tail report.

To enable an objective analysis of the likely databases already in use, each database was assessed using four main criteria for success:

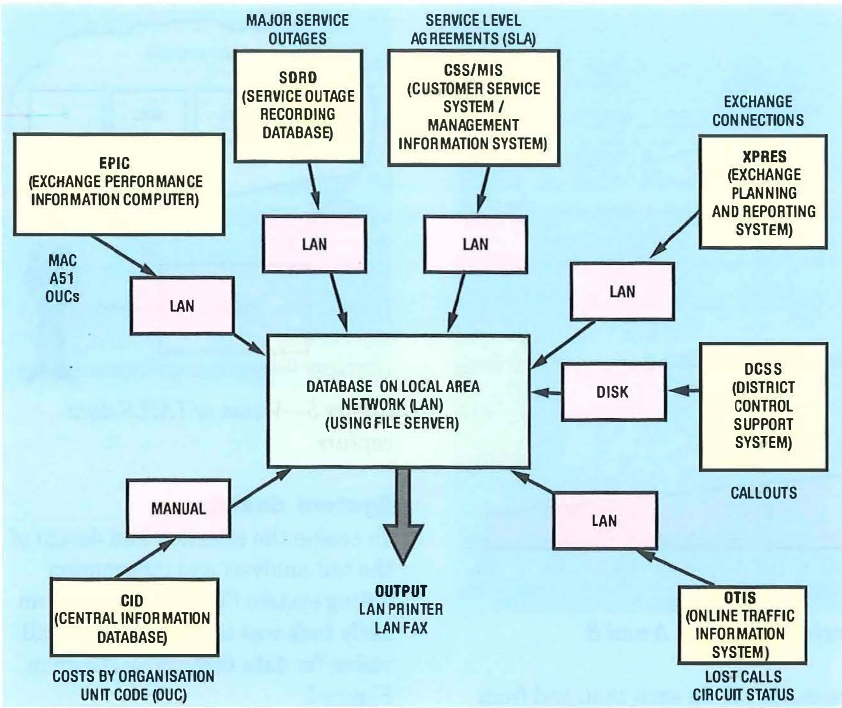


Figure 6—A block schematic of the NHC database

different data sources (owing to different standards between one host system and the next). The reference database also provided the ability to identify the field and control performance owners of the units.

Another added benefit was that the database was accessible to a number of users via the LAN in the network operations unit (NOU) owing to the location of the database and its data on a fileserver.

The system shown was sufficiently robust that it became the basis of both of the major TAILS releases.

flexible electronic input from a number of data sources, the ability of the database to apply tail thresholds, flexible and adaptable outputs and ease of development to meet the deadline. Each WN zone network-performance group was visited to see which system was in use, either for tail management or general management reporting.

From these visits, a short list of three zones (Midlands, Northern Home Counties (NHC) and North West) was produced and a more in-depth analysis of each was carried out including end-user training, system development and support resourcing and future-proofing based upon a commercially available database package. The system chosen was the one developed by NHC. Figure 6 shows a block schematic of the system used by NHC in Cambridge.

In addition to the three data sources shown in Figure 5, the NHC database had access to the exchange performance information computer (EPIC) which was the access to MAC data, customer fault report and zone managers information (organisational unit codes (OUC)), the service outage recording database (SORD) for major service outage (MSO), the exchange planning and reporting system (XPRES) for exchange identities and network connection data, the district control support system (DCSS) for engineer emergency callout data and the online traffic information system (OTIS) for access to network circuit status reports and lost call data.

Also depicted in Figure 6 is the type of data capture used by the database: a mixture of local area network (LAN) access, computer disk transfer or manual input (the CID access was subsequently converted to LAN access prior to delivery of the system to the end users). The system was capable of outputting information via electronic means, facsimile or paper.

The database was written in a proprietary database software called Clipper (a DB4 derivative) running on a 486 PC under the Microsoft disk operation system (MSDOS). The heart of the NHC system was a reference database which was the method of providing links between the unit descriptions from the

Output report design

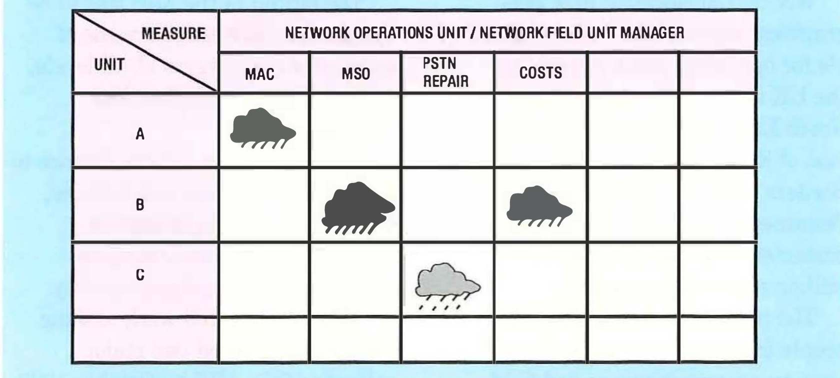
Another task was the design of a TAILS report to illustrate the concepts and enable the development team to start the system output design (Figure 7).

There were two important concepts. Firstly, the report should be targeted at a manager and give him or her all the available tail performance information that was relevant to his/her job. Secondly, only those areas in the tail should be reported; that is, management by exception.

The basic conceptual design was to output a matrix of the manager's unit responsibilities and a list of measures so that the manager could analyse the information either by unit or measure as the situation dictated.

The contents of the report were not declared at this time, since the

Figure 7—Conceptual view of a TAILS management-by-exception report



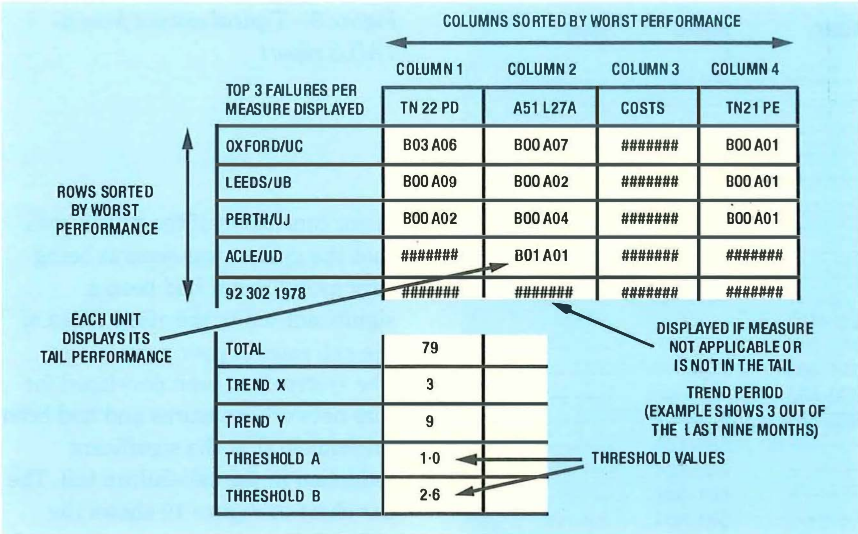


Figure 8—The format of a typical TAILS report

actual data to be output had not yet been determined, but was depicted by a gauge (rain clouds!) to indicate the severity of the result.

Figure 7 was the conceptual view of a tail management-by-exception report developed at the early stages of the project.

It does not represent any particular job in WN nor is it meant to imply one. The picture does, however, imply that for that responsibility there are clear areas for concern, be they light showers or hurricane clouds! The clouds pictured were, of course, replaced by tail performance results indicating which threshold has been broken. As an extension to this, it was decided to list all units for which the manager was responsible even those whose performance did not exceed the threshold. This was done to give some positive feedback to the manager that those units were performing acceptably and the omission of this may have lead to the belief that the tail performance data was missing or corrupt.

System development

Following the selection phase of the project, the NHC development team set to work in adapting their database to reflect the requirements of the TAILS.

The main difficulty of the development was not the design of the system, or its creation, but the ability to gain secure and stable access to the host systems; this was due in part to the variety of the operating environments of these systems, computing platforms and data transfer capabilities. The fact that the pilot system was delivered on time was in no small way a tribute to the tenacity and patience of the NHC team. Version 1 of the system was successfully launched in the North East Zone in November 1992 and installed in all zones by March 1993.

After a period in service there were some modifications required and some additional functionality added. In October 1993 the second major release was delivered.

One of the new functions of the new TAILS included automatic sorting of the measures into priority order from left to right on the report. This was achieved by using a combination of a measure 'weighting factor' to rank each measure in order of its importance, and a volume figure to give an overall priority score; this was performed whenever a report was ready for output. The original function of listing each unit in the order of its performance (worst at the top) was retained. The intention of these was to assist managers to home in on the performance that warranted the most urgent attention.

The output formats also included trend analysis options whereby any measure could be analysed for any combination of 12 months (if the data was available) ranging from a one month out of one (the last month result) to 12 months out of 12; that is the unit would only appear in the report if the threshold for that measure was exceeded for all of the previous 12 months. This was to allow some of the more underlying performance trends to be exposed (for example, by choosing a 12 out of 12 scenario, a consistently poor performer would not be masked by a serious 'one off' occurrence). Additionally the user could specify how many units should be displayed (for example, the top three, or top ten, or all units) and profiles for each functional manager were supplied with the system to assist the operational users to set up the actual profile for the zone.

TAILS Outputs

The design of the report for the second release of TAILS is shown in Figure 8 with an explanation of the fields and their contents.

Figure 9 shows a typical extract from a TAILS report including the first 'non-network' performance measure attempted, which was a motor transport measure (from a system called DRIVE) to indicate fleet vehicles under-utilisation. Reference information for each measure was also included in the report to indicate the current status of the threshold values used, trend values and the totals for each measure.

Some additional functionality which resulted from user feedback included 'what if' scenarios—these enabled the operations people to either predict performance at a more critical threshold, or by selecting a more relaxed threshold, home in on the very poor performers. Other features included the ability to download reports into Excel spreadsheets (to enable the TAILS report details to be included in management reports), and a specialist report format to mirror reporting arrangements for managers' objectives.

Use in service

From the initial roll-out, a national user forum comprising network performance people from all zones was put into place and regular feedback was received from this forum and from the national performance managers' meeting. During

TOP 10 FAILURES PER MEASURE DISPLAYED	DRIVE	SORO	DRIVE	DCSS
925566005	B04-A04	---------	B01-A03	---------
923011393	B04-A04	---------	---------	---------
903011150	B04-A04	---------	---------	---------
923010440	B03-A04	---------	---------	---------
905560577	B03-A04	---------	B01-A04	---------
925562333	B03-A03	---------	---------	---------
923011224	B03-A03	---------	---------	---------
903072356	B03-A03	---------	---------	---------
923012074	B03-A03	---------	---------	---------
925561041	B03-A03	---------	---------	---------
SLOUGH B	---------	B03-A03	---------	---------
BASINGSTOKE/B/O	---------	B00-A04	---------	---------
CAMBERLEY D	---------	B00-A03	---------	---------
READING/SOUTH C	---------	B00-A03	---------	---------
SLOUGH F	---------	B00-A03	---------	---------
905560504	---------	---------	B03-A04	---------
923010995	---------	---------	B02-A04	---------
923010997	---------	---------	B01-A04	---------
893000225	---------	---------	B01-A04	---------
925564195	---------	---------	B01-A04	---------
925564929	---------	---------	B01-A03	---------
893000009	---------	---------	B01-A03	---------
RG/TK PW	---------	---------	---------	B03-A03
RG/TK TRS	---------	---------	---------	B03-A03
LOL/B TRS	---------	---------	---------	B03-A03
HY PW	---------	---------	---------	B02-A03
BLR PW	---------	---------	---------	B02-A03
LOL/B PW	---------	---------	---------	B02-A03
NU PW	---------	---------	---------	B02-A03
BLM PW	---------	---------	---------	B02-A03
GI/B PW	---------	---------	---------	B02-A03
GI/B TRS	---------	---------	---------	B02-A03
TOTAL ITEMS FAILING	0070	0005	0027	0027
MONTHS OVER THRESHOLD	3	3	3	2
ANALYSIS PERIOD	4	4	4	3
THRESHOLD A	3.0000	12.000	500.00	4.0000
THRESHOLD B	5.0000	48.000	200.00	6.0000

Figure 9—Typical extract from a TAILS report

the early months of use in the field, there was a great deal of debate regarding the contents of the reports, mainly due to the various levels of understanding of the tails philosophy and changes to responsibilities arising from the newness of the organisational build in the field since the formation of WN. As a result, there was a need to revise the TAILS outputs to reflect these and, following a review in March 1993, it was agreed that there would be a second release of TAILS later in the year.

The most urgent need for tail information was in the network call-performance and network switch-outages areas. The information was actively used by the performance managers to drive corrective actions into the field. An example of this approach was the use of the TAILS output to influence the exchange modernisation programme to ensure that the poorly performing units were replaced at an earlier time than would otherwise have been the case. A more indirect effect of producing the TAILS reports was the increased awareness of a number of groups of people, particularly in the area of network utilisation, where the loading of network routes was looked at using the tail performance philosophy and changes were made to network capacity to reflect these.

As time went on, the most encouraging feedback was the urgent need to include more measures in the report that are network oriented and also on cost effectiveness. A prime example of this was the use of fleet vehicle measures to enable selection of individual vehicles for replacement or disposal. Additionally, to re-enforce the TAILS output use, there was a strong demand to ensure that senior zone managers continued to be supplied with regular outputs.

In the latter part of 1994, a substantial review of TAILS was performed using a combination of questionnaires to all users and interviews with the majority of the TAILS owners within the zones. An excellent response was received with a consistent view emerging from the majority of the respondents; the major conclusion of the review was that the system was seen as being very useful and it had been a significant aid to the elimination of the extremes of poor performance. The system had been developed for core network measures and had been instrumental in the significant reduction in the call-failure tail. The bar chart in Figure 10 shows the scale of the reduction in numbers of customers in the daytime local-call tail measurement since the introduction of tail management philosophy.

Looking to the future, the view supported by the review is that the system needs to be grown by the addition of new measures that concentrate on delivery of service to customers rather than internal core network measures. This will then enable the tail philosophy to further assist the network organisation to meet the challenges of consistently improving customer perception.

Conclusion

By considering the level of service that gives customer satisfaction, and then concentrating on those customers who are in the tail, and hence receiving a worse than average performance, it is possible to identify those exchange units that are under-performing. Once corrective actions are put into place, then the quality-of-service improves. This approach has been demonstrated to be effective for the network quality of service measures, and there is no reason to suppose that the approach cannot be used for any type of quality, cost or effectiveness measure.

The management information system that was designed and adapted to collect and manipulate the tail performance data has provided operational managers with a clear indication of exchange units that are under-performing by identifying the measures that are in the tail (that is, exceeding the threshold). Further analysis of the tail could be undertaken using trend analysis over a period up to 12 months.

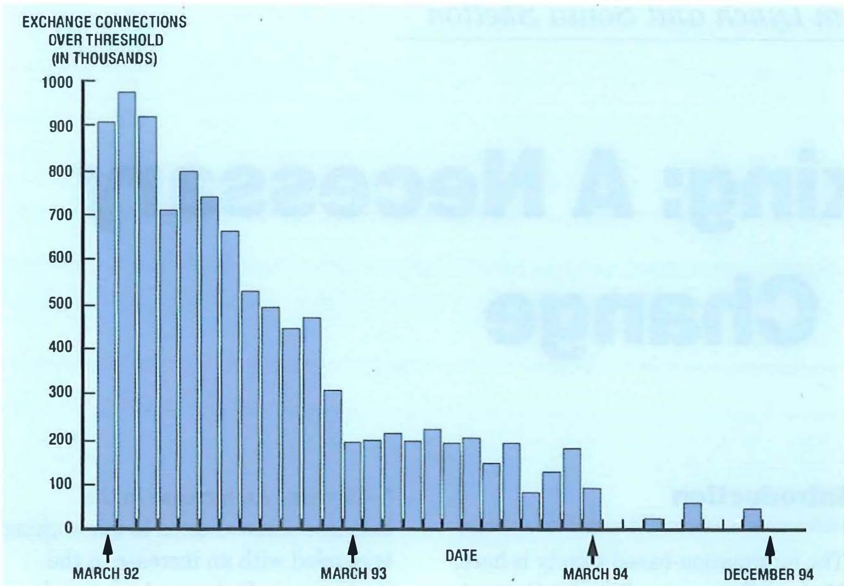


Figure 10—Improvements since the introduction of tail measures

This has enabled operational managers to take effective corrective action in a prioritised way, as the system shows which units are the worst performing.

Furthermore, by being able to supply detailed information on tails performance to all operational managers in the Worldwide Networks division, it has successfully facilitated the introduction of the tails philosophy into the 'bloodstream' of the division.

Although the systems described in this article have been used mainly for network measures, call failures, network fault reports and exchange downtime, the system is flexible enough to be able to deal with other non-network measures; for example, safety, vehicle utilisation, or personnel.

In the current competitive environment, the quality of service provided is a major factor in maintaining and improving market share. It is therefore necessary to eliminate, where possible, any performance that causes customer dissatisfaction. Indeed, there is now a strong desire by many service providers to seek to delight their customers. The approach to tail management outlined in this article goes a long way to making sure all customers receive the quality of service they desire.

Acknowledgements

The authors wish to thank the members of the tails quality improvement team for their contribution to this article. Thanks are also expressed to Brian Wood (BT Network Performance, WN) for his early work on the tails concept and the development of the call failure tail measures.

Biographies

David Smith
BT Networks and Systems

David Smith joined the British Post Office as an apprentice in 1966 in the Birmingham Telephone Area. In 1977, he was employed at the British Telecommunications Engineering College as a trainer on network switch technology, progressing to training design of System X maintenance courses. In 1983, he joined National Networks (later evolving into Worldwide Networks) headquarters in a digital switch maintenance policy role and ran transmission and trunk switching in the North East Region until 1991. He then moved into Worldwide Networks Operations Network Support Unit and was responsible for network performance monitoring and target setting. He is currently an operational manager within the Network and Service Operations Central Support Unit.

David Tidswell

In 1959, David Tidswell joined the British Post Office as an apprentice. He has spent much of his career in network planning and operations, covering a range of jobs. In 1983, he became Deputy General Manager and then General Manager of South London Area. He was later appointed to be Technical Director for the Canary Wharf project, a fully digital, optical-fibre network in the London Docklands. He went on to manage a number of local optical-fibre projects. When the company reorganised in 1991, he headed a unit responsible for network quality of service. This was followed by a time leading a team developing the business plans for Worldwide Networks. David is a Chartered Engineer and a Fellow of the IEE. He is now working as a telecommunications consultant.

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Tom Lynch and Sonia Skelton

Teleworking: A Necessary Change

The information-based society, supported by information technology and advanced communications infrastructure, will inevitably lead to flexible organisations and new ways of working. An example of this is the rise in the prominence of teleworking.

Introduction

The information-based society is here. Michael Carpentier, Director General of DGXIII, has observed that 50% of employment in Europe now involves information management and 80% of new jobs are created by small businesses in the service and information sector[1]. Even in sectors not traditionally associated with information technology (IT), information processing constitutes a major element of the production and delivery process. For example, today 50% of the value of a car is in its information content (conception, design, marketing, sales, operation of assembly). This proportion can be expected to increase.

In response to rapidly changing and highly competitive markets, organisations are focused on cost reduction and organisational efficiency. In the UK, 90% of large organisations have carried out restructuring in the last 5 years. Managers now are expected to operate in a more flexible manner and need to add new skills to existing ones. Of those managers who survived restructuring programmes, 75% had seen an increase in their responsibilities and workload, requiring access to new sources of information[2].

The information-based society, supported by IT and advanced communications infrastructure, will inevitably lead to flexible organisations and new ways of working. A prominent example of this is the rise in popularity of teleworking.

This article explores the factors that will support new workstyles and the technologies and applications that can be employed to implement changes successfully within the next 5–15 years. An increase in the business sectors suited to teleworking is coupled with an increase in the deployment of advanced communications applications and IT in the workplace. Industry characteristics, such as a high degree of competition, increase the probability that advanced communications will be used to differentiate an organisation from its competitors.

Although the focus of this article is on teleworking, many of the observations apply equally well to other aspects of the future working environment. This is not intended to provide a definitive picture but to provide a view that will stimulate further thought on the issues raised.

For the purposes of this article the following definition of teleworking is assumed:

'Teleworking is a flexible way of working which covers a wide range of work activities, all of which entail working remotely from an employer, or from a traditional place of work, for a significant proportion of work time.... The work often involves electronic processing of information, and always involves using telecommunications to keep the remote employer and employee in contact with each other.

This definition excludes traditional "outworkers", as well as people who work at home very occasionally, but includes:

- *people working at home,*
- *people working from home,*
- *people working at work centres, and*
- *people working at two or more of these locations[3].'*

Advanced communication networks and services will greatly increase our ability to access information remotely, and therefore increase the attractiveness of teleworking as an accepted workstyle.

Teleworking Drivers

Trends in the use of advanced communications

The success of teleworking will depend on our ability to use telecommunications and IT to access information to do our jobs. Advanced communication networks and services will greatly increase our ability to access information remotely, and therefore increase the attractiveness of teleworking as an accepted workstyle.

Table 1 lists some of the characteristics which, if exhibited by companies, imply advanced communication deployment[4]. These factors are, largely speaking, independent of the actual business of a company; they are dictated more by the structure of the industry and the relative position of the company within the product value chain.

Using the criteria listed in Table 1, some key areas have been identified where new opportunities exist for advanced communications. These are shown in Table 2. Many of the functions described could become location independent.

Requirements of the future organisation

Future organisations will be operating in a business environment characterised by rapid change and intense competition. The concept of the virtual office has been offered as a means by which companies can change in order to thrive. The virtual office will allow people to work effectively together, sharing data and tasks, independent of their physical location. It will encompass a number of different types of new flexible working practices, including home working, but will also involve many people working in 'regular' offices—but these may, however, be smaller and more widely scattered.

The labour market

The trend away from vertical and horizontal integration, and back to corporate focus on core business,

Table 1 Characteristics of European Businesses Likely to Deploy Advanced Telecommunications Applications

Characteristics	Rationale
Degree of competition	The more competitive, the more likely to use advanced communications applications to differentiate
Size and nature of customer base	Broad customer bases do not lead to direct customer contact by telecommunications, unlike business-to-business transactions
Value and nature of product	High-value products and funds transfer applications are most likely to use advanced communications
Volume of products	Production of high-volume components needs applications to control stock levels and optimise cash flow
Nature of production process	The nearer to continuous processing, the more advanced IT usage
Degree of centralisation	Highly distributed companies need communications applications
Company size	Some communication applications have a higher profile in those sectors with a small number of large players

Table 2 Employment Sectors Likely to Implement Advanced Telecommunications

Sector/Sub-Sector	Industry Trends	Job Functions
Finance	Increasing competition. Broadening customer base. Consumer applications.	Telesales. Telemarketing. Telephone enquiry agents.
Retailing	International competition. Perishable product: time criticality. High cash flow. Centralised purchasing for distributed outlets.	Stock control, just in time. Finance functions. Remote monitoring and control.
Manufacturing	Competitive. High-value products. Many components. Computer-defined manufacturing processes.	Stock control, just in time. Finance functions. Remote monitoring and control.
Professional services	Competitive. High-value product. Diverse communications partners. Information intensive.	Customer interface. Cooperative remote working. Graphic design. Copywriting.

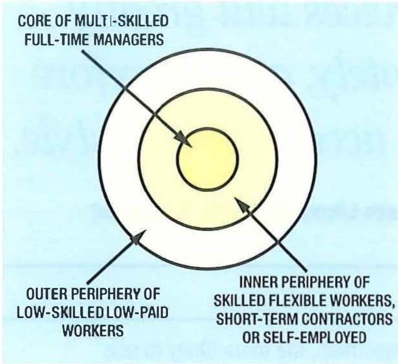


Figure 1—The dual labour market

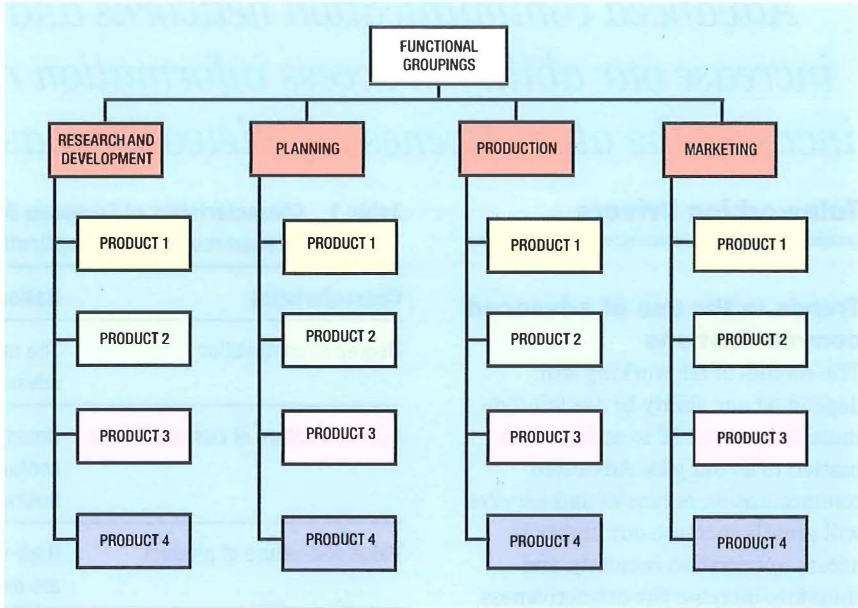


Figure 2—Traditional company organisation

implies fewer staff and (probably) fewer skills. The correct identification of core skills and their quality will be critical to companies' success. Figure 1 illustrates how the labour market may look.

The inner periphery workers will be likely to telework largely under their own control in a professional capacity. Those within the outer periphery are most likely to do piece work remotely, and be disadvantaged by losing their permanent employee status.

Accessing and engaging temporary staff for short-term projects will be facilitated by communications networking. 'Agents', both those seeking work and those attempting to resource it, will be able to trade in an electronic marketplace. There is evidence today that managerial staff are becoming more mobile: a European manager can expect to change job once every 6 years, a US manager, once every 3 years[1].

The move towards globalisation, which telecommunications technology has facilitated, will lead to international teleworking. Future automatic text and speech translation will enable the formation of teams across cultural and international boundaries. Investment in international communications infrastructures may be such that international teams of teleworkers may occur before organisations adopt teleworking nationally. The effects of time zones, differential labour rates and work practices are much more pronounced on an international scale. Therefore, the potential perceived benefits of teleworking from an employer's perspective are commensurately greater with 24 hour shifts at day rates.

However, the existence of different national and cultural characteristics may mean that a single managerial style or approach may not be universally applicable[5]. It may be postulated, therefore, that cost and availability advantages gained from access to a global workforce, may in part be eroded without careful consideration of the management issues involved.

The organisation of the future

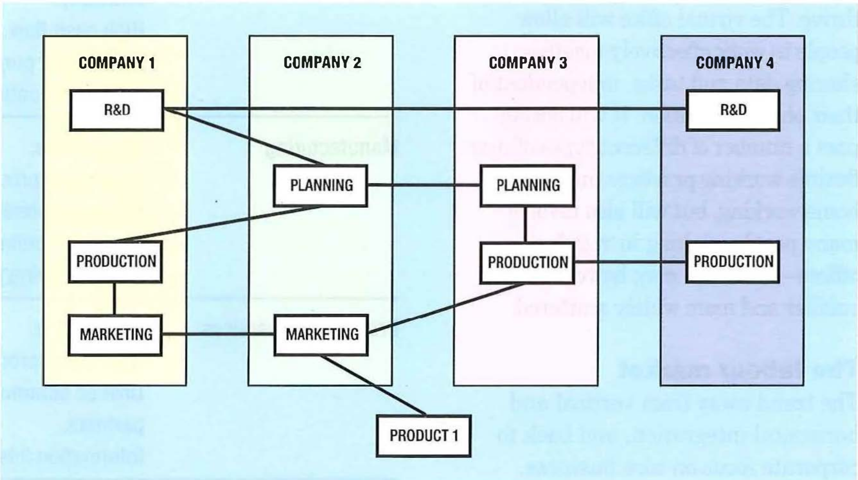
Future requirements of organisations are unlikely to be satisfied without substantial changes to corporate structures. Figure 2 illustrates a typical organisation structure of today. The structure tends to be static and, generally, the major functional areas are staffed by employees with skills for that function alone.

Organisational change and business process re-engineering in response to competition are encouraging companies to re-examine how they resource projects. MCI could be considered to be a virtual organisation. Its management system is a 'shared idea'. The organisation can reconfigure itself rapidly by maintaining a flexible, dynamic and non-bureaucratic organisational form. Principles, value and culture hold the company together, not structure and rigid management systems[6].

Improved telecommunications will enable businesses to draw on resources from other companies and individuals when the need arises. An example of such a working arrangement is illustrated in Figure 3.

Product 1 could be said to have been developed by a virtual company: human and technical resources, from **a number of different companies**, working together **temporarily** for the duration of a single product's

Figure 3—The virtual company



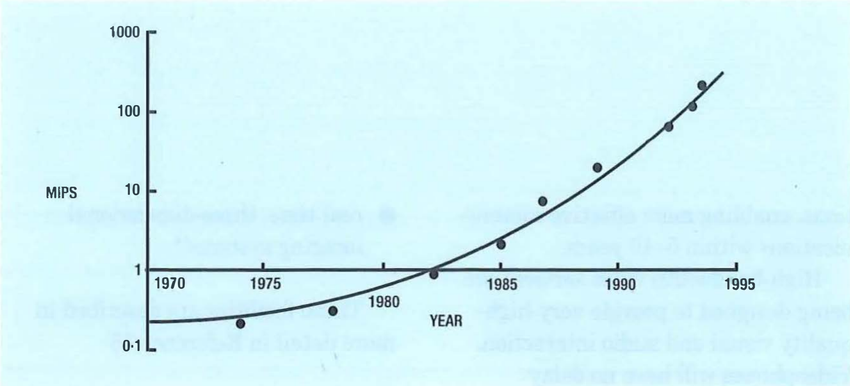


Figure 4—Microprocessor speeds over time

development, manufacture and launch. This could lead to a range of specialist companies who will provide a particular function to a range of corporate customers. These companies will have a very small fixed employee base and will consist mainly of a network of self-employed individuals with a varied skill set who will come together to form teams appropriate for a specific project.

Business process re-engineering

Business process re-engineering is helping to accelerate the advance of distributed computing as organisations try to put more computing power in the hands of the average worker. Electronic access can reduce dependency on rigid vertical channels of communication sometimes enabling the reduction of layers of management.

This trend in business management is expected to continue. It offers great potential for teleworking. Teleworking could be incorporated as part of a process re-engineering initiative. Re-engineered processes and workflow applications are generally supported by IT systems. The communications aspects of accessing these systems remotely could be included explicitly.

Legislation and the environmental imperative

In the United States, new legislation is putting pressures on employers to pursue ways for employees to work from, or closer to, home. The Clean Air Act 1990, which took effect in November 1992, forces employers in areas of high pollution to find ways to reduce the polluting effects of commuting.

At the European Summit in Copenhagen in June 1993, the EC invited proposals for action to stimulate teleworking and to assess its impact. Teleworking in Europe is seen as being of crucial importance to Europe's economic development[7,8]. These moves themselves will not directly lead to an increase in teleworking. However, they make a contribution to the attractiveness of teleworking alternative, in terms of cost and practicality.

Computing and communication trends

The growth in employment within the service sector has resulted in a corresponding growth in the number of individuals that can be considered to be information workers. The Information Intensive Individual, or I3, can be defined as an extensive user of IT, both at work and at home. These individuals have an increased tendency to work from home at present.

Attitudes of those who have a computer in the home are even more positive towards teleworking than those who use one at work[9]. With an increase in computer literacy, the general population could be expected to take advantage of falling prices and increasing functionality of IT in general. The 'push' for teleworking from employers responding to changing business pressures may well be answered by a corresponding 'pull' of interest from the working population.

One of the fastest growing sectors of the entertainment industry is that of video/CDI games. Interactive games are becoming increasingly popular, allowing players to compete against the game and each other. Already games can be linked over the telephone network for games between players at a distance. With high-bandwidth optical-fibre communication, the scope for game development is boundless. In the future, interactive high-definition television (HDTV) and virtual reality entertainment applications will enter the home.

Figure 4 indicates rapid growth in computer processing speed. As can be seen from the diagram, there is approximately a hundredfold increase in processing speed, as measured in MIPS (millions of instructions per second), every 10 years or so.

It is likely that this trend will continue beyond 2005. The increase in processing power at reduced cost will lead to greater amounts of affordable processing power in the home. An increase in home IT facilities would boost the attractiveness of teleworking from home.

Technologies, Applications and Networks

Technologies

The key developments that will facilitate effective remote working are those which allow people to replicate the way they interact in a centralised workplace. Managers currently spend (approximately) 25–50% of their time in meetings or some form of interactive communication activity[10,11]. Communication occurs in many different ways: by speech, writing or drawing, by pointing and manipulating, and by a wide range of facial expressions and other non-verbal forms. One of the most frequently stated disadvantages of home working is the sense of isolation and lack of social interaction. Formal contact, such as team meetings, and informal communications channels, such as the chance meeting and the coffee break, can easily be lost when not physically present in the office.

Widespread adoption of teleworking requires technologies that will provide this range of human and machine communication between people on a global basis. The technologies currently used—telephone, fax machine and e-mail—fall far short of this ideal. New technologies will largely overcome current limitations, enabling more effective communications within 5–10 years.

High-bandwidth video services are being designed to provide very-high-quality visual and audio interaction. Videophones will have no delay between image and voice and will be of very high resolution. Facial expressions will be clearly visible and conversations can occur at the normal speed of a face-to-face encounter. In parallel, display-screen technology will enable much larger screens to be developed, so that the video image is actual size. If this is combined with wrap around screen presentation, which occupies almost all of one's peripheral vision, the effect is to submerge the caller in the screen image.

The office or workplace for the telecommuter will be radically different from that of the present. In a recent trial, participants were able to converse with each other using video cards in a standard PC (BT's VC8000) connected to standard ISDN links[12]. In the future, higher-bandwidth capabilities delivered to the desktop will enable even greater image quality, enhancing the potential uses of these systems.

Extensive use of *hot-desking*—sharing of office facilities—will depend on the ability to provide information across a wide area in an efficient manner. Whether at home or in a remote site, the desk of the future will be much more active than at the present. It will feature a number of facilities, such as the following:

- a large rear-projected HDTV monitor for computing, videoconferencing and electronic whiteboard facilities;
- a liquid crystal display (LCD) shutter in the screen with a video camera for remote eye-to-eye contact;
- 'hands-in-the-screen' interfaces;
- speech recognition by machines[13]; and
- real time, three-dimensional imaging systems[14].

These facilities are described in more detail in Reference 15.

Applications

Groupware

The term *groupware* is used to describe software products which help groups of users to cooperate and share information. Products in this category range from messaging and mail packages to products which help schedule or run meetings, and systems which allow users to share documents and workflow packages.

In a future teleworking environment, groupware products are likely to play a major role. The ability to schedule meetings, interrogate databases, obtain on-line support and communicate on a social basis with work colleagues is crucial to the substitution of centralised working with a teleworking solution.

Intelligent databases and automatic text summarisation

Isolated workers may find it time-consuming and stressful searching through large information sources for the information that they require. This is most prevalent for information delivered in more traditional broadcast modes such as TV. However, stress may be reduced by information filtering. Intelligence within the network or in the user's own environment could be used to filter information in a manner that reflects the work patterns and preferences of the individual.

Intelligent agents can be used to learn the habits of the user when selecting or accessing data. The agent can then select data, not from a list of preferences, but from the working habits of the user.

Even with intelligence in the network to filter out a subset of the vast amount of information available, there is still a possibility of information overload. For example, there may be a large number of long articles which contain only a small amount of information of interest. Trial systems have been developed which allow the automatic summarisation of articles[16]. The teleworker could therefore be presented with filtered and summarised information which will minimise the time necessary to select data of interest.

Teleworker support systems

Whether the teleworker is in the home, in the car, or in a remote centre, the provision of support, both technical and nontechnical, will be vital. A number of tasks concerned with maintenance and support need to be performed on-line and essentially in background. For example, new systems implementations would be carried out over the network as would database management and maintenance functions. These operations should be transparent to the operator and, where necessary, training for new versions must be provided. In many cases, personnel may work alone, and therefore a sufficient amount of time must be allocated for training so that pressure of work does not lead to insufficient familiarity with new versions of software. The use of groupware would allow an on-line help system between users as well as the operational and administrative support functions. The interaction of these with video applications would enable the sharing of screens so that an interactive help facility would be available.

The essential element of these interactions is the personal touch. Present-day videophone and small-scale videoconferencing facilities do not give sufficient quality to remove the need for face-to-face meetings altogether. Even with high-bandwidth video communications, it is unlikely that personal contact between a manager and his or her team will be completely replaced.

Networks

Currently, technology solutions are supported on the ISDN platform. The increase in processing capability and the use of interactive video applications will lead to a demand for communications bandwidths which can be supported only by optical-fibre systems.

There may be decentralisation where business parks, etc., that justify the capital cost of connection to the main fibre highway, are set up away from built-up areas. Teleworking centres could then be set up to exploit the advanced communications facilities which would result from connection to the fibre network. Requirements for advanced facilities would therefore limit the location independence of these workers.

The demand for increased bandwidths will not come only from increased processing capabilities and the associated man–machine interactions. The increase in intelligence, in both machines and the network, will rapidly increase the transactions carried out between machines. These interactions will be limited only by processing speeds and network capabilities, and not by time of day as in the human case. Potentially, the demand on the network could be dominated by the machines themselves.

Table 3 summarises typical uncompressed bandwidths for a range of services and how they could be supported to the home over fixed media. In each case, service quality will be greatly improved in the future with higher bandwidth fibre networks.

Table 3 Typical Bandwidth Demands of Some Selected Applications (broadcast quality, uncompressed)[17]

Application	Typical Bandwidth	Supported by
Telephony, e-mail, fax, data on demand	64 kbit/s	Copper pair/fibre
PC-based videophone	128 kbit/s minimum	Copper pair/fibre
Colour fax, file transfer	2 Mbit/s	Copper pair/fibre
Local area network (LAN) interconnect	1–100 Mbit/s	Copper pair/fibre
Metropolitan area networks (MANs)	10–50 Mbit/s	Copper pair/fibre
2-way, broadcast TV quality video services	45–120 Mbit/s	Copper pair/fibre
Interactive HDTV	150–800 Mbit/s	Fibre

Mobility

In the far future, we will have 100% access, anytime, anywhere, anyplace, to a full range of multimedia services via small pocketable terminals.

Important considerations for mobile users are:

- *roaming capability*—allowing users to move between cells and be tracked by the network,
- *hand-over capability*—allowing users to move between cells during calls and have the call maintained,
- *visitor registration*—allowing users to visit remote sites and have their calls forwarded via the local wireless PBX, and
- *feature transparency*—allowing mobile users to enjoy the same level of features as wired extensions.

Mobility at the workplace

Within the office, whether at home, at a central location, or at a remote site, there will be a need for flexibility in terms of people and workspaces. Cordless technologies and wireless LANs will enable the rapid reconfiguration of the workplace. Such technologies are available and will interwork with network services such as the integrated services digital network (ISDN). High-quality video and voice applications with transmission rates of 10 Mbit/s will be supported by 1996. In the future, optical wireless systems, analogous to radio, will allow even greater bandwidth communication around the workplace.

Mobility away from the workplace

GSM, a digital mobile standard, supports high functionality communication throughout Europe. In the future, personal numbering will allow a person to be location independent and to receive a wide range of intelligent services. Smart cards can be used as personal security devices as well as storing workplace configuration information. Inserting a card into a piece of terminal equipment and entering an identification number, will allow access and automatic configuration to the user's individual needs.

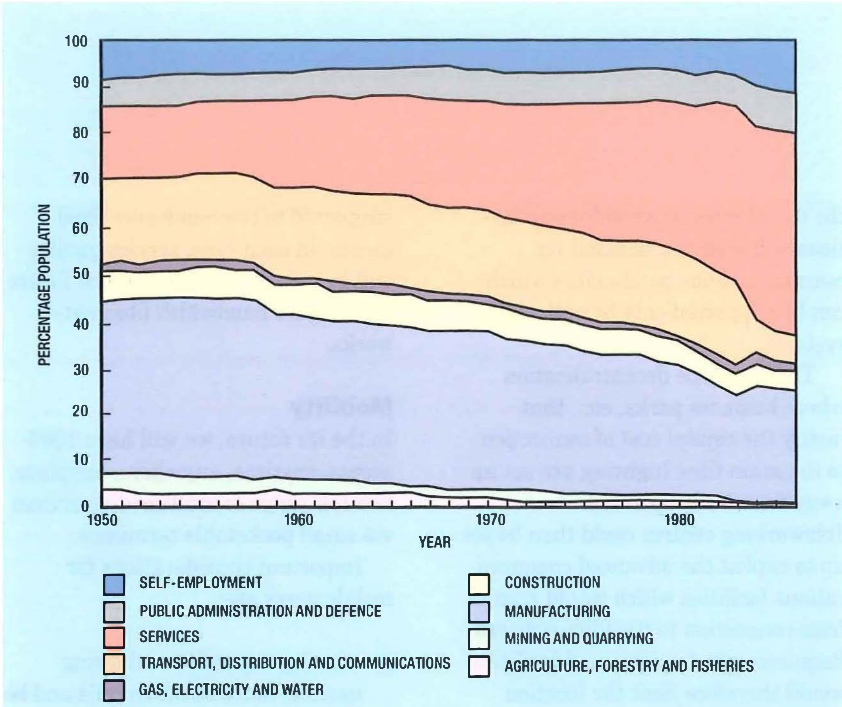
The next generation of mobile technology will integrate cellular, business and residential cordless communications. It will have increased quality and support flexible high-bandwidth services. Standards for this new unified technology are not expected to come into existence until around 2010.

Mobile equipment

There has been a change in the development trends for mobile equipment. The future will see a focus on communication capability. A need for reliable remote access to systems and applications via fixed and wireless technologies together with wireless network management services will drive new developments.

Looking to the future, the personal digital assistant (PDA) will act as the main communications channel for the

Figure 5—Distribution of UK working population 1950–1986 (Reference 19)



mobile worker providing mobile telephone and data entry and receiving capabilities. It will be able to send and receive faxes as well as possessing some limited imaging capability.

The interface to PDAs will be considerably improved by pen-based systems recognising handwritten instructions. Artificial intelligence within the terminal will also allow a machine to 'learn' an individual's handwriting and thus reduce errors in recognition. This interface will facilitate the uptake of mobile computing even by those who are unfamiliar or uncomfortable with a keyboard and mouse.

Widespread Adoption of Teleworking

Benefits of teleworking

Although people have been teleworking for some time, significant progress has come only in recent years with the advent of new 'affordable' technologies. The most influential is the cheap, yet powerful, personal computer.

Employers are most likely to encourage remote working for its benefits. The major motivating factors can be split into four broad categories[18]:

- retaining employees,
- overcoming staff shortages,
- keeping growth up and costs down, and
- increasing productivity.

Employees may benefit in different ways:

- flexibility in working hours,
- avoiding the chore of commuting,
- the entrepreneurial aspects of becoming a self-employed teleworker.

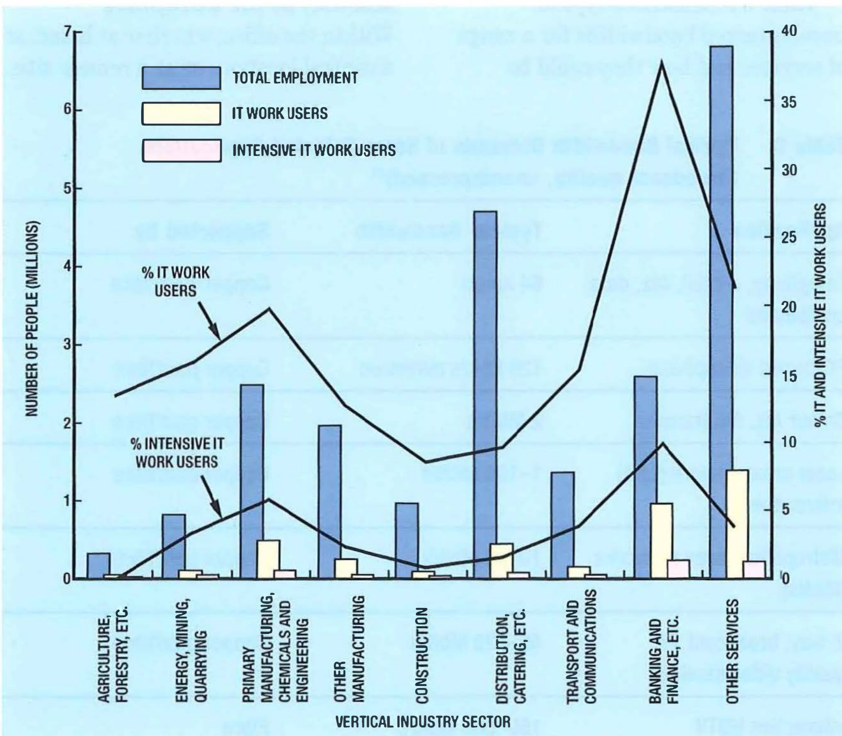
Department of Employment figures show that around 1·5 million people currently telework for three or more days a week, a figure that is currently growing at around 7% a year.

Business sectors suited to teleworking

The success of teleworking will depend on our ability to use telecommunications and IT to access the information necessary to do jobs. The increase in the service and communications industry sectors and the reduction in the traditional manual labour based sectors, illustrated in Figure 5, has meant that there is an increasing proportion of the employed population whose occupations could become location independent.

Figure 6 shows current use of information technology by employment sector. Effective teleworking is facilitated by an acceptance and familiarity with computer equipment.

Figure 6—Employment and IT use in the UK



The acceptance of teleworking in the home will depend on the acceptance of the computer in the home and the social ramifications that will ensue.

Therefore, those sectors of industry using IT at present could be expected to be in a better position to capitalise on the benefits of teleworking in the near future.

Inhibiting factors

The evolution to wide-scale adoption of teleworking will depend on a number of factors. The technology to provide the majority of requirements is already available. However, the cost of the equipment, as well as that of communications, is high. It can be difficult to demonstrate clear monetary cost savings to businesses. In addition, attitudes to teleworking from both employers and employees is not wholeheartedly positive for a number of reasons. Each of these factors is considered below with a prognosis for overcoming the barriers.

Familiarity with IT

The acceptance of teleworking in the home will depend on the acceptance of the computer in the home and the social ramifications that will ensue. Many of the barriers will disappear for the next generation of workers[20]. With the widespread use of computers in schools and the boom in the games markets, especially in the male 5–15 age group, the demand for computers in the home will increase. This will also create demands for multimedia services such as video on demand, teleshopping, interactive networked games, etc.

The use of computer-based technology in the home will become commonplace and related usage for work purposes will only be a subset of its purpose. This will bring large changes in lifestyle. It has been observed that, in households that had computers, the amount of television watched reduced and the amount of time spent with other family members also reduced[20]. There could therefore be tensions in domestic relationships associated with inappropriate use of computers.

The increasing dominance of information-based occupations could lead to a two-tier society. Those who cannot use, or afford to use, the new technology will be unable to undertake much of the available work. Unless society takes steps to address this concern, there is a risk that the information 'have-nots' could form a poor underclass, representing a threat to societal stability.

Attitudes to teleworking

Psychological barriers to teleworking from home may prove most difficult to overcome. The ability to work in a decentralised manner will be limited by the user's ability to use the available technology to replace and enhance the interactions which occur in the traditional workplace. The issues of social contact, and informal information flows, can be addressed by future technology and applications. The effects of the feeling of isolation in the home can reach beyond work issues. It is therefore unlikely that remote communications will completely replace face-to-face contact.

Organisational culture, management style and past practice can strongly influence the acceptability of a teleworking initiative. Further work on establishing improved productivity and benefits for both employer and employee may help to ensure that teleworking is used responsibly by businesses, and not exploited.

Cost saving to businesses

As the cost, in real terms, of the technology required reduces, the desire to minimise accommodation costs will increase. Care must be taken, however, to ensure that the true costs are counted. The scope of the support functions required, the effectiveness of operations, the efficiency of the workforce and the form of remuneration packages offered must be taken into consideration.

Flexible tariffing arrangements could be attractive to an organisation using teleworkers. For example, closed user group schemes could be of value particularly when coupled with innovative discount options. Flexible billing systems will also be required to allow employers, employees and consultants to monitor and analyse their communications bills and allocate costs accordingly.

The environmental impact of teleworking, largely perceived to be benign, has been recognised in Europe, the United States and at the Rio Earth Summit, and makes a powerful case for allowing greater flexibility to stimulate the teleworking market.

Conclusion

This article has drawn together many of the drivers and enablers of teleworking practice, together with the factors that may inhibit its successful adoption. Although communication and information technology trends have been described, together with requirements of future organisations and the benefits of flexible working for the organisation and the individual, there are many more hidden factors yet to emerge.

The office of the future will be constructed in a manner to allow rapid reconfiguration for hot-desking and organisational flexibility. Advanced and intuitive human computer interfaces could enable even the most 'computer illiterate' to use highly sophisticated IT and communications services. Future mobile communication technologies have the potential to render working location of much less significance to the functionality of the terminating equipment used and applications. Software tools using artificial intelligence can provide efficient management support systems. It can be expected that future technology will help to erode many of the narrow work style definitions used today. Increases in processing capability and the use of interactive video applications will lead to a demand for communications bandwidths which can be supported only by optical-fibre transmission systems.

Organisational structures and processes can be expected to change in response to rapidly changing markets and intense competition. While the take-up of advanced communications cannot be seen as equivalent to an increase in teleworking, it does provide facilitating infrastructure and awareness.

Teleworking represents a major opportunity for businesses to achieve flexibility and responsiveness and to reduce costs. The expected large number who will want to telework represents a significant source of potential revenue for communications companies.

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Biographies

Tom Lynch
BT Networks and Systems

Tom Lynch graduated with a B.Sc. in Applied Physics from Strathclyde University and an M.Sc. in Optoelectronics from Heriot-Watt University before joining BT Laboratories in 1986. He obtained a Diploma in Management from The Open University in 1994 and is currently studying for the MBA. Between 1986 and 1992, he worked on various aspects related to optical networks and technology. Since 1992, he has been part of a group investigating various aspects of the future business environment for communications products and services. These include modelling of future service provision and aspects of future working such as teleworking.

Sonia Skelton
BT Networks and Systems

Sonia Skelton joined BT Laboratories in 1992 after graduating from Middlesex University with an MBA. Sonia had previously run her own business prior to joining BT&D, a joint venture company owned by BT and Dupont. There she worked in the Research Products department undertaking product marketing for advanced opto-electronic components. Since joining BT, Sonia has worked within the Econometrics and Business Systems groups. She has been involved in business modelling of future telecommunication products and services and in investigating new organisational structures and practices. She is currently working in the area of modelling interconnection scenarios and regulatory environments.

Kim Fisher, Rob Taylor-Hendry, Dave Linton and Martin Cooper

Non-Verbal Guidance for Cyberspace Explorers

Future users of cyberspace will have access to the vast array of data and information services accessible via telecommunications networks. Interfaces that help people gain the maximum benefit from this technology are required. We have therefore designed a set of emotional icons that use movement and sounds to guide users to information, applications and services in a humanistic and intuitive manner.

Introduction

The decade since William Gibson coined the term 'cyberspace'[1] has seen computer networks penetrate every corner of the globe. This technology has the potential for supercharging our ability to work, learn, socialise and play. To get the maximum benefit, people will have to cope with its 'unthinkable complexity'. Tools are being developed to help people search vast networked data banks and to harness the power of increasingly powerful computers to carry out specific tasks[2–5]. One day these systems may be able to deduce users' requirements by analysing their previous actions, as well as obeying direct verbal commands. Like a good personal assistant, the computer will anticipate our needs, discreetly suggest what actions to take and provide all the relevant information in the most convenient form. We are investigating user interfaces for computer-based assistants as part of a broader exploration of useful and easy-to-use high performance information systems.

Interface Agents

One approach currently receiving much attention is to represent the assistant as an anthropomorphic agent such as a person or cartoon[6,7]. Such agents serve as intermediaries between the user and the computer, interpreting what the user requires and carrying out delegated tasks. The key to making an audience believe in a character (in a theatre or on a computer screen) is their portrayal of emotion[8]. An emotionless character seems lifeless and so work is in progress[9] on the creation of self-animating creatures that express emotions.

A humanoid agent has a disadvantage however—it invites us to attribute human capabilities to the system, irrespective of its actual limitations. Furthermore, people from different cultures may not correctly interpret the connotations of appearance and diction used to indicate the agent's capabilities and limitations. We want to avoid these difficulties by *not* presenting an anthropomorphic representation of the support system. Systems could monitor user actions and receive verbal requests without appearing on-screen—as a metaphoric and invisible spirit guide. However, we were left with the problem of how to display its output.

> *'Cyberspace. A consensual hallucination experienced daily by billions of legitimate operators, in every nation, by children being taught mathematical concepts . . . A graphic representation of data abstracted from the banks of every computer in the human system. Unthinkable complexity. Lines of light ranged in the non-space of the mind, clusters and constellations of data. Like city lights, receding . . .'*
>
> from Neuromancer by William Gibson[1]

Animation at the User Interface

We are exploring ways of guiding the user by enhancing icons with animation and sound. A recognised problem with animation is how to make it clear and comprehensible,

Figure 1 – Children enjoy interacting with emotional icons

attractive and appealing[10]. We base our animations on the innate body language of humans (and many other animals) to express intentions, attitudes and emotions. The sequences of characters resembling facial expressions used by some people to represent emotions within electronic messages are an early form of emotional icon. Examples of these 'smilies' include **:-)** , **:-(** and **>:-c**, representing 'happy', 'sad' and 'angry' feelings respectively. When encouraged to try this type of emotional icon, people use them and like doing so[11]. The environment for our experiments is a three-dimensional information space in which icons represent data and applications. The display screen shows a perspective view of this world and the user moves the viewpoint by means of a 'space mouse' (Figure 1). We scale the icons to indicate the amount and importance of the underlying information and endow them with emotional behaviour like friendliness or aggression to guide the user towards particularly relevant information and actions and away from risky operations. The icons respond to the user by movements and sounds. Although this work is at an experimental stage, the results so far are very encouraging.

Body Language

In lower animals, the language of social interaction is mainly innate, having been chosen by natural selection through its survival value. Higher animals are born with more open patterns of social behaviour that are completed by early experience in the family. Apes, monkeys and humans use posture, gesture, proximity, facial expression, eye movements and vocal sounds to signal their emotional states and attitudes. Human babies are born with certain expressive actions like crying, smiling and frowning pre-programmed, and some elements of adult body language could also be innate as they are universally found in so many parts of the globe. For example, people from many cultures indicate 'yes' by nodding their heads and perform a rapid eyebrow flash when greeting someone.

Human body language is pre-programmed in a second way—through the cultural rules and norms passed down from earlier members of the society and taught to the young[12]. These learnt signals vary between different countries or cultures. For example, making a circle with forefinger and thumb can mean OK, money, zero, male homosexual or an obscene insult depending on the nationality of the observer[13]. We tried to avoid such ambiguities when designing the body language of emotional icons!

Emotional Icons

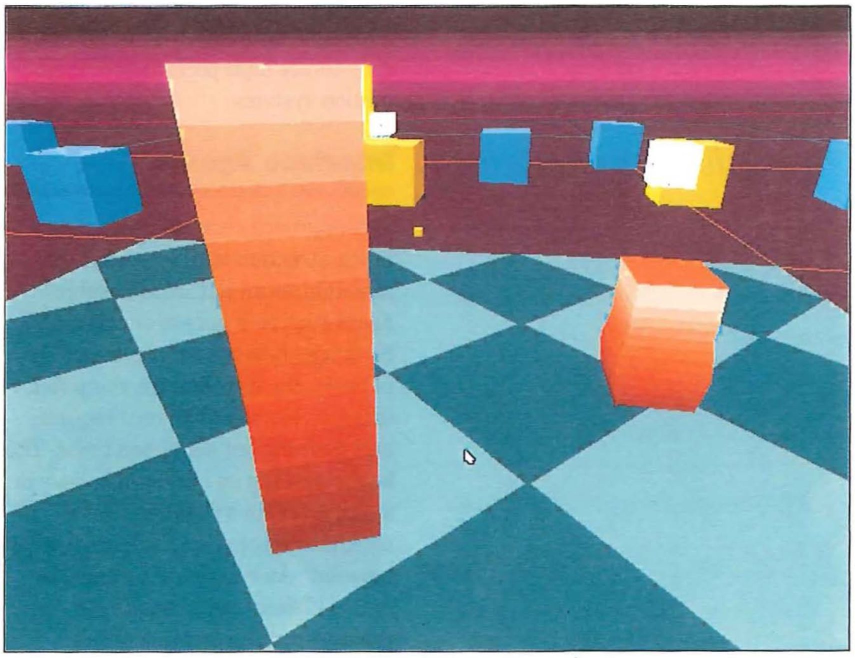
The shy icon

It is sometimes inadvisable for a user to select an icon. For example, it may be best to prevent a user from accessing a database if someone else is modifying it. The shy icon (Figure 2) flees from the user to avoid interaction. It rears up as the user approaches and retreats, emitting a shrill noise like a cry. The icon returns to its original position when the user has moved away.

The aggressive icon

An attempt to interfere with a critical function of the system or to access

Figure 2 – A shy icon prepares to retreat



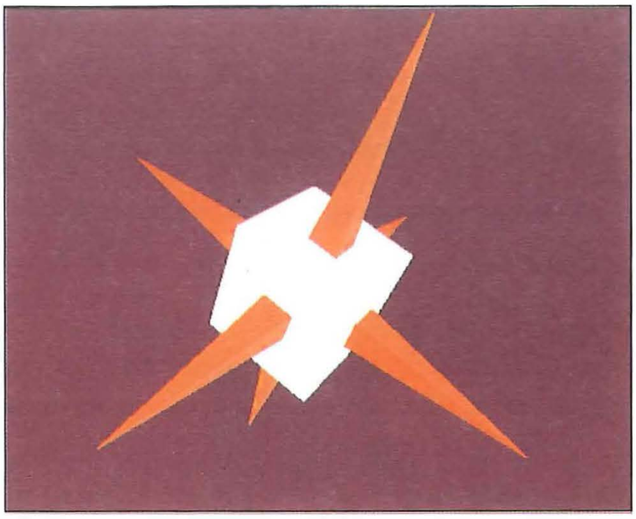


Figure 3—The threat display of an aggressive icon

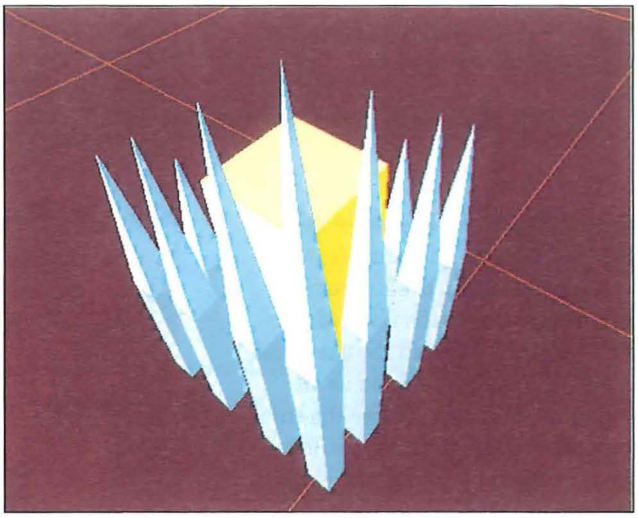


Figure 4—A defensive icon puts up its barrier

protected data arouses aggressive signals from an icon. People indicate aggression by raising their arm, swinging or shaking a fist, stabbing a hand toward the opponent or demonstrating an attack by slicing a forefinger across the throat. If threat gestures fail, the conflict may escalate into a fight. As the user approaches an aggressive icon, it sticks out spikes (see Figure 3) and makes an ominous growling sound to deter the user from getting too close. If ignored, the system could end the conflict by logging the user out of the environment.

The defensive icon

If a social situation seems threatening, people feel more comfortable behind a physical barrier. Children try to protect themselves by raising their arms and only bring down their defences when sure that it is safe to do so. Similar behaviour repels users from a defensive icon but allows through a user with determination and a clear mind. This defensive behaviour could prevent a user inadvertently carrying out risky operations such as bulk erasures or editing critical system files. The icon protects itself by raising a barrier of pointed bars that obstruct further movement towards it (see Figure 4). Only by carefully navigating over the top of the barrier and then vertically down to it or by speaking a password is it possible to gain access.

The disappearing icon

If a person believes that they are in the wrong place at the wrong time, they excuse themselves and leave. In the same way, an icon representing a data item that is not relevant to the user's task retreats at great speed from the current working environment with a noise like a cork flying from a champagne bottle. Icons that are irrelevant or inaccessible jump out of the way as the user passes by leaving only the useful information and applications behind. Disappearing icons return to their locations when the user has moved away or if they subsequently become relevant to the user (see Figure 5). Note that the behaviour of the disappearing icon is related to that of the shy icon, although the sound it makes is quite distinct.

The nervous icon

An angry or frightened person who cannot fight or flee tenses up, shivers and trembles. Uncertain people may physically oscillate between two courses of action. Similarly, an icon representing unstable, contradictory or incomplete data signals with trembling movements (see Figure 6)

Figure 5—A disappearing icon jumps away from the user

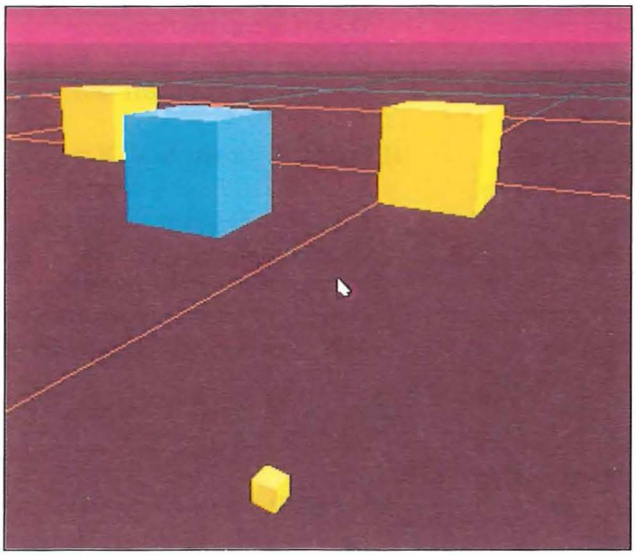
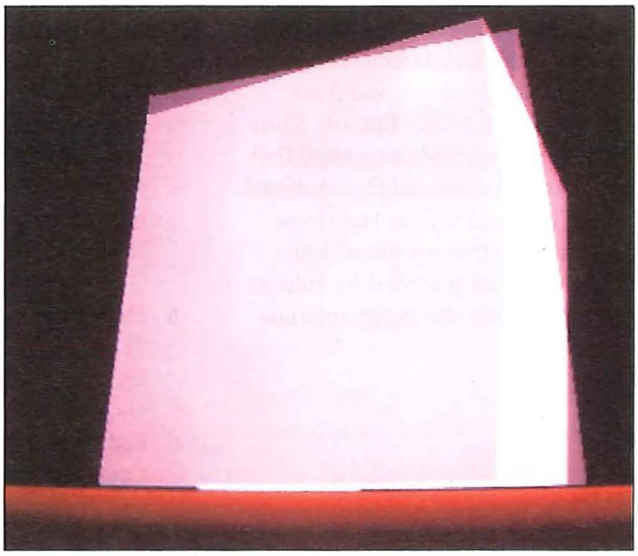


Figure 6—A nervous icon trembles as the user approaches



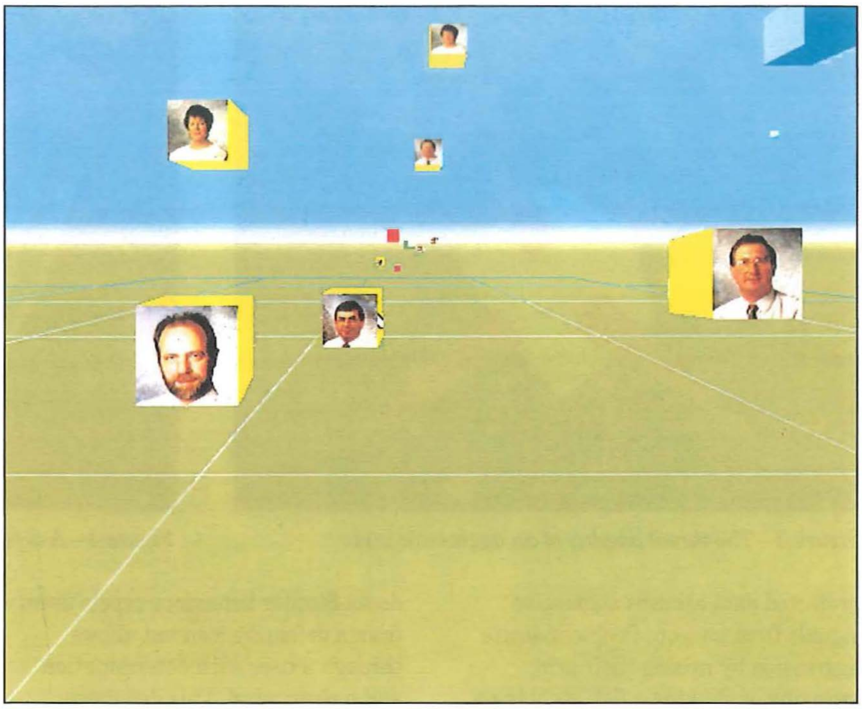


Figure 7—A group of friendly message icons approach the user

and makes a tremulous noise as the user approaches. For example, an icon representing a draft document would become nervous if it had not been spell-checked and the user tried to mail it to someone listed as an important customer. Unlike the shy icon, the nervous icon stays still as the user approaches, its trembling growing as the user gets closer.

The friendly icon

People show their attraction to others by approach, greeting, postural echo, eye gaze behaviour and physical contact. The friendly icon approaches the user and follows them, hovering close by to attract their attention (see Figure 7). This behaviour allows an icon to solicit action from the user. For example, an urgent mail message becomes increasingly friendly until the user reads it. If the user asks for a particular piece of information, the system would find it (locally or by searching the global network) and present it as a friendly icon.

User Reaction

We have populated an experimental three-dimensional user interface with icons capable of each type of emotional behaviour which simulates an information world driven by intelligent data searching and task scheduling software. The system was taken to the 1994 Edinburgh Festival as part of an exhibition that attracted over 10 000 visitors. Many of them tried the system including very young children, elderly people and those who spoke only a little English. Their actions and comments suggested that they readily understood the emotional icons. These and similar tests have demonstrated that emotional icons could have great potential for enhancing the usability of complex information systems.

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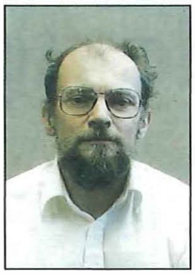
Biographies

Kim Fisher
BT Networks and Systems

Kim Fisher qualified as a product designer in 1975 with a B.A. degree in Industrial Design Engineering. He then worked for Russell Hobbs, moving to Gillette UK Research Laboratories in 1978 and then Pye Telecom in 1979 (later Philips Radio Communications Systems). In 1985, he joined BT Laboratories to set up an Industrial Design Unit, becoming the Industrial Design Manager for the BT products division in 1989. In April 1990, he moved back to BT Laboratories to design concepts for future systems.

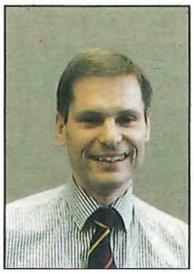
Rob Tayor-Hendry
BT Networks and Systems

Rob Taylor-Hendry graduated as a product designer in 1989 with a B.A. degree. After further studies, he graduated in 1991 from Central St Martins School of Art and Design. He subsequently joined BT Laboratories where he works on concepts for future systems.



Dave Linton
BT Networks and Systems

Dave Linton joined the GPO in 1963 as an apprentice. He worked in telephone exchanges in north Wales and in the Midlands Telecommunication Headquarters on external planning before moving to BT Laboratories in 1979 as a software developer. He has worked on a number of projects including PRESTEL, directory systems and integration of office automation and telephony. Since 1990, he has been working in the Human Factors Unit, mainly involved with user interface design and development for network management and other applications.



Martin Cooper
BT Networks and Systems

Martin Cooper joined the Post Office in 1967. In 1971, he graduated from Southampton University with a B.Sc. in Electronic Engineering and gained an M.Sc. in Work Design and Ergonomics in 1975. He is a Fellow of the IEE and the Ergonomics Society. Since graduation, he has worked on a variety of projects in the human factors field. In 1988, he was awarded the Sir Frederic Bartlett medal of the Ergonomics Society for his contribution to the application of ergonomics in industry. His current role is managing of a team of psychologists, ergonomists, designers and engineers studying ways of matching future systems to the needs of their users.

David Travis, John Miles and Martin Cooper

Working Together in the Electronic Agora

Customers must be provided with products and services that satisfy their needs and are easy to learn and use. This article describes an approach to videoconferencing in which multimedia communication is built into the furniture and facilities of a conventional meeting room. The Electronic Agora allows people to join a meeting from anywhere on the planet and play a full part without special training by using their existing skills.

Introduction

Most of the technological building blocks to deliver multimedia services at the right time and price to fixed and mobile terminals anywhere in the world are already available. The limiting factors to exploiting this technology are no longer technical. One of the main constraints is human—it is necessary to know what services and products will satisfy customers and how to make these easy and enjoyable to use. These human factors will determine what people will buy and how much they will use a service—and hence how much revenue it will generate.

People will put up with unfriendly technology if there is no other way of getting what they want. There is a level of unfriendliness, however, beyond which they will not go—a threshold of frustration. The more advanced features on video cassette recorders, photocopiers and some telephones are close to that threshold. New services must be designed to be well below the threshold if they are to succeed in the marketplace. This needs a human, not a technological, perspective on their design.

One approach that makes good use of existing skills and expectations is to make the technology part of the furniture. People interact with the communication system as easily as they rearrange the furniture—and no 'user interface' gets in the way. This is very different from the more conventional approach of putting the system in a box that the user operates by means of a keyboard, mouse and display. Instead of accessing all applications from a single, general-purpose desk-top computer, we are considering how to distribute the information system, its controls and displays among a network of smart telephones, display screens, environmental sensors, location trackers and portable (or even wearable) equipment. The emphasis is on hiding as much of this technology as possible. The focus is on what customers want to do and on harnessing their existing skills. In this work, we are experimenting with specialised devices, embedded in the environment, that can do just a few things well rather than an all-purpose system that, like the Swiss Army knife, has many features but fails to support any specific task very well.

At first sight, it may seem quite difficult to design an advanced multimedia system that people can walk up to and use without studying a lengthy instruction manual. This article describes a computer-supported vidcoconferencing environment that achieves just that goal.

Videotelephony from a New Angle

In addition to developing faster and better communications technology, work at BT Laboratories is addressing the fundamental reasons why and how people work together. This approach turns the design process on its head to identify the psychological needs and requirements that define how to configure the technology into useful, usable systems.

Work on videotelephony shows that two distinct sets of requirements must be satisfied. Firstly, an image of the other person is needed so that his or her choice of clothing, grooming, facial expressions, and posture can be seen as well as all the other non-verbal clues people use in face-to-face

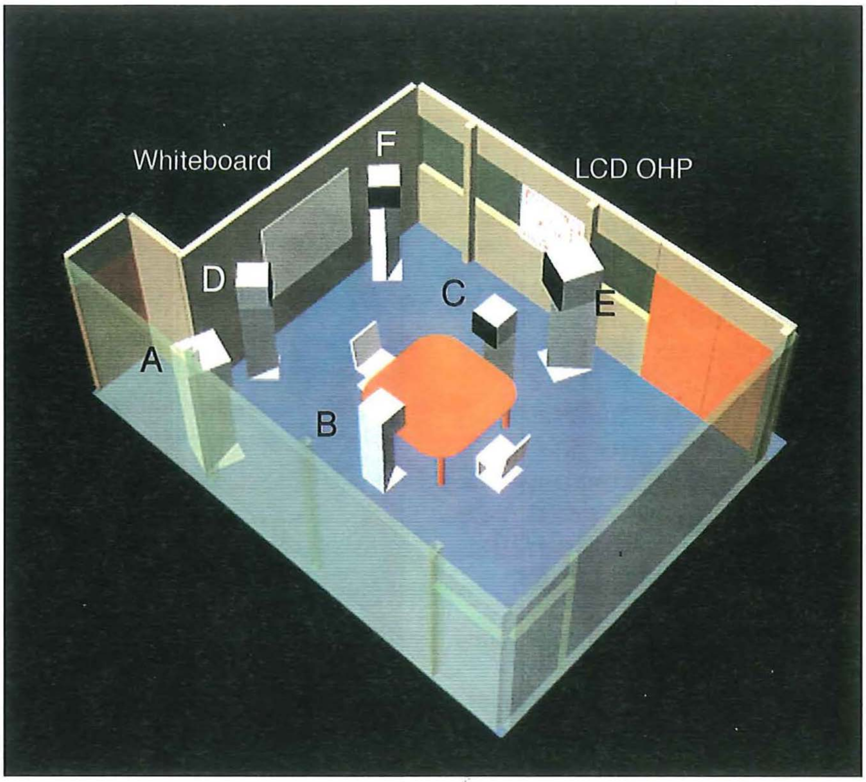


Figure 1—Plan of the Electronic Agora at BT Laboratories

meetings to establish trust, gauge honesty, read intentions and moods and so on. Secondly, the system must support the task in which people are engaged; for example, by allowing joint access to a spreadsheet when budgets are discussed. The relative importance of personal and task support depends on the reason for the call. Social calls need less task support than calls made with a clearly defined purpose, though in most cases both types of information are useful. If you call a friend to plan a night out it could be useful to share a timetable or map, and even the most hard-nosed business discussion can be enhanced by a personal touch. The objective then is to design user-friendly systems that meet both sets of requirements and allow natural transitions between face-to-face communication and access to shared support tools such as spreadsheets, maps and databases.

The Electronic Agora

Videoconferencing is an attractive alternative to physical travel that saves time and money and reduces personal stress, traffic congestion and environmental pollution. Seeing the other people involved in the meeting adds considerably to the quality of the experience and the richness of communication. However, there is scope for further improvements to the ease and naturalness of videoconferencing that would make it even more appealing.

In Athens, the Agora was the marketplace, but also a venue where citizens met to talk and gossip. We use this as a metaphor for a business-meeting environment that is highly interactive and sociable, and which exploits the wealth of interpersonal skills that people already have. In traditional video meetings, people are polite, rarely interrupt and wait their turn before speaking—very different from the animated conversation in the Athenian Agora!

We have built a videoconferencing environment that supports collaborative work by exploiting existing skills and ways of communicating. Figure 1 shows the layout of this system—a room with six combined display and camera units, an electronic whiteboard and networked PC that can display information on a liquid crystal display (LCD) tablet and overhead projector. The display and camera units are known as *surrogates* as they stand in for remote participants in the meeting. Let us consider a typical meeting using this system.

Figure 2—You arrive at the meeting through Surrogate A

Joining the meeting

Imagine that you have been invited to a meeting in the *Electronic Agora*. You are working from home and will participate in the meeting electronically. You dial the access number and are connected to Surrogate A, giving you an establishing shot of the room, much as you would get if you were physically standing by the door. This 'bird's eye' view enables you to see who is there so you can adjust what you say to suit the audience. As you activate the door surrogate, it chimes and the people in the room see you on the screen and welcome you into the meeting, just as if you had physically arrived at the door (see Figure 2).

Talking face-to-face

Having seen who is present, you decide to take up the position at the table represented by Surrogate B, much like physically taking a seat at a table (see Figure 3). You 'move' position by using the Touchtone keys on your videophone. Next, Scott (a second electronic participant) appears on Surrogate A and after a short welcome he moves to Surrogate C. It is clear to Scott that you have the floor because the physically present participants are looking towards your image on Surrogate B.

One of the design aims has been to make good use of the natural head-turning and direction of gaze information that is taken for granted in face-to-face communication. In addition, the television monitors in the surrogates are mounted on their sides (Figure 4), giving a portrait view of the participants that includes most of their upper body and gestures—both important in conveying body language.

Figure 3 – You move to Surrogate B at the table

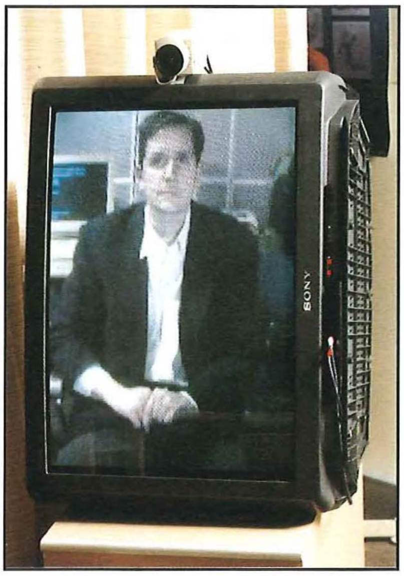
Using the whiteboard

Many people want to use a shared drawing surface at some point in a videoconference[1]. Current systems use on-screen drawing or a remote camera pointing at a suitable drawing surface. The people using these systems adapt their behaviour to suit the technology provided and, as a result, lose information from the conventional cues of social communication. For example, in a face-to-face meeting, someone turning to the whiteboard physically turns away from the other people in the meeting, and, to address a remark to another person, turns and looks that person in the eye to get the message across. This fundamental social skill allows us to move smoothly between using the whiteboard and speaking to someone. It is clear to everyone present what is being done. The aim was to avoid losing or distorting this information for everyone involved in a meeting, irrespective of whether physically present or participating electronically.

In the Electronic Agora, the whiteboard is indistinguishable from a conventional whiteboard. You write on a familiar white surface with a variety of coloured pens and remove errors with an eraser. A computer reads the information written or drawn on the board and can relay it to the display screens of remote participants. Although you cannot write directly on the whiteboard from home, you can annotate the electronic copy, and these annotations are displayed on the LCD overhead projector panel.

Imagine that you want take part in a brainstorming session. You press the key to move to Surrogate F at about head height by the whiteboard, where the person running the session can use head turning cues to control the interaction, as would happen if you were physically present. The views of the other person and of the whiteboard are in the same relative positions in your home and in the meeting room. As you turn your head to look at the image of the whiteboard on your display (Figure 5), it looks as though you are turning to look at the whiteboard in the Electronic Agora (Figure 6). It is clear to everyone what is happening from the body language of each individual. Note also that moving between face-to-face communication and discussing the task on the whiteboard is transparent and seamless: it builds on the skills of communication that we already have and does not require any new learning.

Figure 4 – Portrait orientation makes gestures and body language more visible



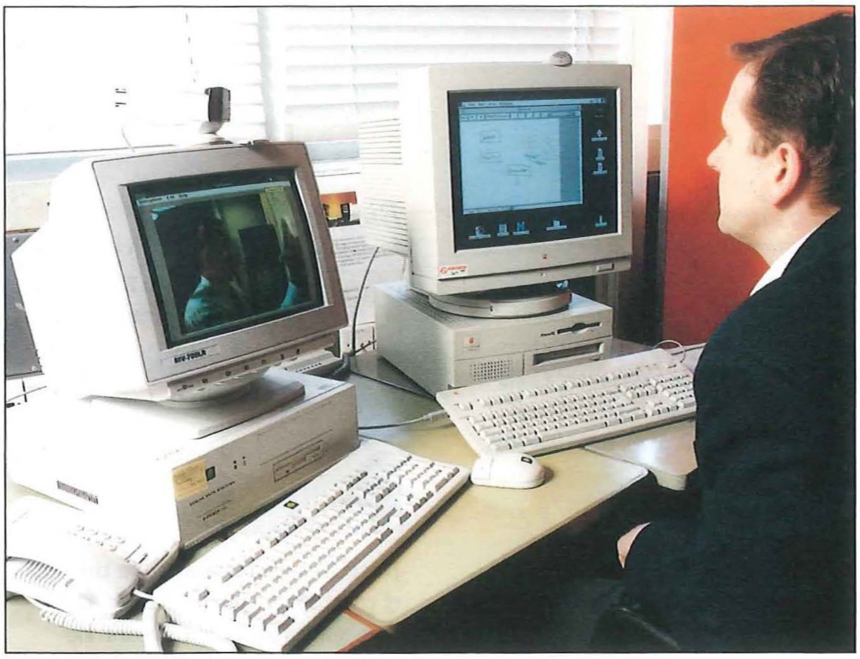


Figure 5—You look at the whiteboard image on your computer at home

Giving and watching a presentation

As a remote participant in a meeting, you naturally want to be able to see overheads and other materials used in presentations. The slides presented in the Electronic Agora are reproduced on your computer screen at home and you can place your own images on the screen in the meeting room. Imagine that you have been asked to present a review of your project at the meeting. You press another key and move to Surrogate E at about head height next to the projector screen (see Figure 7), from where you can see your audience. Since you have remote access to all the presentation facilities in the room, you can transmit slides and video material from the computer on your desk at home and present them on the LCD overhead projector panel. Scott, the second remote user, sees these slides on his local computer screen, although he may also choose to move to Surrogate B where he can see you, the presentation and other people at the meeting.

Figure 6—Studying the whiteboard from Surrogate F

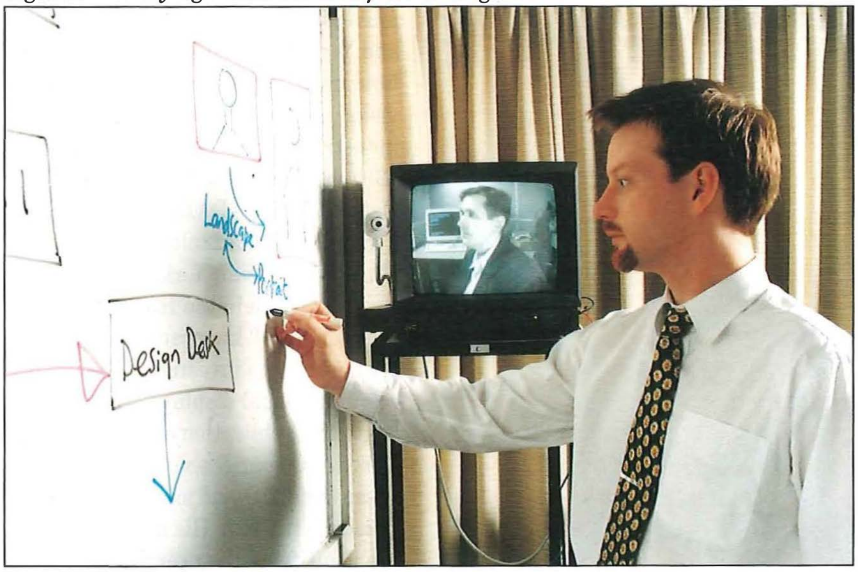
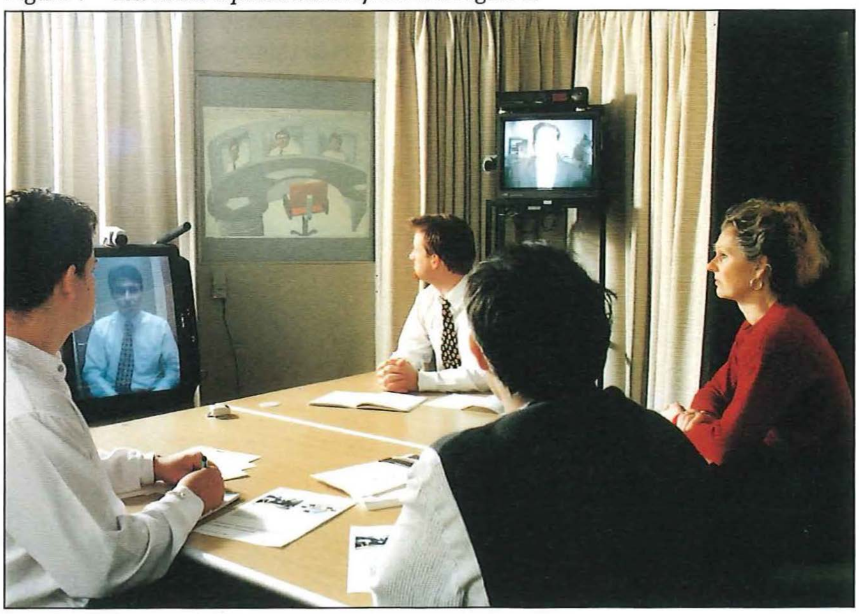


Figure 7—You make a presentation from Surrogate E



Concluding Comments

New services and products should build on the existing skills of their users to make them easy to learn and to use. We have applied this approach to a videoconferencing facility, called the *Electronic Agora*, that harnesses conventional communication skills to control the meeting. This facility has been used for project meetings with remote collaborators. The multiple screens and cameras and shared access to whiteboard and overhead projector significantly improve the experience of participating in these meetings. We are investigating further enhancements such as providing stereo sound. The goal is to remove all signs of a 'user interface'—the interface to the task and the other people in the meeting should be as transparent as it would be in the real situation. We are not there yet, but we are working together in the Electronic Agora to explore this new and exciting path.

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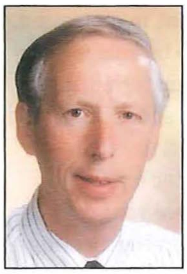
Biographies

David Travis
Systems Concepts Ltd.

David Travis has worked in the areas of psychology, human factors and ergonomics for over 15 years. Between 1983 and 1987, he carried out research in visual perception for the Medical Research Council at the universities of Cambridge, London and York. The research investigated fundamental aspects of human colour vision, and applied the work in industrial and medical settings. In 1987, he was funded by the American Defence Agency, DARPA, to help build a model of human colour vision at the University of New York. In 1988, he was asked to join the Human Factors Division at BT Laboratories to set up a laboratory to investigate the use of colour in visual displays. This work led to the publication of his book, *Effective Colour Displays* (Academic Press, 1992). David joined System Concepts in 1995. His main interests are identifying the user drivers for new technology, especially videocommunication and multimedia. He has published over 25 scientific papers in this area.



John Miles
BT Networks and Systems

John Miles joined the Post Office in 1968 with an HNC in Electronics, to work in the Human Factors Group. Since then, he has provided technical support on a wide range of projects. He has played a major role in the implementation of the Electronic Agora described in this article. He designed several of the pieces of bespoke electronic hardware needed to make the Agora easy and natural to use for videoconferencing.

Martin Cooper
BT Networks and Systems

Martin Cooper joined the Post Office in 1967 as a Student Apprentice. In 1971, he graduated from Southampton University with a B.Sc. in Electronic Engineering and gained an M.Sc. in Work Design and Ergonomics in 1975. He is a Fellow of the IEE and the Ergonomics Society. Since graduation, he has worked on a variety of projects in the human factors field. In 1988, he was awarded the Sir Frederic Bartlett medal of the Ergonomics Society for his contribution to the application of ergonomics in industry. His current role is within the Centre for Human Communications at BT Laboratories where he continues to study ways of matching telecommunications systems to the needs of their users.

Tim Wright

An Architectural Framework for Networks

The very complexity of modern networks and the design dependencies between domains both jeopardises their viability and places considerable constraints on evolution. Network architecture offers a way out of this log jam by providing the discipline, concepts and terminology to compartmentalise the problem into manageable and unambiguous pieces. This article describes, at a top level, the role that network architecture plays in the process from customer requirements capture to network realisation.

Introduction

The complexity of network design and evolution is evidenced by the amount of ongoing debate within individual companies, industry fora and conferences, the trade press and so on. Much of this debate is trying to make sense of the network, to understand how all the various parts fit together, to put it in perspective. However, the approaches taken are many and varied—in how the network is described in words, drawn in pictures. Associations are made between parts of the network that are not associated at all, except in the most tenuous ways, and the logical and the physical are often confused as are the function and the implementation.

Few would dispute that the network is a fearsomely complex entity that is hard to understand. Yet there exists a set of architectural tools—concepts, terminology and drawing conventions—that enable the essential features of the network to be understood in simple generic ways, and enable specific details to be compartmentalised into manageable pieces and to be largely hidden for most purposes, instead of washing around in a huge sea of technical muddle.

Architecture, therefore, is all about the rules for network design rather than the resulting network designs *per se*. An article on designs of networks could become tedious and quickly become outdated; therefore they are not addressed here. Diagrams of lines and boxes which, all too frequently, are claimed to be the architecture of a network are, more often than not, a somewhat ambiguous representation of a physical network design. Such a viewpoint can be perfectly valid and appropriate to illustrate certain things, but a more comprehensive and unambiguous understanding can only be gained and communicated by a more rigorous application of architectural tools.

This article is the second in a series on architecture in the *Journal* and builds upon the first article[1] which showed the increasing importance of adopting an architectural approach, not just in the context of networks, but more widely as part of meeting business requirements. This article deals more specifically with network architecture describing firstly its role in the business process, and secondly the methodology for network architecture.

The Role of Network Architecture

The telecommunications industry, especially in the UK, is subject to considerable customer, regulatory and competitive forces. Typical business responses to these forces include:

- defending and growing markets and developing new markets;
- expanding into markets outside traditional geographic boundaries;
- providing service to, and consuming resource from, other players in the industry; and
- diversifying into other roles such as information network operation and information service provision.

At the bottom of this command and response chain is the network, as

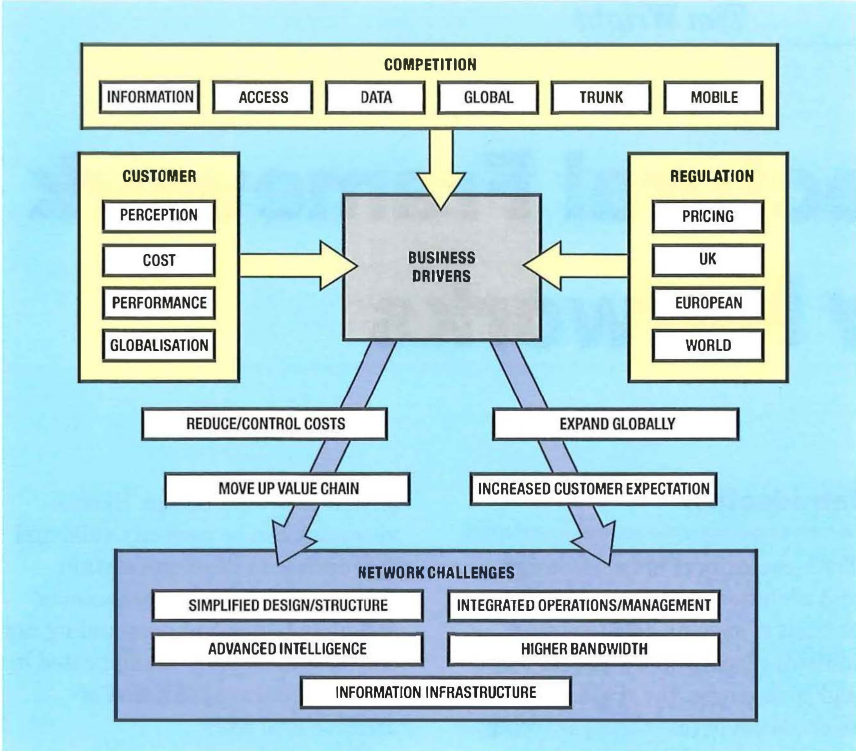


Figure 1—Drivers on networks

shown in Figure 1; somehow it has to enable these business responses. For example, defending and growing markets typically puts pressure on continued exploitation of existing infrastructure by maximising network utilisation, minimising operational costs and improving quality. On the other hand, developing new markets and diversifying place more emphasis on introducing new technology with, for example, higher bandwidths, simplified structure, distribution and peripherisation of processing power, and integrated operations management. Expanding beyond traditional geographic boundaries and interfacing with other players in the industry demand observance of interconnect principles and standards. As if the complexity arising from these responses was not enough, very commonly, when faced with the need to meet a business response in a timely fashion, standalone proprietary solutions have been adopted, introducing the spectre of diversity.

Diversity

Diversity in itself is not a bad thing; indeed it may be viewed as a strength rather than a temporary aberration to be corrected by the uniform application of universal solutions. Who, for example, would be brave enough to say today which of tomorrow's technologies will win in the marketplace? The modern network is not a monolithic monument of central planning; it has grown gradually over time as a result of a vast number of individual planning decisions each constrained by the need for compatibility with its environment and the need to meet strict investment or strategic criteria. Moreover, with more and more players in the industry operating at the same or at different levels in the value chain, it will become even more impossible to apply ideologically pure solutions over wide areas.

But diversity comes at a cost, especially in terms of disproportionate use of capital expenditure and skilled resources and limitations on service/service feature interworking and evolution potential. A significant architectural challenge is to determine the criteria for deploying a standalone proprietary solution and for its possible evolution to a more integrated conformant solution.

The overall result, therefore, is a cocktail of technical complexity and diversity of solutions driven by relatively short-term business pressures and longer-term industry trends. And it is not a static situation; the pressures and trends are continually being modified and therefore the network itself has to adapt. In evolving the network it can be useful to define a target as a focus for design, development and standards making, but care needs to be taken not to be too dogmatic. Designers must be free to choose network or technology options on the basis of the commercial pressures at the time rather than on the basis of some well-meaning but irrelevant target network set in an earlier era. This is not a recipe for short-termism or a free-for-all, since commercial pressures should reflect business strategy and direction.

Complexity and diversity are not just short-term phenomena: they are here to stay. Indeed, things are likely to get more complex as the number of players in the telecommunications and information technology industries increases. Moreover, even for a single player, there is considerable risk in backing just a single solution; not only could it be the wrong horse but there will always be something better over the horizon to which an evolution path must be sought. It has been said that, for any given capability, there will always be a minimum of three technologies to deal with: the obsolescent, which is widely deployed and still earning revenue; the current, which is the technology being deployed now; and the next generation, which will start to be deployed in a few years time. The biggest challenge facing the architect is to manage heterogeneity and yet drive towards the most advantageous overall cost-benefit solutions.

Network Architecture Solution

As much as anything, network architecture should be seen as a philosophy, as a discipline, as a culture which needs to be engrained into the business processes. This is illustrated in Figure 2. Managing heterogeneity and evolution requires a coherent framework within which the design and implementation of networks can be addressed. Network architecture provides that framework. The frame-

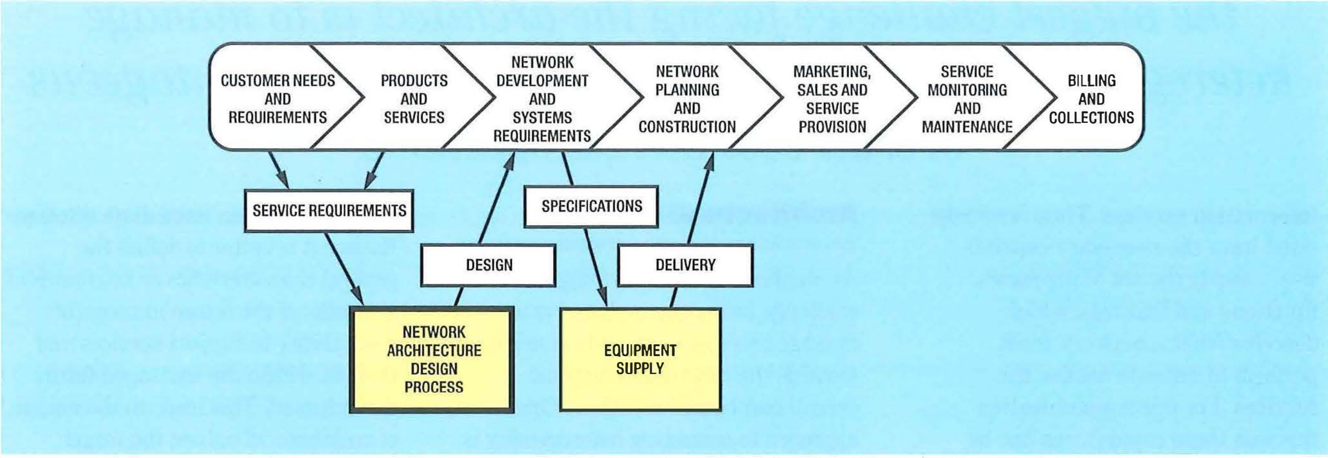
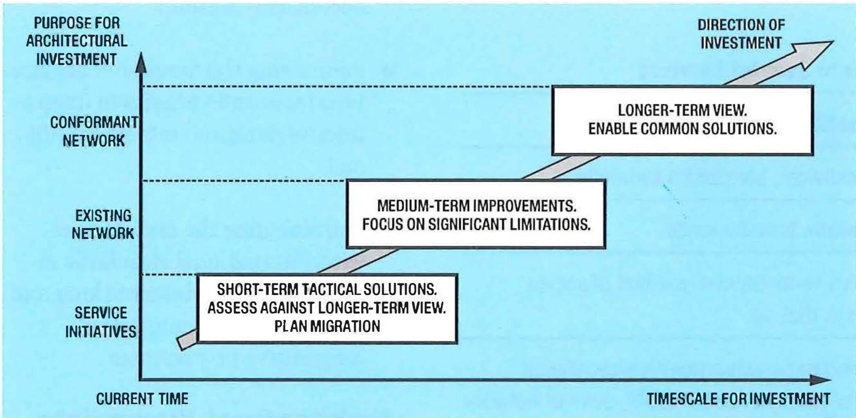


Figure 2—Network architecture as part of the business process

work can be used to determine the appropriate balance between the level of investment in developing the network towards the longer-term architecture, in improving the identified significant network limitations and in developing short-term less-compliant solutions to meet specific service initiatives as shown in Figure 3. The framework provides the architectural tools for describing the mechanisms from customer requirements capture through to network implementation (including network design) and includes a set of architectural values to guide network development, but which can endure over time and remain valid, irrespective of the changing pressures. In practice therefore, network architecture ranges from general guidance to concrete rules which are mandatory. In the former, the architecture acts as a tool for comparing options, whereas in the latter it leads to an elaboration of a network design and system specifications.

Figure 3—Architecture as part of the investment process



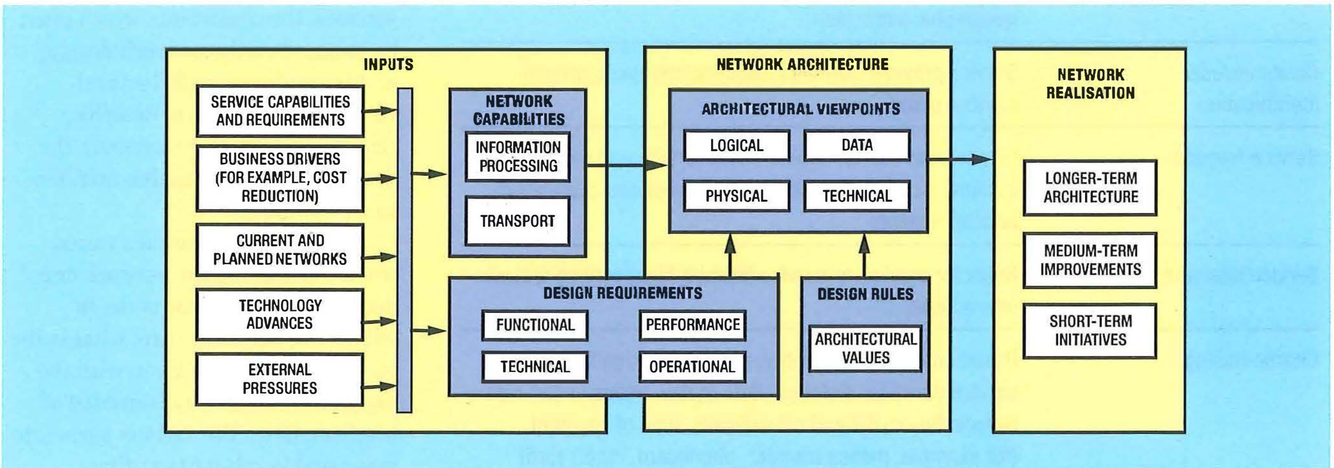
Methodology for Network Architecture

A high-level architecture framework relevant to most of BT's activities has been the subject of a study within BT. Many differing 'architectures' have been developed within BT and their methodologies have been found to have sufficient commonality to define a general, high-level framework of architectural concepts and terminology which can encompass all architectures. Using this framework enables network architecture to be consistent with BT's overall architecture. The concepts and terminology for network architecture are illustrated in Figure 4.

Network Capabilities

The purpose of any network is to support telecommunications and/or

Figure 4—Concepts and terminology of network architecture



the biggest challenge facing the architect is to manage heterogeneity and yet drive towards the most advantageous overall cost benefit solutions

information services. Thus networks must have the necessary capabilities, namely the set of processes, functions and features, which describe what a network must perform in order to realise the services. For telecommunication services these capabilities can be grouped as shown in Table 1.

The various capabilities could be provided by any arbitrary network design unless requirements are imposed on that design. For example, performance requirements specify how well services should perform when invoked by users in terms of quality-of-service parameters; technical requirements describe services using standardised methodologies; and operational requirements relate to the design of a network to enable its operational control, such as ease of remote management.

Architectural Values

As mentioned earlier, the biggest challenge facing the architect is to manage heterogeneity and yet drive towards the most advantageous overall cost benefit solutions. One approach to managing heterogeneity is to define a target network and to encourage the various strategic, tactical and planning decisions to conform with the target so that, with time, the network becomes less diverse and complex. However, this approach is often fraught with difficulty since the target network is described in technical terms only, and thus can only be a snapshot in time. It tends to assume that heterogeneity is a temporary aberration which, with stricter application of the rules, can be made to go away. And it is an approach which does not lie easily with the very real near-term commercial pressures which demand an immediate solution. Rather, it is better to define the general characteristics or attributes of networks of the future in terms of their ability to support services and their fit within the envisaged future environment. This leads to the notion of *architectural values*; the target network should be characterised by a set of architectural values or principles which can endure over time, irrespective of the changing pressures, and which can be used to guide network development. Examples of such values include:

- ensuring that interconnect and evolution are taken into account from the outset;
- promoting development of networks towards service-independent capabilities while recognising that a single network is not necessarily the aim;
- minimising the number of physical interfaces and variants to improve interworking and interoperability; and
- underpinning the architecture with international standards to optimise service interworking and to provide opportunities for competitive procurement.

Table 1 Classification of Network Capabilities to Support Services

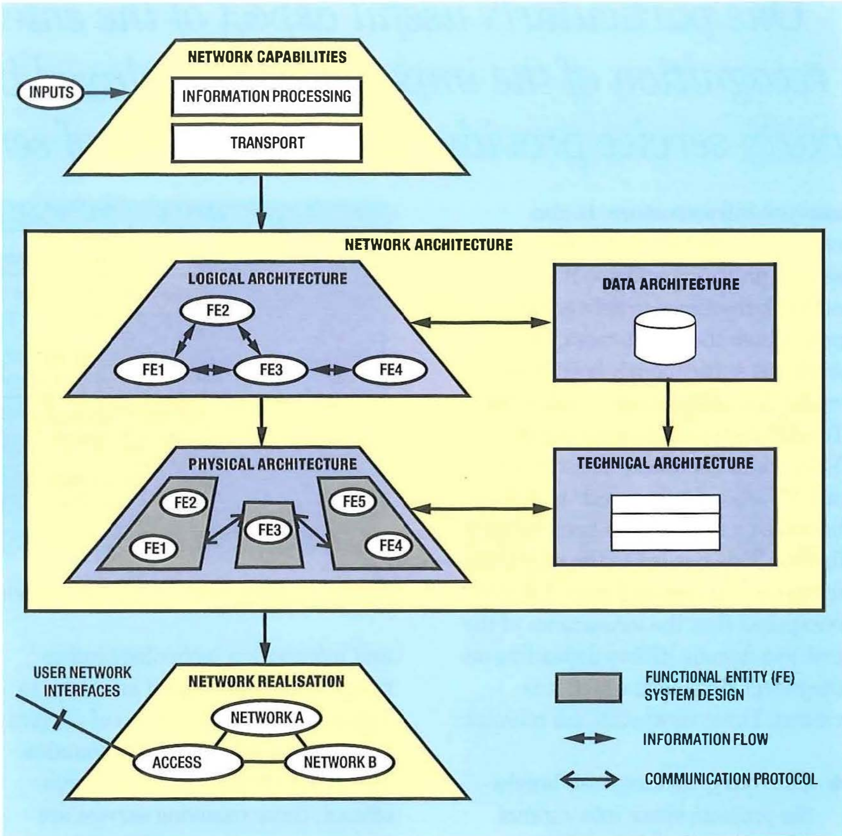
Capability	Examples of Capability
Access transport	Access media, bandwidth, bandwidth symmetry
Connection type	End-to-end bandwidth, transfer mode
Connectivity type	Point-to-point, point-to-multipoint, method of access such as dedicated or dial-up
Service access and identification	Dialled codes having geographic significance, dialled service number (for example, 0800, 0860), point of network ingress/egress (for example, leased line), port of network entry (for example, virtual private network)
UNI numbering scheme	Public line directory, data network numbering, leased line geographic addresses
Customer/user identification	Service provider numbers, personal numbers, private number plans
Service features	Line number identification, call diversion and completion, automatic call distribution, charging options, automated announcements
Service interworking	Rules for service-to-service interworking, service feature interactions
Charge raising	Based on customer identity, geographic significance, service duration, distance, time of day, usage or flat-rate options for on-net and off-net calls, type of payment (for example, money transfer, phonecard, credit card)

Architectural Viewpoints

Having derived the capabilities that the network must exhibit to support services, the constraints which must be imposed on the network design, and the enduring architectural values, it is possible to describe, rigorously and unambiguously, the design using the available architectural techniques.

One of the major issues raised when considering the network or a network enhancement is the fit within the bigger picture; what is the wider environment? Even with the big picture, some way is needed of breaking down the various parts into manageable sub-parts so that

Figure 5—Architectural viewpoints



individual expertise can be brought to bear during the design process without leading to ambiguity or mismatches. *Encapsulation* is the technique which allows both the big picture to be seen and the underlying detail; it is a way of unambiguously describing networks at a particular level of abstraction in a manner which hides all unnecessary detail. *Layering* is a classic example of encapsulation. Particularly successful forms of encapsulation have a high degree of recursion such that the descriptive techniques appropriate for a small part are the same as for the whole. Transport architecture is a good example of recursive encapsulation as is briefly shown later.

Networks can be rigorously described using four viewpoints each representing different facets of network architecture (see Figure 5) as follows:

- *Logical architecture* is an implementation-independent view of the network capabilities broken down into the functions which the network has to perform and the information flows between functional entities. It is neither constrained by physical resources nor by implementation dependent requirements; for example, performance.

- *Data architecture* is a view of the information required by the network for its operation. Data entities include numbering schemes, service information (for example, dialling codes), network information (for example, routing tables) and system operating data.

- *Technical architecture* is a view of the technical standards that should apply to a network and the systems forming that network. These should lead to specifications of the network design; for example, software interfaces, communication protocols and transport layers.

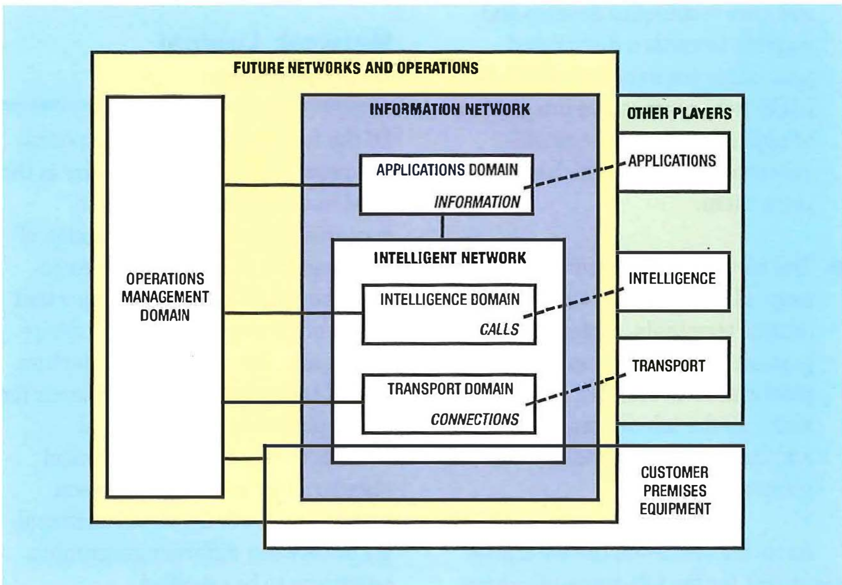
- *Physical architecture* is a view of the physical implementation of a network in schematic form; that is, it shows network systems of common and differing types, the technical relationships between systems and the topological structures which interconnect the systems.

Network realisation is the application of the logical and physical architectures to the real world.

Roles Models

It can be very useful to have a model as the first step in breaking down the problem space. In 1994, the model shown in Figure 6 was developed to assist in describing BT's current and future networks and operations by dividing the problem into domains of expertise. The model is valuable in that it recognises the need to separate applications (and services) from the underlying telecommunications

Figure 6—Functional domains



One particularly useful aspect of the enterprise viewpoint is its recognition of the important roles played by end users and third-party service providers in the delivery of services and applications.

network infrastructure. It also recognises the fact that third-party service providers will use BT's network resources to deliver their products to their customers. Much work has subsequently been done within the collaborative work of the Telecommunications Information Network Architecture Consortium and BT's ComBAT project[2] to show how such a model could be developed further. This has led to the viewpoint framework shown in Figure 7 which recognises that the appearance of the problem domain differs depending on the perspective from which it is viewed. Three viewpoints are relevant:

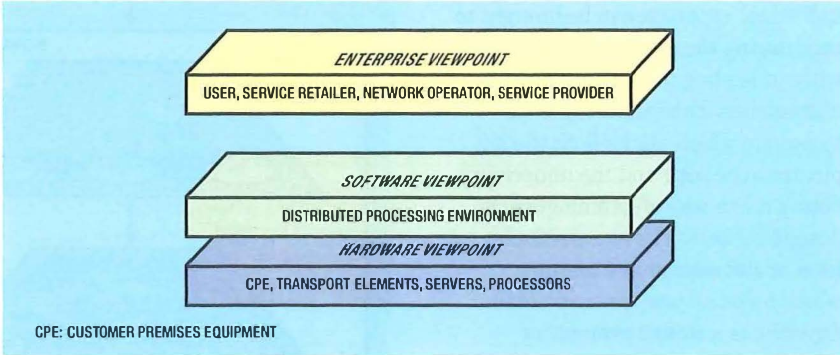


Figure 7—Viewpoint framework for telecommunications and information networks

- The *enterprise viewpoint* breaks the problem space into various roles with the relationships between them characterised in terms of services offered by one role to the next. One particularly useful aspect of the enterprise viewpoint is its recognition of the important roles played by end users and third-party service providers in the delivery of services and applications. This is an absolutely fundamental viewpoint and should be the starting point of any architectural decomposition.

- The *software viewpoint* represents the applications, intelligence and operations support systems. As software techniques develop and migrate towards a distributed processing environment, there is likely to be progressive integration of applications and the intelligence/management which supports them.

- The *hardware viewpoint* represents all the physical equipment, that is, terminals, cables, transport equipment, processing platforms, servers, etc., which make up the telecommunications and information technology infrastructure.

At its highest level, the enterprise viewpoint for the telecommunications and information technology industries can be represented as shown in Figure 8 in which the roles of players are grouped into four basic domains. The arrows represent the services offered; those receiving service are customers (or clients) while those providing service are suppliers (or servers). More detail can be found in Reference 2. The enterprise viewpoint (or *industry roles* model) recognises the distinction between players and their roles. A single player (that is, a company) may choose to play in several roles where each role could potentially be a profitable standalone company. It also recognises that the services supplied by one role and used by another are often characterised by a technical or administrative interface which may need standards support. Each role implements a partition of the software and hardware viewpoints.

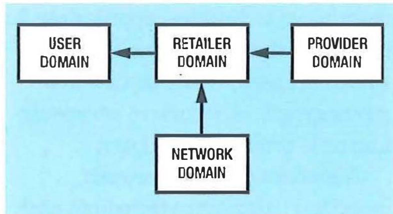


Figure 8—Top-level enterprise viewpoint

Network Logical Architecture

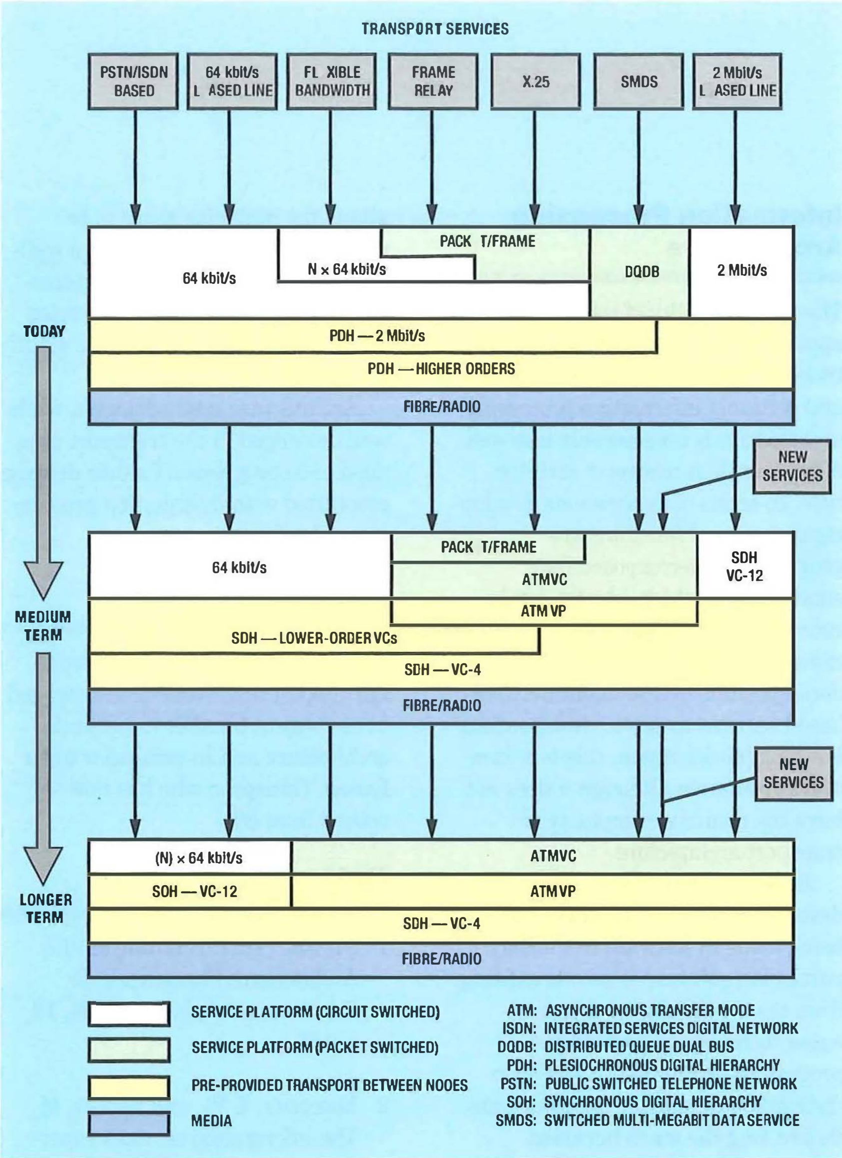
Of the four architectural viewpoints, the network logical architecture is the most onerous to derive since it concerns the more abstract notion of functionality in the network. Arguably though, it is the most important and is often overlooked in the desire to consider the physical architecture. One of the most important reasons for developing the network logical architecture is to enable technical standards for interfaces between higher and lower levels of functionality or between different geographic partitions to be specified.

Each logical function carried out in a network can be classified as a *transport* or *information processing* function, roughly corresponding to the hardware and software viewpoints of Figure 7. Transport is the function of actually transferring information between points at different locations, be they distant or in the same equipment. It includes not only the information-carrying functions of all the various kinds of transmission systems but also the information-carrying functions of switches and cross-connects. Information processing is the function of acting on information under the control of a software application. Examples of information processing functions include the following:

- *Service control functions* These enable the dynamic setup, use and termination of services provided by the network, including service operation, customisation and service assistance.

- *Connection control functions* These exercise the connectivity capabilities of the network

Figure 9—Core network transport evolution



resources (that is, controlling where and when connections are made and broken). When supported by automated signalling, control can be sophisticated and rapid, but in other circumstances, it can be slow, often manual and frequently implemented physically in a management system.

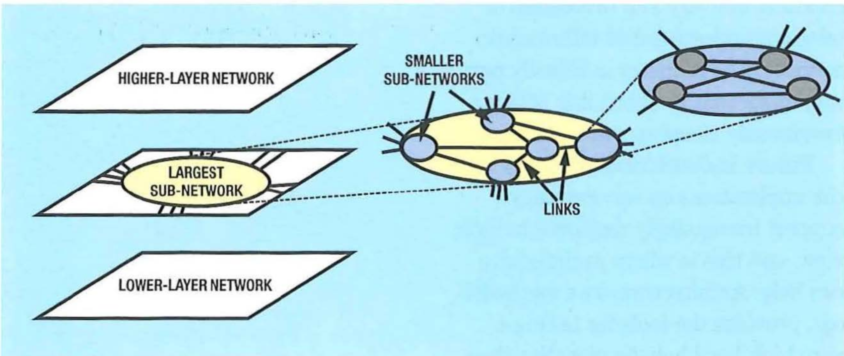
- *Management functions* These concern setting up, changing and maintaining the service level agreements with the customers, maintaining the health of the network, adding capacity, naming end points, etc. Although there is a functional distinction between service/connection control and management, in terms of implementation, it is expected that the boundary will become blurred as operational support systems move towards more real-time working.

Transport Network Architecture

Transport network functional architecture is given in ITU-TS Recommendation G.803[3] and its derivatives. Encapsulation of the transport network is by means of layering and partitioning. Layering is the horizontal division of the world's transport network into layers, each layer being responsible for a distinct kind of information. Familiar examples of layers include 64 kbit/s A-law encoded audio, the 2, 34 and 140 Mbit/s plesiochronous digital hierarchy (PDH) bit rates and frame structures, the asynchronous transfer mode (ATM) virtual channel and virtual path. Layer networks are supported one on another with higher layers supported by lower layers. Figure 9 is an example of layering showing how core transport networks are expected to evolve over time. Partitioning is the vertical division of each layer network into linked domains. Any layer of the network is composed of many fixed point-to-point links which can be connected together by sub-networks (that is, points of flexibility such as switches, concentrators, cross-connects or distribution frames) and access links between sub-networks and the logical layer boundary. Figure 10 shows the recursive partitioning of a single layer network (three recursions shown).

The generic functions of transport networks are *connection*, which provides for transparent information transfer; *adaptation*, which is the process whereby the characteristic information of the client layer network is adapted into a form suitable for transport in the server layer network; and *termination*, which provides information about the integrity of information transfer. These functions can be assembled into more recognisable 'packages' with names like *multiplexing*, *concentration*, *grooming*, etc.

Figure 10—Recursive partitioning of a single-layer network



Information Processing Architecture

The very flexibility of software applications makes rigorous descriptive techniques less easy to identify, and certainly information processing architecture is considerably less well developed than transport architecture. In terms of applications development, top-level functions are progressively decomposed into smaller parts which, ideally, can be reused in other applications. An example of this approach is the decomposition of intelligent network-based services to service independent building blocks. Again, this is a form of encapsulation although it does not have the recursive simplicity of transport architecture.

As distinct from applications development *per se*, advances are being made in software technology. In particular, software is now benefiting from the availability of object oriented techniques, applications programming interfaces, and open distributed processing environments. Before long the much heralded software agent technology should considerably reduce software construction and testing time.

Conclusions

The move from networks where the functions are, to a large extent, directly reflected in the physical design and implementation, to hardware-lean networks where the functions can be software defined, or at least software configurable, opens up major opportunities for the rapid creation, delivery and invocation of telecommunication and information services. The industry is already part way down that road but it is proving enormously complex and uncertain.

Future network developments and the implications on services they support increasingly require a holistic view, and this is where architecture can help. Architecture, as a methodology, provides the tools for taking a very high level holistic view but then allows the problems space to be progressively broken down in a well-defined manner so that the interactions, service limitations, synergies and opportunities can be more readily recognised.

Architecture methodologies, while well developed in the transport area, need to be progressed further in areas associated with information processing and software.

Acknowledgements

The author wishes to acknowledge the support of his colleagues engaged in one way or another in network architecture and in particular to Dr Robert Thompson who has now retired from BT.

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3 ITU-TS, Recommendation G.803, Architecture of transport networks based on the SDH, March 1993.

Biography

Tim Wright
BT Networks and Systems

Tim Wright presently works in Future Platform, part of the Design and Build directorate within BT Networks and Systems, on architecture and standards where he is responsible for determining the overall architecture of BT's networks and for pulling together BT's commercial direction on network standards. Until about two years ago, he had spent some 10 years as an active participant in international standards meetings with a variety of chairmanship roles with particular focus on the transport aspects from speech coding to synchronous digital hierarchy (SDH) and ATM. More recently, he has been addressing the longer-term architectural aspects of information networks and the convergence of the information technology and telecommunications industries. He has been with BT since graduating from Imperial College in 1972.

Peter Kiff

A Fresh Approach to Cooling Network Equipment

New-generation network cooling systems have halved previous cooling costs. This article explains how these savings have been achieved.

Introduction

Switching and transmission equipment dissipate heat into the immediate environment. This heat must be removed so that the space temperature stays within predetermined limits and the equipment is not damaged by the effects of excess temperature.

Until recently, space temperatures were held at a nominal 24°C, this being deemed a suitable temperature for both equipment and people. Cooling, at all but the smallest installations, was done using outside-air ventilation during the cooler parts of the year and by refrigerative cooling during the warm summer days.

Several factors have now enabled the development of a new, cheaper cooling system for application to new multiple-suite switching installations. The new system has halved previous cooling costs.

The factors that prompted the reassessment of cooling methods are as follows:

- A European Telecommunications Standard[1] for room temperature and other environmental conditions has been introduced. ETS 300 019, published in 1992, defines the allowable room temperature and humidity range within which the equipment must work. The Standard is intended to apply to all telecommunications equipment sold within, or to, Europe. This enables a UK cooling system designer to design a cooling system which provides a standard environment suitable for any type of equipment purchased from anywhere in the world.

- Equipment rooms are largely unattended. Fifteen years experience with digital switching and transmission systems combined with the development of remote monitoring and control has led to equipment rooms becoming unattended. The room environment no longer has to be suitable for permanent occupation and need only cater for short term visits.

- There is a long-term need to eliminate chlorine-based refrigerants in accordance with the Montreal protocol and subsequent European Directive. Chlorine-based refrigerant gasses, if released into the atmosphere, damage the ozone layer. Containment is one option, but this can be difficult to achieve in practice. Alternative refrigerants have their own problems. Elimination of all refrigerants is the preferred solution.

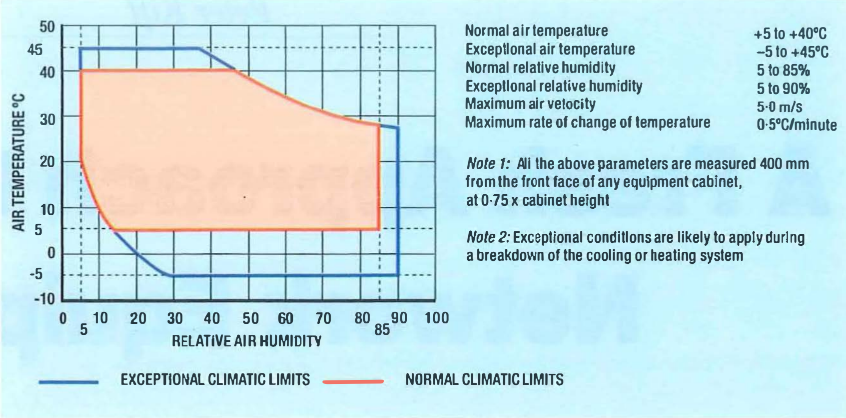
- BT has successfully introduced a cost-reduction culture. It is everyday business to exploit ways of reducing costs. Cooling policy and provision reflect this.

Design Goal

Lowest whole-life costs, commensurate with being a good employer and an environmentally sensitive company, became the obvious design goal for the new cooling system.

It was decided that the initial design would address the needs of equipment. Equipment needs are easily quantified, whereas the interpretation of people's requirements is more subjective and less easily quantified. This approach provided the base, and therefore

Figure 1—Climatic parameters of ETS 300 019 Class 3.1



cheapest, cooling solution which could then be modified if necessary, at known cost, to accommodate the needs of people.

Design Performance Criteria

The cooling system had to meet two performance criteria:

- The ability to provide a room environment which met European Telecommunications Standard ETS 300 019 Class 3.1 (see Figure 1). The **average** room temperature is a significant factor in relation to equipment fault rate and service life, but has not been defined in the European Standard. BT has set the design average room temperature at 24°C by agreement with its major switching equipment and battery suppliers.

- A reliability of 5000 years mean time between system failures (MTBSF). The cooling system would be deemed to have failed if the room environment went outside the temperature and humidity limits of Class 3.1. The most critical parameter was considered to be the normal upper temperature limit of 40°C. Excursions above this temperature might not only lead to loss of service to customers, but may potentially be accompanied by permanent damage to the telecommunications equipment itself.

Existing Cooling Systems

It is perhaps worth reviewing the type of cooling systems that currently exist at most digital switching and transmission installations.

Small sites, with few equipment racks, use ventilation systems comprising one or more fans pushing outside air into the room via disposable air filters (see Figure 2). Refrigerative cooling is not available or necessary. The fans only run when needed, thereby keeping energy consumption to a minimum. Good air distribution is assured due to the small size of the installation. Air is supplied at the rate of 1 m³/s for every 6 kW of room cooling load, which is sufficient to keep the room temperature to no more than 5°C above outside ambient.

Larger installations usually require ventilated ceilings or ventilated floors to distribute the cooling air evenly along the intersuite gangways (see Figure 3). Ventilated ceilings and floors, in turn, require a constant air supply to work properly and therefore cooling unit fans run continuously and energy consumption is relatively high. Air is supplied at the rate of only 0·5 m³/s for every 6 kW of room cooling load, which is sufficient to keep the room temperature to within 10°C of outside ambient. During warm summer days, refrigerative cooling has, until now, been necessary to keep the room to a nominal 24°C for people comfort. Since the transition to unattended equipment rooms, refrigerative cooling is strictly only

Figure 2—Cooling arrangement at existing small sites

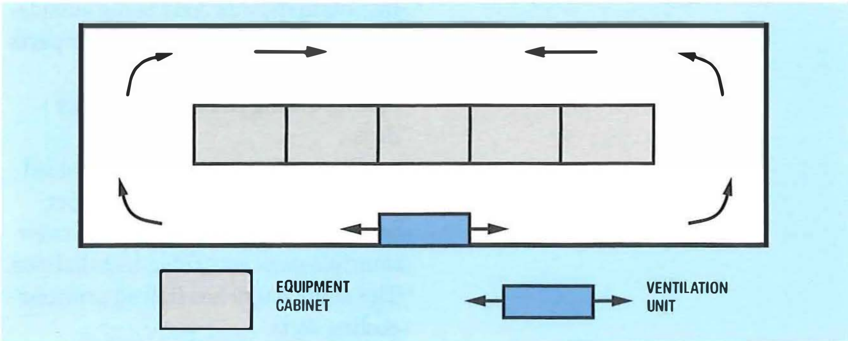


Figure 3—Cooling arrangement at existing larger sites

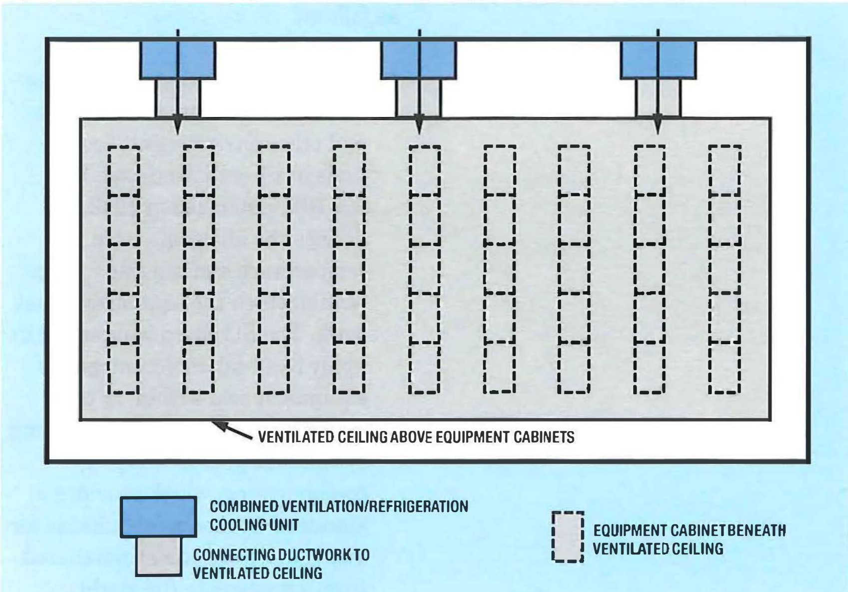
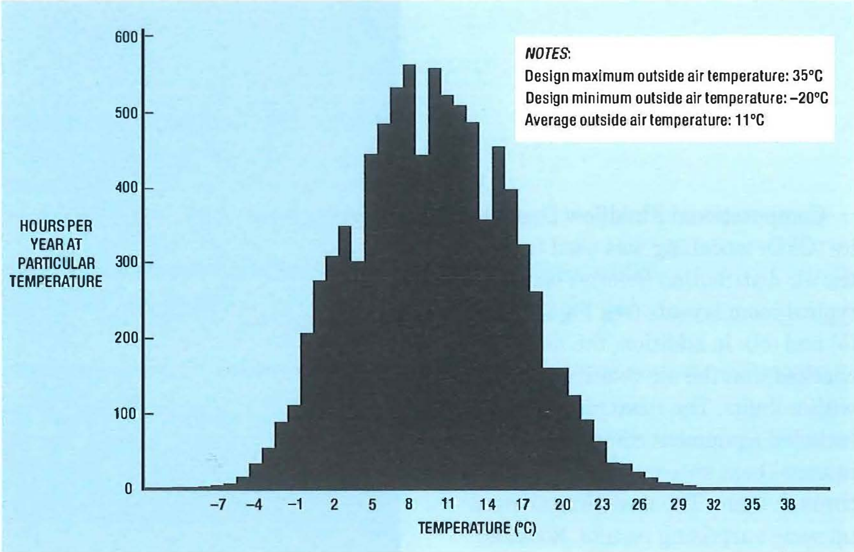


Figure 4—Typical UK outdoor ambient temperature distribution (London Heathrow)



necessary during the warmest summer days, when without it the telecommunication equipment's normal upper temperature limit of 40°C would be exceeded. The refrigeration facility on such systems could not be eliminated completely unless the air-flow rate was doubled. However, this would nearly double their energy consumption as fans would still have to run continuously to ensure correct working of the ventilated ceilings and floors.

Outside Temperatures in the UK

Figure 4 shows a typical UK annual temperature distribution. This is significant as it demonstrates that there is a clear margin of 13°C between the average outside air temperature of 11°C and the design average room temperature of 24°C; and 5°C between the maximum outside air temperature of 35°C and the normal room temperature limit of 40°C specified for Class 3.1. This gives scope for the use of outside-air cooling for all of the year.

The New Cooling System

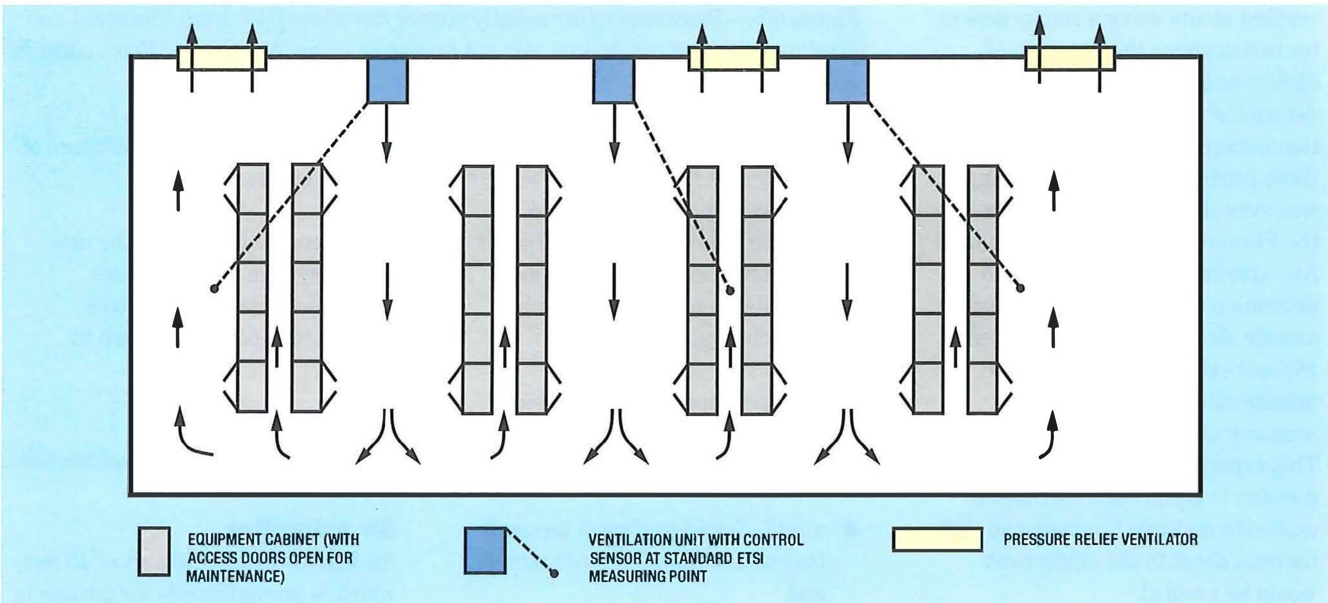
Consideration of the outside temperature data, the ETS 300 019 Class 3.1 temperature limits and the existing cooling systems suggested that the new cooling system design would use outside air in large quantities, as at existing small installations. Refrigerative cooling would then not be necessary at any time of the year. The challenge was to design a method of air distribution which would be effective at larger installations without having the air fans permanently switched on. Switching off the fans when not required is the only way of keeping energy consumption within acceptable limits.

Air distribution

It was thought that the positioning of the room exhaust pressure relief ventilator relative to the supply air could be used to control the flow of air in the room without the need for a ventilated ceiling or ventilated floor. The main constraint was that, at most sites, the supply and exhaust apertures needed to be on the same face of the building. The second important constraint was that Class 3.1 required that the velocity of the room air did not exceed 5 m/s in the vicinity of the front face of the equipment cabinets. The simple concept shown in Figure 5 satisfied both constraints. The design works as follows:

- Outside air is blown at low level between the equipment suites.
- As the air moves down the gangway, it mixes with room air and slows down before drifting slowly back across the room and out of the pressure relief ventilators.

Figure 5—Simple arrangement of equipment suites, ventilation units and pressure relief ventilators ensure good air distribution



Computational Fluidflow Dynamics (CFD) modelling was used to test the air distribution theories on typical room layouts (see Figures 6(*a*), (*b*) and (*c*)). In addition, the model checked that the air velocity was within limits. The room model included equipment cabinets with internal heat source and airflow through them. The modelling showed up some surprising results. Room air velocities of 5 m/s which fully met the Class 3.1 requirements had significant adverse influence on the natural convection through the equipment cabinet. For this reason, the new cooling system design has kept velocities across the front faces of the equipment cabinets down to below 2 m/s where they have little or no influence on the airflow through the cabinet.

The modelling showed up some surprising results.

A small dummy installation comprising 10 cabinets and a ventilation unit was set up at Ongar telephone exchange in Essex. This real installation was then modelled on the computer. Modelling results were verified at site using a smoke generator to determine the direction of airflow and a hot wire anemometer to determine the velocity. The correlation between measured results and those predicted by CFD modelling was very close, giving confidence in the Flovent[2] modelling software used. An experiment was then done to determine the maximum flowrate of outside air that could be tolerated without exceeding the 0·5°C per minute rate of change of room temperature allowed under Class 3.1. This experiment resulted in a decision to equip each ventilation unit with multiple fan stages so that thermal shock to the equipment would be avoided.

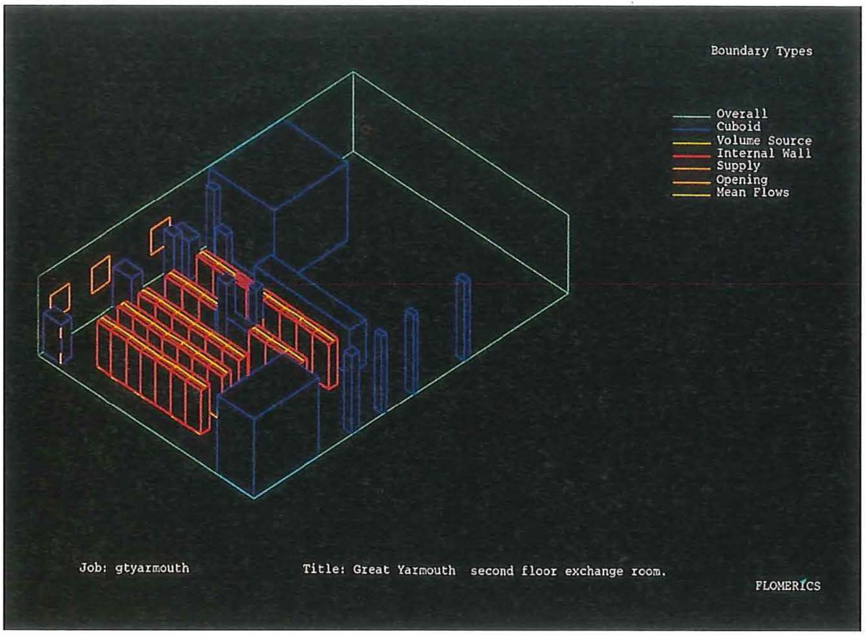


Figure 6(a) – Typical room model showing ventilation units and pressure relief ventilators on far wall and equipment suites towards the centre of the room. Columns and secondary rooms can be seen clearly

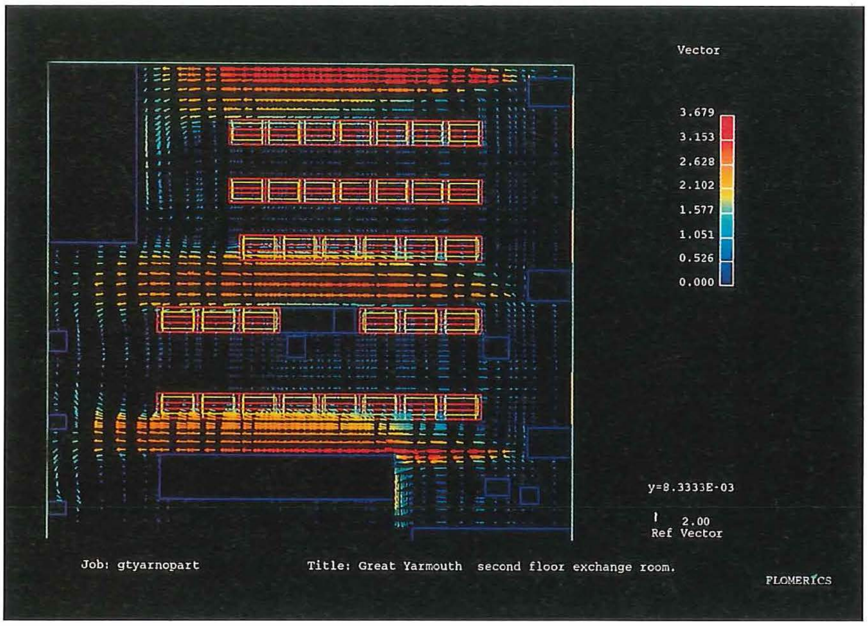


Figure 6(b) – Plot showing air velocity vectors just above floor level. The speed and direction of the air can be seen. Air can be seen entering the cabinets. Room shots for greater detail are easily obtained

Controls

Cooling system controls need to satisfy the following criteria in order to maintain a suitable environment for the telecommunications equipment (including batteries):

- a room temperature which stays between the limits of +5°C and +40°C,
- a rate of change of room temperature of less than 0·5°C per minute, and
- an **average** room temperature of 24°C or less.

The controller used in the new cooling system achieves these conditions. The expected room temperature profile is shown in Figure 7.

People Comfort

Air velocities

Air leaves the cooling unit at 10 m/s, which is uncomfortable for anyone in

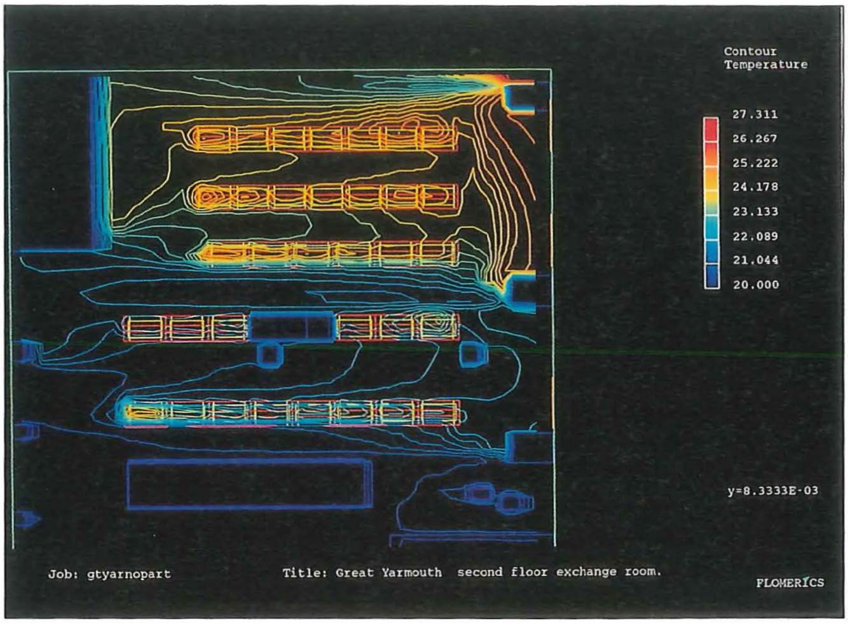


Figure 6(c)—Plot showing temperature contours just above floor level. A similar plot can be produced for any section

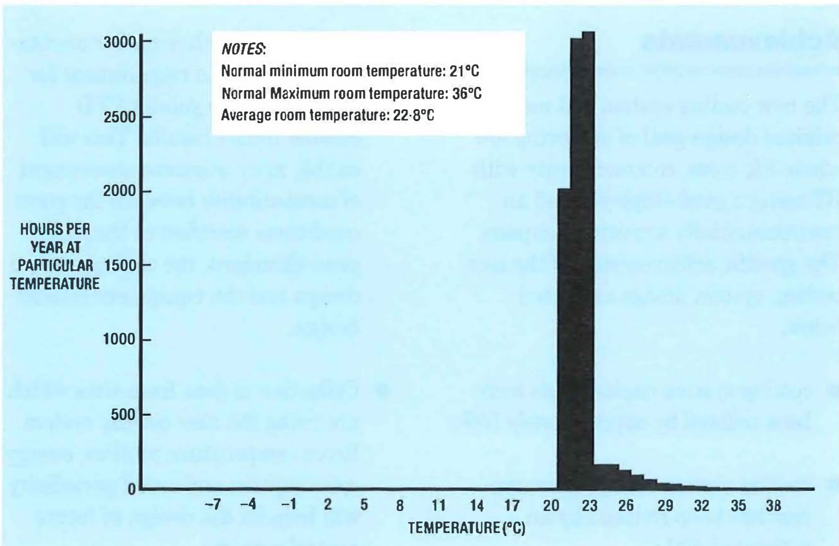
CFD room modelling

Computational Fluidflow Dynamics (CFD) is a software tool that enables the resolution of velocity and temperature of air flow at any point in a three dimensional environment. The CFD modelling technique has become accepted practice for designers of telecommunications equipment cabinets, enabling potential hot spots to be identified and eliminated on the computer screen before the real thing is built. However, its application to room cooling analysis is fairly new.

Flovent[2] CFD software enables the cooling system designer to model a complete room together with any equipment cabinets, ventilation units, pressure relief ventilators and any other heat sources and physical obstructions to air flow.

In BT's case the cooling system design had to ensure that room conditions specified for Class 3.1 were met. In practice this entailed ensuring that adequate air was supplied down each gangway, at a velocity below 5m/s, and at such a temperature that the rate of change of temperature did not exceed 0·5°C per minute.

Figure 7—Expected yearly room temperature profile



close proximity. However, the velocity drops to 5 m/s within 2 m of the cooling unit. Any person standing at the front face of an equipment cabinet will be subjected to air velocities less than 2 m/s, which will not be uncomfortable.

Acoustic noise

The cooling unit, with all fan stages in operation, emits NR65 (70 dBA) measured at a distance of 2 m. This is subjectively twice as loud as a typical single fan-cooled telecommunications equipment cabinet. However, it is not uncomfortable to hold a conversation adjacent to the unit and the level is well below that which would cause any health concern over hearing damage.

Temperatures

Figure 4 shows that for most of the year the outside ambient temperature is less than 18°C, which is considered too cool by most people. During the same period, the room temperature will be about 22°C at most installations, which is acceptable to most people and more comfortable than being outside.

The outside temperature will be above 18°C for only 11% of the year and for this period the room temperature will be 5°C or less above that outside temperature (that is, 25°C outside results in 30°C inside). However, during this period the cooling system fans will be in operation, creating air movement in the main gangways. This air movement will contribute to the feeling of comfort and will largely offset the effects of increased temperature. People entering the building when it is a sunny 30°C outside, will walk into a room at 35°C but the absence of direct solar radiation and the presence of air movement (air velocity of between 1 and 2 m/s) will offer a reasonably comfortable environment.

Maintenance of the New Cooling System

Quarterly maintenance routines consist largely of the simple

Switch, transmission, accommodation and cooling planners need to work as a team from the earliest stages of a project.

replacement of disposable air filters and a visual check to ensure that the room is adequately sealed against excessive air leakage.

Fault rectification is quicker and easier than with previous systems as any component can be replaced in less than 30 minutes. Previous systems required that most major components could be replaced within one hour, although the replacement of certain refrigeration circuit components did take considerably longer.

For the new cooling system the maintenance technician needs only to be electrically competent in order to diagnose and change faulty components. Previous cooling systems required electrical competence, a knowledge of refrigeration and, if certain refrigeration circuit components needed changing, brazing skills.

The simpler cooling unit design contains only about half the number of component parts of previous cooling systems. This makes spares holdings cheaper and more manageable.

Integration of Switch, Cooling and Accommodation Planning Practices

Traditionally, equipment cabinet and suite layouts have been independent of the cooling system used. The cooling system planner was able to accept a finished equipment layout and then set about cooling it.

The new cooling systems require a fixed relationship between the position of the ventilation units and the equipment suites. This is possible only within suitable accommodation. A new approach to the planning process is required.

Switch, transmission, accommodation and cooling planners need to work as a team from the earliest stages of a project. Various options of accommodation and layout will probably have to be considered in order that the optimum solution can be identified.

Whole-Life Costs

The interdependency of accommodation, suite layout and cooling method means that the cost element of all three must be taken into account when determining the best solution for any particular installation.

The option chosen will have the lowest, or near lowest, whole-life cost and will preferably utilise a cooling system which contains no refrigerant.

Limitations of the New Cooling System

The new cooling system is most suitable for new installations where an integrated layout of equipment suites, ventilation units and pressure relief ventilators can be accommodated in a contained space which can be reasonably sealed against leakage. It is not suitable for fitting retrospectively at existing installations.

Certain instances of exceptionally high equipment heat density, non-standard telecommunications equipment or large equipment rooms may continue to need the positive air distribution afforded by a ventilated ceiling or ventilated floor and the continuous cooling-air supply that these systems demand. It is hoped that such cases will be a reducing minority as planning teams become smaller, more integrated, and better able to plan to avoid such situations.

Achievements

The new cooling system has met its original design goal of achieving low whole-life costs, commensurate with BT being a good employer and an environmentally sensitive company. The specific achievements of the new cooling system design are listed below.

- cooling system capital costs have been reduced by approximately 50%;
- cooling system energy consumption has been reduced by an estimated 50%;
- all refrigerants have been eliminated—the new cooling system has no refrigeration process;
- on-site maintenance times have been reduced owing to the simplicity of the system and good design of the ventilation unit;
- maintenance skill level has been reduced to single (electrical) rather than dual (electrical plus refrigeration) competencies; and
- spares holdings have been reduced as the simpler ventilation unit design contains only about half the number of component parts of previous cooling units.

The Future

Future work will concentrate on extending the use of outside air cooling to all types of telecommunications equipment. Specific areas which need to be addressed are as follows:

- Ensuring that **all** equipment brought into BT meets the relevant class of the European Telecommunications Standard ETS 300 019.
- Reducing maximum room air velocity specified in ETS 300 019 Class 3.1 to reflect results of BT's CFD modelling.
- Amending purchasing documentation to include a requirement for all suppliers to submit CFD cabinet model results. This will enable more accurate assessment of compatibility between the room conditions specified in the European Standard, the cooling system design and the equipment cabinet design.
- Collection of data from sites which are using the new cooling system. Room temperature profiles, energy consumption and on/off periodicity will help fix the design of future control systems.

Acknowledgements

The author would like to thank Paul Holder and Dave Sheffield from BT Laboratories for the modelling work which has been central to the project.

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1 Environmental Conditions and Environmental Tests for Telecommunications Equipment. ETS 300 019. European Telecommunications Standards Institute (ETSI), Sophia Antipolis, France (Tel: +33 92 94 42 00).

2 Flovent CFD modelling Software is supplied by Flomerics Ltd., 81 Bridge Road. Hampton Court, Surrey KT8 9HH (Tel: (0181) 941 8810).

Biography

Peter Kiff
BT Networks and Systems

Peter Kiff is manager of BT network cooling policy and Secretary of the European Telecommunications Standards Institute (ETSI) Committee responsible for equipment environments. He joined BT after leaving school in 1965 and is thoroughly enjoying a career which has included Strowger maintenance, the development of automatic postal letter sorting machines and noise control in BT's seven factories. He has been involved with network cooling since the introduction of the first digital switch in the early 1980s and has been actively involved in the move away from large central chilling plants to the small self-contained modular cooling units which are commonplace in today's telecommunications centres. He is a Chartered Engineer and a Member of the Chartered Institution of Building Services Engineers.

Steve Wright, Richard Millard and Malcolm Payne

Procurement of Software-Rich Systems

Software is an important component of many systems, and is vital in providing organisations with competitive edge. However, it is often extremely complex and difficult to produce. Hence, it can be difficult to estimate accurately how long development and testing will take, or how much effort will be needed. This poses a significant risk to delivery in terms of the functionality of the system, time-scales, cost and quality. This article reviews what can be done to reduce these risks, based on the authors' experience of applying the techniques to bought-in systems development.

Background

Software and software-rich systems now form the life blood of many businesses and are often used to provide those businesses with a competitive edge. There are many examples of this in fields as diverse as telecommunications, insurance and travel. For example, in telecommunications it is acknowledged that MCI exploited its customer billing information systems to launch the Family and Friends service, which took the long-distance telecommunications market in the United States by storm and was responsible for their customer base growing by several millions in just one year. Direct Line was spectacularly successful at capturing market share in the UK car insurance market by using systems that allowed it to sell insurance directly to customers over the telephone line. The American Airlines *Sabre* reservation system, an attempt at improving efficiency, became a source of profitability for the airline when the system was used to provide service to other airlines.

The introduction of software-rich systems can provide significant rewards to the companies that successfully deploy these systems. However, there are significant risks and many published instances of public failures that can cost many millions of pounds. In recent years we have seen the failure of Taurus, the UK Stock Exchange settlement system, costing the Exchange £75M in development costs and the traders an estimated £300M. The collapse of the London Ambulance computer-aided dispatch system following its introduction in 1992 put lives at risk. Defects in a single line of code were responsible for the loss of telephone service to many millions of customers for many hours at various locations in the United States in 1991.

The telecommunications industry is already at the forefront of the challenge of managing software-rich systems. Its dependency on software is set to grow rapidly, driven by competition and the technology available. Operators have modernised their networks with digital transport and switching systems. Computer-controlled digital switches make up all of BT's core national and international network and over 90% of the UK local network. Digital network elements are being rapidly introduced in the transmission network, which is becoming increasingly software rich†. Control of these network elements is increasingly performed remotely and is distributed around the network. At the same time, more complex systems for billing, workforce management and administration are being deployed, becoming an integral part of providing service and managing the network. More control will rest with the customer and service providers as intelligent network systems are deployed and enable the customisation of services and service management for the needs of individual customers. The growing complexity of these systems and their interrelationship provides a challenge for any telecommunications operator. The key technical competences required for the development of these systems, their integration, migration and operational management are not in abundant supply. No operator can

† 70% of the development cost of modern transmission systems is for the software, 30% for the hardware.

undertake alone all the required developments. This article reviews the risks associated with the acquisition of software-rich systems for telecommunications and discusses some of the tools and techniques that can be used to control those risks.

The Risks

The acquisition risks can be categorised into three main headings:

- *Commercial* Often, customers license the right to use software and it is very difficult to determine a fair price. The software may be bundled in the overall system price and the nature of the relationship with a supplier is often long term with the customer single-sourced for maintenance and enhancements. This can make it difficult to know what proportion of a supplier's development costs should be borne by each customer. Unforeseen changes to the way the software is used can require the renegotiation of the licence terms, putting the buyer in a relatively weak position. The best overall arrangement with a supplier can be difficult to define, especially in cases where the customer needs a mixture of applications development, applications licensing, system and user support, and enhancement and maintenance.

- *Technical* The technical risks are related to whether the customer can be confident that a particular software application can meet the performance and functional requirements. Even the simplest application requires extensive testing and more complex applications cannot be completely tested in advance of operational use. Many modern systems require a great deal of skill and effort to integrate them successfully into their operational environment. The technical risks are significantly higher for new and unproven technology and applications.

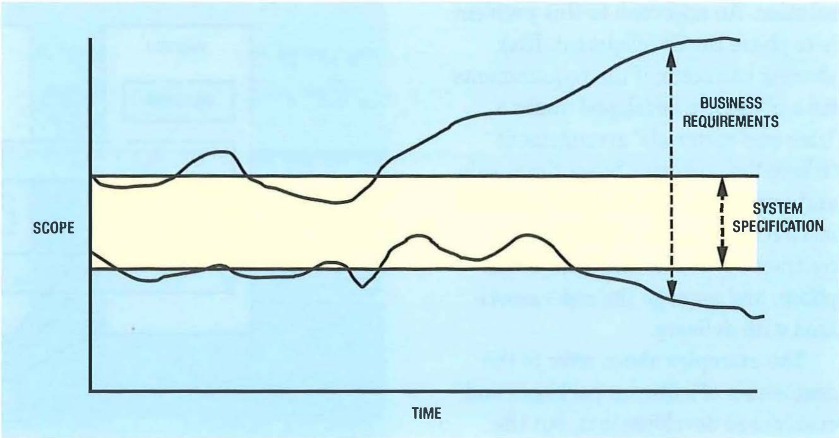


Figure 1 – System specification failing to track business requirements

- *Management* The definition of management risks covers the management of the whole project life cycle from supplier selection, requirements, management of the development, acceptance, roll out and support in the field. It is recognised that these risks are within both the supplier and customer domain. The most common and significant risks are the poor understanding of requirements, an undisciplined customer–supplier interface, and inadequate project/programme management.

The supplier may bear most of the risk; for example, the financial risk for the supply, customisation and maintenance of a business software package. However, the delivered functionality may not meet the business need because the system is too slow (technical performance overlooked), difficult to use (requirements ill-defined in users' terms) and delivered too late (poor project controls). It is often not sufficient simply to blame the supplier. Even in this simple customer–supplier model the customer is still left with a useless system, delivered late. The lost opportunity costs are often more than the original contract value.

In other cases, the customer may bear more of the risk. This can happen when the customer produces the requirement, dictates the technical architecture and the supplier is dependent on the customer to deliver critical elements of the solution. The customer needs to ensure that the commercial arrangements are matched by a well-thought-out approach for dealing with the management and technical risks; for example, applying incentives for early delivery.

In practice, the risks are often shared. Two examples here are the development of a large infrastructure system, and the integration of a proprietary system with an existing infrastructure. In the case of the infrastructure development (for example, for billing or customer handling and service), the complete development may take about 18 months to develop, and may not track business requirements during this time (see Figure 1). The target requirements in terms of flexibility, market segmentation, number of customers, services and discount packages may be predicted from a knowledge of the current market trends, the telco's market-share prediction and the current regulatory environment. Clearly, the precise requirements are dependent on the business environment, which in a competitive market is changing fast. The customer needs to ensure that the commercial and management aspects of this development are given equal weight to the need to develop a well-defined technical

The customer needs to ensure that the commercial and management aspects of the development are given equal weight to the need to develop a well-defined technical solution.

solution. An approach to this problem is to phase the development. Risk sharing can occur, if the requirements for a phase are developed under a 'time and materials' arrangement (where the customer bears time-scale and cost risks). The supplier will then more readily agree a fixed price contract for the development of the phase, and manage the risks associated with delivery.

The examples above refer to the acquisition of software packages and customised developments, but the risks apply equally to the procurement of proprietary network and system equipment. The added commercial complication is that the requirements of a particular network operator are one of a set of customer and market requirements that the supplier is attempting to satisfy, Figure 2. The customer needs to ensure that its business requirements have sufficient priority, and are based on a sound approach to the management and technical risks. In this case, the supplier takes the risks associated with product evolution and control of overall delivery, and the customer takes the risks associated with the control of business requirements, and the understanding of technical interfaces and integration issues.

There is not a complete set of established methods that can be applied to the complete range of software-rich acquisitions. The *STARTS Purchasers' Handbook*[1] gives useful guidance on both data-driven and event-driven systems, but puts its emphasis on fixed models of the development life cycle. It is being updated to deal fully with the dynamic environment that we have to deal with today.

The scale and complexity of software-rich systems are increasing faster than the maturity of the methods used to manage these developments. Suppliers are increasingly recognising this and are attempting to improve their methods through an engineering approach to software development. Customers also need to recognise the need for improvements. This can also be achieved by using suitable tools and techniques within a procurement environment.

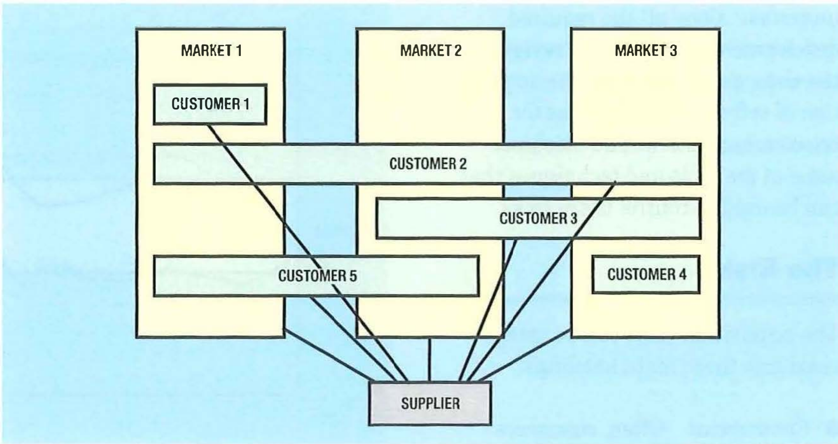


Figure 2—Supplier must satisfy requirements of many customers and markets

Software Acquisition Tools and Techniques

The greatest risk to the successful delivery of a software rich system comes when significant development or integration work is necessary.

The four features of a system development that can be controlled (Figure 3) are:

- *Scope or functionality*—which user requirements will be satisfied by the delivered system?
- *Schedule*—when will the delivery occur?
- *Quality*—how well will the user needs be satisfied?
- *Cost*—what will you pay for all this?

They are related, but it is very tempting to treat them as independent. If we concentrate only on one or two of them, the others will spiral out of control. For example, if we concentrate on controlling cost, a developer who has underestimated the difficulty or size of the job may pare away at the scope to be delivered, or on the quality. If we concentrate on the schedule, more resources may be piled on to keep the timetable, and costs rise. Each project manager should have his or her own view of where they wish to be in the tetrahedron shown in Figure 3.

System development is usually controlled by using a development life cycle, such as that shown in Figure 4. The theme of verification and validation is key in this representation of the life cycle. The theme appears in several ways. First, work done at any stage should be verified by checking that the work product has been 'built right' during that stage. This might be done by peer reviews of the work product. Secondly, the work product should be validated against the original customer or user requirement: is the right product being built? Here requirements traceability can be very helpful. Thirdly, Figure 4 shows

Figure 3—Features of system development

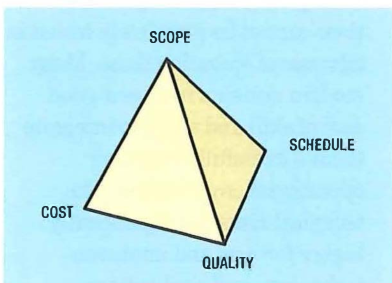
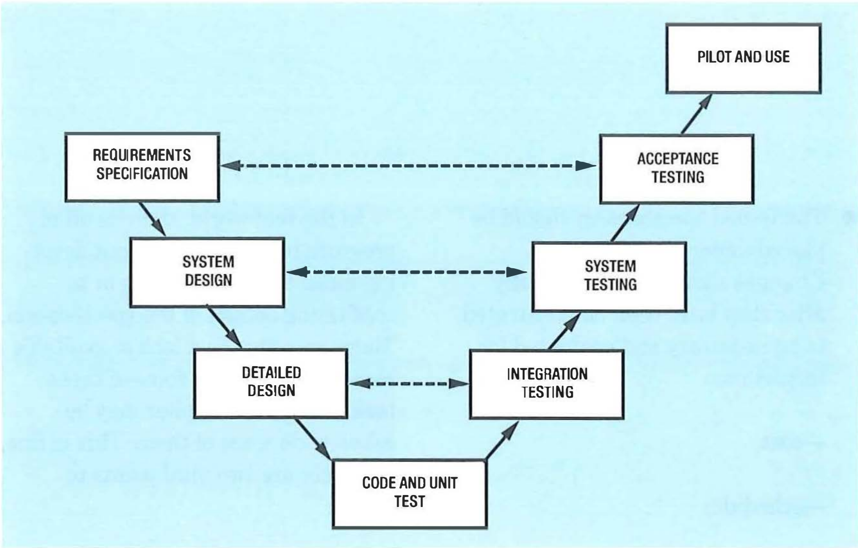


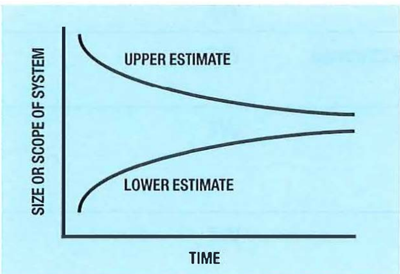
Figure 4—Typical system development life cycle



the importance of testing (on the right hand side of the V shape). It also shows the role of testability analysis. For example, as the requirements specification is being developed, it should be reviewed for testability, and the user's acceptance tests should begin to be defined.

Within this framework, the project manager may be able to use risk management throughout the delivery cycle to shorten the overall time-scale. This can be achieved by undertaking some tasks in parallel rather than in series; that is, by starting one stage before the previous stage is complete. For example, design and development work might start before the specification of all the modules is complete. This is feasible if the risks to the overall development are quantified and limited; for example, if the unspecified modules are self-contained. The specification can then be refined later, while the mainstream development continues. Risk management throughout the delivery cycle requires the project manager to focus on the critical or near-critical paths and actively manage the risks. This is particularly important in the earlier stages of the life cycle, when uncertainty is greatest (see Figure 5). A high degree of flexibility and control is essential to get the best results. This can be achieved only when the customer, rather than the supplier, retains management control of the complete development.

Figure 5—Uncertainty about development projects reduces with time



The rest of the article discusses how scope, schedule, quality and cost can be controlled. Not all of the techniques described will be appropriate for every development, but the methods outlined provide a firm baseline from which informed risk management decisions can be made.

Control of Scope

The classical approach (which is often forgotten about!) is to start with a statement of the requirements. There are a few key points about this:

- Include as much as is known at the time of writing.

  —If some requirements are known in outline only, then somebody will have to do the work necessary to refine them with more detail until a system developer can use them as the basis for development work. This can be done by the developer, but the developer will need special skills in the relevant application area if this is to happen.

  —Pay careful attention to any interfaces that the system requires. If these interfaces are standard, mature and well known, there may be little difficulty. However, if they are proprietary or are to bespoke heritage systems, then it is likely that a lot of effort will be needed to ensure that the system works successfully across the interface.

- Review it for testability. This is probably one of the most valuable things that can be done. For every requirement, ask 'how would I know if this requirement was satisfied?' The review can be used to develop an (outline) of the eventual acceptance tests.

- Review it to ensure all the requirements are traceable. It is often helpful to ask the developer to provide traceability from the customer requirements to:

  —the system specification (which the developer will produce),

  —the detailed design of the system,

  —the acceptance tests.

  This should be demonstrated by means of a traceability matrix (an example is shown in Figure 6).

Figure 6—Traceability matrix

USER SPECIFICATION		SYSTEM REQUIREMENTS SPECIFICATION		DESIGN		ACCEPTANCE TEST
PARA	REQUIREMENT	PARA	REQUIREMENT SUMMARY	PARA	MODULE	
1.2.1	THE SYSTEM SHALL BE MAINTAINABLE	2.5	ON-LINE DIAGNOSTICS	2.5	ONSTUB	TEST 14.5.2
		2.6	OFF-LINE DIAGNOSTICS	2.6	OFFSTUB	TEST 14.5.3
		6.8.5	TEST EQUIPMENT	6.8.5		TEST 44–45

- The issued specification should be placed under change control. Changes should be allowed only after they have been demonstrated to be necessary and evaluated for impact on:

  —cost,

  —schedule,

  —quality, and

  —functionality/the rest of the system design.

Key intermediate work products (especially the system requirements specification) should also be agreed and formally signed off. Examples for common deliverables are shown in Table 1, together with outline acceptance criteria for them.

In the real world, there is often pressure to go ahead without devoting much time to planning or to confirming details of the specification. There may also be a lack of available resource to perform some of these tasks, so that a supplier may be asked to do some of them. This is fine, but there are two vital points to watch:

- Traceability and change control of the emerging requirements are **essential**.
- It must be clear that the chosen supplier understands the business at the detailed level necessary to capture and understand any requirements work they are asked to do. This applies particularly in the case of any interfaces to existing systems. These have often evolved over a period of time: the documentation, owing to operational pressures, has often not quite kept up and there may be a lot of custom and practice which the operational people understand but which a newcomer to the scene will not.

Control of Schedule

The developer will usually have made an estimate of how long the work will take. There are two key questions to ask:

- What planning has been done on which to base the estimate?
- Where is the evidence that **this** development organisation can produce a system of **this** scope in **this** time?

Table 1 **Example Deliverables and Acceptance Criteria**

Deliverable	Acceptance Criteria	Acceptance Method	Sign-Off Authority
Solution specification	Fully documented solution, describing any external systems involved, new developments, alternatives considered and reasons for recommending this solution	QA review	Systems engineering team, delivery manager, business assurance, technical assurance, VVT
High-level design	Architectural description; identification of sub-systems and their interfaces, and external systems interfaces; description of design decisions	QA review, design walkthrough	Technical assurance. delivery manager, VVT
Detailed design	Defines internal and external interfaces, identifies data formats between systems	Design walkthrough	VVT
System test plan	Describes approach and plan for testing, identifies testing roles and responsibilities, provides schedule plan for testing activities, identifies testing priorities and any functions not to be tested	QA review	VVT
Test summary report	Identifies tests carried out and the test results, highlights any major or critical test failures, demonstrates level of successful interworking, identifies the test coverage achieved	QA review	VVT
User manual	Contents to describe fully the use of the delivered features such that the need for training is minimised. Configuration and administration details should be provided in a separate section	QA review	Delivery manager (on behalf of QA review team)
Installation guide	That instructions for installation and build work correctly	Test use	VVT
Training/ education	Provision of detailed plans and training material	QA review	Delivery manager (on behalf of QA review team)
Code	Successful installation and run on target machine	Demonstration	VVT

QA: Quality assurance   VVT: Verification, validation and test

Planning

The first question is: 'Is there a project plan?' When the developer shows one, check it against the following points:

- Does it identify the critical path?
- Does it include all necessary activities, such as

  —support to customer integration?

  —review and rework of work products?

- Does it allow enough time for each activity? Example rule of thumb: requirements capture for any but very small projects will take at least two months.
- Does it show a suitable distribution of effort across the life cycle? Example rule of thumb:
  $^1/_3$ on requirements and design,
  $^1/_6$ on coding,
  $^1/_2$ on test preparation and test.
- The elemental task size should be about two weeks long (this would be suitable for project progress reviews every month).
- Does it indicate external dependencies?
- Are meaningful checkpoints built in?

Evidence of previous achievement

There should be evidence that the developer has achieved something similar before. Evidence will need careful interpretation. The amount of product from a development team will be greater if:

- the team has a greater productivity,
- the team is larger (the amount of effort available is increased), and
- the development is allowed more time.

There are two **key points** to watch:

- Productivity varies not only from developer to developer but also between different kinds of development (for example, a team developing a management information system in structured query language (SQL) will write more lines of code per week than a team developing a real-time control system in assembly language).
- The relationships between achievable product size, effort and time-scale are not linear, so either compare developments of similar size to the one being planned, or make some assumptions about what the relationship is. There are many models on the market; a helpful one is[2]:

  achievable product size = (*productivity index*) x $(effort)^{1/3}$ x $(time\ allowed)^{4/3}$.

For each project, estimates of size and effort must be produced (there will already be an estimate for the elapsed time required). The size estimate may be in terms of measures such as non-comment lines of source code, of function points[3], or of compiled file size. The effort figure might naturally be in terms of labour-months required. An indication of how confident the developer feels is gained by asking for a range around the estimate; and asking **why** the range quoted is a reasonable one.

After this, the same information (size, effort and time) for a few similar projects that the developer has completed successfully must be acquired. The historical information must be compared with the plan for the project. The developer will probably be optimistic in the plan. However, the developer must jusify the optimism and demonstrate that the historical projects are similar to the proposed one. The ensuing discussion will be effective at uncovering assumptions that the planners have made—which may or may not be justified. Customer references for the historical projects must be sought; following these up can be very illuminating about how the developer behaves in real life.

Checking a development proposal

Before agreeing a development proposal, **always**:

- ask the developer for a project plan, and review it; and
- ask how the estimating has been done, and what is the basis on which the estimate was arrived at.

The good developer will be able to answer these legitimate questions. The poor developer will have more difficulty, perhaps because the information has not been collected or analysed. In this case, there is a risk. There are several ways in which this risk might be addressed, including:

- going to a different developer,
- reducing the scope of the development until it fits the available time-scale,
- allowing more time, and
- phasing the development (so that the most urgent or the most stable requirements can be delivered in phase 1 and the others are left until later phases).

Progress reviews

It is natural to hold regular progress reviews. Monthly intervals are often suitable. It is usually helpful to cover:

- tasks and milestones completed since the last review, versus the project plan;
- predictions for the coming period;
- a review of risks/issues; and
- a review of current project metrics.

Control of Quality

Quality gates

Projects are usually broken down into phases. Figure 4 shows a typical life cycle for a development project—based on the traditional 'V' life cycle.

Quality gates define the end point of each phase to confine issues before moving on to the next one. Panel 1 gives some examples of what the quality gates might be, based on the life cycle in Figure 4. Each of the gate criteria should also have some standard associated with it. Thus the developer should be able to define the contents of a system test summary, or a system specification or the methods used for, and the outputs of, a system design review.

Table 1 shows what the acceptance criteria might be for some of the quality gate deliverables. The developer must be asked what quality gate criteria are used in the life cycle for their development process. The good developer will be able to list these straight away. The poor developer may not have quality gate criteria in place, or may not even have a defined development life cycle. In this case, the only protection is to ask for any evidence there might be of past achievements on quality, and hope that the project follows a similar course.

It is often sensible to include the agreed quality gates in any contract with the developer, and to link any payments to their achievement. For example, instead of making an interim payment upon completion of the system design document, make one upon completion of the system design phase when:

- all of the quality gate criteria for the system design phase have been met, and
- the design document itself meets its acceptance criteria.

Panel 1—Example quality gates

Phase Gate 1	**Requirements Specification** High-level project plan Verification, validation and test plan Metrics plan Project and quality plan Configuration management plan Acceptance test plan Reliability growth plan Whole life costing Risk analysis
Phase Gate 2	**System Design** System test plan System specification System design review Risk analysis
Phase Gate 3	**Detailed Design** Design specification Design review Unit test plan Integration test plan Risk analysis
Phase Gate 4	**Code and Unit Test (Implementation)** Unit test summary report Unit test defect analysis Code walkthrough Risk analysis
Phase Gate 5	**Integration Testing** Integration test summary report Defect analysis Risk analysis
Phase Gate 6	**System Testing** System test summary report Defect analysis Risk analysis
Phase Gate 7	**Acceptance Testing** Acceptance test summary report Defect analysis User documentation Risk analysis

Metrics

Metrics can be used as part of regular project progress reviews to help judge whether the project is on course. Choosing which metrics are to be reviewed is quite easy, using the three step 'goal–question–metric' approach.

- First, decide the goals.
- Second, list questions to ask to see if the goals are being reached.
- Third, the questions immediately prompt related metrics.

Often, there are four main goals: to have a system

- of the agreed scope,
- delivered on time,
- and to budget, and
- with the agreed level of quality and reliability.

As an example of the approach, take the goal about scope. Relevant questions might include:

- Is all of the scope specified, agreed and under change control?
- Have all of the specified requirements been reflected in the top-level system design?
- and in the detailed design?
- and in the written code?
- and in the system and acceptance tests?

The related metrics might just be a simple 'yes/no'; or at a more sophisticated level, a percentage figure supplemented by a list of the requirements not yet realised.

An example of a set of metrics which address all four goals is shown in Panel 2. It is often helpful to ask the developer to suggest suitable metrics. It is rarely useful to insist on particular metrics if the developer's infrastructure or project control system cannot provide them. The costs and time-scales involved in changing the infrastructure will probably throw the project out of kilter. Another perspective on how well the development is controlled can be gained by reviewing the set of metrics that the developer **can**

Panel 2—Example project control metrics

1 Actual staffing levels in each phase compared with plan.

2 Actual effort expended on each phase against plan.

3 Major milestones and deliverables achieved with dates and expected completion dates.

4 Estimate of the total size of the software and an estimated size range for each subsystem.

5 A cumulative plot of actual and planned software size against weekly time periods, showing the elements that are attributed to ported or re-used code, new code and corrected code.

6 Actual amount of tested software with results.

7 Amount of software under configuration management.

8 Number of software errors found.

9 Number of software errors corrected.

10 Number of elements comprising the system (with an indication of any changes).

11 Status of each element as it moves through the development process.

12 Planned and actual test execution metrics for unit and system tests against weekly time intervals, including:

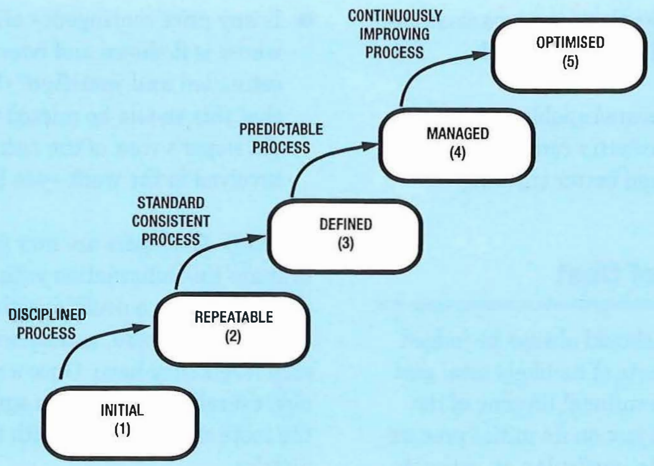
- the number of tests performed,
- the number of tests passed,
- a plot of the cumulative defects found in each period of the testing phase(s).

13 Achieved test coverage of statements (requirement: 100%).

14 Achieved test coverage of branches (requirement: 100%).

15 Achieved test coverage of paths (linear code sequence and jumps. Requirement: at least 70% of maximum possible).

Figure 6—Capability maturity model



provide. The good developer will be able to show metrics they have collected on previous projects, and to discuss their interpretation. The poor developer may not be able to produce any at all. Very often, the first metrics that a developer collects will be about the testing process (such as how many test cases have been run and how many have passed). It may also be possible to agree a longer term improvement in the provision of metrics, particularly in a phased development.

Remember that metrics have to be interpreted. There is little use in having a meaningless number. For example, if 40% of all requirements have been implemented in code, is that a reasonable figure to have at this stage, or should it be 60%? The good supplier will have a history of metrics and will be able to show what they each mean, and whether they are highlighting any emerging risks.

Process capability

A model in common use in BT for assessing the capability of a developer's process is based on the *capability maturity model*, which was itself developed on behalf of the United States Department of Defense[6]. Its five-level improvement model for software development is shown in Figure 6. The levels are designed so that the capabilities at lower levels provide a progressively stronger foundation on which to build the upper levels. The levels are characterised as follows:

- *Initial* The development process is *ad hoc*, and occasionally even chaotic. Few processes are defined, and success depends on the effort of a few key individuals.

- *Repeatable* Basic project management processes are established to track cost, schedule and functionality. The necessary process discipline is in place to repeat earlier successes on projects with similar applications.

A proposal should always be judged on an estimate of its likely total cost over the operational lifetime of the system, not just on its initial procurement cost.

- *Defined* The development process for both management and engineering activities is documented, standardised and integrated in to a standard development process for the organisation. All projects use an approved, tailored version of the organisation's standard process for developing and maintaining software.

- *Managed* Detailed measures of the software process and product quality are collected. Both the development process and its products are quantitatively understood and controlled.

- *Optimising* Continuous process improvement is enabled by quantitative feedback from the process and from piloting innovative ideas and technologies.

Panel 3—Key processes in the capability maturity model

Level 2
Verification, validation and testing *
Software configuration management
Software quality assurance
Software subcontract management
Software project tracking and oversight
Software project planning
Requirements management

Level 3
Customer support *
Development environment *
Peer reviews
Intergroup co-ordination
Software product engineering
Integrated software management
Training programme
Organisation process definition
Organisation process focus

Level 4
Reliability management *
Quality management
Process management and analysis

Level 5
Process change management
Technology innovation
Defect prevention

The key process areas marked * are ones added to the model by BT for its own use.

Except for level 1, each maturity level of the capability maturity model is decomposed into several key process areas. To reach each maturity level, an organisation should focus on controlling the key processes which comprise that level. The complete set of key processes is shown in Panel 3.

For each key process area, the model requires:

- goals to be established,
- a set of activities to be performed,
- implementation to be monitored,
- implementation to be verified,
- that the organisation is committed to perform, and
- that the organisation has the ability to perform.

A few points should be made about what to expect from suppliers of differing capabilities:

- level 1 suppliers can produce good software but cannot control time, cost, quality and scope;
- level 2 suppliers can only poorly control time, cost, quality and scope;
- 95% of development organisations are level 1 or level 2; and
- more mature/capable developers will have better control over the project and better tracking metrics.

Control of Cost

A proposal should always be judged on an estimate of its likely total cost over the operational lifetime of the system, not just on its initial procurement cost. In particular, an estimate of the system's support costs should be made, and agreements reached with the developer about the level of any support charges. BT's WINA (whole-life investment appraisal) system[4] helps to estimate such whole-life costings.

Separately, the reasonableness of the developer's cost proposals may be judged. It may be possible to get a further opinion on what such a development should cost (for example, by the use of competitive tendering, or by asking another developer to produce an independent estimate). Another possibility is to ask the developer for price build data:

- What is the work breakdown? (This should be available from the project plan: are unnecessary items included?)

- What is the effort per item? (In labour days: are the estimates reasonable—use historical data as a guide, or have them reviewed by an in-house developer.)

- What labour rates are used? (By skill grade, cross-referenced if possible to standard British Computer Society skills descriptions: how do the rates line up with the market?)

- What are the non-labour charges, and how are they estimated and justified?

- Is any price contingency allowed, where is it shown and how is it estimated **and justified**? (Note that this should be related to the developer's view of the risk involved in the work—see later.)

Many developers are now prepared to share this information with their clients. It gives a useful insight into their cost structure, and shows the skill levels they have. Once a reasonable overall price has been agreed, the costs can be tracked with the metrics.

Contracting and Risk Management

Agreeing a contract is essentially an exercise in risk management. Before agreeing a contract, the project manager should have a clear picture of how risk is to be managed in the project. Active management is usually the most effective way to reduce overall risk, although some things may also be done to affect the distribution of risk. For example, agreeing a fixed price contract often relieves the customer of some of the financial aspects of risk. The aim is to choose a development supplier that can:

- (help) control scope, schedule, quality and cost simultaneously; and
- has a high rating on the '3 Ps' (Reference 5):

  —uses a good development *process* (see above),

  —can provide good *people* to work on your project,

  —(where applicable) has good *products* demonstrable to you.

If any of these do not apply, there is a corresponding risk to successful delivery. Some guidance on how to address risks is given below.

The negotiations leading to an agreed contract should take account of all of these points, and the contract should include the following items:

- *compliance matrix and supplier's agreed proposal*;
- *description of deliverables, for example*

  —approved solution,

  —reviewed design,

  —delivered and installed system with

  —acceptance test report,

  —user documentation

  —etc;
- *acceptance criteria for each deliverable*;
- *dated milestones*;
- *price/payment schedule*;
- *contract management methods, including:*

  —agreed configuration management and change control mechanism,

  —metrics,

  —risk management, and

  —definition of quality gates.

It is often helpful to ask the developer to provide a statement of the probability and impact of any risks there may be, together with proposals on how to deal with them. Of course, many developers will respond with a list of risks which are not under their control, but principally under **yours**. However, this can be very useful. Firstly, it will show where they feel most vulnerable. If some of these areas can be dealt with, it may, for example, be possible to agree on a more favourable time-scale or price. Secondly, it gives an opportunity to discuss any risks that may have been noticed from an evaluation of their proposal in such a way as to give them confidence that there is no attempt to get a one-sided advantage: the basis for any long-term relationship has to include a two-way element of trust. Thirdly, the discussion of risks can be arranged to form the basis of a risk management plan to help the progress of the projcct.

Once work actually starts, do not underestimate the amount of project management effort that will be needed to keep the work on track. This will include the regular progress reviews with the developer, and any actions arising, and the effort needed to review all of the agreed deliverables before acceptance.

However, this will greatly improve the chances of a successful development and a delighted customer.

Acknowledgements

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Steve Wright
BT Networks and Systems

After graduating in Electrical and Electronic Engineering in 1973, Steve Wright worked on the development and testing of high-reliability micro-electronic circuits at BT Laboratories. He moved to Procurement in 1988 and was responsible for a number of quality- and reliability-improvement initiatives with major suppliers. In 1992, he set up the Software Acquisition Team, with combined commercial and technical expertise to improve the acquisition of software. He is now Manager of Programme Supplier Relationships, where he is responsible for the development linkages with external suppliers. He is on the STARTS management board. He holds an M.Sc. in solid-state electronics and an M.Sc. in Telecommunications Management from BT's Masters Programme in 1992.

Richard Millard
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Richard Millard is a member of the Programme Supplier Relationships team within the Networks and Systems Division. He is responsible for helping development programmes to draw on the skills available in the supply base in the best possible way. He joined the Post Office after graduating in 1975. He worked in several areas related to quality assurance, including the development of ways to assure system reliability. More recently, he was responsible for the development of methods to reduce risks in software development projects, and has applied them to the development of several of BT's operational support systems.

Malcolm Payne
BT Networks and Systems

Malcolm Payne has worked in a procurement function for 20 years and has experience of software development and implementation projects. He has been involved with developing methods for improving the acquisition processes used by BT for software rich systems, before moving into the Programme Supplier Relationships team. He holds B.A. and M.B.A. qualifications, is a member of the British Computer Society and co-author of a book on software projects.

Michael Parkin

Assessment of Network Performance: The ISDN Performance Analyser (Part 2)

An earlier article[1] introduced the ISDN performance analyser (IPA) that has been developed to provide an indication of the performance of data calls carried within BT's basic-rate integrated services digital network (ISDN). This article summarises the progress made since the previous article and provides a summary of the results obtained from the IPA system during 1994.

Introduction

Since BT launched its integrated services digital network (ISDN) in 1991, the product has rapidly penetrated the UK market. A part of the ISDN launch process, in support of the Open Network Provision (ONP) European initiative, required the facility to report on the call performance of basic-rate ISDN data calls (termed ISDN2) and to achieve this the ISDN performance analyser (IPA) was developed at BT Laboratories under the sponsorship of BT Networks and Systems. This article reports on the progress made since the publication of the first article and summarises the results obtained from a survey conducted during 1994 that was made possible by the deployment of the system developed.

The ISDN has been described in detail in a previous edition of this *Journal*[2] and it is not intended in this article to describe the ISDN in detail except when it is necessary to explain a particular aspect of the IPA.

Technical Summary

The previous article[1] described the IPA system in detail. This section provides a technical overview of the system in more general terms. The IPA comprises two sub-units that form the system:

- call sending units (CSUs), and
- the data control unit (DCU).

CSU and DCU IPA stations gain access to the ISDN2 service off the 'S-bus' interface provided from the network termination equipment (NTE) in a similar manner to customer premises equipment (CPE).

Each CSU is able to establish ISDN2 data calls through the network to other CSU stations. On receipt of an incoming data call, the receiving station digitally loops the 'send' and 'receive' directions of transmission to allow the CSU to perform a series of tests based on it sending and then receiving a 64 kbit/s pseudo-random data pattern. Each test call made has a duration of three minutes before the CSU terminates the call, followed by a period of 30 seconds in which the CSU collates the results gained into a call record before initiating the next call in its sequence.

Each CSU follows a call sequence programmed into it under the control of the DCU's system controller by means of an ISDN2 call established between the CSU and the DCU. In this manner, all IPA stations can be managed from a central location by the system controller to enable:

- retrieval of call records stored by each IPA station (system uploads),
- reconfiguration of an IPA station's call sequence (this may include up to 22 destinations to call with the sequence repeated every 24 hours (system downloads)),
- time synchronisation with the DCU acting as the master clock with individual IPA stations being synchronised to this during every upload made, and

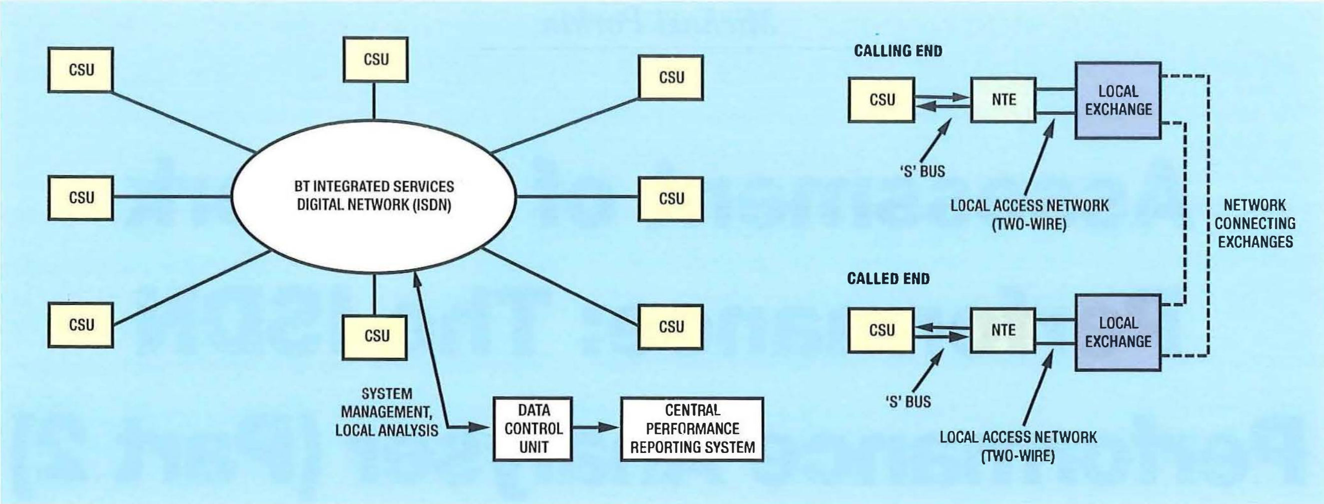


Figure 1—Concept of the IPA system

- operating system reloads where the DCU may be used to reload the working system software in each IPA unit following the release of new software.

Call data records retrieved by the DCU from an IPA station are collated into a format that allows local analysis of the data or for transmission to a central reporting system that enables a number of users access to the results obtained.

The system management and control aspects of the DCU are realised by means of a personal computer (PC) running a 'front-end' control package specifically written within the IPA development project. Figure 1 illustrates the concept of the IPA system.

During the latter part of 1993, IPA stations were established at several sites in the UK to give a mix of city, town and rural locations, following the project's second year development phase (IPA Phase 2). Sites included:

Basingstoke	Belfast	Cardiff
Cardigan	Dorchester	Edinburgh
Faversham	Great Yarmouth	
Holyhead	Lerwick	London
Manchester	Penzance	Stranraer
Torquay		

This network was run throughout 1994 with the objective of:

- gaining ISDN2 call performance results, and
- gaining experience of the operational and management aspects of a live system that could then be reflected back into developing the system.

The results presented in this article were gained from the 'IPA Phase 2' network.

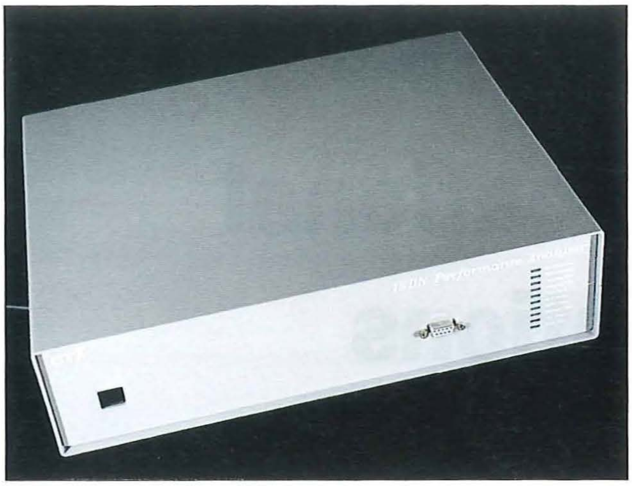
Summary of ISDN2 Call Performance

Table 1 gives results from a survey of 7565 ISDN2 call attempts made between IPA stations from January to December 1994. The results are categorised against the parameters outlined in the previous article[1] under:

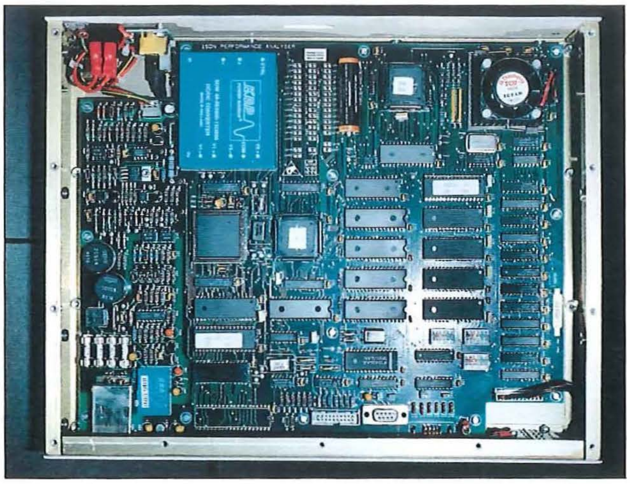
- call establishment phase,
- data transfer phase, and
- call release phase.

Table 1 Survey Results

Measure	Comment	Result
Call Establishment Phase:		
Call establishment failure	31 call attempt failures were recorded out of 7565 ISDN2 call attempts made	>99·59% of calls successfully established
Call establishment delay	The mean call establishment delay was based on 7534 successfully established ISDN2 calls	1·463 seconds
Data Transfer Phase:		
Loss of an established call	Out of 7534 calls successfully established between IPA stations, no calls were recorded as releasing early	100% clear
Degraded ISDN2 calls	Out of 7534 ISDN2 data calls made, 364 calls were recorded as having suffered from one or more digital bit errors at the 64 kbit/s level	>95·168% free
Error free periods of 60 seconds	Out of 22 598 minutes transmitted within the survey, 706 minutes suffered one or more bit error degradation at the 64 kbit/s level	>96·875% free
Severely errored seconds	Out of 13 558 800 seconds transmitted within this survey, 1413 severely errored seconds[3] were recorded	>99·9895% free
Errored seconds	Out of 13 558 800 seconds transmitted within the survey, 4921 errored seconds[3] were recorded	>99·963% free
Call Release Phase:		
Call release delay	The mean call release delay was calculated using 7534 ISDN2 calls within the survey	0·361 seconds



Example of an IPA unit



Example of the interior of an IPA unit

Conclusion

The IPA has enabled a survey to be conducted into the call performance of BT's basic-rate ISDN (termed *ISDN2*), with the results of the survey forming the basis for this article in terms of:

- successfully establishing an ISDN2 call,
- the quality of the ISDN2 connection once it has been established, and
- successfully releasing an ISDN2 connection.

Since launching ISDN2 in 1991, BT has rapidly rolled-out the service throughout its network. A part of the post-launch process has involved the development of the IPA system that enables the performance of ISDN2 calls to be assessed in terms of what ISDN customers may experience.

The results presented in this article were derived from the data collected using the IPA system developed at BT Laboratories. This system has been deployed by Network and Systems throughout the BT network, at its extremities and a number of intermediate locations, to form a network. The experiences gained through this network have enabled the IPA to be contracted out for manufacture[4].

The IPA system has also enabled the feasibility of assessing from the UK international ISDN call performance to a number of destinations throughout the world through its ability to establish calls to ISDN 'loop-back' numbers.

In a similar manner to the basic-rate ISDN service, a development project is currently being progressed to enable primary-rate ISDN call performance to be assessed. This development has been based on the concept of the IPA system.

The manufactured version of the IPA system is to be deployed at a number of key locations in the UK network from mid-1995 and will replace the earlier IPA network. This will enable BT to continue to assess and publish its basic-rate ISDN call performance in response to the requirements of customers, the European Union and UK Government.

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Biography

Mike Parkin
BT Networks and Systems

Mike Parkin joined Post Office Telecommunications in 1976 as a trainee technician in the Guildford Telephone Area. After completing his apprenticeship in 1979, his duties included line transmission and microwave radio maintenance. Having followed the City and Guilds of London Institute Course 271 in telephony and radio systems, he gained a place at the University of Manchester Institute of Science and Technology (UMIST) in 1981 and graduated in 1984 with a first-class honours degree in Electrical and Electronic Engineering. He became an Executive Engineer in Thameswey District, moving into BT Headquarters in 1986 to work in the Network Standards Division. Currently, he works in the Network and Systems ISDN Programme Office as the senior project manager for several projects related to quality of service. He is a member of the Institution of Electrical Engineers and a Chartered Engineer.

Hugh Smith and Richard Kemp

National Vocational Qualifications

There have been many changes to the education system in the United Kingdom over the years. One of the most radical has been the introduction of National Vocational Qualifications (NVQs). Many people have heard of NVQs but do not understand what they are and how they will impact on everyone. This article explains the background and the structure of NVQs, particularly those that relate to BT.

Introduction

In 1986, the Government published a White Paper called 'Working Together—Education and Training' that was based on a review of existing vocational qualifications. Its main conclusions were that the UK's existing system of qualifications was:

- not closely related to the needs of employment; and
- over-complex.

In addition, it expressed the view that, of the UK's working population, too few people held relevant vocational qualifications.

The Government decided, as a consequence of this paper, to establish the National Council for Vocational Qualifications (NCVQ) to:

- improve vocational qualifications by basing them on the requirements of the workplace;
- establish a national framework for the qualifications;
- make access to qualifications easy; and
- assist individuals' personal development.

National Vocational Qualifications (NVQs) were developed to meet these criteria, with the intention that they would become the main qualification for most of the working population. (The equivalent qualifications in Scotland are called *Scottish Vocational Qualifications* (SVQs)).

The Qualifications

NVQs are different from other qualifications in a number of significant areas:

- they recognise the individual's ability to do a job well;
- they are based on the particular contents of a job and the skills required to do it;
- anyone can work towards an NVQ (there are no entry requirements);
- NVQs are not a memory test (there are no examinations); and
- there is no time limit imposed on candidates to complete their qualification.

Like most other qualifications, candidates do have to put in significant effort to achieve them, but there is no concept of failing an NVQ. If they are classified as 'not yet competent' they may take steps to improve and then be reassessed, in those parts of the NVQ they have yet to complete.

The Structure of the NVQ System

NVQs involve a number of bodies and various people in their development and assessment. It is important to realise that they were intended to provide the qualifications industry wanted (and still wants). Hence there is a major input into the qualifications from each industry via its own representative body called a *lead body*. Equally, to

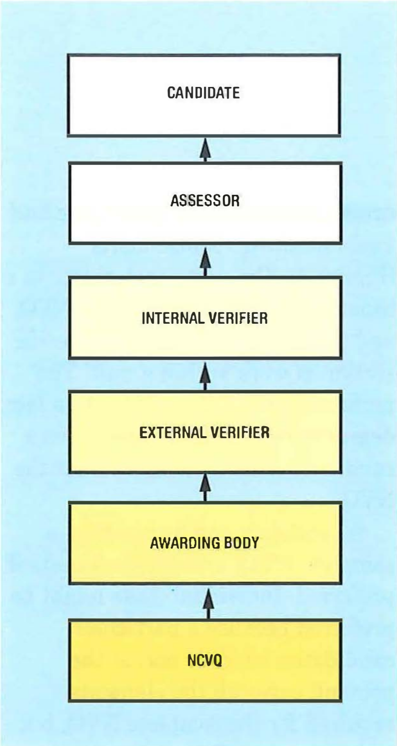


Figure 1—The interrelations in the assessment structure

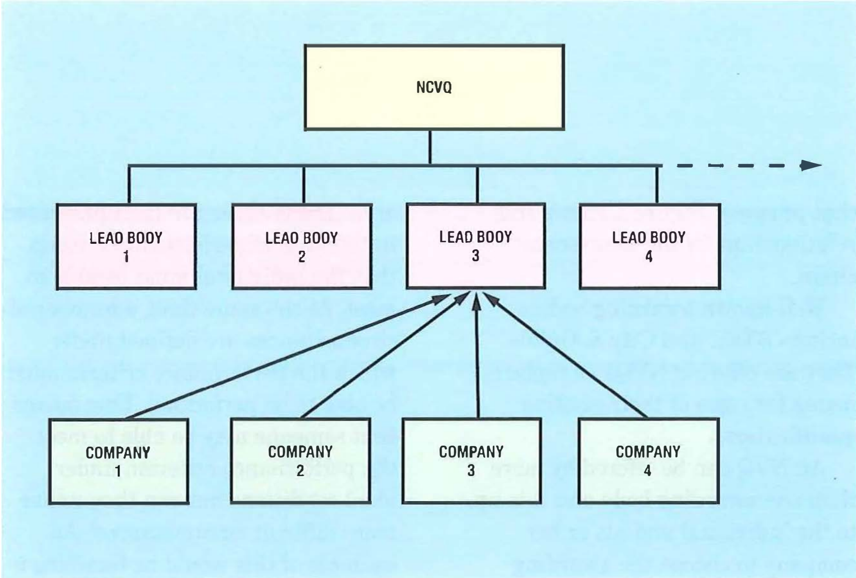


Figure 2—The interrelations in the NVQ design structure

ensure the candidates get what they want from the qualifications, the assessment system is candidate driven. That is to say, the candidate sets the pace of the assessment by asking to be assessed when he or she feels ready and in agreed areas of the NVQ.

Candidates

Candidates aim to demonstrate competence to do their job. They have to meet the performance criteria laid down in the NVQ across a defined range(s) of circumstances. Initially, this was intended to be shown completely through demonstration of ability to an assessor. However, some circumstances occur infrequently and having the assessor present at the relevant time can be very difficult, if not impossible. This is tackled through two methods. Either a simulation can be devised to allow the candidate to demonstrate ability or the candidate can write up a short case study of a live event that includes the required situation, and provide backup evidence.

This case study technique is becoming the preferred option because it does not rely on the assessor being present and because it saves management time, while still providing sufficient evidence of competence.

Candidates are never thought of as failing an NVQ. Instead the candidate is considered as 'not yet competent' and can continue working towards the qualification until it is achieved. The only constraint is that the performance criteria already assessed as competent, must still be current when the NVQ is completed. This means that the assessor must be confident that the same competent performance can still be achieved by the candidate.

Assessors

Assessors are usually the candidates' line managers. It is possible to use assessors external to the company, but this can be expensive and time consuming.

Assessors carry out assessments on the candidates in live situations and assess candidates' portfolios of case studies (where the candidate records work done, without necessarily being formally observed). The portfolio includes evidence of the candidate's performance that could include letters from customers, statements from colleagues and managers, recordings, photographs and work records. In fact, anything can be used as evidence provided it is valid, sufficient and attributable to that candidate.

The assessor should hold units of the NVQ in assessment or, at the very least, be working towards them. This ensures that the assessor is making assessments based on the NVQ criteria and is competent to carry out assessments. Ideally, the assessor should also hold the NVQ being assessed. In the early days, this is not essential, otherwise no NVQs could ever be awarded. (The first Chartered Engineer must have been assessed by a non-Chartered Engineer!)

Internal verifiers

Internal verifiers check the work of the assessors within their company and ensure that all assessors work to the same standards. This is to ensure that all candidates are treated equally and that different assessors would make virtually the same judgement regarding a candidate's work.

External verifiers

External verifiers check the work of internal verifiers and assessors. Their task is to ensure that the same standards are being applied across different companies, for the same NVQ. They do this by sampling the records of assessments of candidates, interviewing some candidates, assessors and internal verifiers and observing some assessments being carried out.

Awarding bodies

The awarding bodies, as their name implies, award NVQ certificates after the candidates have been assessed as competent. They maintain the quality of assessments through the use of external verifiers, often consultants employed for that purpose. Figure 1 shows the relationships in the assessment chain.

Well-known awarding bodies include BTEC and City & Guilds. They are offering NVQs as replacements for some of their existing qualifications.

An NVQ can be offered by more than one awarding body and it is up to the individual and his or her company to choose the awarding body they prefer, on grounds of quality, cost and expediency.

Lead bodies

The lead bodies are set up by each industry to design NVQs for that industry. They use representatives from companies within that industry to ensure the qualifications meet the needs of industry. The qualifications are designed by analysing the work functions in the industry and then dissecting them into component skills. These skills are then used to define the competences that individuals require to do particular jobs in that industry, and the competences are grouped to form the NVQs. BT has representatives on many lead bodies, in particular on the telecommunications lead body—Telecommunications Vocational Standards Council (TVSC)—and the Customer Service Lead Body.

National Council for Vocational Qualifications (NCVQ)

The NCVQ was set up by the Government to oversee the whole NVQ system. All proposed qualifications have to be submitted to them for approval and only those they accredit become NVQs. They also have the final say as to the level of any NVQ submitted by industry through their lead bodies (Figure 2).

Design of NVQs

The lead bodies split their industries into broad job areas. Each area is analysed to determine the skills needed by a person working in that area. These skills are then presented in the form of performance criteria that the individual must be able to meet. At the same time, a number of circumstances are defined under which the performance criteria must be able to be performed. This means that someone may be able to meet the performance criterion under ideal conditions but can they under more difficult circumstances? An example of this would be handling a customer query under normal circumstances and handling a similar query for a customer with some form of special need, perhaps a hearing or speech impairment.

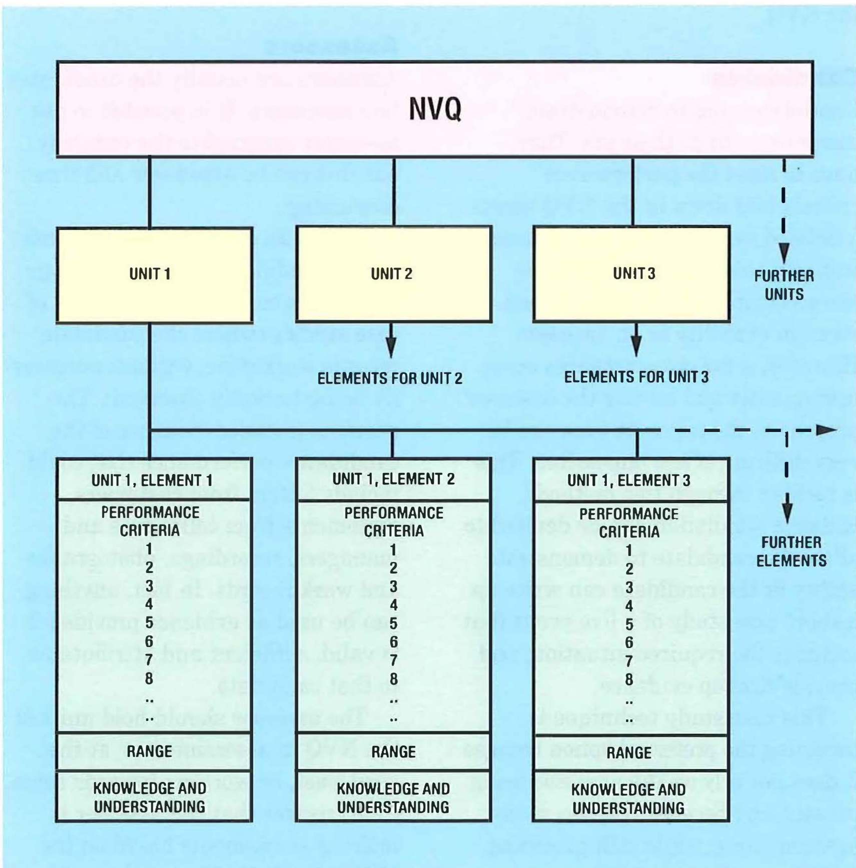
Structure of an NVQ

An NVQ is a qualification specific to a vocational area of work. Each NVQ is made up from several *units of competence*, known simply as *units*. These are sub-divided into *elements*, each containing a number of *performance criteria* and associated *range statements* and *knowledge and understanding* requirements (Figure 3). The units each relate to a broad area of work within the NVQ, and the elements describe a specific section of work within a unit. The performance criteria define, to a fair degree of detail, the competences a candidate must demonstrate for the NVQ.

A candidate can be awarded a complete NVQ, or individual units if preferred. Individual units might be preferred because a particular candidate's job does not, at the present, cover all the elements required for the complete NVQ, but it does cover sufficient for one or more units. All units can be held, and further ones awarded, until the full NVQ is achieved.

An example of gaining units only is the assessors' qualification. The assessors work towards the Training and Development NVQ, which covers an extremely wide area of compe-

Figure 3 – The structure of a typical NVQ



tence. In order to be qualified to assess, only two units of the whole NVQ are required. Thus assessors are likely to hold units of the NVQ and not the complete qualification.

How NVQs are Assessed

By observation

The candidate carries out the normal work and the assessor watches the work being done. He or she then determines which performance criteria and ranges the candidate has fully met and records the fact. In addition, the candidate's knowledge and understanding are tested through questioning to ensure that the observation is not simply seeing a repetitive, unthinking process, but that the candidate understands what he or she is doing, why, and the reasons for doing it that particular way.

By simulation

Where performance criteria cannot be assessed, because a suitable situation does not occur naturally, it is permitted to set up the required conditions in a simulation. The assessor can then observe the candidate's performance in the usual way. A company would want to use a simulation where doing the required work in a live situation would adversely affect service to customers. Should such a situation occur in normal course of events, assessment would be not be the pressing requirement. (An extreme example would be how an airline pilot deals with a crash landing!)

By use of portfolios

This technique recognises that line managers cannot observe everything a candidate is required to do for an NVQ without spending an enormous quantity of time assessing. Instead, it allows the candidate to record, in the form of a short case study, work that he or she has recently done and highlight the performance criteria he believes he can claim. At the same time the candidate presents evidence to back up these claims, in the form of letters, documents, computer printouts, etc. Should any of these be confidential, or in commercial confidence, they may simply be referred by their location in such a manner that they can be retrieved by an authorised person, but no one else. An example would be to quote a computer database reference to a job. Here an authorised BT assessor could look up the screen and check the details, but the confidential information would not appear in the portfolio. External assessors would not have access to that level of detail and would take the views of the internal assessor and internal verifier on the validity of that evidence. Candidates must ensure they do not include information that could identify individual customers, their addresses and telephone numbers in any case study.

A case study is unlikely to work systematically through an NVQ. Instead, performance criteria will be achieved that are scattered throughout the qualification. This isn't a problem, providing all the performance criteria are eventually collected for a unit to be awarded. The other criteria can be achieved gradually from further case studies until the whole NVQ is achieved.

The case studies build up to form the portfolio, which also holds copies of the assessments of those case studies as completed by the assessor.

NVQ Subjects

NVQs are eventually intended to cover all parts of all industries. Most industries now have some NVQs but complete coverage of individual industries is not yet complete. Many have a lot of work still to do before every job has a relevant NVQ.

In addition, there are NVQs in areas that spread across many industries. In particular, the Customer Service NVQ applies to every job where there is interaction with customers and it is important to remember that colleagues can also be regarded as customers when services are provided for them.

NVQ levels

NVQs are available from level one through to level five. These can be approximated to the following standards:

L1—someone working in the field

L2—someone carrying out a degree of supervision

L3—a middle management/ professional role

L4—a more responsible management/professional role

L5—strategic management

Not all levels are available for most qualifications, and some may never be produced. In general, levels two and three are the most common and these are the levels of NVQs currently being used within BT.

Acceptance within BT

BT has put a lot of effort into developing telecommunications NVQs, through the industry lead body, the TVSC. These qualifications cover installation and maintenance of telecommunications equipment, both fixed and mobile. At present these are available at levels two and, in the near future at level three.

In addition, the Customer Service NVQ at level three is relevant to a large number of people in the company and is starting to be used widely.

Why Work Towards NVQs?

NVQs are becoming the qualification for the future. It is the Government's intention that by 1996 50% of the UK's workforce will be aiming to achieve NVQs (or SVQs) and 50% will hold S/NVQs, at level three, by the year 2000.

They are starting to be quoted as requirements in some job advertisements for posts inside and external to BT. They are recognised across companies and, in some cases, across industries. For example, telecommunications NVQs may be relevant to non-telecommunications companies, who nevertheless use a great deal of telecommunications.

Conclusions

BT is committed to introducing NVQs within the company. In a world where increasing job mobility is expected, it is important that BT's people are continuously developed in a way that achieves externally recognised standards. To this end, BT is establishing NVQs as a major development and training route.

Biographies

Hugh Smith
BT Development and Training

Hugh Smith graduated from Edinburgh University with a B.Sc. Honours degree in Biological Sciences in 1974. After six years with Dalgety Spillers in procurement and business roles he moved to Canada in 1980 with a Commonwealth Scholarship. At McGill University in Montreal he gained his MBA in 1982 before returning to the UK and joining BT in the Strategic Development Unit of BT Enterprises. He then moved into Telecom Red where he launched and marketed the Telecom RedCARE alarm service. Subsequently, he led the introduction of total quality into the value-added services units of BT, and managed the people aspects of the Putting Customers First programme. He is now responsible for the Group-wide aspects of graduate entry and development, and for the implementation of externally accredited development initiatives, particularly NVQs, across BT.

Richard Kemp
BT Networks and Systems

Richard Kemp gained an Honours degree in Electrical and Electronic Engineering at Loughborough University in 1974 and joined the maritime satellite development group of PO Telecommunications in London, working on prototype ship-to-shore satellite systems. He then moved to Training Department at Horwood House running electronics training courses and organising sponsored student training. After another period in London, working on international network planning, he returned to training to progress the early trials of NVQs and the start of the Young Apprenticeship scheme. He has assisted in the development of telecommunications NVQs with the TVSC and assessed candidates on the Customer Service NVQ at the BT Customer Service Centre in Brighton. As a consequence of this work, he has gained the assessor units of the Training and Development NVQ. He is also a Chartered Engineer. Richard now works in the IBTE Office as the Assistant Editor of this *Journal*.

FIFTY YEARS AGO

THE POST OFFICE ELECTRICAL ENGINEERS' JOURNAL

Vol. XXXVIII July, 1945 Part 2

FOREWORD BY

COL. SIR A. STANLEY ANGWIN, K.B.E., D.S.O., M.C., T.D., M.I.E.E.

Engineer-in-Chief to the British Post Office.

NOW that hostilities in Europe are over it is an appropriate time to put on record in this journal of the Post Office Electrical Engineer, some of the work performed during the war years by all members of the engineering staff of the Post Office.

Of a peace-time staff of approximately 50,000, over 8,000 were mobilised on the outbreak of war, and a further 8,000 have since been released for service with the Armed Forces, mostly as technical staff in the Royal Corps of Signals or for flying duties with the Royal Air Force. Over 300 men have also been released for service in a civilian capacity with the Service and Supply Departments, etc. 620 members of the Engineering Department made the supreme sacrifice.

At home, a large proportion of the energies of the Department has been devoted to providing and maintaining service for the numerous naval, military and air force establishments in this country and for key industries. This involved the provision of a private wire network, mostly between sparsely telephoned localities, greater in extent than the pre-war trunk network and the extension of certain of the public services. All lines and equipment have had to be maintained in a high degree of efficiency with a diluted staff and in face of sustained enemy aerial bombardment. At sea, too, our routes to allied countries have had to be maintained in service and new routes provided. High praise is due to the staffs of our cable ships on whom this task fell and who suffered grievous casualties in carrying out the work.

A further load which has been willingly shouldered by the Engineering Department has been assistance to the Fighting Services in the design and production of all types of telecommunications equipment. The Post Office Research Station and the Post Office factories have been almost entirely employed on work of this nature, and the Post Office also undertook the purchasing of vast quantities of signals equipment on behalf of the three Fighting Services. The Engineering Department co-operated whole-heartedly in the work of the various inter-service technical and production committees and was responsible for the control of the production of most telecommunications equipment and cable.

In the months to come it may be possible to lift the curtain gradually on these war-time activities and to describe in this Journal some of the enormous tasks that were undertaken. In the meanwhile, members of the Engineering Department may rest content in the knowledge that the vital tasks allotted to them have been well and truly done.

In giving this brief summary of Post Office engineering war work, I should like to express my confidence that the same spirit of comradeship and co-operation which has contributed so largely to the success of our war-time tasks will enable the goal now confronting us of bringing the Japanese war to an early conclusion, of effacing the ravages of war in this country and of reharnessing our energies to the peace-time services to be speedily and smoothly attained.

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Launch of Telenordia

BT, Tele Danmark and the Norwegian operator Telenor have launched a new telecommunications operator, Telenordia, in the Swedish market.

Telenordia, owned equally by BT, Tele Danmark and Telenor, aims to become the leading alternative telecommunications operator in Sweden. It will invest about £200 million by the end of the decade, of which approximately half will be in switches and network capacity. In its first year the company aims to recruit about 100 additional employees.

Full regulatory clearance from the European Union has already been given, and the joint venture requires no further legal clearance from the European or Swedish authorities.

Telenordia will offer global voice and data communications solutions via Concert—the BT and MCI global networking company—as well as national data communications services, corporate and public voice services.

Initially, Telenordia's main target customers will be Swedish and international companies with significant volumes of national and international telecommunications traffic, and all companies requiring advanced voice and data communications solutions. This will include BT's current customers in Sweden and subsidiaries of Norwegian, Danish, UK and multinational companies with offices in Sweden.

The international data communications services offered via Concert will be supplemented by a national service incorporating Tele Danmark's Temanet, which will have an 80 per cent geographic coverage in Sweden by the year 2000. Telenordia will start its national voice service by autumn this year.

Terje Thon, Chairman of the Board of Directors, Telenordia, said: 'With Telenordia, we are ensuring customers in Sweden have a real choice in terms of provision of comprehensive and high-quality telecommunications services, meeting their national, Nordic and global needs. The partners in Telenordia firmly believe that by working together they are better able to meet customer needs both now and in the future.'

B. Rehn, Managing Director Designate of Telenordia, said: 'Telenordia will be characterised by flexibility, sensitivity to customer needs and service.

'As a new player in the market, we will provide a high quality, leading edge network infrastructure, providing cost-effective communications capability to our customers, drawing on the technical expertise of our parent companies from the Nordic and international telecommunications market.

'Through Concert, Telenordia will be able to offer a larger selection of international telecommunications services than any other operator on the Swedish market.

'Telenordia and its parents' presence in Norway and Denmark will enable consistent solutions across the Nordic market. This is an important benefit, as half of all international telecommunications traffic in the region is between the Nordic countries.'

Low-Cost Telecommunications Lasers

Researchers in BT Laboratories' (BTL) optoelectronics group have developed a simple low-cost technique, capable of coupling greater than half the light output from a semiconductor laser into an optical fibre. This new technology overcomes the current problem of alignment between lasers and fibres. It could reduce the cost of lasers and bring forward the day when every home could have its own dedicated laser-driven link to the global information superhighway.

The breakthrough combines advanced laser design and fabrication with state-of-the-art silicon microbench-based packaging to achieve the necessary alignment passively. This allows crude, and therefore cheap, automated pick and place assembly to replace today's time-consuming and costly high-precision method of active alignment. The new passive process allows the same proportion of light (greater than 50 per cent) to be coupled into the fibre as the more expensive active process.

Although other laboratories have reported similar passive alignment techniques, the BT result is over seven times more efficient than the best reported anywhere else in the world to date.

Ian Lealman, a member of the development team, said: 'For the last two decades, BT has used optical-fibre communications to transmit huge amounts of information between the nation's telephone exchanges. These new techniques should help to accelerate the extension of these links into the home to give everybody access to the wealth of knowledge on the information superhighway, and bring us into the information age that will be the 21st century'.

BTL's researchers have overcome the coupling problems between semiconductor lasers and optical fibres by a combination of three inventions:

- Enlarging the laser spot size until it is the same as the fibre—this improves the efficiency of coupling light into the fibre and simultaneously reduces the incredible precision normally required in positioning the laser to the fibre.

- Precision cleaving of the laser—this means the laser can be cut so precisely that the laser emission spot is known to a precision of 0·2 microns (2/10 000 of a mm) relative to the side of the laser.

- Making a precision profiled silicon chip with V-grooves and a silica wall, all to sub-micron precision—with this, the laser can be positioned precisely by laying it in a groove and gluing it in place.

VIAG Interkom is Launched in Germany

BT and German industrial group VIAG announced on 3 May 1995, the launch of a joint venture to offer telecommunications services in Germany, VIAG Interkom KG. Both parties have 37·5 per cent of the new venture with the remaining 25 per cent to be taken up by other German partners.

VIAG Interkom is offering data communications, corporate voice, virtual private networks as well as international voice and data services from Concert, the BT and MCI global networking company. The company will also offer management and outsourcing services.

This is the first phase of the strategic plan for the joint venture company that will seek a licence in Germany to offer a full range of telecommunications services, including public voice.

In line with European Commission directives, telecommunication services and infrastructure are set to be fully liberalised in Germany by 1 January 1998.

The company's joint managing directors are Hans Ivanovitch from BT and Hans Jochem Weiher from VIAG.

Initial investment in the venture will be Dm 1·2 billion (approximately £600 million) over ten years, with a considerable increase should the venture be given a full licence to provide services. In its first year, the joint venture will have 350 employees which will increase to 1000 in the medium term. Turnover in the first year is expected to be Dm 90 million (approximately £45 million).

VIAG Interkom will have ten offices and has the use of more than 200 nodes. In addition, it will have access, when regulation permits, to 4000 km of optical fibre through Bayernwerk, the Bavarian energy company. This is one of Germany's largest private fibre grids. It will also develop an asynchronous transfer mode network.

Rural Schools Pioneer Multimedia Technology Links

BT's videoconferencing technology is being used to bring together children in some of Britain's most remote schools.

The initiative by BT, Olivetti and Strathclyde Regional Council will link 40 schools. Some schools are so remote that they have only one or two teachers, with classes made up of pupils from five to twelve years old. The project will allow pupils to link up with others of their own age in distant schools to participate in lessons specifically designed for their age group.

The schools will use PC Videophones which feature BT's latest videoconferencing equipment—personal computers fitted with BT's VC8000 communications card, a tiny video camera and running Olivetti's Personal Communication Computer (PCC) software. High-quality moving images, pictures, voice and data are transmitted at high speed between schools using BT's ISDN2 network.

This pilot classroom application using the PC Videophone has been developed through on-site testing at selected schools over a period of six months. As a result, the full curriculum will be available to all students, regardless of their location. The PC Videophone also allows Strathclyde Regional Council to improve support for staff.

Peter Humpherson, BT's local government manager for West of Scotland explained: 'This project is an excellent example of education and business working in partnership. Through this approach, the technology has been developed to support real applications led by the needs of schools in rural communities.'

Gordon Jeyes, assistant director of education at Strathclyde Regional Council said: 'Our remote teachers working at these rural primary schools were experiencing problems of resourcing and staff development. There was a real need for cooperative working among the teachers. Videoconferencing enables us to take the next exciting steps in enhancing the school cooperatives set up over the last five years.

'The use of this visual communications technology will help facilitate economic regeneration and keep rural communities alive. Although rural schools have a considerable amount of dynamism and high standards of education, they may lack specialisms and peer-to-peer group interaction. The PC Videophone solution provided by BT and Olivetti removes their feelings of isolation.'

An initial 40 schools in the division are to be equipped with the PC Videophone solution with a further 40 installations to be completed later. Every school is able to communicate with all the others by face-to-face video conversations, can transfer information (data, text, photography and video) and work simultaneously on the same document.

BTL's World Wide Web Server

BT Laboratories (BTL) has launched a World Wide Web server on the Internet at http://www.labs.bt.com. The server provides information on BT's research and development (R&D) activities, graduate opportunities and short-term fellowships at BTL.

Listings of books and papers published by BT researchers and BTL's press releases are also available.

Information on the BT Global Challenge yacht race is available on the 'Events' page and, in future updates, it is planned to give users the opportunity of trying out new software technologies for themselves. The server went live on 1 May 1995 and is linked to BT's home page (http://www.bt.com) which provides general information about BT.

Investment in IT

The first survey of the UK's top companies' expenditure on information technology (IT) has revealed that BT is the UK's top IT investor. According to monthly magazine, *Corporate IT Strategy*, BT spent over half a billion pounds on IT during the past 12 months.

Electronics giant General Electric Company is in second place with an investment of £388 million and third is British Gas with an IT expenditure of £313 million.

The survey said that BT's IT spend is split into a number of distinct areas. The administration of its networks alone is a huge overhead. Increasingly sophisticated management tools are being used to spot and repair faults more rapidly, ensuring a consistent service. As BT moves into new services on the superhighway and expands globally, this overhead is set to increase.

Customer service is a priority for BT and is supported by a heavy IT spend. IT systems allow BT to treat its customers as a group of individuals rather than as a homogenous whole. This increases customer satisfaction as the people handling enquiries have more information at their fingertips.

Rapid Growth for ISDN

Integrated services digital network (ISDN) is currently one of the fastest growing businesses in the UK, according to BT, having experienced an unprecedented take-up of service during the financial year 1994/5. ISDN now accounts for 20 per cent of BT's new business exchange lines with growth for ISDN2 at 147 per cent and 58 per cent for the more mature ISDN30 service. ISDN2 traffic to Europe has increased by 236 per cent.

Commenting on the rapid growth of BT's ISDN service, Ray Pritchard, BT's global market manager for ISDN, said: 'The growth of ISDN can be attributed to the cost and productivity benefits it offers, and the realisation of market-driven applications developed with the customer in mind.

'In particular, BT has focused on its customers, and their needs. The customers are increasingly becoming aware of the advantages of switched digital technology. ISDN applications are attractive to all industries and BT does not just sell lines, but addresses markets with tailored solutions.'

ISDN30 has been considered the preferred method of meeting large businesses' voice communication requirements since 1990. The trend has continued this year and has been helped by opening up ISDN30 to small- and medium-size businesses with a six-channel entry.

The growth in usage to Europe can be accredited to the decision, by all European operators, to develop a common ISDN standard, facilitating the integration of pan-European solutions and simplifying the product-approvals process.

Growth in usage has increased to all regions and not just to Europe. BT now has connections to 30 countries, including recent launches to South Africa and Moscow. New countries adopting ISDN have also tended to opt for the European standard.

End of an Era...and the Start of Another

A new era in UK telecommunications began on 23 June 1995, when BT switched off the last of its old mechanical exchanges, at Crawford in Scotland, and replaced it with the most modern computerised technology.

It was the latest milestone in BT's £20 billion investment in the UK's telephone network over the past 11 years.

On 23 June, BT Chairman Sir Iain Vallance said: 'Today marks an important event in the development of UK telecommunications. One era has closed and a new one begins.

'BT's investment in the future of UK telecommunications has been massive. And it has been accompanied by real reductions in the overall costs of telephone services.

'Modernisation has also brought a much more reliable network and a range of new services and facilities for all of BT's customers, including per-second pricing.'

In 1984, BT inherited a network of more than 6700 telephone exchanges, many of which were based on electro-mechanical technology developed 100 years ago. Now, they have all been replaced by digital or modern electronic exchanges. The new exchanges have no moving parts, so they are much more reliable and provide almost instant connections and clearer conversations.

Strowger in the UK network

The UK's first automatic exchange, based on Strowger's design, opened at Epsom in Surrey in 1912. The UK network became fully automatic in 1976 with the closure of the last remaining manual exchange at Portree on the Isle of Skye.

England's last Strowger telephone exchange at Beaford, near Barnstaple in Devon, went silent on Friday 16 June 1995.

Scotland's (and the UK's) last Strowger exchange at Crawford was switched off one week later on the 23 June 1995.

Answering Machines becoming more popular with British Householders

British householders are catching up with their communications-crazy American cousins. One in six British homes (16 per cent) now owns an answering machine—a rise of almost 20 per cent since last year.

But a majority of Britons still risk missing vital calls from family and friends without ever realising it.

Compared with the USA—where more than 50 per cent of homes have an answering machine—many millions of calls made in the UK every day remain unanswered. Over-complicated technology has been a major factor in the reluctance of Britons to buy an answering machine. But now, ultra-simple budget-priced machines are available from BT.

The Response 10 and 100 are the simplest answering machines to use that BT has ever produced. Both have a pre-programmed message so users just have to plug in and turn on. Each machine enables users to check who is calling before deciding to pick up the telephone, and both have a beep facility to let users know a message is waiting. They can also be accessed via another telephone to check if any messages have been left.

Fear of Answering Machines?

Britons do not like the sound of their own voices, according to BT's *Answer Back* study. Almost three in five admit having a fear of talking to answering machines. The study also found that people:

- feel awkward leaving recorded messages (58 per cent);

- think they sound stupid on tape (18 per cent); and
- get nervous and tongue-tied (12 per cent).

Psychologist Jane Firbank, said: 'An answering machine phobia is really a kind of stage fright related to the fear most people have of performing or speaking in public. Shy people are especially prone as they often fear what others will think of them. But almost everyone can have bouts of "phone fright" when the message is particularly important.'

Laura Chard, BT communications manager, said: 'We wanted to find out why answering machines are more popular in some parts of the country than others. Although people enjoy receiving messages on their machines, the study revealed surprising regional differences in people's insecurities when leaving messages.'

East Anglians were most concerned about sounding silly on tape (41 per cent), followed by Londoners (28 per cent) and Scots (26 per cent). Geordies (8 per cent) were least concerned about how they sounded, followed by the Welsh (10 per cent) and Westcountry folk (11 per cent).

Women (22 per cent) are more worried about sounding silly than men (14 per cent), with young people (37 per cent) being five times more worried than those over 45 years old (7 per cent).

Jane Firbank believes that owners of answering machines can make things easier for prospective callers. She said: 'An unfriendly or off-putting message may stop callers leaving a message or cost a business important custom. Listen to your message and make sure it sounds warm and welcoming. Try using "feel-good" words such as please, thank you and sorry and let people know when you will be calling back. It helps persuade people to leave a message.'

For those who fear answering machines, Jane Firbank believes that the key is in knowing what to say, having the words to say it and sounding clear and pleasant while saying it.

UK Completes National Code Change

On 16 April 1995—Easter Sunday—the UK National Code Change was completed. On this day the old codes were withdrawn and connected to recorded announcements. This was the conclusion of a period of parallel running of old and new codes which began on 1 August 1994. The network changes to implement the recorded announcements were completed on time and without any interruption in service for customers.

The publicity programme had reached almost complete awareness among telephone users and about half of national dialled calls were using the new codes prior to PhONEday. After the changeover, calls to recorded announcements were well within the available capacity.

The successful implementation involved the close cooperation of BT and Mercury Communications along with other UK operators and overseas administrations.

Charging by the Second

On the 28 June 1995, BT introduced call charging by the second, instead of by the unit. Per second pricing (PSP) means that customers are charged for the exact time they use the telephone—subject to a minimum charge of 5p (including VAT), which reflects the cost of setting up a call and the initial time used.

PSP will allow customers to gauge accurately the costs of calls and have greater control over their bills.

'Of all the price changes in the past couple of years, this is probably the one that brings most all-round benefit to the UK telephone user', said Bill Mieran, executive chairman of the Telecommunications Users' Association.

Different rates apply to calls made using BT Chargecards and BT payphones will continue to be charged in 10p units.

At the same time as introducing PSP, BT also made a 5% price cut, bringing the cost of a local weekend call down to 1p per minute and a local daytime call to 4p per minute.

OFTEL Sees Trouble-Free Changeover and Looks to the Future

Don Cruickshank, Director General of Telecommunications, congratulated BT, Mercury and the other operators on the smooth implementation of the extra digit '1' on Easter Sunday.

Speaking at the OFTEL offices on 18 April, Don Cruickshank said: 'Today is the first working day since the introduction of the extra digit and we have now had time to assess the effectiveness of the plans to minimise disruption to customers. I congratulate BT, Mercury and the other operators on their technical expertise that has resulted in a virtually trouble-free changeover.

Turning to the future he said: 'References have been made to the fact that some call areas are beginning to run out of numbers. This information has been made known since OFTEL took over the administration of numbering from BT and has been readily available to the industry and the public through our library.

'The introduction of the extra digit '1' has freed up the use of extra numbers and I will be consulting both the industry and public at large on how they would like some of these numbers to be utilised. I will be putting before them choices on how we might supply the extra numbers needed for local call areas. Some of these choices will **not** involve changing any of the existing '01' numbers. Recent reports that a further imposed code change is either necessary, or planned, are unfounded.'

OFTEL has issued a consultative document addressing these issues. It is asking for views on how to use the '02' numbers and how to stretch '01' in areas that may become short of numbers, so that customers always have a choice. One guiding principle will be to take steps that cause the minimum disruption for customers.

It is important that efficient use is made of all available numbers. This means operators will have to conserve the stock of '01' numbers. There is an increasing choice of new services delivered over telecommunications networks for both business and residential customers and this is likely to increase considerably in this multimedia age. OFTEL has a duty to ensure that opportunities for customers in telecommunications services are never limited by lack of numbers.

Liberalising Telecommunications Infrastructure in the European Union

Extensive consultations show wide-ranging support for the European Commission's proposals for the liberalisation of telecommunications infrastructure. A report on the results of the consultations, which involved several hundred organisations and more than 100 written submissions, was adopted by the Commission on 3 May 1995. There is general agreement on the need for a transparent, predictable and effective regulatory framework to allow competition, particularly in universal service, interconnection and licensing. The Commission believes that Member States should choose their own financing methods, in accordance with the principle of subsidiarity. Respondents also stressed the need for interconnection between networks, and access to third country networks. The Commission will present proposals in time for full liberalisation by 1998.

Choices for Residential Customers

Don Cruickshank, Director General of Telecommunications, issued at the end of May two publications focusing on telecommunications for the residential customer—their choices today and their hopes for the future.

Telecommunications: the consumer viewpoint summarises the results of an in-depth survey carried out for OFTEL by MORI. The OFTEL report *Promoting Choice for the Residential Customer* comments on the MORI survey findings and other recent activities and research.

The Director General said: 'Our aim at OFTEL is to get the best possible deal for customers in terms of quality, choice and value for money. To measure our progress and to focus our work for consumers effectively we need high-quality information about customers' views—both on services they are receiving now and those they would like to be offered. The reports highlight two particular areas where customers felt they were not getting what they want. These are:

- better, clearer information on prices and services. The uptake and awareness of additional services, apart from directory enquiries and itemised billing, was low and people had little detailed knowledge of prices.
- more flexibility and choice in the package of services on offer. For example, only a third of those asked preferred the way they were paying their bills at present when given a choice of other tariff packages.'

The MORI survey gives, for the first time, a comprehensive 'snapshot' of what customers use and their opinions on a wide range of issues—from BT's prices to likely demand for multimedia services. The survey was carried out in autumn 1994 with over 3000 residential customers being interviewed. The survey's findings included:

- For the one in twelve households who do not have a telephone, cost is the main drawback.
- Over half (52 per cent) of households with a telephone line have more than one telephone.
- 53 per cent of customers think quality of service is better than five years ago.
- Only 15 per cent of customers could identify three premium rate dialling codes from a list of six codes.
- When asked about future multimedia services, more households were interested in business services (for example, home banking) than entertainment.
- Over 80 per cent of customers dislike unsolicited sales telephone calls at their home.

The OFTEL report discusses the MORI findings in the light of emerging competition in the UK telecommunications market. It also outlines plans for producing comparable quality of service indicators and other initiatives aimed at improving the information available to customers.

Fifth BABT Metering Report

The fifth report of the British Approvals Board (BABT) for the approval of public telecommunications operator's (PTO) metering systems was published on 9 June 1995.

Covering the year 1994, it describes the progress made towards approval of the metering and billing systems of the PTOs presently covered by the meter approval scheme—BT, Mercury and Kingston Communications (in Hull). BT's metering systems used for metering customer-dialled calls were approved on 5 December 1994. Mercury and Kingston Communications have submitted applications for approval of their meters to BABT. These are presently under consideration.

OFTEL is holding discussions with Vodafone and Cellnet with the aim of bring their metering and billing systems into the meter approval scheme as soon as possible.

Information Society and Telecommunications Networks

To develop the Information Society, the European Commission has outlined ways for the European Union to make the best use of its resources and has drawn up guidelines for priority projects. Where commercial viability is uncertain, the Commission suggests the European Union can act as a catalyst. This could mean maintaining an inventory of projects, bringing together players with common interests, and providing guidance and financial support. The Commission has earmarked 450M ECU for telecommunications networks from the Trans-European Networks support mechanism. In accordance with Article 129c of the European Community Treaty, the guidelines propose areas of common interest in which the Commission would invite project proposals. The areas include a wide range of research, education and service applications, generic services and basic networks, such as ISDN.

IEE Proceedings Journals Go Online

The Institution of Electrical Engineers (IEE) has announced an agreement with OCLC† to make all 11 of the IEE Proceedings journals available over the Internet, beginning in January 1996. The IEE Proceedings will be accessible as both individual journals and as one comprehensive journal containing all the individual journals.

'With the ever increasing demand for technical information to be delivered to the desktop of the engineer or scientist, the IEE is staying at the forefront of electronic publishing by adding to its offering of online information,' said Jeff Pache, IEE Electronic Products Manager. The IEE's rapid-publication letters journal, Electronic Letters Online, is currently available through the OCLC Electronic Journals Online system.

'The IEE Proceedings journals represent a highly acclaimed, comprehensive collection covering the key areas of electrical and electronic engineering', said Andrea Keyhani, OCLC Electronic Publishing Manager. 'Subscribers to the whole collection will be able to search across all the journals for important new developments that may have applications to other fields. Alternatively, researchers can subscribe to the specific journals of interest to them. In either case, subscribers will have fast and convenient access to cutting-edge research.'

The IEE Proceedings Online will use OCLC's windows-based graphical interface, Guidon, which operates in the Microsoft® Windows™ environment. Specific features include: full-text searching of all articles; typeset quality display and printing of text, equations, tables and figures; a table of contents created for each article which makes it possible to browse an article sequentially or to jump to any listed section; hypertext links to and from the figures and tables as well as footnotes and cited references; linked documents such as comments on articles already published and authors' replies flagged when any of the linked documents is viewed; hypertext links from cited references to abstracts in the INSPEC database; automatic notification of newly published articles in your field by weekly facsimile, mail or e-mail.

†OCLC is a non-profit computer library service and research organisation whose computer network and services link more than 20 000 libraries in 61 countries and territories.

New VoicePrint Security System

Bell Security is offering a voice verification security access system, in the UK and Europe, designed to counter the abusive, unauthorised use of corporate telecommunications facilities by both employees and outside hackers. This includes so called 'toll fraud' (such as the making of expensive personal international calls) and the accessing of voice mail boxes and teleconferencing networks.

By crosschecking a live voice-sample with a previously stored digital voice template, the system ensures that only bona fide users, both on-site and off-site, are granted access to the facilities they are authorised to use. The system is being marketed to end-users and resellers.

Enrolment of each user can be carried out in under two minutes and is initiated by setting up a data file. A personal identification number (PIN) is allocated and the user then repeats phrases or passwords into any telephone connected to the system, which the computer stores and analyses to obtain a voiceprint. To gain access, the user enters the PIN that prompts the system to ask for a test phrase to be repeated. This phrase is then compared with the stored voiceprint and, within a few seconds, if there is a match, access is granted.

The biometric technology embodied within the system is highly sophisticated. It can tolerate users with colds and sore throats but it will not respond to a tape-recorded voice.

Alliances—The Name of the Game in Telecommunications

Broadview Associates report that the largest alliance, in monetary terms, in quarter one of 1995 was the cross-share holding alliance between UK-based Cable & Wireless and German conglomerate Veba group, with a total aggregate value of over $1·5 billion. The deal follows BT's alliance with VIAG, and Thyssen's intention to join forces with BellSouth, one of the largest regional telephone companies in the United States.

Broadview Associates Managing Director, Patrick Seely said: 'The major European telecommunications players are forming alliances in order to take advantage of anticipated changes in the European telecommunications landscape. With Deutsche Telekom's monopoly ending in 1998, the Cable & Wireless and Veba alliance is clearly designed to allow them to bid jointly for a licence to operate telecommunications services in Germany.'

Alliances have continued in quarter two with Unisource, the joint venture between the Swiss, Swedish, Danish and more recently Spanish national telecommunications carriers, forming a strategic alliance with Compagnie Generale des Eaux, one of the largest and most influential French industrial conglomerates. The alliance will target the French corporate telecommunications market.

Interphone Public Payphones

The DTI has awarded IPM Communications plc a licence to operate a public payphone service in the UK. The new service will be called Interphone. The licence follows an agreement between IPM and Mercury Communications in which IPM will install new enclosures and advanced equipment at over 1500 Mercury payphone street site throughout the UK. Interphone launches with a coin only service, though there are plans to introduce a credit card option later in 1995.

COLT Granted National Licence

COLT has been granted its national UK telecommunications operator's licence. Under the terms of the licence, COLT will be able to expand its telecommunications network beyond the confines of the city of London to other major UK business centres such as Manchester and Birmingham.

Early in June, COLT was awarded a licence to operate a network in Frankfurt, Germany.

Data Communications and Networks—3rd Edition

by R. L. Brewster

The explosion in demand for data communications derives from the rise of the computer and the need to share its processing power beyond the confines of its immediate environment. Over the past 20 years, the same technology that made computing possible has spawned the rapid development of the digital telephony networks of today. As a result, we have a mix of state-of-the-art broadband data networking techniques running alongside the technologies designed to exploit the analogue voice network. This theme is developed in Brewster's introductory chapter and sets the scene for the material to come.

Building on this introduction is a survey of techniques for sending data over analogue lines, followed by an overview of the open system interconnect seven layer (OSI 7-layer) model which, unusually, concentrates on the upper four layers.

A chapter on standards gives a welcome overview of the processes within the International Standards Organisation (ISO) and the International Telecommunications Union (ITU), as well as covering the influence of the European Commission within Europe. Only passing mention is made of industry bodies such as the Frame Relay Forum and the ATM Forum, which is surprising given the influence they have on the growth of these technologies. However, this indicates how rapidly the impact of these bodies has grown.

Two chapters on integrated services digital networks (ISDNs) explain the basics of both narrowband and broadband ISDN and include an interesting study of the market for narrowband ISDN in 1992. The fundamentals of the asynchronous transfer mode (ATM) are covered here, with an outline of the issues as they were at the time of writing. A further two chapters cover the basics of the main types of local area network (LAN) and their higher protocols. Particularly topical is the coverage of the Internet protocols.

A review of wide-area networking covers frame relay, switched multimegabit data service (SMDS) and broadband ISDN and includes material on interworking. A further chapter looks at second-generation LANs and metropolitan area networks (MANs), such as fibre distributed data interface (FDDI), distributed queue dual bus (DQDB) and ATM rings.

The final chapters describe data over cellular radio (analogue and GSM digital), broadcast systems (including teletext, Nicam and radio data system (RDS)) and a user's view of image networks requirements.

This book has the advantage that it draws on the material from a range of industry experts. However, there are a few omissions; for example, bridges and routers are touched on only briefly and X.25 packet switching is hardly mentioned.

There is little discussion of network management. It should be said that moving users' data through the network is often the easy bit. Ensuring it is done under control, reliably and meeting the users' quality-of-service requirements is a considerable management task for today's network operator.

Nor is there much on the users' applications that drive the need for networks in the first place. As they become more diverse and complex, their requirements demand specific characteristics of the network that serve them. How well any network can support a diversity of services in terms of cost and performance will dictate how soon we can realise the dream of a single broadband network.

Despite these observations, the book provides a very useful overview of a wide range of data communications technology within one cover and should prove a good source of information for both the student and those wishing to keep abreast of the technology.

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Reviewed by Nick Cooper

An Introduction to GSM

by S. M. Redl, M. K. Weber and M. W. Oliphant

The first thing to notice about 'An Introduction to GSM' is that it is not! Rather, this is a book containing a lot of information, providing the reader with a range of topics about cellular telephony.

It is divided into four parts: an introduction to cellular telephony, the GSM (Global System for Mobile Communications) air interface and mobility management with some discussion of services, testing GSM and finally competing cellular standards.

In these sections, a great deal of the text is given over to a comparison of GSM with CDMA (code division multiple access), the American proposal for cellular air interface. This is interesting and useful, but it is surprising to find it in a book on GSM.

The general introduction in the first part of the book, together with the first few sections of part two, provides a good background to the evolution to GSM as it stands today.

For real GSM enthusiasts, these 120 pages, out of the 379, form an adequate introduction to GSM and for those people familiar with cellular systems, this section contains valuable, detailed information.

Part three contains information about the GSM air protocol in detail and provides a very good discussion of the GSM system. As usual, speech is the main service discussed but there is some coverage of the data service channel coding schemes that does acknowledge the data side. It is a shame that there is not more on the data services in general, as this is the key service area that differentiates GSM from other cellular systems. There is almost no mention of the innovative *Short Message Service*, the first value-added service built into a mobile system. This warrants a section of its own.

Competing cellular standards are discussed in part four, focusing on DAMPS (digital advanced mobile phone system) and CDMA. The factual information is good and is useful as background reading. However, for someone new to cellular telephony, it can easily confuse a reader who is looking for a discussion around GSM.

In summary, this book is made up of three main strands: the GSM system, testing the GSM air interface and competing cellular standards. Each section is factually correct, but the book is by no means the only GSM book you need. However, it is a very useful reference for those wishing to know about the GSM air interface, especially in comparison to CDMA.

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Reviewed by Chris Fenton and Kevin Holley

Articles for British Telecommunications Engineering

Contributions of articles to the *Journal* are always welcome. **Anyone** who feels that he or she could contribute a telecommunications-related article (either short or long), which may embrace technological, commercial and managerial issues, is invited to contact the Managing Editor, BTE Journal, Post Point G012, 2–12 Gresham Street, London EC2V 7AG (Tel: (0171) 356 8022; Fax: (0171) 356 7942). Authors should contact the Managing Editor before committing significant effort to preparing articles. Guidance notes for authors are available and these will be sent on request.

Field Focus

Field Focus is a feature in the *Journal* comprising short articles (up to about 600 words) on specific local BT projects. For example, novel solutions to field problems could form the basis of very interesting articles. Potential authors of items are also encouraged to contact the Managing Editor, or their IBTE Local Centre contact point (see list inside back cover).

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THE INSTITUTION OF BRITISH TELECOMMUNICATIONS ENGINEERS

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The following is a list of Local-Centre contacts to whom enquiries about the Institution may be directed. Where no Membership Secretary details are shown, membership enquiries should be directed to the Local Secretary.

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Associate Section Zone Committee Contacts

The following is a list of Associate Section Zone contact points to whom enquiries about the Associate Section should be directed.

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Northern Ireland	Brian Walker	(01232) 232413
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Scotland	Raymond MacMillan	(01463) 665913
Southern Home Counties	Martyn Harvey	(01273) 568388
South West	Roger Garland	(0117) 920 5485
Wales	Ferg Brown	(01952) 249886

IBTE National HelpLine — (0171) 356 8008

CALLING ALL IBTE MEMBERS

IBTE Members are reminded that the IBTE Member-Get-Member recruitment campaign finishes on **30 September 1995**.

Packs of brochures describing IBTE's benefits and services, together with a letter explaining the scheme, have been sent to BT people who are Senior Section Members or Associate Section Members receiving *British Telecommunications Engineering*.

Members are asked to use every opportunity to talk to colleagues about IBTE and encourage them to join.

Stocks of the recruitment brochure and further information about the campaign are available from the IBTE Office. Simply telephone the IBTE HelpLine (0171) 356 8008.

HOW ABOUT BECOMING AN IBTE MEMBER?

IBTE helps its Members to understand better the industry in which they work, and provides a powerful self-development opportunity for all BT people. So, if you are employed by BT or one of its subsidiaries, and not already an IBTE Member, why not consider becoming one? For further information about IBTE and its services, call the IBTE HelpLine: (0171) 356 8008.

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