VOLUME 11 PART 2 JULY 1992

BRITISH TELECOMMUNICATIONS ENGINEERING

Included in this Issue

IBTE Congress—Address by BT Chairman

Payphones

Switched Multi-Megabit Data Service

Safety in BT

The Journal of The Institution of British Telecommunications Engineers

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

Printed in Great Britain by Unwin Brothers Limited, The Gresham Press, Old Woking, Surrey, GU22 9LH.

Subscriptions and Back Numbers
Price: Single copy—companies, universities, libraries and other bodies £5·00 (£5·75 including postage UK, £7·00 including postage overseas); private individuals (paid by personal cheque) £3·50 (£4·25 including postage UK, £5·50 including postage overseas). Annual subscriptions (including postage)—companies etc. £23 UK, £28 overseas; private individuals (paid by personal cheque) £17 UK, £22 overseas.

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

Price to BT staff: £1·20 per copy.

Back numbers can be supplied if available at the single copy rates given above.

Orders, by post only, should be addressed to *British Telecommunications Engineering Journal* (Sales), PP: G012, 2–12 Gresham Street, London EC2V 7AG.

Remittances for all items (except binding) should be made payable to '*BTE Journal*' and should be crossed '& Co'.

Advertisements
All enquiries relating to advertisement space reservations should be addressed to The Advertisement Manager, *British Telecommunications Engineering Journal*, PP: G012, 2–12 Gresham Street, London EC2V 7AG. (Telephone: 071–356 8050. Fax: 071–356 7942.)

Communications
All communications should be addressed to the Editorial Office, *British Telecommunications Engineering Journal*, PP: G012, 2–12 Gresham Street, London EC2V 7AG. (Telephone: 071–356 8050. Fax: 071–356 7942.)

Binding
Readers can have their copies bound at a cost of £19·00, including return postage, by sending the complete set of parts, with a remittance to Pressbinders Ltd., 8 Newington Industrial Estate, Crampton Street, London SE17 3AZ.

0262–401X/92 $2·00 + ·00

BRITISH TELECOMMUNICATIONS ENGINEERING

Contents

VOL 11 PART 2 JULY 1992

TELECOMMUNICATIONS ENGINEERING: A STRUCTURED INFORMATION PROGRAMME

ISSN 0262-401X

BRITISH TELECOMMUNICATIONS ENGINEERING

EDITORIAL

I was very happy to accept the invitation to become Chairman of the Board of Editors for the *Journal*.

I have been particularly impressed by the improvements that the Editorial Board, under the chairmanship of Colin Shurrock, have made in the quality of the *Journal* to ensure that it continues to meet readers' needs. The Board has placed the editorial plan onto a sound footing, introduced a bright modern cover design, launched the *Structured Information Programme*, and included more special issues.

Indeed, the improvements do not stop there. We will be introducing an attractive more-readable page-layout design in October, and we will be broadening the scope of articles, including more written by authors from outside BT.

At its recent Congress Dinner, the IBTE was privileged to have Iain Vallance, the Chairman of BT, as guest speaker. He had some very supportive messages about the role of IBTE, and the way in which the Institution was tackling the educational needs of professionals within the company. The *Journal*, of course, is an essential element of the services that the Institution provides to meet those needs. The full text of Mr. Vallance's speech begins on p. 74.

I fully support the Editorial Board's policy of continuous development of the *Journal*, and I am proud to be taking over as Chairman at such an exciting stage. I hope that readers will enjoy the future editions as I am sure they have in the past.

JOHN PRIOR
Chairman of the Board of Editors

IBTE Congress—Address by Iain Vallance, Chairman, BT

Iain Vallance, Chairman of BT, addressed The Institution of British Telecommunications Engineers (IBTE) at its recent annual dinner held in conjunction with the 1992 IBTE Congress. He reinforced the future role of the IBTE in BT, and went on to give his view of the future in the telecommunications industry and to outline BT's strategy. The full text of the speech is reproduced below.

INTRODUCTION

Ladies and Gentlemen, I was delighted to accept Alan Rudge's† invitation to speak to you this evening because it enables me to talk a little about two of my hobby horses. One, of course, is the future telecommunications industry, and BT's part in it. And the other, less obviously perhaps, is education.

EDUCATIONAL NEEDS AND THE ROLE OF IBTE

As I'm probably one of the very few non-engineers in the room I'm certainly not going to try to teach you about the details of synchronous digital hierarchy! I'll leave that sort of thing to your good President here. But education in its wider sense is a topic that must be of interest to us all. The telecommunications industry is becoming increasingly complex. That reflects on one hand the ever-improving wizardry of the underlying technology, and on the other the increasing sophistication and demands of our customers. To keep pace, indeed to anticipate these changes, successful companies need to put a premium on the quality, professionalism, training and education of their people.

This is inescapable; information and knowledge are becoming the primary resources of the economy. Six out of ten European jobs already depend directly or indirectly on information technology. And by the year 2000, according to the European Commission, some 70% of all European jobs will require professional skills.

Britain, worryingly, has been relatively slow to respond to these trends. We have not invested enough in a well-trained workforce. In the USA for example, 85% of managers are graduates; in France it's 65%, but in Britain it's only 24%. And although in British terms BT is something of a model in the provision of training for its people, even we have some way to go. That's why we are committed to the target of every BT employee receiving at least two weeks training and development per year by 1995.

Self-help has a vital role to play in training, particularly in professional education. Professionalism, by definition, implies adherence to standards of work that are recognised throughout an industry, standards that transcend the firm you may work for. Consequently, intelligent debate about what constitutes professional standards and how one achieves them needs some degree of independence from the company. That is just the role that has been performed so well by the IBTE and its antecedents over the years. It is particularly gratifying to see the renewed vigour with which the Institution is tackling the educational needs of professional engineers within the company and in that regard you have my and our Board's full support.

Iain Vallance, Chairman, BT

The role of the IBTE will be increasingly important to the success of BT over the coming years. Our company has gone through enormous changes as you know. But, forced by customers and competition, the pace of change is only going to increase. Customers are demanding new services which in turn are stretching the limits of the technology. Clearly, professional engineering skills will be absolutely vital in developing the solutions our customers need; engineering is at the heart of our business and will remain one of our core competencies. But engineers, like everyone else in the company, need to look beyond the bounds of their own discipline and into the sales and marketing arena. You must ask yourselves: 'how can I translate engineering excellence into product and service excellence'? There will be no prizes in the 1990s for solutions that are simply elegant in engineering terms; that type of thinking went out with Concorde. Fulfill-

---

† Dr. Alan Rudge is Managing Director, BT Development and Procurement, and IBTE's President.

Part of this text is to be published in 'Communications After 2000 AD', R. Soc. Lond./Chapman and Hall, 1992.

ing the needs of customers, not managing the technology of telecommunications, will be the driving force of BT. The number of one priority for you is to work out how to make the technology serve the customer.

Not so long ago such a statement would have been heresy to many in BT. The fact that this is no longer so is due to no small measure to the activities of the IBTE. Your lecture series, talks, and of course the Business Game, in which some of you here today participated, have all helped to sharpen your focus on the customer. Indeed, my main message to the IBTE this evening is that you must continue down that path in the years to come.

FUTURE OF THE TELECOMMUNICATIONS INDUSTRY

Which brings me to the second part of my talk. What will the years to come be like for the telecommunications industry? How successful will BT be? Such questions are irresistible; we all feel the lure of the future and, in a sense, who better to gaze into the crystal ball than your Chairman. After all, if you could sum up my job, it would be to make sure that BT is fit for whatever the future will bring. So let's have a shot at predicting it.

In the last few years, the telecommunications industry has begun to merge with the communications services sector which, in turn, has coverged with information services to produce the hydra-headed information technology or IT industry. An exciting combination of customer demand, increasing competition and advancing technology has created a fast-moving industry, which is constantly transforming itself in the development of new areas of business, constrained only by politics and regulation.

By the end of the 1990s, advances in information technology will allow us to provide services to our customers anywhere, anyway, and anytime they want them. That's a very challenging vision, but one that is underpinned by two unstoppable forces that are with us now—digitalisation and the increasing level of software control, or intelligence, in the network.

Today, voice, video, image, character, and data are still treated more or less separately. But, I don't have to remind you that, to a digital network, these elements are all just 0s and 1s, on and off, which means they are capable of being re-formed in any way that the customer wants, whether it be speech into text or data into images. This malleability of information will allow the technology to shrink wrap itself around the individual and be unique to a persons' needs and desires. You can see the beginnings of this trend in the world of personal computers. Customers take standard hardware platforms, standard operating systems, and off-the-shelf application programs. In no time at all the machine is customised to the needs of the person who uses it. Telecommunications services are going the same way. Already, virtual private networks allow businesses to control their service levels and network configuration.

The individual customer will likewise demand access to the services that he wants, anywhere and anytime—and that means being allowed to take an active role in specifying, developing and managing the system he or she requires. The science fiction dream of everyone being issued with a unique communications identity at birth and being contactable anywhere on earth, throughout their lives, is not that far away. Some of you might consider the idea to be more of a nightmare than a dream, but there will always be an 'off' button!

Business in the global networked economy of the near future will be more complex, more interrelated and more dynamic. Multinationals will require information technology supplied on a global basis. Those who wish to win their business will have to operate globally, and refuse to be hamstrung by national boundaries. BT's vision of becoming the most successful worldwide telecommunications group is a clear and direct response to this challenge.

By the end of the decade, geographically dispersed organisations will be able to function as coherent wholes. Picture the scene; directors in boardrooms in several countries, one in a plane, another on a train, another working from home, all participating in a three-dimensional video conference, seeing and talking to one another as though they were in the same room. The basic technology is already here; what remains is to harness it to meet the needs of the customer.

And there, for the moment, we should leave the future. To bring us down to earth a little, the point we must never overlook is that, although our projections are based on the best information available, there is always that nagging possibility that the future will be different in fundamental ways from our best guesses. Speculation is essential, but we should never lose sight of the fact that it is an inexact science. The only thing we can say with certainty is that the future is essentially unknowable and elusive.

STRATEGY

It follows that you cannot base a successful business strategy on a detailed picture of the future, whether that picture is derived from economic forecasting or any other form of necromancy. Building a strategy on the conviction that you know exactly what the world will be like in five or ten years time is no more and no less scientific than backing every favourite on the card at the races!

The only viable strategy is based on imaginative commitment to the customer and speed of reaction to changing circumstances and priorities. We cannot say exactly what the world will be like but we can put ourselves in a position to compete, whatever it is like. Successful companies will be those that listen to their customers, ones that are willing to change as the times change and are better at changing than their competitors. That is the only form of long-term sustainable strategic advantage. The key to strategic success is precisely not being burdened with a too detailed view of the future.

And what is BT's strategy? Well it's simple and, even more important, focused on well-defined objectives; it concentrates on the things we know how to do well—the running of telecommunications networks and the provision of services across them, both in the UK and internationally. And there are two prongs to our strategy: the domestic and the global.

Taking the UK first. The vast majority of BT's revenues and profits derive from activities in the UK. Our UK strategy reflects the increasing levels of competition we are facing and is about our response to the erosion of market share. It has a defensive element, but is not a defensive strategy. It is about creating the right balance between holding what we have and seeking opportunities for new growth by paying meticulous attention to customers of all kinds, not just the supposedly more glamorous ones.

We are most vulnerable in our dealings with those customers who will play a major part in shaping the future: intensive users of telecommunications services, both individuals and companies. We need to fight to retain our position with these customers and to win back those we have lost; and we will do this through the quality of our services and the innovativeness of our service and pricing packages. The real cost of telephone services has fallen by some 25% since 1984. And we have achieved major progress too on quality of service. Nowadays, fewer than 1 in 250 calls fails due to network problems and a customer is only likely to experience a line fault once every 7 years. These trends of improving value for money need to be consolidated and reinforced.

In order to do so we have to reap the productivity improvements that new technology makes available—our investment has been substantial: more than £13 billion has been spent on expanding and modernising our networks and services in the past five years. Over the next decade we shall offer the benefits of digital technology to all our customers. IT facilities (which only a few years ago were the jealously guarded prerogative of major corporations, defence establishments and the better-funded universities) will be generally available. And, they will be available to our domestic and small business customers as well as to the big spenders.

So that's the UK. Turning now to our international strategy. The majority of our current profits derive of course from our activities based in the UK. But even if we were only making, say, 10 per cent from sources outside the UK by the year 2000, that's still an awful lot of money. And it needs an awful lot of attention.

The customer base of the telecommunications industry is itself going global. Multinationals will be increasingly eager to avail themselves of the services of a truly global supplier—one who can design and manage global networks on a one-stop shopping basis. We simply cannot afford not to provide such services; remember, many of the biggest multinational are UK-based and others have UK-based subsidiaries; if we cannot serve their global needs, by the same token we will lose their business here in the UK.

In the next few years our main international business will be the traditional one of switched voice and international private leased circuits. But, we are also developing a broader capacity, by, for example, extending the reach of BT Tymnet or by running the networks of multinationals via Syncordia. But, we will not be making acquisitions for their own sake; once again, the emphasis is on focus and keeping it simple.

The writer Somerset Maugham once argued that you should do only those things which only you can do, provided, (and it's a big 'provided') that you can afford to pay someone to do the other things for you. In his view, a writer should be writing, not papering the hall or doing his or her accounts. It's all a matter of energy efficiency.

A similar precept applies in corporate life. Companies are best off doing those things which they do best. In strategic terms, knowing what you don't want to do is as vital as knowing what you do want to do. BT is not in manufacturing, nor is it in financial services, or the entertainment business. We will not be beguiled by standalone domestic opportunities overseas, such as local privatisations or adventures in Eastern Europe, nor will we be seeking minority mobile stakes in other countries, unless they serve our broader plans for a presence there.

What this means is that BT has by far the most focused strategy of any of the would-be global players in our industry. And our customers and shareholders appreciate that.

I said that it would be a mistake to try and picture the future in too much detail. However, perhaps even more counterproductive than attempting to base a strategy on a fixed and detailed picture of the distant future, is to assume that the future will be like the past, and that all we need to do is do what we have done before, only better and more of it.

Blithe futurology may lead you down blind alleys; but assuming that the future will look like the past with knobs on results in organisational sclerosis, an irreversible and fatal hardening of the arteries.

We have to offer customers not futuristic technological solutions, but goods and services that will transform their lives today and tomorrow. And then, when they change their minds, want improvements, want something else, we have to go with them. We have to recognise that we have a range of responsibilities, not just to customers, but to the people who work for the company, shareholders, governments and to Society with a capital 'S'. And, we have to achieve that balance in such a way that truly adds value to the world in which we operate.

No other strategy for the year 2000 and beyond has a chance.

Developments in Payphones

JOHN B. EMPRINGHAM†

This article describes the continuing development of payphones in BT and in particular gives an introduction to the new range of payphones being introduced to provide improved customer features and reliability for the 1990s.

INTRODUCTION

In an article titled 'Payphones in the Nineteen-Eighties' published in April 1982[1], John Lewin concluded that the introduction of the next generation of payphones would not wait for a further 24 years, the time that had elapsed between the introduction of a new range after the introduction of pay-on-answer. Now 10 years later and only two years since the last rented pay-on-answer payphone was replaced, the introduction of that next generation is already well under way.

This article traces some of the changes that have occurred to the current payphone range and describes the development, facilities and features of the new generation of payphones.

HISTORY

The first of the modern 'self contained' payphone designs, the Blue Payphone 1, or CT22, was introduced into service in 1980. This was soon followed by the Cardphone and later the Blue Payphone 2, or CT24, which gradually superseded the CT22 in all sites. These two products, with subsequent updates, now constitute the total public payphone population of about 100 000 payphones. Approximately 20% of the population are Cardphones. One of the subsequent enhancements was to add a credit card reader (swipe reader) on to the side of the Cardphone which allowed payment for calls to be made by credit card or by BT Chargecard via the cashless services system[2].

In the private payphone market, several products were introduced to give a range of facilities at an economic price: the Payphone 100, which was a table-top model; the Payphone 200, a plastic-cased wall-mounted payphone with a similar mechanism to the Payphone 100; and the Payphone 300, a metal-cased wall-mounted payphone. For the top end of the private market, the Payphone 500 was introduced as a cost-reduced and more-attractive version of the CT24.

All of the previously mentioned payphones derive their charging from periodic 50 Hz meter pulses derived from the local exchange. This system provides an accurate and straightforward method of charging. However, with the increasing availability of larger low-power memory devices and lower-cost microprocessors with accurate real-time clocks, it became possible to design a payphone that calculated the cost of a call from the number dialled and an internal look-up table. This gave increased flexibility in charging and allowed payphones to be installed on PBX extensions for the first time. (50 Hz meter pulses cannot normally pass through a PBX.)

The first product to offer 'pulseless' operation was the Moneybox launched in the mid-1980s. This became a popular and successful payphone owing to its lower price and flexibility. However, certain disadvantages were apparent: it accepted a single 10p coin only and during the installation of the payphone a somewhat lengthy programming cycle was necessary by the owner to enable accurate charging to be given. The other less-desirable customer feature, common to all self-tariffing payphones is that a press-on-answer button is necessary to initiate charging, as without meter pulse signals the network is unable to provide an answer signal.

IMPROVING THE PUBLIC PAYPHONE SERVICE

The public and private payphones introduced during the early-1980s provided BT's customers with a greatly improved range of facilities, including a wide range of coins, inserted via a single slot; visual display of remaining credit; and full international dialling. In addition, several benefits were introduced for the first time to assist administration of the payphone service including automatic self-diagnostic testing of the payphone and simple remote reporting of faults and cash-container contents.

Much experience has been gained from operating these payphones, particularly in the hostile street environment, where a payphone must withstand the full range of environmental conditions, often with minimal protection from the housing in which it is installed. It must also be able to withstand physical abuse and fraud attacks.

---

† BT Personal Communications

Serviceability

It became increasingly apparent that the public payphone service being offered by BT was not achieving an acceptable performance level. While service measures appeared to show a satisfactory performance, in practice the actual serviceability seen by BT's customers was inadequate with too many payphones out of service at any time. A major programme, called the *Payphone Enhancement Programme* (PEP), was launched in order to improve the public payphone service. One of the first actions was to obtain a real measure of serviceability as seen by customers, and a completely independent programme of measurement was introduced. This involved sending research workers to payphones, selected at random, to make a call. The percentage of unsuccessful attempts was recorded and used to calculate the serviceability in percentage terms. These measurement techniques continue to this day and are published on a regular basis.

Early results from these serviceability surveys showed significant problem areas with figures as low as 77% being recorded in some areas. The PEP set out to discover and overcome these problems. It was quickly apparent that there was no one single problem but rather a series of measures that could be taken to improve the situation. These included product design improvements, resource planning, spares availability, management of the fault data, avoidance of cash-box fulls etc.

Analysis of Serviceability

During the PEP, a detailed analysis showed that the serviceability of a payphone can be described by a simple equation:

$$\text{Serviceability (\%)} = \left\{ 1 - \frac{AFR(TTD + TTC)}{24 \times 365} \right\}$$

where AFR is the annual fault rate,
TTD is the time to detect faults in hours,
TTC is the time to clear faults in hours.

It was apparent that each of these three variables needed more detailed analysis in order to improve the serviceability.

The time to clear faults is primarily a function of the availability of people to visit the payphone and to clear the fault; however, this can be improved by ensuring that faults are cleared first time and ensuring that people are fully trained and supported by ready availability of spares.

The time taken to detect faults can be substantially reduced by effective automatic fault reporting by the payphone and by quickly passing the fault, on reception by the payphone management system, through to the customer service system (CSS) repair handling where it can be actioned. The operation of the payphone management systems are described in an article by Les Williams in this issue of the *Journal*[3].

The fault rate of the payphone is clearly the key driver of serviceability; a zero fault rate, although not achievable, would lead to 100% serviceability.

Product Enhancements

During the PEP programme, a full analysis was carried out of the fault rate of the existing public payphones. Many product improvements were identified, which have been retrospectively installed into the products as part of the PEP programme. This work was fully supported by BT's public payphone suppliers GPT and Landis & Gyr Ltd who both assisted in analysing problems and worked with BT to develop solutions. There is not space in this article to describe fully the enhancements; however, below are a few of the key elements.

Conformal Coating

Environmental testing demonstrated conclusively that several intermittent failures were being caused by condensation forming on critical areas of the payphone electronics, particularly affecting the coin validator and microprocessor random-access memory. The solution was to apply a conformal coating to the main printed circuit boards, to remove unused test pins and to apply an improved conformal coating process to the coin validator. The resulting retrospective upgrade programme has successfully reduced the fault rate and this is particularly noticeable in the damp and wet winter months where serviceability used to reduce significantly.

Defensive Programming

The method of operation of the payphone software was critically reviewed. Some basic approaches were used to ensure that, if a failure was detected by the payphone self-test routine, the payphone was only switched to 'emergency service mode' as a last resort and made every attempt to self correct the problem first.

The self-report codes to the management system were reviewed and revised with the objective of sending only actionable fault codes and eliminating intermittent fault codes. Although not totally successful, this approach has led to an improvement in the accuracy of the remote reporting to the extent that over 70% of faults on payphones are now detected automatically via the integrated payphone operation and management system (IPOMS) before being reported via other means (for example, by a customer via the operator).

Handset

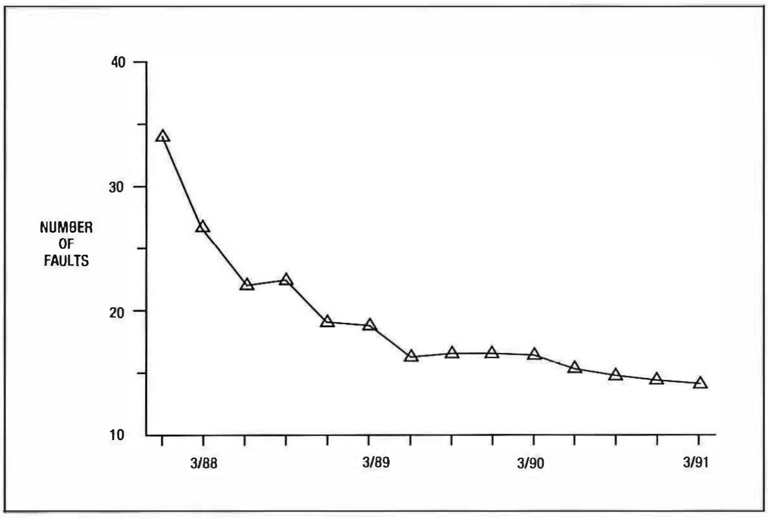
The handset is one of the most vulnerable parts of a public payphone, being frequently abused and often used as a 'hammer' to strike the casework of the payphone. Analysis of the failure mechanisms enabled an improved design, often known as the *PEP 2 handset*, to be introduced. This featured an alternative transducer of the magnetic coil type, which resists impacts more successfully than the original rocking armature type; the introduction of a strain wire in the stainless steel amoured cord to resist pulling; and the provision of a standard plug to simplify maintenance.

Winning the Battle

The PEP programme has proved to be highly successful and has resulted in a steady reduction in the fault rate of BT's payphones (see Figure 1) and a continued improvement in the serviceability, which has reached over 96% at the time of writing this article. It is a tribute to the skills and teamwork of the people working in payphones at all levels that such improvements can be achieved.

Phase 3 of the PEP programme investigated how still higher serviceability levels could be achieved. It was apparent that the current product range would need to be gradually replaced by a new range which offered very high levels of reliability, designed in at the outset, together with an enhanced management system interface, which would deliver faster automatic reporting of a high percentage of payphone faults. In addition, the new range would provide improved user facilities to enhance revenue opportunities.

Figure 1
Public call office—faults per annum



THE NEW PAYPHONE RANGE

The new-range strategy adopted was to develop three new core products each with variants that would cover most market sectors. This strategy would allow the large range of older products that had been introduced over the years to be rationalised thus economising on spares, training etc. The differentiation between the products is based on the strength of the casework (to withstand vandalism and theft), the level of facilities provided to customers and the level of administration facilities such as remote management. The new product range was given code words which describe the product:

NTT	New Tabletop	Launched in 1991 as Payphone 190
NMR	New Mid-Range	To be launched as the Payphone 290, 390 and 490 in summer 1992
NTR	New Top-Range	To be launched in early 1993

Payphone 190

The Payphone 190 was launched during 1991. It is currently the least expensive payphone supplied by BT. It replaced two products in the BT range, the Moneybox and Payphone 100. It is a compact payphone developed and supplied by Rathdown Industries Ltd., Ascot, with the styling design carried out by BT Laboratories. Five coins are accepted as payment for calls through a single slot: 10p, new 10p, 20p, 50p and £1.

It is supplied for tabletop use (Figure 2(*a*)), although, with the addition of a special bracket, it may also be wall mounted (Figure 2(*b*)). When

(*a*) Tabletop use

(*b*) With wall-mounting bracket

Figure 2—Payphone 190

reconfigured in this way, the wall mounting base allows the cashbox capacity of the payphone to be significantly increased. It is designed for use in supervised or some semi-supervised locations where vandalism and theft are not a problem.

Casework

The case is manufactured with a gloss finish from high resilience ABS plastic and is light grey in colour with the buttons and pictogram manufactured in a contrasting dark grey. It utilises the Vanguard handset and button set. The case hinges open from the front to allow access to the coin storage area in the base. A feature of the product is the ready accessibility of the coin mechanism to the owner to allow clearance of any debris or foreign material inserted via the coin slot.

Tariffing

The Payphone 190 can be configured either for meter-pulse operation or for self-tariffing operation. When configured for self-tariffing operation, a PRESS ON ANSWER button is installed, and a special module, called the *plug in customiser*, (PIC) is fitted. In self-tariffing mode, the liquid crystal display (LCD) shows the remaining credit during the call in time (seconds), whereas in meter-pulse mode, the remaining credit is shown in pence. This is because in meter-pulse mode the tariff is controlled by the local exchange and is not known by the payphone at the outset of the call.

The PIC is one of the key new innovations introduced into the Payphone 190. It is a small pre-programmed memory pack which contains the tariff tables and destination charge rates for a charge area. The PIC is a robust unit and can be easily installed by the payphone owner from inside the mechanism top when opened for access to the coins.

The payphone can either be fitted with a *universal* PIC, which gives a simplified tariff structure and is suitable for sold payphones, or can be fitted with one of approximately 640 different variants of the PIC that correspond to the national number groups and offer accurate charging and local code exceptions. The PIC not only contains the tariff structure, but also the default list of barred numbers and other variable data which enables the payphone to offer a degree of 'future proofing' since changes in the tariff structure can be catered for by simply plugging in a revised PIC.

The provision of the PIC minimises the necessity for local programming, which research shows many customers find difficult to carry out. All that is necessary is to programme the internal clock (self-contained version) and the owner's personal identification number (PIN), which then allows the payphone to be used.

The Payphone 190 can be used as an ordinary telephone by keying in a simple key sequence including the PIN number on the keypad. This PIN number is set by the owner when the payphone is first installed and can be changed later when required.

Power Supply

The Payphone 190 is powered by AA-size batteries fitted into a battery box, which is accessible when the top case is hinged up. These batteries will last for up to one year's operation of the payphone, depending on usage, and a warning is given to the owner on the display of the need to replace the batteries.

New Mid-Range Payphone (Payphones 290, 390 and 490)

The new mid-range payphone is supplied and developed by GEC Plessey Telecommunications Ltd. (GPT), Liverpool. It is designed to replace all the wall-mounted mid-range models in the BT range including Payphone 200, Moneymate and some Payphone 500 sites. It is planned to launch this new product in the summer of 1992 after an extensive field trial phase.

The NMR is available in three versions:

Version 1: (Payphone 290, see Figure 3(*a*))

With plastic case and internal cash container.

Version 2: (Payphone 390, see Figure 3(*b*))

With plastic or metal case and external cash compartment.

Version 3: (Payphone 390, see Figure 3(*c*))

With plastic or metal case, credit card swipe reader and external cash compartment.

In all three versions, five coins are accepted as payment for calls through a single slot: 10p, new 10p, 20p, 50p and £1. A coin escrow (or coin store) is provided which can store up to four coins after validation. Unused coins are returned to the user at the end of a call.

The payphones in this range are normally wall mounting, but Payphone 290 is supplied with four rubber feet enabling it to be desk or shelf mounted if required.

Plastic versions of the payphone are designed for use in supervised or some semi-supervised locations where vandalism and theft are not a problem. The metal versions are more suitable for a wider range of semi-supervised locations.

Casework

The payphone is available with a plastic or metal case. Plastic versions have a front cover in gloss-finish high-resilience ABS coloured in light grey. The rear case is also high-resilience ABS but spark finished in dark grey.

In the metal version, the front and rear covers are manufactured from die-cast aluminium, which is painted to match the light and dark grey finish of the plastic version.

(*a*) Payphone 290 (*b*) Payphone 390 (*c*) Payphone 490

Figure 3
New mid-range payphones

The case is opened by a lock on the right-hand side of the case, the lock having three positions. The third position is used to provide the owner with the facility to make calls without inserting coins. With the front case open, the payphone owner has access to the coin mechanism with special features that allow the owner to clear any debris or foreign material inserted via the coin slot.

Tariffing

The payphones in the NMR range are highly intelligent and can be used either for meter-pulse operation or for self-tariffing operation in a similar way to the Payphone 190. However, the larger memory capacity allows the complete UK tariff table to be stored, and all that is necessary to provide accurate charging with local code exceptions in self-tariffing mode is to enter the national number of the telephone into memory.

Power Supply

As in the Payphone 190, the NMR range makes use of batteries to provide power for the normal operation of the payphone. Six AA cells are installed into a battery box situated behind the refund cup. The memory is also supported by a lithium battery which prevents loss of data in the event of a battery failure.

A mains transformer can optionally be provided on the Payphone 390 and 490 which is used together with NiCad cells in order to power the payphone.

Remote Management

A V.22 modem is fitted in the Payphone 390 and 490 versions to provide a two-way transmission path to and from the payphone management system (IPOMS). The modem provides a full V.22 protocol at a 1200 baud data rate.

When configured to report to the management system (IPOMS), the payphone automatically reports faults and reports revenue data each time the cash container is removed from the payphone for emptying. In addition, the management system can, during such an automatic report, download revised tariff parameters to the payphone memory. This offers significant flexibility and savings as engineering visits are not required to reprogramme the tariff settings.

New Top-Range Payphone

The NTR payphone (see Figure 4) is being developed with the primary objective of achieving very reliable operation in public payphone sites while also offering a wider range of customer facilities. For the first time, payment for calls can be made by coins, Phonecard or credit card and Chargecards in the same payphone. The development of this new advanced payphone is being carried out by Landis & Gyr Communications Ltd.

Casework

The design of the NTR continues with the trend of using stainless steel for the front cover because of its strength and ease of maintenance. Stainless steel is hard wearing and easy to clean and very resistant to graffiti and other forms of deterioration due to the environment. The back case is of die-cast aluminium finished in a durable black-paint finish. The door is hinged on the right-hand side of the payphone to enable it to be installed on the existing mounting holes for the cash payphone to the left of BT's KX range of kiosks and to give a clear path for the door to swing fully open to allow easy access for maintenance.

The payment methods are grouped at the top of the payphone with the coin slot in the top right-hand corner where research has shown it is easiest for customers to locate. The credit-card reader, which is of the 'post box' type is located at the top left of the payphone with the Phonecard reader located directly below. A fully configured NTR has all three payment options fitted; however, the flexibility of the design allows for any combination of the payment options to be installed in any particular payphone location. The upgrade to additional payment options (or removal of payment options) can be undertaken on site with the insertion or removal of blanking plates. The payphone control software automatically recognises which modules are installed and alters the user instructions on the display to match the payment options.

Customer Interface

During development, a significant amount of work has been directed into the ease of which customers can use the various facilities. It was recognised early in the development that, with the wide range of facilities and payment options, there was a significant danger of customer confusion. The Human Factors Group at BT Laboratories was therefore commissioned to design and test the user interface on a computer simulation before the operational software design had been completed. Subsequent testing of the payphone in controlled tests has largely confirmed the success of this approach with only limited changes to some of the messages and message timings necessary.

Key features of the user interface to note are:

- It is possible to switch between coins and Phonecard on the same call as payment. For example, a user can start a call by using a Phonecard with a few units left and, when this runs low, can add coins to extend the length of the call.
- The payphone has been designed to assist the user at all times through the progress of a call. For example, on previous payphones it has been necessary to lift the handset before inserting coins. On the NTR, coins can be inserted before the handset is lifted and the display will prompt the user: 'please lift the handset before dialling'.
- A large high-contrast-ratio LCD display with two rows of 34 characters plus the credit display is provided. Instructions are provided in descriptive language. Six languages are available on the display selected by the language-select button (English, Welsh, French, German, Spanish and Italian).
- A secondary display featuring four configurable or service buttons is provided. These are available for taxi or hotel services for example or possibly for information services in airport or station locations. The display message and button function are downloaded from the management system and changes therefore do not require an engineering visit.

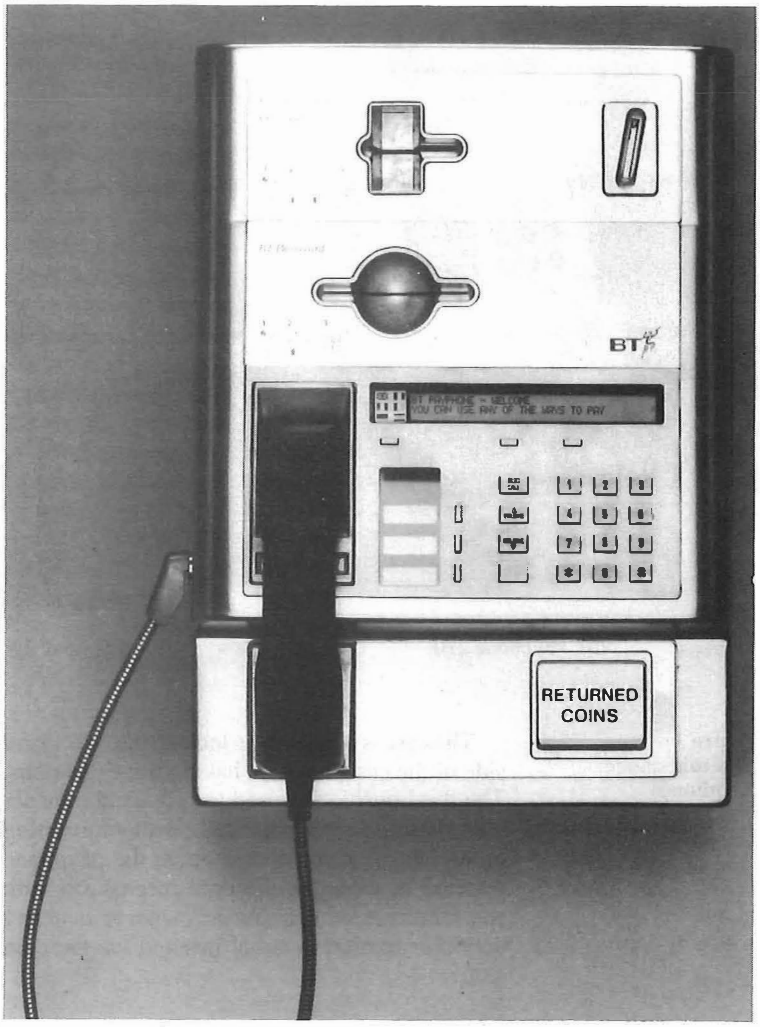


Figure 4
New top-range payphone

- Volume-control buttons are provided which allow the receive volume to be increased (or decreased) in steps.
- Two 'soft' or configurable keys are provided which are associated with the main display and allow choices to be presented at specific times in the progress of the call (for example, to eject a Phonecard which has a single unit remaining so that a further card can be inserted to continue the call).

Use by Disabled Customers

The payphone has been specially designed so that it can easily be used by customers with disabilities. As with previous payphones, it is possible to reach all the functions when seated in a wheelchair, the handset is fitted with an inductive coupler to assist users with a hearing aid when switched to the 'T' position and the keypad is marked with a pip on the 5 to assist in locating the numbers for a blind user.

New features include:

- large buttons in a wider spacing to give easier dialling for customers with arthritis and tremor;
- a backlit display for easy viewing under low-light conditions;
- a voice synthesis system, activated by a button on the keypad, which enables a blind user to

obtain a simplified version of the messages displayed on the main customer display; and

- payment options recognisable by distinctive shapes around the card and coin slots.

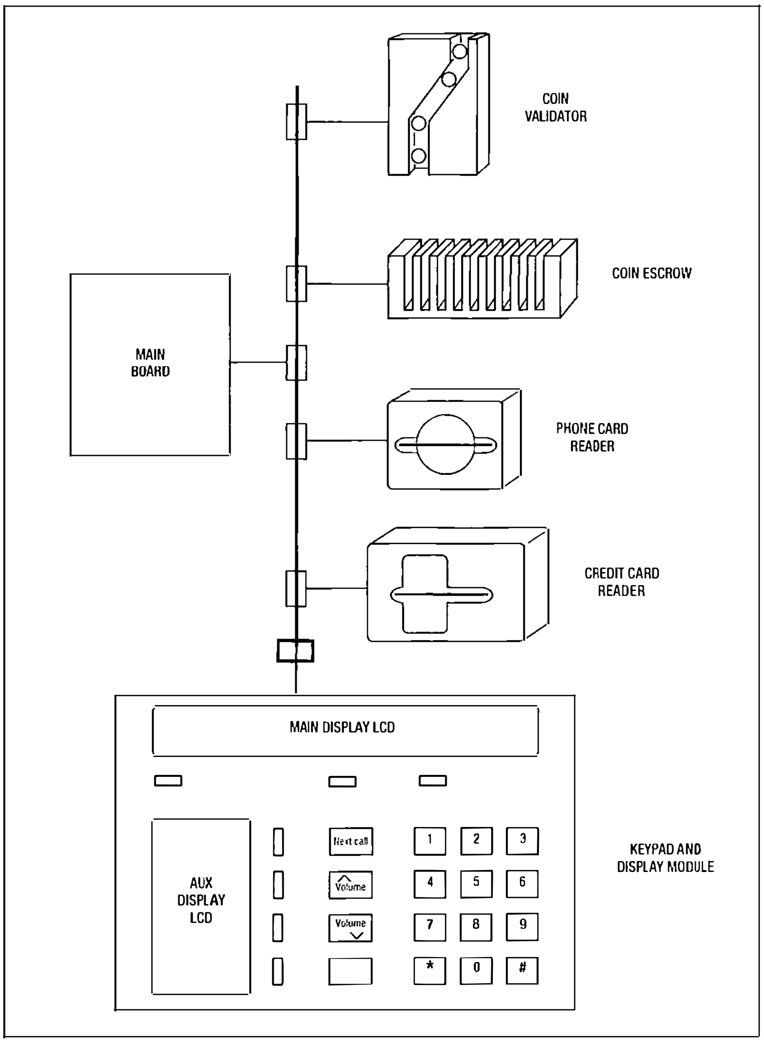
Modularity

A major requirement for the NTR is reduced operating costs. A design objective has been to reduce to a minimum the number of modules in the payphone which are replaceable during maintenance. This achieves greatly reduced stock costs and simplifies the on-site time necessary to complete a repair. If the casework is excluded, then there are essentially eight replaceable modules in the NTR design:

Main control printed-circuit board (PCB)
Coin validator
Coin escrow (coin store)
Phonecard reader
Credit card reader
Display and keyboard (desk) module
Handset
Line connection and over-voltage protection

Each of the main modules (excluding the handset and connection PCB) are interconnected via a serial communication bus (as shown in Figure 5). This has the advantage of electrically isolating each of the modules, reducing the number of wires interconnecting the modules and hence reducing fault liability and providing the capability to add (and remove) modules easily by simply extending the bus. Each of these modules has an independent microprocessor and runs a self-test diagnostic program.

Figure 5
New top-range payphone bus structure and modular approach



It is clearly important that any new product introduced is 'future proofed' to the maximum extent possible. The bus structure is an important part of this philosophy as it simplifies the addition of new facilities. For example a smart-card reader could be added at a later date should BT wish to adopt this alternative form of payment.

Payphone Management System

The NTR also contains a V.22 modem to provide a two-way transmission path to and from the payphone management system (IPOMS). The modem provides a full duplex V.22 protocol at 1200 baud data rate. The payphone automatically reports faults, revenue data and a wide range of statistical data, which is collected by the payphone. This statistical data is not sent routinely at each call to the management centre but is requested, when required by the management centre.

After receiving a message from the payphone, the IPOMS can transmit information to the payphone. This downloaded information is particularly comprehensive and includes:

- tariff information,
- revised display messages,
- service button display and telephone numbers,
- telephone number for the IPOMS,
- time of day,
- new coin parameters, and
- new software modules.

The flexibility of the payphone is therefore greatly enhanced: routine visits to change tariffs and even add new coins into the set are unnecessary. Should a software enhancement be required, or a correction to a 'bug' discovered then this can be accomplished by downloading a revised module or even the complete operational software of the payphone.

THE FUTURE

The introduction of the NTR payphone into service will give a platform onto which future services can be added. Of particular interest is the possible use of smart cards, which could be readily added as a method of payment using the modularity built in to the design. In addition, the opportunities offered by network-based intelligence and the integrated services digital network will be further explored and offer much potential for new services.

In the private payphone market, the pace of product change is expected to increase with product life cycles reducing in line with other customer premises equipment as the benefits of the reducing cost of electronics and display technology continue. Further developments in coin handling techniques, together with widespread use of surface mount device (SMD) technology are likely to allow a reduction in the overall package size.

References

1 Lewin, J. R. Payphones in the Nineteen-Eighties. *Br. Telecommun. Eng.*, Apr. 1982, **1**, p. 2.

2 Pope, N. G. The BT Cashless Services System. *ibid.*, July 1990, **9**, p. 112.

3 Williams, D. L. Payphone Remote Management Systems. *ibid.*, July 1992, **11** (this issue).

Glossary

CSS	Customer services system
IPOMS	Integrated payphone operation and management system
LCD	Liquid crystal display
NMR	New mid-range
NTR	New top-range
NTT	New tabletop
PCB	Printed circuit board
PEP	Payphone Enhancement Programme
PIC	Plug-in customiser
PIN	Personal identification number

Biography

John Empringham joined BT as a technician apprentice. He subsequently received a scholarship award for full-time study at the University of Surrey, where he obtained an honours degree in Electrical Engineering with Electronics in 1973. He has subsequently been involved in a number of customer's equipment development areas including the introduction of new inter-PBX signalling systems. He joined the Payphone Division of BT in 1979 and worked within the team that introduced the new range of public and private payphones. He is now Development Manager responsible for operational support and product development of payphone equipment in BT Payphones.

Payphone Remote Management Systems

LES (D. L.) WILLIAMS

This article describes the developments in systems for the remote management of payphones, and introduces the new functionality for management of payphones in the 1990s.

INTRODUCTION

In an article 'Payphones in the Nineteen-Eighties'[1] published in 1982, John Lewin described the introduction of *automatic reporting* payphones. This article outlines the developments in automatic reporting, with the introduction of computer management systems, and goes on to describe the current developments of remote management that provide far wider functionality, including remote management of tariffs and other operating parameters, and remote changing of the payphone software.

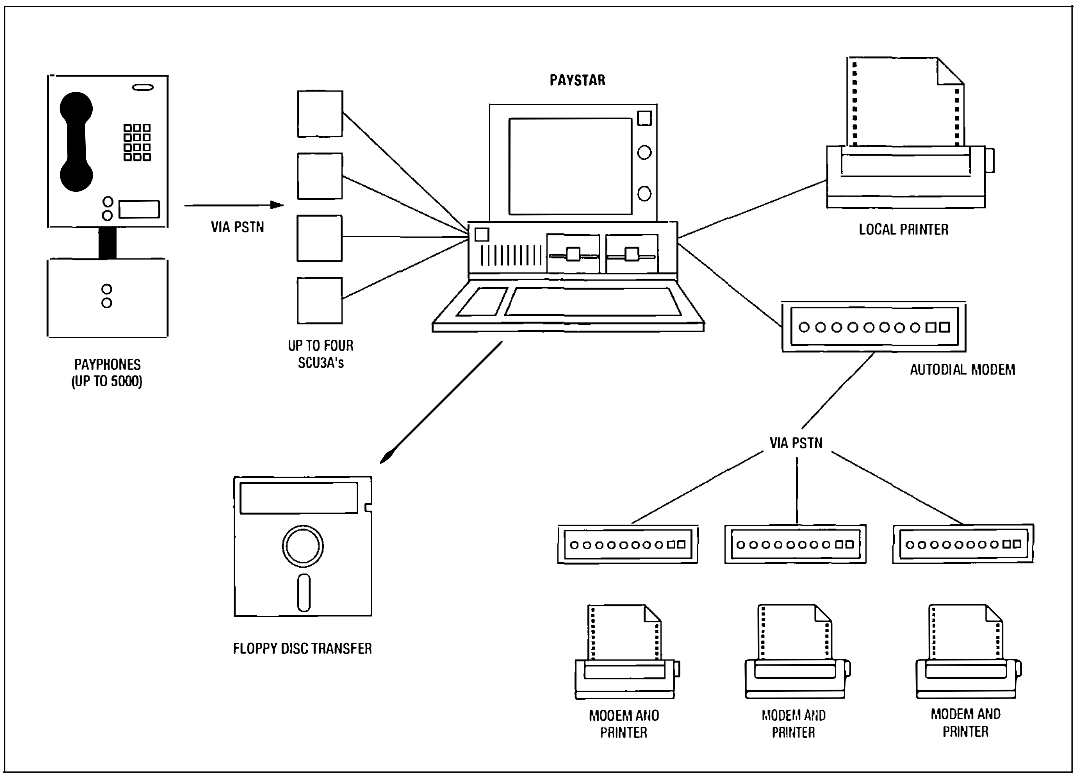
Remote management of payphones offers benefits to customers, site owners and the service provider. Customers benefit in terms of higher levels of serviceability, a more flexible and user-friendly service with enhancements available sooner, and a more price-competitive service from reduced operating costs. Site owners benefit from improved service, better management information, and the option of having the service managed by the service provider. The service provider benefits from the reduced costs of providing service, being able to react quickly to changing market needs, being able to identify and combat the inevitable fraud and theft activities, being able to readily identify additional revenue opportunities, and improved management information on the business.

PAYSTAR

Many of the current range of payphones have an in-built facility which allows them to make self-reports over the public switched telephone network (PSTN) to programmed destinations by using MF4 signalling. A Signal Conversion Unit 3A (SCU3) receives these messages and outputs them in a printable format.

The PAYSTAR computer system was developed to receive the output from up to four SCU3s, to process it into a more readily usable format, and to distribute the information to where it was required (see Figure 1). The system was implemented on a District basis during the 1980s.

Figure 1
PAYSTAR system



---

† BT Personal Communications

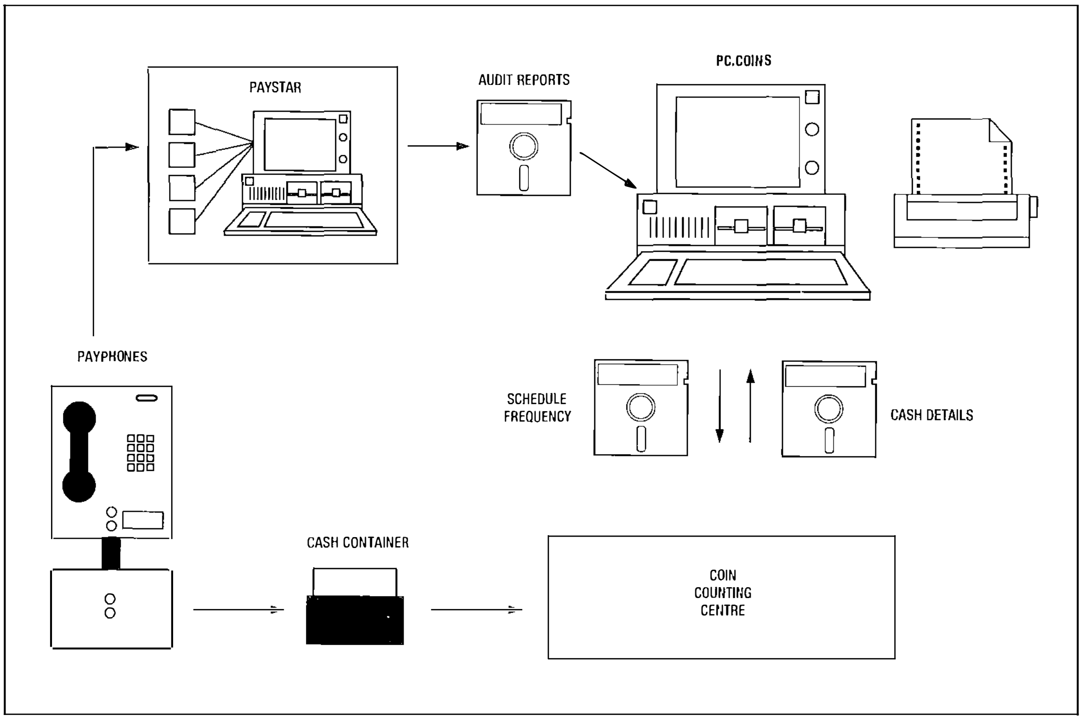


Figure 2
PC.COINS system

The PAYSTAR system runs several real-time processes concurrently; however, the nature of its output is very much batch-based with up to 10 summaries per day going to each local or remote centre. The system caters for up to 20 logical centres, which can be a mix of shared or separate physical centres.

Payphone self-reports include information relating to the fill of the cash container, including 75% and 100% cash-box-full reports, and the value of the contents when it is collected. These are in addition to a range of fault, alarm and test reports. The cash-collection information is used by the PC.COINS system for management of the cash collection and revenue reporting.

PC.COINS SYSTEM

The PC.COINS system (see Figure 2) was developed during the 1980s from its predecessor—the COINS system for management of public call offices. This consists of a detailed site inventory, a comprehensive revenue suite and a less-developed maintenance/service suite. The revenue suite provided financial reports on public payphone revenue by site. PC.COINS receives cash details from coin counting centre systems and audit data via PAYSTAR. PC.COINS also provides the collection schedules for use by the cash collector.

SERVICEABILITY

In the article 'Developments in Payphones' in this issue of the *Journal*[2], John Empringham describes the serviceability equation used as the basis for the payphone enhancement programme to improve serviceability, by concentrating on the three factors of annual fault rate, time to detect faults and the time to clear faults.

The self-reporting system was seen as a key contributor to improved serviceability because the time taken to detect faults by this method is considerably shorter than the other major methods of detecting faults, especially from public call offices.

Under the payphone enhancement programme, the self reporting was enhanced in three ways: firstly, the enhancement of the product to detect more failures and report them; secondly, by improving the success rate of the self-report signalling system by improvements to the SCU3; and thirdly by enhancing the handling of self-reports so that they can be passed automatically into fault queues within the customer service system (CSS) repair handling system. It was to meet this final requirement that a new strategy for payphone management systems was agreed.

The strategy being followed is the development of a 'back office' system specifically for the management of payphones, with interfaces to the 'front office' and other systems as appropriate. This payphone back-office system is referred to as the *integrated payphone operation and management system* (IPOMS). Thus those tasks appropriate to the front office can be handled by BT's main front-office systems—for example, CSS order handling, billing and repair handling (CSS RII)—and those that are specific payphone requirements can be handled on the back-office system.

SPECIFIC PAYPHONE REQUIREMENTS

Existing Self-Reporting

Payphone self-reporting handled through the PAYSTAR system was approaching the end of its design capability. It was essential that self-report faults were automatically transferred into fault queues on CSS RH, as quickly as possible. In addition, the need to maintain only one database was an important consideration.

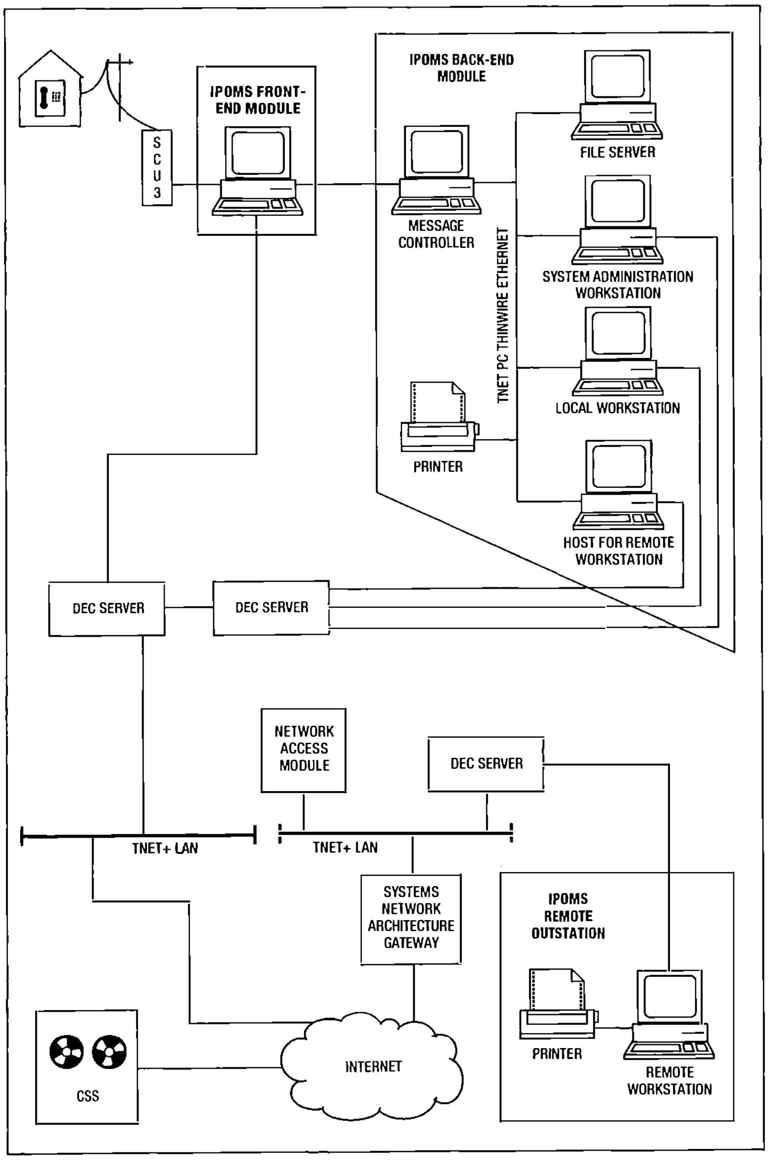
Cash Collection Management

The single-user PC.COINS system reached the point where size and processing speed were no longer adequate to carry out the necessary functions within the time available, especially as activities were being organised into larger units. Conversion to multi-user working linked in with the provision of new facilities was the necessary way forward.

The PC.COINS database already held a large amount of data about payphone sites not handled by other systems; therefore, this database was used to form the basis for the IPOMS database.

The real-time distribution of self-reported cash-box-fill status, cash collection and audit information to other users on the IPOMS system was also seen as an enabler to more-effective contract management.

Figure 3
Typical IPOMS network



Payphone Site Management

A medium-term objective was to be able to identify costs as well as income to individual sites, as the developing competitive environment made it crucial to have the right sites.

New Payphone Range

The payphone enhancement programme identified the need for a new range of payphones with lower fault rates and more facilities for customers. The new top-range payphone currently under development will place significant additional requirements on the management system so that many of the functions that currently require site visits can be carried out remotely. To achieve this, an enhanced signalling system between the payphone and its management system was necessary. Proposals for a turnkey system from the potential payphone suppliers were reviewed, but it was decided to follow the strategy of evolving BT's own system by agreeing an interface between the new payphone and an IPOMS front-end processor.

The new mid-range payphone for the renters and managed payphone markets will be equipped with self-reporting facilities; however, the functionality will be reduced from that of the top-range payphone.

The products at the lower end of the new payphone range currently do not have remote management facilities, as product price is the dominant factor. As the cost of modem technology continues to fall, it will probably be cost effective to have remote management even on these products in the future.

IPOMS DEVELOPMENT

The IPOMS system is being developed for BT Payphones by BT Customer Systems in Leeds.

The initial phase of the IPOMS development consisted of a per-District system based on a file server and networked personal computers (PCs), and was implemented during 1991–2. The system covers the following functional areas:

- redesign of the self-report handling system to include interactive working with CSS RH, with the provision of on-line and historical analysis facilities;
- payphone revenue management including cash and cashless revenue; and
- provision of a single database with expansion to cater for the market segments identified by the BT Payphones Product Plan.

A typical configuration of a phase 1 IPOMS system (see Figure 3) consists of:

- several front-end modules which receive self-reports from the payphones and pass these to CSS and to the IPOMS database as appropriate;
- a message controller which handles the communication between the front ends and the IPOMS back-end local area network (LAN); and

- a Novell LAN with file server, local workstations, system administrator workstation and hosts for remote workstations.

Connectivity into CSS is via BT's corporate data network, for both front-end modules and local workstations that can switch between being IPOMS terminals or CSS terminals.

Attention was paid to providing the necessary security on the links to CSS, without compromising the required functionality. CSS access is currently by terminal emulation. Security is managed by the system administrator from a special terminal. The establishing of sessions from the front ends to CSS is controlled by a *route map*, which is a database controlling the necessary steps. This route-map concept enables most changes in network or CSS software to be handled without the need to change the IPOMS software itself.

Having the front end connected to the LAN by a serial interface provides greater resilience and configuration flexibility; however, this is only possible because each front end requires only a small sub-set of the database in order to operate.

The next phase of the development, currently taking place, will cater for the requirements of the new payphone range. The main area of change is the enhanced communication with the payphones.

Emphasis is given to the benefits that can accrue from enhanced signalling between the payphone and the management system(s). While improvements in electronics and coin handling will reduce the volume of fault handling in the management system, the need for advanced management facilities and information will more than offset this.

The existing communication is unidirectional in that information is passed from the payphone to the management system only. By introducing two-way communication, several remote management facilities are made possible and others are enhanced. These include:

Commissioning In order to ensure that the management system database reflects accurately the installed base, the payphone will not become operational until it has completed a data interchange with the management system, including a call back to verify the correct telephone number has been programmed.

Tariff Management The system will enable the tariff parameters used in the payphone to be set remotely by the management system down to an individual payphone basis. Tariffs will be either network derived or self-tariffing, and the management system will be able to switch a payphone between the modes. Tariff-posting numbers will be used to verify that the correct tariff is in operation.

Facility Management During the life of a payphone product it is likely that new facilities will be added, or existing facilities removed. This can be managed remotely by the management system in two ways. Firstly, parameter changes can be downloaded, such as details of what coins to accept, or display messages. Of particular relevance will be the ability to tighten up selectively the windows of acceptance for coins when slug frauds are detected.

Secondly, software modules can be downloaded that change the way the payphone operates more fundamentally than can be achieved via parameters.

The second aspect of the enhancement in communication, which currently applies only to the top-range payphone, is the move to a high-level dialogue protocol. The existing self-report format is a fixed format message. The protocol developed for the new top-range payphone allows the data transferred to be varied under the control of the management system. This means that information can be selectively requested or downloaded and enhancements to the payphone software can be implemented without the protocol having to change. The use of a specialised high-level protocol contributes to the security of the payphone/management system interface.

By introducing a dialogue protocol, several remote management facilities are made possible and others are enhanced. These include:

Statistics Reporting The payphones will be able to record a number of statistics; however, these will only be required on a sample basis or during trials for instance. These statistical counters can be enabled when required by the management system. Reading of these counters is then handled within the dialogue, only when necessary.

Fault Reporting The fault reporting is enhanced in that the payphone will identify itself and give its 'reason for calling'. As a result of this 'reason for call', the management system can then request additional data items from the payphone, such as the status of specific modules. In this way, a more precise fault location can be carried out before a maintenance person is dispatched to site. The modular basis of the payphone should allow fault location to module level.

Clear Reporting When modules are changed during a maintenance visit, the payphone will notify the management system of the changes. All electronic modules will be electronically serialised, thus enabling more systematic control of spares.

The dialogue protocol does, however, have a significant impact on management system sizing: with fixed format protocols, it is easy to arithmetically size the system. For the dialogue protocol, a more statistical approach has to be taken.

System sizing is also affected by the calling pattern. As the payphone uses its normal line for reporting to the management system, it is necessary to program periodic reporting to take place outside the main usage periods of the payphones; for example, between 24.00 and 06.00 hours.

The changes to IPOMS to handle the new top-range payphone involve a different front-end processor configuration (see Figure 4). In place of SCU3s, banks of modems handle the com-

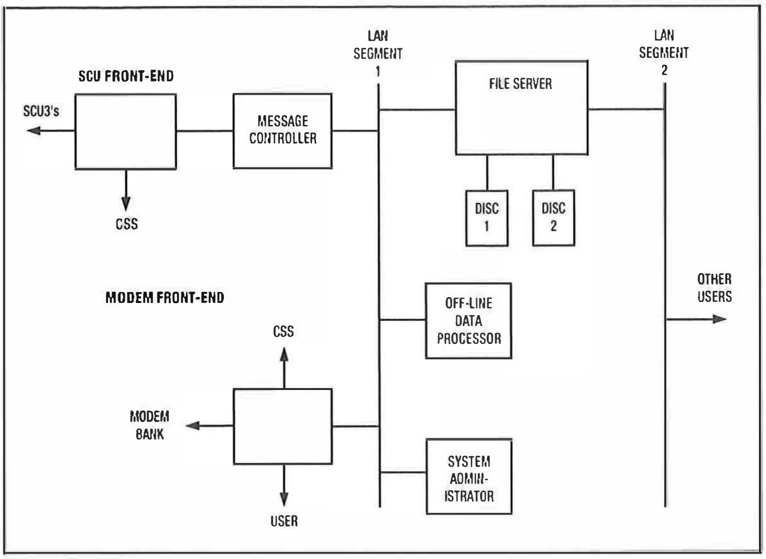


Figure 4
IPOMS modification for new top-range payphone

munications with the payphones. The front-end processor has been moved onto a LAN segment with the file server because of the heavier usage of the database required by the communication. This LAN segment is reserved for handling the interface with the payphone.

The design of IPOMS allows the addition of front-end processors which will handle the protocols for the different supplier products, in the same way that the new payphone range has separate front ends to the existing products. Further front ends can be added to increase capacity as the population of particular products grow. The introduction of standards for the protocols across different suppliers has some benefits to offer; however, a public-domain protocol would impact the security, and the complexity of the protocol for the top-range payphone could not be cost justified on products lower in the range. Work on developing standards for payphones for the integrated services digital network (ISDN) is seen as the most practical way forward.

Further enhancements are being evaluated or planned in the following areas:

- Connectivity to other main BT systems where information required for running the payphone business is held. The main systems include works management system, stores systems, CSS billing and order handling, and the cashless services system.
- The expansion of the database and facilities to handle the requirements of the renter's payphone equipment segment of the market.
- Development of the system to exploit voice response to provide further automation in the monitoring of site inspection/cleaning visits to measure serviceability and record faults and clears.
- More detailed management information including cost and revenue tracking to managers.
- Functionality to support new processes and organisation, aimed at reducing the costs of operating the payphone business. As standard processes are implemented in the payphone business, the opportunity to automate these processes, where possible, is being taken.
- Functionality to support the use of ISDN for both communication between the payphone and management system, and between remote users and the management system. The modular construction of the new top-range payphone will allow new modules, such as an ISDN interface, to be implemented. The ISDN will offer significant user enhancements as well as developing even further the extent of the management facilities. It will also enable this without intruding into the time available for customers to use the payphone.

CONCLUSIONS

The existing remote management of payphones has proven effective in enabling simple data, originating at the payphone sites, to be collected automatically. The passing of faults detected by the payphone, into job queues on CSS has proved a significant step. The enhancements under development for the new payphones, especially the new top- and mid-range, are enablers for significant cost reduction in the running of the payphone business.

The next developments are likely to be in the use of the ISDN, which has potential for further enhancement of facilities at the payphone and reduction in operational costs.

References

1 LEWIN, J. R. Payphones in the Nineteen-Eighties. *Br. Telecommun. Eng.*, Apr 1982, **1**, p. 2.
2 EMPRINGHAM, J. B. Developments in Payphones. *ibid.*, July 1992, **11** (this issue).

Biography

Les Williams is Operational Systems Development and Support Manager for BT Payphones. He graduated in Electrical Engineering at Reading University in 1975 and joined the then Post Office in the Development Department working on a range of power equipment for customer apparatus. In 1979, he transferred onto the development of the first microprocessor-controlled self-contained payphones. In 1984, he moved into payphone finance group where he was responsible for managing the specification and development of payphone management systems including PAYSTAR and PC.COINS. In 1990, under Project Sovereign he was appointed to his current post in BT Payphones.

Glossary

CSS	Customer service system
CSS RH	CSS repair handling
IPOMS	Integrated payphone operation and management system
ISDN	Integrated services digital network
LAN	Local area network
PSTN	Public switched telephone network
SCU3	Signal Conversion Unit 3

Switched Multi-Megabit Data Service—The First Step in High-Speed Data Communications

GRAHAM WILLIAMS and JOHN WILSON†

BT plans to trial a new high-speed data service in the second half of 1992, and the first trial customer will be University College, London. Initially, seven university buildings will be linked together via a new type of switched network service, which is aimed at providing higher speed, greater flexibility and better network economics for customers. This article provides an overview of the market, technical analysis and BT's rationale for this new service.

INTRODUCTION

As business communications needs have developed over the years, most of BT's large customers have built their own voice and data networks. The prime driver for this has been the relative economics between continuing to use the public network and the often more predictable costs involved in investing in the provision of private circuit links. Other issues like security have also been an important driver for some businesses.

Though voice communications have been the dominant factor in the early deployment of private networks, this is increasingly less the case as, over the past few years, data needs have grown much faster than voice and have now taken on significantly more importance.

MARKET DRIVE FOR A SWITCHED MULTI-MEGABIT DATA SERVICE (SMDS)

Application Drivers

The underlying driver for increased networking speeds is the emergence of image- and video-based applications. Such applications, compared to earlier text-based applications, demand significantly more power and capacity from the computer on which they run and require high-speed intersite communications if the applications are to work with reasonable user response times across networks. Graphical user interfaces (GUIs) have emerged which allow computers to be used in a more intuitive way, and this has provided a platform and stimulated the development of image-based applications.

Growth in Local Area Network Market

Local area network (LAN) data traffic is growing at 30% per annum and this trend is expected to continue during the next 5 years as image-based applications escalate and the use of GUIs continues to grow.

Trends in Customer Premises Equipment

On the demand side, annual price-performance improvements in personal computers (PCs)/LANs/wide area networks (WANs) are a major driver behind LANs becoming the dominant office network. Strong growth is forecast over the next 5 years and it is estimated that, by the early-1990s, most workstations will be connected to LANs.

The UK LAN market at present is the biggest in Europe. In addition, rapid volume growth in PCs and workstations is increasing the number of LAN connections and putting pressure on the speed requirements for LANs and LAN linking.

On the supply side, higher-speed private data networking components such as the fibre distributed data interface (FDDI), the distributed queue dual bus (DQDB) and extended channel architectures for mainframe computers are providing the capability for transmission speeds with broadband specifications. LAN bridges, for example, are approaching the capacity of LANs themselves.

Trends in Networking Equipment

Most private networks in the UK were originally installed to interconnect PABX systems. Many high- technology manufacturing concerns are increasingly moving towards Internets (bridge/router-based internetworking architectures) for LAN interconnection, and computer connectivity, rather than conventional public data networks. High-speed networks such as these will be justified on the strategic value of the applications they support, and, for many corporations, high-speed applications will be in the critical path to corporate success.

In the UK, bridge and router shipments are growing at 60% and 80% respectively, indicating

---

† BT Products and Services Management

a sharply increasing requirement for off-site connectivity.

Trends in Computing Equipment

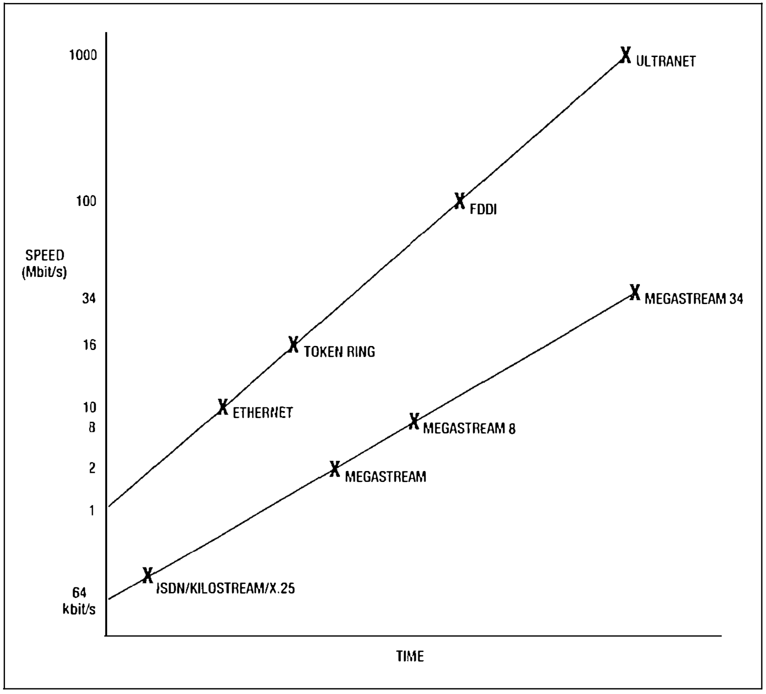
Hardware

The continual development of more powerful processor chips and advances in memory (for example, WORMS and CD-ROMs), cost and capacity, are continuing the trend of bringing processing power to the user.

Software

In operating systems, the trend is to move from DOS to operating systems such as OS/2 and UNIX. These multi-tasking operating systems with their reduced instruction sets give cheap price/performance (moving towards 200 million instructions per second on the desk), and are creating a broad base of desktop and personal workstations that require high bandwidth for file sharing and data transfers.

Figure 1
Comparative trends in speeds of local area networks and wide area networking



The resultant proliferation of ever more powerful workstations is leading to increased traffic on networks and fuelling the demand for higher-capacity LANs and backbones such as the 16 Mbit/s IEEE802.5 token ring and the 100 Mbit/s ANSI FDDI. These developments place all the more pressure for comparative wide area data networks. Figure 1 shows the increase in speed of LANs compared with the increase in speed of public network data services.

Mainframe Trends

Mainframe-to-mainframe data transfer is moving towards a 200–500 Mbit/s requirement.

IMPLICATIONS FOR WIDE AREA NETWORK SERVICES

Public Network Services Providers

The LAN market is mainly outside the control of public service providers. They provide the connectivity for LAN interconnect only where interconnection is to networks outside an enterprise. In these circumstances, there are essentially two methods of doing so: leased lines, for point-to-point connections, and via the public data X.25 network. However, as solutions, they represent extremes of the emerging LAN interconnect need because:

- as the demand for high speed grows, the X.25 option will become less appropriate (too slow); and
- as the demand for networking grows, the leased-line option increasingly results in expensive, non-optimum, solutions.

Private Network Solutions

Third-party vendors work by selling (or reselling) bandwidth on a physical or virtual connection basis. They maintain their margins by consolidating and sharing backbone links. The projected LAN trends in demand for higher speed and networking are putting them under severe pressure to upgrade towards higher-speed spines (for example, 34/45 Mbit/s), which will allow them to offer high-speed customer interfaces (for example, 2/1·5 Mbit/s). The economics of network design (that is, the relationship to size and fill) and the current price breaks (for example, of 2 Mbit/s to 34 Mbit/s) make it very difficult for them to meet the increasing cost/performance demands of customers. Hence many vendors are promoting a new way of selling bandwidth; for example, by offering ‘logical’ connectivity by means of frame-relay technology.

Opportunity for Switched Multi-Megabit Data Service

LAN traffic tends to be characterised as bursty such that high throughput, with low delay, is required for short periods, resulting in a very low average bandwidth utilisation. These characteristics of LAN data traffic further exacerbate the economics of network design. Therefore, as the dual trends towards higher speed and greater networking converge private solutions will increasingly become less cost effective for the increasing base of information processing systems that depend on:

- distributed processing and databases,
- software and resource sharing,
- user-friendly graphical interfaces, and
- image handling and processing.

The switched multi-megabit data service (SMDS) specifically addresses the dual requirement of high-speed low-delay interconnection and flexible networking and aims to offer customers an optimised solution where tariffing and costs are more tailored to usage. An SMDS solution would also plug an obvious gap in the telephone operators' portfolio and (competitively tariffed) could be positioned as an attractive alternative to private solutions for intra- and inter-company communications.

WHAT IS SMDS?

SMDS is a high-speed packet switching service that transports customer packetised information across a wide area. The method of data transport employed is termed *connectionless*, which is a method of transmitting user data without the need for prior call establishment. All the information needed to route the message to its destination is contained within the data packet. (This is analogous to posting a letter where all the information needed to route the letter to its destination is contained on the envelope.) Connectionless transport gives the advantage of low latency but with the possibility of unacknowledged data loss. The connectionless packet service will provide LAN interconnect and maintain LAN-like performance across a wide area.

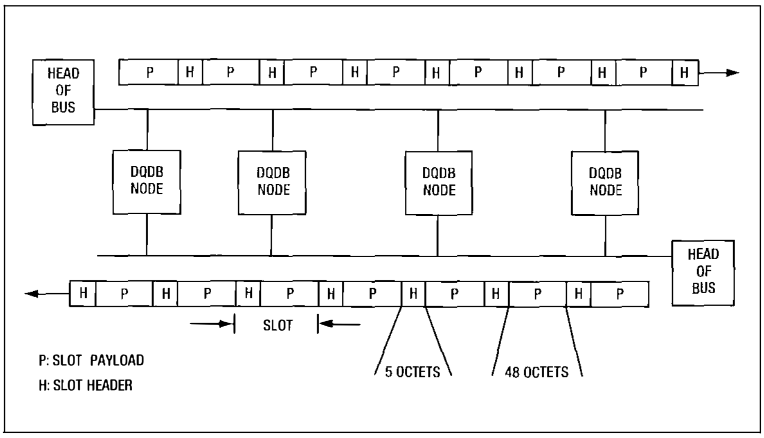
SMDS will provide interconnection between customers' systems with minimal changes to those systems. This protects end users' investment in their existing data communications and processing environment.

The service will allow interconnection of both similar and dissimilar LANs and will be offered to the customer over dedicated local access links running at speeds of 2 or 34 Mbit/s. For customers who wish to restrict incoming or outgoing traffic, source and destination address screening allow restrictions to be placed on where data can be sent and from whom it can be received. These features can be used to, for example, create a *logical private network*.

Other service features include the ability to send the same data packet to multiple destinations (multicast addressing) and to limit the maximum access speed to less than the full rate of the transmission system being used on the access link (access classes).

ENABLING TECHNOLOGY

SMDS is specified as a technology-independent service. In theory, different network platforms capable of providing the service features and appropriate quality of service requirements can be used. However, in reality of course, in order to provide the service, a particular network technology and, in order to stimulate customer premises equipment (CPE) development and ensure its availability, a particular CPE interface must be selected. For SMDS, the initial network platform and interface specification will be based upon an emerging technology called the *metropolitan area network* (MAN). The MAN technique selected as being particularly suited to the SMDS service is termed the *distributed queue dual bus* (DQDB) and is standardised by the Institute of Electrical and Electronic Engineers (IEEE) as the IEEE802.6 standard.



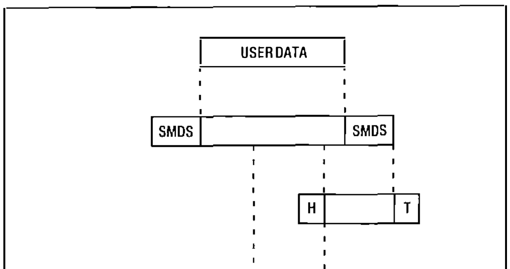
DQDB: Distributed queue dual bus

Figure 2
Basic DQDB subnetwork

The basic configuration of a DQDB subnetwork (a subnetwork being a single dual bus with a number of nodes connected) is shown in Figure 2. Fixed length data units, called *slots*, comprising a 5 octet header followed by a 48 octet payload are generated at the head of each bus. The header contains control information used by nodes on the bus to read/ write data to and from the bus, and the payload field (which is initially empty) is used to carry parts of the user's data packets along with additional information required to reassemble the data packet at the destination.

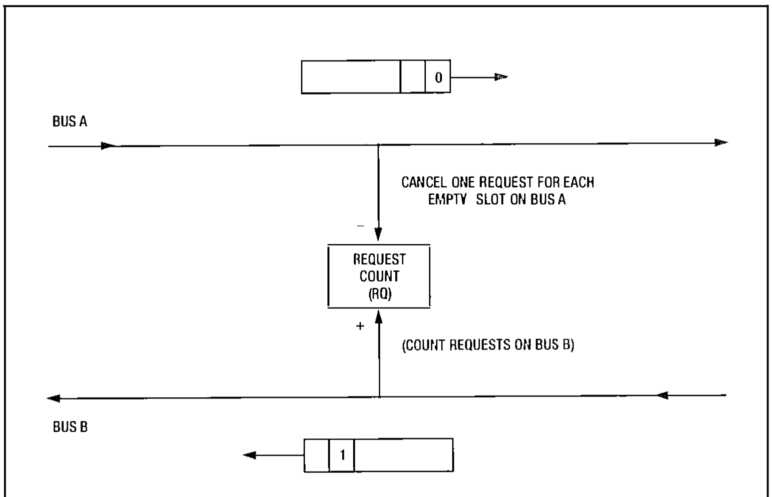
Slots pass down the bus and when allowed by the distributed queuing protocol are filled by nodes with data to transmit. At the destination, the receiving node copies the slot into its receive buffer and, when all the parts of the original packet are received, passes the complete data packet to the customer's equipment.

The mechanism for segmenting user data packets, which can be of a variable length up to 9188 octets, ready for transmission on the bus is shown in Figure 3. The variable length data unit (usually a LAN data packet) is encapsulated in a header

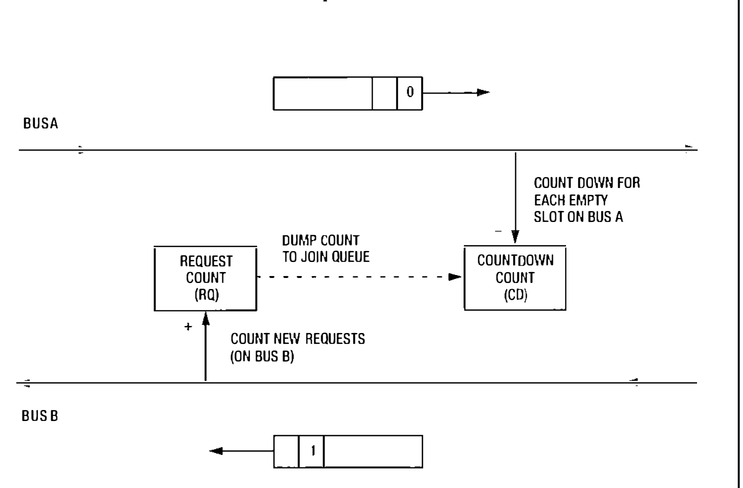


SMDS: Switched multi-megabit data service

Figure 3
Segmentation of user data



(*a*) Node not queued to send (bus A)



(*b*) Node queued to send (bus A)

Figure 4—Distributed queueing

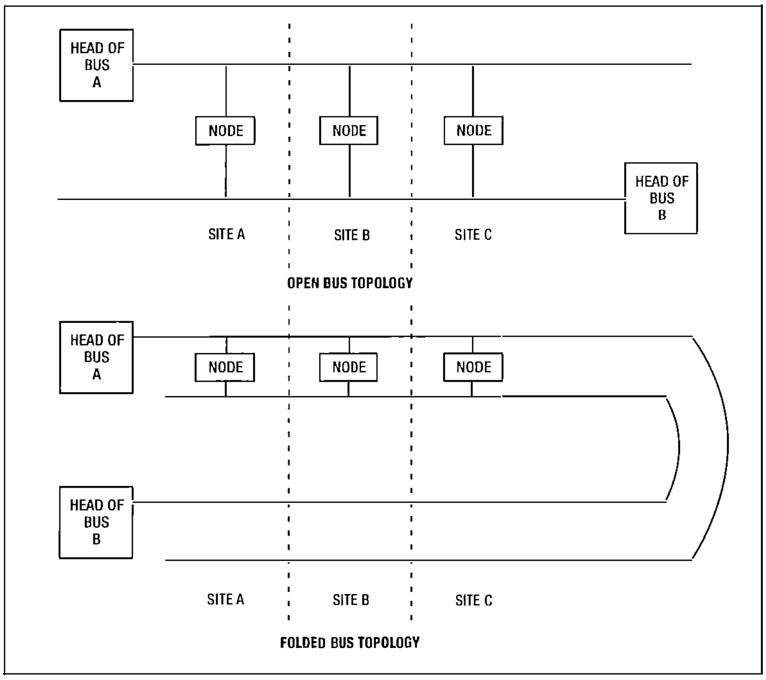


Figure 5—Bus topology options

and trailer, which contain the source and destination addresses of the packet along with a variety of fields for error detection and protocol identification. The encapsulated packet is then sliced (segmented) into 44 octet units and a further header and trailer added to each slice. These contain further error-detection mechanisms plus information required to reassemble the original data packet at the destination node.

The segmented data packets are then placed in a queue waiting for transmission onto the bus. So that all nodes on the bus can get a fair share of the empty slots that are passing by, a mechanism is needed to control access to slots at each node. In the case of the DQDB protocol, a distributed queuing technique, developed by a student and lecturers at Western Australia University, is used. Figure 4 shows the basic operation. To gain access to empty slots on bus A, a node sends a message, that it has data to send, to all upstream nodes on bus B. This is done by setting a bit in the slot header. The upstream nodes take note of this request message, by each incrementing a request counter, and allow an empty slot to pass them by for each request received (for each empty slot that passes a node the request counter is decremented by one). If upstream nodes wish to send data themselves, they place themselves in the queue by transferring the current value of the request counter (which indicates the number of empty slots which must be let past before access can be allowed) to a countdown counter and decrementing the countdown counter by one for each empty slot that passes the node. When the countdown counter reaches 0, the node is free to load data into the next free slot. During the countdown process, received request bits are registered on the request counter to indicate the number of slots which must be left before another slot can be used by that node for sending data.

The protocol itself is almost transmission-speed independent, but has typically been designed to run over public network transmission systems at speeds of 2, 34 and 140 Mbit/s. In networks where only two nodes are connected (point-to-point configurations), there is no limitation on distances between nodes (links have been in operation in Australia over distances up to 4000 km); however, for networks where more than two nodes share the same bus, a single subnetwork should be limited to 150 km.

The dual bus can be configured in one of two ways, either as an open or folded bus (see Figure 5). The folded-bus configuration has the advantage of resilience because the DQDB protocol can detect line failures and reconfigure the bus around the failure. The exact method of operation for reconfiguration is outside the scope of this article but Figure 6 shows the basic principle.

DQDB busses can be joined together into a variety of configurations allowing a wide range of network configurations to be easily constructed. In particular, in order to support the SMDS service, the dual bus can be used as an access protocol between the customer's premises and the main network switching equipment (known as the MAN switching system or MSS) and can be combined to form MSSs and the links joining them.

DQDB IN THE CUSTOMER ACCESS NETWORK

In order to allow access to the SMDS service from a variety of customer's equipment types, an open interface based upon the IEEE802.6 standard has been specified. Two basic options are possible, the first uses the full DQDB protocol to provide access from the MSS to a number of DQDB nodes sited at a customer's premises. (For security reasons, all SMDS customers have their own dedicated access link.) (See Figure 7.) The second, and most likely option in the short term, is the use of a simple subset of the DQDB protocol to provide point-to-point connection between a single customer node and the MSS (see Figure 8). In both cases, the format of the transmitted data is the same (customer packets transported in fixed length slots); however, the simple point-to-point implementation does not use the distributed queue technique as there are no other nodes to compete with for bandwidth.

DQDB AS PART OF THE SMDS MAIN NETWORK PLATFORM

In order to provide the high-speed switching and data transport required for SMDS, DQDB sub-networks can be joined together to form a switched network (see Figure 9). In the case of core networks, all the busses use the full DQDB protocol and can make good use of the network-reconfiguration feature discussed earlier. The nodes on each subnetwork can be located close to each other within an exchange to provide a centralised switching function, or they can be dispersed to provide a distributed switching arrangement. The network can be expanded by the addition of additional nodes on a bus or by the addition of extra subnetworks.

FUTURE NETWORKING POSSIBILITIES

As mentioned earlier, SMDS is specified as a technology-neutral service. To preserve this requirement, it is important that future networking techniques allow for the provision of SMDS without any perceivable changes to the service from the customers' point of view (except possibly for improvements in throughput or quality of service). In the future, high-speed networks will develop using a technique similar to DQDB (that is, the transport of data using fixed-length slots) called *asynchronous transfer mode* (ATM). ATM has been identified as the transfer method for future broadband integrated services digital networks (B-ISDN), and it is expected that SMDS will become the first service to be supported on the B-ISDN if and when it becomes available. Standards are currently being developed which should allow the same SMDS packet to be transported across networks using either DQDB fixed-length slots or ATM fixed-length cells (see Figure 10).

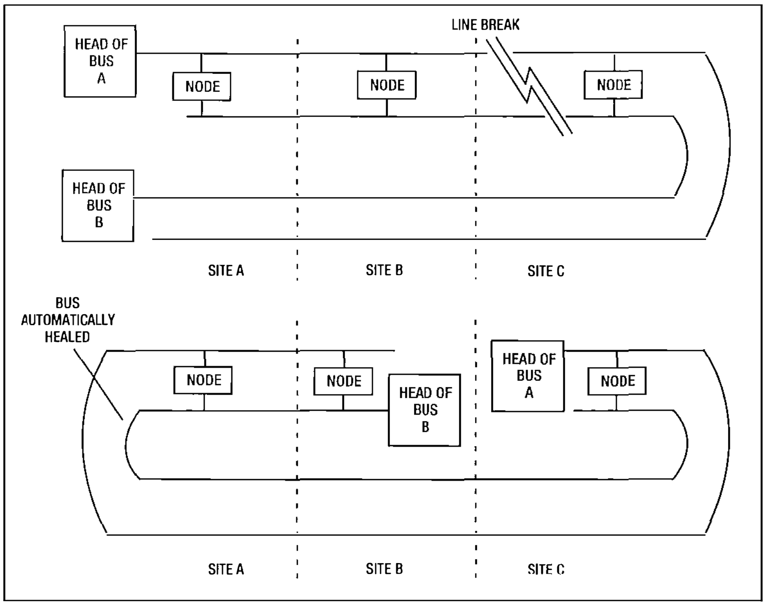


Figure 6—Bus reconfiguration around line failures

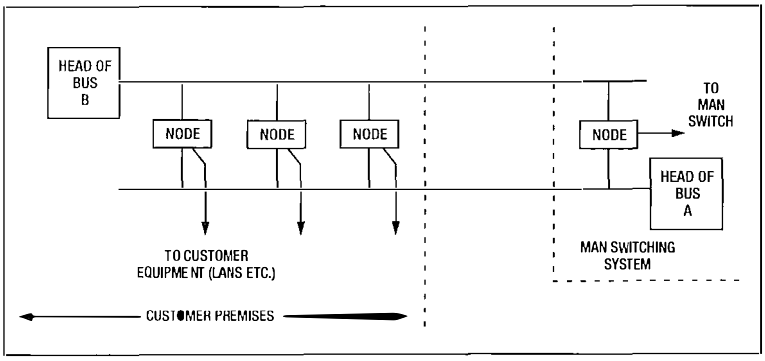
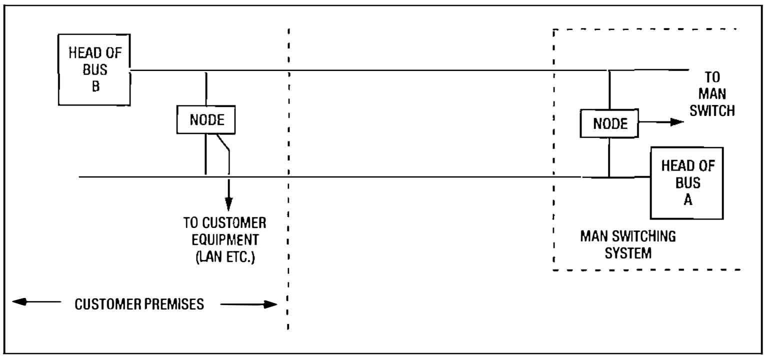


Figure 7—Full DQDB access link

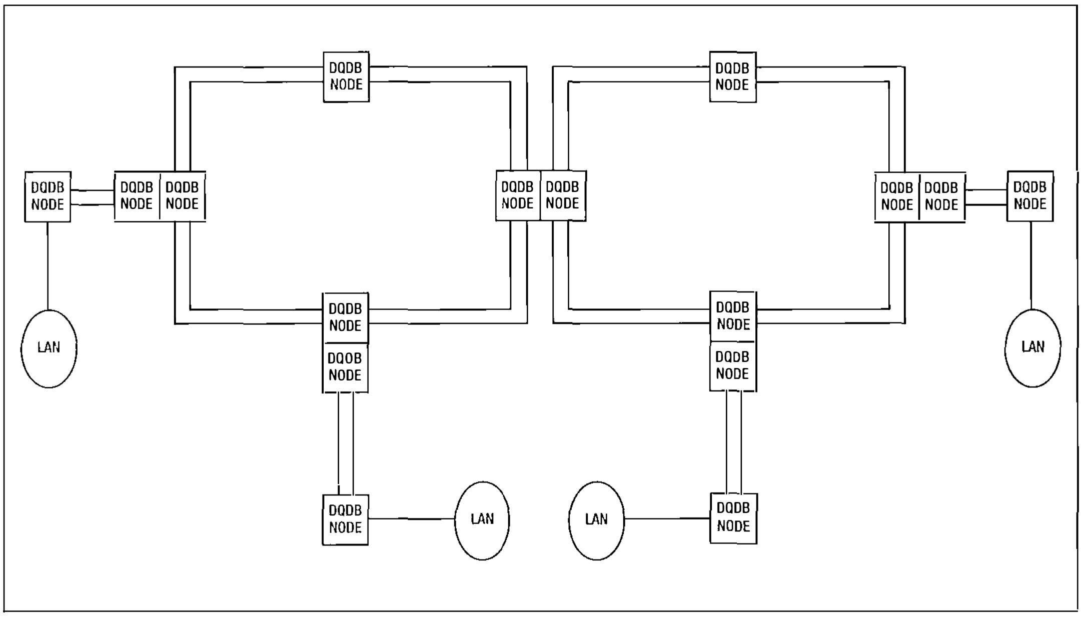


LAN: Local area network MAN: Metropolitan area network

Figure 8—Point-to-point access using simple protocol

The possibility of offering the same service over a variety of evolving network platforms is important as it allows customers to invest in a long-lasting service and provides a degree of future proofing to minimise their risks.

Figure 9
Use of DQDB subnetworks to build a public data network



DQDB Distributed queue dual bus LAN: Local area network

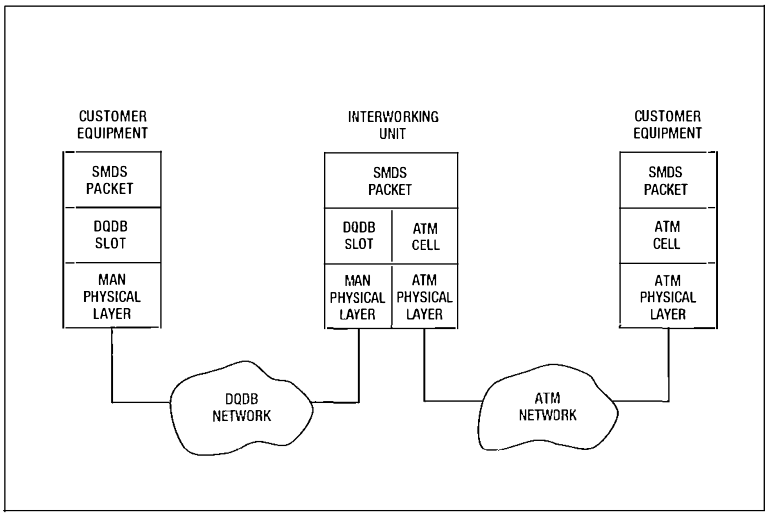
INTERNATIONAL PERSPECTIVE

Standards

The SMDS service was originally specified in a series of technical advisory documents produced by Bell Communications Research in the USA. The European Telecommunications Standards Institute (ETSI) is now in the process of producing a series of general standards covering a european version of SMDS. The standards are currently of a general nature and of insufficient detail to enable equipment to be built with confidence of interworking.

So that more detailed specifications can be produced, an industry group has been formed—the *European SMDS Interest Group* (ESIG). The group's aims are, inter alia, to produce early SMDS-compliant specifications (by filling in the gaps in the ETSI standards) and to promote the SMDS service in Europe.

Figure 10
SMDS over DQDB and ATM networks



ATM: Asynchronous transfer mode
DQDB: Distributed queue dual bus
MAN: Metropolitan area network
SMDS: Switched multi-megabit data service

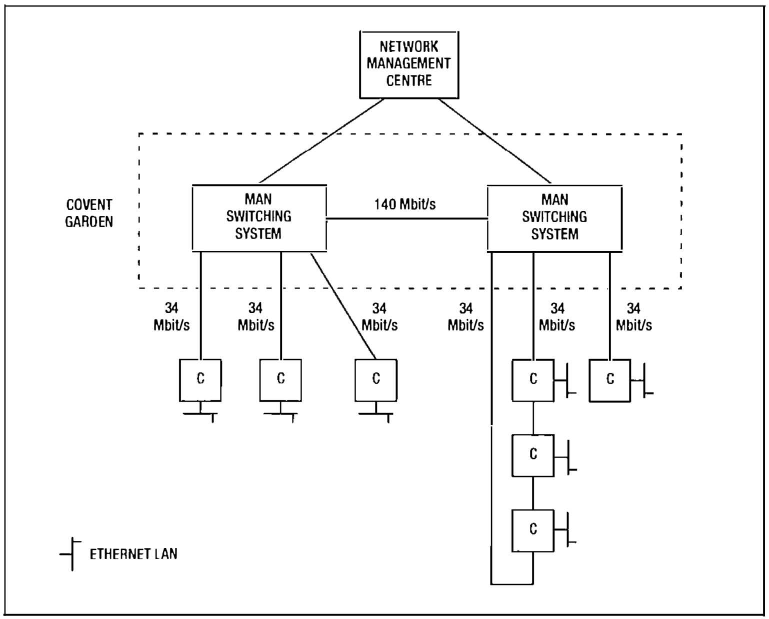
The group is attended by network providers, equipment suppliers, consultants and users, and is open to anyone who wishes to join. The ESIG has been established in Europe in order to compliment the work of the SMDS Interest Group in the USA. This group has been established for 18 months and provides a central point for SMDS technical development and promotional activities within the USA.

SMDS Trials

Many trials of the SMDS are currently being undertaken or planned worldwide. In the USA, most of the Regional Bell Operating Companies (RBOCs) are operating SMDS trials with one or two already nearing the tariffed-service phase. Other trialists include: Australia, Germany, Sweden, Denmark, Italy, Spain, and Switzerland.

BT SPECIFIC ACTIVITIES

BT is currently conducting a trial of a pre-SMDS service (not all the service features are present) with University College, London (UCL). The UCL trial network (run by the Bloomsbury Computing Consortium) is shown in Figure 11. Seven sites, each with several EthernetLANs connected to a router, will be interconnected at access speeds of 34 Mbit/s via an MSS. The speed of operation of the main network is 140 Mbit/s. The network equipment has been installed at London's Covent Garden exchange. During the trial period, which will last until mid-1993, BT will work with UCL to assess equipment performance and gain service-development information derived from the customer feedback on the range of desirable service features which are required to enhance the early equipment. UCL was asked to join BT in this trial because it:



C: Customer gateway MAN: Metropolitan area network

Figure 11
BT trial network configuration

- had a large existing private network with many users,
- had experienced staff,
- runs a variety of networking and application-layer software on the network, and
- has some specific new high-speed applications.

Building on the trial experience, but subject to business-case authorisation, the plan is to offer a pilot service to a selected group of major customers, chosen for their fit with a limited geographical roll-out. UK roll-out will then follow the pilot service and will be driven by customer demand.

Results from the trial and an update on the future development of the service will be given in future articles in the *Journal*.

Biographies

Graham Williams joined the London Telephone Region as an apprentice in 1970. He moved to headquarters in 1982 where he worked in a variety of areas including numbering and addressing strategy and interconnect negotiations with other network providers. From 1987 until 1991, he worked in the area of high-speed networking standards where he was involved in B-ISDN and SMDS standards specification. During this period, he became responsible for LAN and MAN standards and was chairman of the ETSI group responsible for producing European MAN standards. He is a founder member of the ESIG and is now working in Advanced Business Services, BT Products and Services Management, as product development manager for switched high-speed data services.

John Wilson joined Glasgow Telephone Area in 1969. He has extensive experience in the specification and development of telephony networks and facilities having worked on various assignments including intelligent networks, ISDN, CCITT No. 7 signalling system and switching standards. He moved into the Marketing Strategy Unit in 1989 and led studies into the development of broadband services with specific focus in the area of high-speed data communications for business users. He is currently product manager for switched high-speed data services. He is a Chartered Engineer and member of the Institution of Electrical Engineers. He holds a CEI Pt. II in Electronic Engineering and a first class BA(hons) in Technology from the Open University.

Glossary

ANSI	American National Standards Institute
ATM	Asynchronous transfer mode
B-ISDN	Broadband integrated services digital network
CPE	Customer premises equipment
DQDB	Distributed queue dual bus
ESIG	European SMDS Interest Group
ETSI	European Telecommunications Standards Institute
FDDI	Fibre distributed data interface
IEEE	Institute of Electrical and Electronic Engineers
GUI	Graphical user interface
LAN	Local area network
MAN	Metropolitan area network
MSS	Metropolitan area network (MAN) switching system
PC	Personal computer
SMDS	Switched multi-megabit data service
UCL	University College, London
WAN	Wide area network

Safety in BT is no Accident

KEN CLARK†

This article considers safety in the newly reorganised BT, in particular the safety targets, and how these are to be achieved. It outlines the increasing UK legislation arising from Europe, and considers the likely impact of this legislation on the people of BT. The organisation and arrangements for safety within BT are explained, as are the key roles and responsibilities of every individual.

INTRODUCTION

'Our ultimate objective is to be an accident-free company.' These are the words of the Deputy Chairman, Mike Bett, in his statement included on every safety policy notice, and in every copy of the safety policy and guide booklet. These are important words, worth remembering, and must be taken seriously. Note that the words do not refer to BT's objective, but to *our* objective. This distinction emphasises that it will be through the people of BT, at all levels, working together that this objective will be achieved. Every individual has an important part to play. This article explains the organisation and arrangements within the company, and the legislative framework within which all employees must work to achieve the ultimate objective.

LEGISLATION

No matter what safety initiatives a company is considering, the basic requirement is to comply with the law. Where health and safety at work are concerned, the law can generally be viewed as setting the minimum requirements. Later on in this article the additional legislation stemming from Europe is explained. However, the prime piece of health-and-safety legislation in the UK remains the Health and Safety at Work etc Act 1974.

Health and Safety at Work Act

This is an enabling act in that it grants powers to introduce subsequent legislation as required. Most of the health-and-safety legislation stemming from Europe is being introduced as regulations under this act. The act outlines the general duties of employers and individuals. It also covers self-employed people and those who may be affected by people at work. In general, an employer is required to ensure, so far as is reasonably practicable, the health, safety and welfare at work of all the employees. The term 'so far as is reasonably practicable' indicates that a judgement has to be made concerning a cost/risk balance. Consideration has to be given as to the obviousness of the hazard, the likelihood of injury and the seriousness of injury. This judgement must be made no matter what activity is involved. In some cases, such as working aloft or with asbestos, the precautions will be elaborate, because of the need to commit additional expense in order to offset the increased risk. Costs do not simply involve the provision of safety equipment, but also need to cover the additional time required to operate to a safe working practice; for example, testing a pole and lashing a ladder before climbing, or operating a permit to work before working on power equipment (Figures 1 and 2). Employees for their part are required to ensure that they comply with the company's safety rules and do not misuse anything provided in the interests of health and safety.

Both companies and employees can be prosecuted for breaches in the act, the highest penalties being unlimited fines and/or imprisonment for up to two years. Prosecution will usually be made only as a last resort, but can be expected if a serious accident has resulted from some failure to follow safe working procedures. There are two

Figure 1
Safety is an important part of overhead work

---

† BT Group Personnel Services

enforcement actions that can be imposed short of prosecution. The first is an *improvement notice*. This is served on a company when in the opinion of the Inspector there is a breach in the safety law, but no immediate risk to life or limb. The improvement notice allows time for the situation to be corrected. The second type of notice is a *prohibition notice*, which is served when the Inspector is of the opinion that a severe risk of personal injury exists. When this is served, the particular activity creating the risk must stop. Depending on the activity involved, commercially a prohibition notice can be more damaging than a prosecution and fine, because it could effectively stop a company's operations, thereby hitting sales, income and the market share. More and more frequently, large reputable companies are asking questions about enforcement notices when seeking tenders for work. If a company fails to comply with an improvement notice, then unless there is good reason, this can result in the serving of a prohibition notice. Being safe and complying with the law make not only good moral sense, but also very good commercial sense. Some examples of existing regulations made under this act are:

- Control of Substances Hazardous to Health Regulations,
- Electricity at Work Regulations,
- Noise at Work Regulations, and
- Safety Representatives and Safety Committees Regulations.

The European Scene

There can be few people who have not heard of '1992'; indeed, most people will probably know that it has something to do with the European Community (EC) and a 'single market'. Certainly it has much to do with harmonising standards across the member states. However, as far as safety is concerned, 1992 is merely a year of preparation; it is in 1993 that a host of legislation written as a result of EC requirements comes into effect.

The European Commission wants to ensure that all over the EC, whether it be in Birmingham or Bonn, Norwich or Naples, the same set of safety standards applies. So back in 1988 the commissioners proposed an overall general safety standard, the *framework directive*, to be supported by five further more specific 'daughter' directives.

The directives themselves do not actually have the force of law within the EC. What they do is require each member state to introduce domestic law which meets the requirements of the directive, and set a date by which this must be achieved.

The Framework Directive

The framework directive, which is similar to the UK's Health and Safety at Work etc Act 1974, applies to all sectors of work activity. In Britain, the proposed Health and Safety General Provisions Regulations will implement the provisions of this directive. These regulations will make the employers primarily responsible for the health and safety of their employees, much as the Health and Safety at Work etc Act already does, but they set out general principles as to how this should be achieved. These include:

- the assessment of risks and the introduction of appropriate preventative measures;
- the development of an overall accident prevention policy;
- training and information for employees;
- the provision of health and safety assistance; and
- consultation with employees' representatives.

Additionally, the framework directive requires employees to take care of their own safety and not endanger other people. They must also cooperate with their employer on health and safety matters.

The Health and Safety Executive (HSE) has also produced draft regulations to put into effect the requirements of the five 'daughter' directives.

Display Screen Equipment Regulations

The draft Health and Safety (Display Screen Equipment) Regulations are directed at the protection of employees (users) who habitually use

Figure 2
Permits to work and interlocks are an everyday part of power work

display screen equipment as a significant part of their normal work. Display screen equipment is not limited just to typical office visual display terminals, but also covers such items as microfiche readers. Portable display screen equipment, such as laptops, are excluded from these regulations unless they are in prolonged use at a workstation (Figure 3). The regulations also apply to homeworkers.

The employer must assess all workstations to evaluate health and safety conditions, taking appropriate measures to reduce any risks found. Such measures include the design of the workplace, the equipment used and work patterns.

These regulations will also entitle people to have eye or eyesight tests if they wish.

Personal Protective Equipment Regulations

The Personal Protective Equipment (PPE) at Work Regulations set standards for the use of all equipment that is worn or held to protect a person against hazards arising at work. However, PPE should only be used when the hazards cannot be avoided or cannot be sufficiently limited at source. An assessment should be carried out to ensure that the particular type of PPE supplied is suitable for the hazard being faced and should also take account of the demands of the job (Figure 4).

The regulations also set standards for maintenance and storage of the equipment and the provision of training, information and instruction.

Provision and Use of Work Equipment Regulations

Minimum health and safety standards for the use of work equipment such as machines and tools are covered by the draft Provision and Use of Work Equipment Regulations. The employer must ensure that this equipment is safely used and properly maintained.

Workplace Regulations

The draft Workplace (Health, Safety and Welfare) Regulations implement the provisions of the EC workplace directive and deal largely with matters which have long been requirements of British health-and-safety law. However, these new regulations have drawn together the assorted legislation on the subject into one central code.

Basically, the regulations set out minimum standards for workplaces and work activities in or near buildings, covering such aspects as their construction, the way people use them and the provision of basic welfare facilities. As such, these regulations will repeal many sections of the Factories Act and the Office, Shops and Railway Premises Act.

Manual Handling Operations Regulations

The draft Manual Handling Operations Regulations attempt to reduce personal injuries arising from this type of work. Manual handling means more than just lifting; it also includes pushing, pulling, carrying or moving. The main aim of the regulations is to avoid manual handling, but

Figure 3—Laptops are covered by the law if they are in prolonged use

Figure 4—Proper use of protective equipment keeps you safe and comfortable

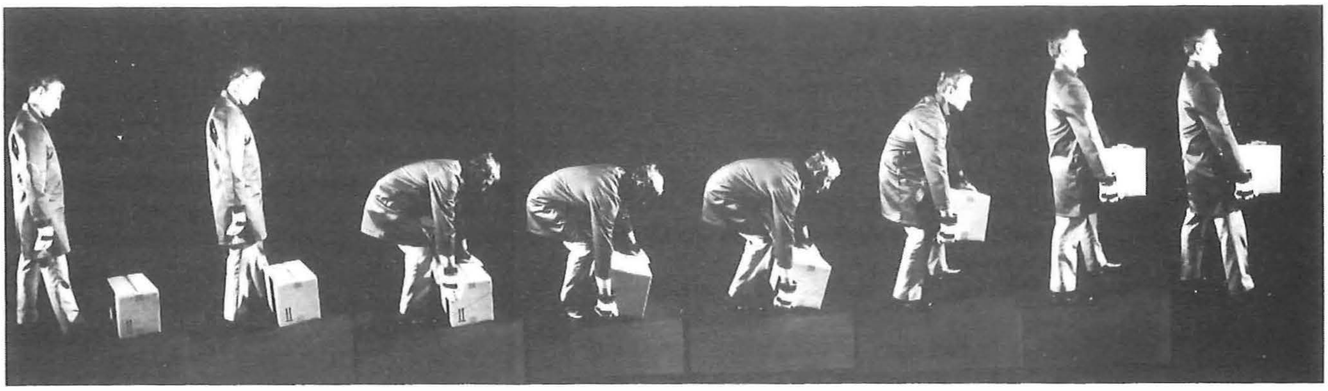


Figure 5
The correct lifting posture avoids injury

where this is not possible an assessment should be made and steps taken to reduce the risk of injury to the lowest reasonably practicable level. The assessment should take into account the task, the load, the working environment and the individual capacity (Figure 5).

Generally, these regulations should help in improving the management of health and safety, not only within BT but throughout the country. However, because the UK has a fairly well-established legislative framework in this area, for the most part these new regulations do not greatly change existing obligations. Nevertheless, the new regulations provide BT with an opportunity to reinforce its efforts to have a safety record of which it can be proud. This is an opportunity that should not be missed.

ORGANISATION AND ARRANGEMENTS

The reorganisation of BT through Project Sovereign gave an opportunity to review the safety organisation within the company to ensure that it best suited the company's needs. As a result of this review the company now has a safety policy unit (BT Safety Unit) and a safety delivery arm within Group Personnel. BT Safety Unit (Figure 6) is responsible for developing BT safety policy on behalf of the board, for providing professional support to other policy makers within the company and to the company's safety officers, to compile and publish company accident statistics, and to publish safety publicity material. The company's safety policy is promulgated through ISIS and safety manual documents. This safety policy applies both at home and overseas, and represents the minimum requirements, unless local country laws require more. The safety policy documents are supplemented by a series of engineering safety guides.

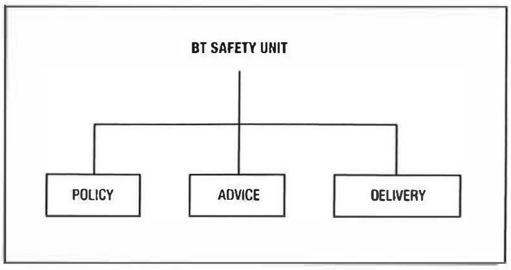


Figure 6—BT safety unit

Safety Teams

Group Personnel (GP) provides the direct interface with divisions through teams of safety professionals. Its role is to provide professional support and advice to line management. The GP geographical structure has the same boundaries as Personal Communications Division with the exception of the Home Counties Zone, which provides service to an area covered by both Northern and Southern Home Counties.

A safety manager leads a safety team in each zone consisting of a number of safety officers, approximately one for every 3500 employees located within the zone, and one person to provide clerical support for the team. The size of each safety team is based on a national paradigm developed by using the Midlands Zone as a template for a typical team. This allows team numbers to be matched to the size of the customer base, but allows special features, such as those existing in London, to be taken into account.

Unlike many other personnel services functions, the safety officers in each team are not centralised in one location. With safety officers stationed in different parts of the zone, the safety team is able to provide a presence which is close to their customers. The infrastructure of district safety officers provided a ready-made starting point for building zone safety organisations using existing strengths. Only minor changes to existing boundaries were necessary to provide an effective organisation from day one of zone working.

Although the basis of the new structure existed, the changes in organisation gave the safety services teams a unique opportunity. Modifying this structure was the ideal time to carry out a fundamental reappraisement of the quality of safety support to line management. The ability to focus much more closely onto their needs as customers could now be built into operating procedures. Previously, safety officers had reported to a wide range of management chains. This had made it difficult to coordinate and manage a consistent, planned approach to meeting customers' needs. Now, with only eight safety managers for the UK mainland, and with clear lines of responsibility and a common management hierarchy, safety teams are better able to provide a coordinated, high-quality service across the organisation.

With customer divisions often crossing zone boundaries, it is essential that a standard service, using the same procedures, is supplied by all safety teams. As a part of that drive towards a high-quality service, a Safety Quality Council has been established. Its task is to address a wide range of customer services issues and build a consistent approach to them. The best practices in the safety teams are being identified with the aim of applying them across all zones. The Quality Council is also building into these the performance measures to monitor the activities of safety teams in supporting line management.

Safety Teams in Operation

To build this new organisation in a quality way, it was essential to have a clear understanding of roles, responsibilities and objectives. This was achieved in two ways. The first step was to develop national job descriptions for both safety managers and safety officers. Secondly, these job descriptions led to the building of *service level agreements* (SLAs), agreed with the major customer divisions such as Worldwide Networks, Personal Communications and Business Communications. The SLAs set out agreed standards of service which were clear to both the safety teams and the customer divisions. The law quite specifically places the responsibility for the safety, health and welfare of all employees with all managers. The responsibility for the day-to-day safety at work of every BT employee is a function of line management, with the safety teams providing specialist advice and support. The fact that the safety teams carry no operational authority within the divisions is reflected in the SLAs. The main features of these cover the provision of professional advice with two levels of response. Under the SLAs, any issue which affects BT's ability to provide service to paying customers is responded to within 24 hours. Other safety queries will be responded to with 48 hours depending upon urgency.

Safety auditing is another key role of the safety team which is detailed in the SLAs. Here, the customer requirements and safety teams' capability must be agreed. The audits are to be to a standard procedure used by all safety teams. Under the SLA, a written report will be provided within 14 days of the audit. The audit function is intended to provide a professional view of safety standards and is carried out in a constructive and supportive manner. The results of the audits will help senior divisional managers to identify the successes they can build on as well as highlighting general areas which may require an improvement plan of action. The audit can help them develop the strategies to achieve, through planned stages, the BT goal of becoming an accident-free company.

To achieve these SLA requirements and provide a better service to the divisions, there have been some important changes in the way safety officers carry out their function. It was recognised in the early days of the new organisation that there was a need to provide a single point of contact to deal efficiently with customer enquiries and to facilitate the measurement of the team performance against the SLA targets. Help desks have been set up in each zone to log enquiries and ensure a response within the appropriate time-scale. Providing a single point of contact also eliminates the uncertainty on the part of the customer as to which safety officer to get in touch with or what to do in the event of the safety officer being unavailable. The help desk also allows the safety team to make the best use of its resources and improves customer service by making it easier to obtain prompt advice. In many cases, it has been found that the help desk is able to answer the enquiry directly and save the need to contact a safety officer. This is particularly the case where the manager who is making the enquiry is not aware that detailed written advice is already available. This arrangement also allows a more efficient use of safety officer time so that they can be more proactive in their support.

Focusing on customer needs has identified the need to appoint 'lead' safety officers to act as a customer contact for divisions whose boundaries incorporate several safety team zones. This is intended for strategic issues rather than day-to-day matters and allows the divisions to talk through issues with one safety manager who will act as a coordinator for all the safety teams in the zones affected. Once again, this change is one which will build a consistency into the standards of service and advice received across the company.

In any effort to improve the quality of service to customers, the measurement of what is being achieved is essential. With this in mind, key measurements have been introduced to monitor the performance of the safety teams against the three most important features of the SLAs. The service to each division is monitored and the results provided to senior management on a monthly basis. The current measures are the percentage of enquiries responded to within 24 hours where service to BT's paying customers is impaired, the percentage of non-service affecting matters responded to within 48 hours, and the percentage of audit reports provided within two weeks of the closure of the audit. With these measures in place, safety managers are able to review performance standards constantly to formulate a plan of action towards continuous improvement in the quality of the safety service provided by their team.

As with every major change in organisation and approach, it has taken a little time to bed in the new procedures, but the 'new look' zonal safety service is now set to build on its potential. Its aims are clear: to provide a first-class professional safety service to support line managers in their drive to achieve the company's safety strategy.

Because of the special nature of the work at BT Laboratories, Martlesham Heath, a safety officer is dedicated to this site. Similarly, Motor Transport has its own safety officer. Another exception to the safety team approach is that for Worldwide Networks where work on radio masts and towers is concerned (Figure 7). This work is considered to fall within the scope of the Construction Regulations, and as such there is a specific requirement to appoint a *safety supervisor* to oversee the safety of the operations. These safety supervisors have some executive authority, and therefore they need to be closely associated with line management. They are primarily concerned with lifting operations at radio stations, and tower access and egress, including the standards of ladders, platforms, handrails and toeboards. They are also concerned with the protection of BT people and members of the public from radio-frequency radiation.

Corporate Safety Auditors

In addition, the company has two full time safety auditors, whose job is to audit the management of safety within the company, including the subsidiaries. The auditors work to a three-year rolling programme and assess the management of safety against a number of expectations including:

- *Management*: that managers at all levels understand their safety responsibilities and demonstrate their understanding with a committed approach to safety with respect to their staff and themselves.
- *Manager practice*: that the level of awareness and safety application of managers in fulfilling their day-to- day activities is, without exception, both appreciated and acted upon to meet their safety responsibilities.
- *Safe systems of work*: that the unit follows safe systems at work at all times and that such systems are adequately documented and staff are trained to an acceptable standard.
- *Communication and information*: that the safety communications and information systems in operation are of sufficient quality and relevance to stimulate and persuade the recipients.
- *Accident reporting and recording*: that the system for the reporting and investigation of accidents both complies with legal and BT policy requirements and fulfils the primary aim of such procedures to provide information to initiate action sufficient to ensure prevention of future occurrences. Also, that the requirements of the Reporting of Injuries, Diseases and Dangerous Occurrences Regulations are satisfied.
- *Training*: that all staff are trained to a standard that will provide a satisfactory level of safety knowledge and to ensure a consistent and adequate safety performance.
- *Contract supervision*: that an adequate system of control exists to ensure that contractors are made aware of the safety requirements of the work they must undertake both in terms of the safety of their own staff and the possible effects of their work on others.
- *Fire responsibilities*: that an effective fire-management system exists and is properly measured and monitored. Also, that staff are fully conversant with fire routines and procedures.
- *Safety Committees*: that the safety committee structure ensures operational management commitment and concentration on accident prevention.

Figure 7
The construction regulations are applied to work on radio masts and towers

The auditors provide a report to the division or unit being audited, which includes their findings and recommendations. Follow up audits are conducted to ensure that any necessary action has been taken.

The audit programme and progress is agreed and monitored by a Safety Audit Review Board chaired by the Director, Employee Relations and attended by representatives from the company's main divisions.

Safety Committees

Although BT successfully operated safety committees before the Safety Representatives and Safety Committees Regulations came into force, these regulations make the holding of safety committees a legal requirement, when a request to set them up is made in writing by two nominated safety representatives. The safety committees provide a forum at which management and the unions can get together to agree campaigns for accident reduction etc. Because BT is now organised such that different divisions operate across the same geographical area, BT safety committees are organised on a zone basis rather than a divisional one. There are nine main zonal safety committees, each committee covering a Personal Communications Division zone but with representatives from all the divisions. The exceptions to this arrangement, because of the special nature of the work is that there are safety committees for BT Laboratories at Martlesham Heath, for Motor Transport, Operator Services and BT Training.

Safety committees should be looking strategically at accident reduction rather than concentrating on individual cases.

In spite of their name, safety committees should be reviewing the arrangements for safety and health directly related to work operations, accident prevention and safety procedures relative to each of the businesses in the zone. First aid arrangements can also be proper matters for discussion. The safety committee should also be used as the forum to consider action proposed as a result of any local safety audit.

In addition to the zonal and divisional safety committees, the company operates a national safety committee known as the *BT Safety Committee*. This provides a forum at which management and the unions can consider company-wide safety initiatives and issues. It is chaired by the Director, Employee Relations, and is represented at senior level by the main divisions and by national officers of the unions.

Union Safety Representatives

In addition to BT's professional safety organisation, *union safety representatives* also have a role to play in improving workplace safety. Under Section 2 (4) of the Health and Safety at Work Act, regulations were made, effective from October 1978, to provide for recognised trade unions to appoint safety representatives from among the employees. The regulations are supported by an Approved Code of Practice, which lays down general principles under which the regulations may be complied with. Union safety representatives have a unique position as their role and function is clearly defined in law. They are also protected by law against being held legally responsible for carrying out their duties as safety representatives. This legal protection reinforces the line management responsibility for safety. Qualifications for safety representatives are that appointed persons shall have worked for their present employer for the preceding two years or have had at least two years' experience in similar employment. This is to ensure that those appointed have the kind of experience and knowledge of their particular type of employment necessary to enable them to make a responsible and practical contribution to health and safety in their employment.

Union safety representatives carry out the following functions:

- Investigate potential hazards and dangerous occurrences at the workplace and examine the causes of accidents at the workplace.
- Investigate employees' complaints relating to health, safety or welfare at work.
- Make representation to the employer on matters relating to health, safety and welfare.
- Carry out regular safety inspections of the workplace.
- Represent the employees in consultation with the Health and Safety Executive and other enforcing body inspectors and receive information from such inspectors.
- Attend safety committee meetings.

Union safety representatives are trained through a joint BT/BTUC three-day course, which is held at a BT Technical Training College. The course content covers principles of safety legislation, accident causation and prevention, accident investigation and workplace inspection.

RESPONSIBILITIES AND DUTIES

The vast majority of BT employees can rest assured that they are not breaking any safety law, and will therefore not be faced with the trauma of prosecution as long as they follow BT's safety rules. However, anyone not following the rules, is technically breaking the law and could be prosecuted. Even if a prosecution does not result, an accident most likely will. If an unsafe act is repeated often enough, it will be guaranteed to result in an accident. It may not happen today, it may not happen tomorrow, or even this year, but it will happen. It is wishful thinking to imagine that, just because an accident has not happened yet, it never will.

Managers carry additional safety responsibilities, because not only are they responsible for their own acts or omissions, but could be held responsible for the acts of the people they supervise. If a manager fails to ensure that the people supervised are following the safety rules, and an unsafe act results in an accident, then that manager is at a very great risk of prosecution. This applies to the office as well as to the engineering environment. The company is also exposed to prosecution.

In order to equip BT's managers to discharge their safety responsibilities, a Safety Training for Managers course has been developed. This course outlines the legal responsibilities and the organisation and arrangements for safety in BT. In addition to this, a *safety management system* is being developed in order to assist managers in identifying the duties they need to perform to discharge their responsibilities. The safety management system forms an integral part of the local quality management system.

In the performance of any work activity there will be phases in which safety hazards exist, and as a result the adoption of safe working practices is necessary to eliminate, reduce or avoid these hazards. Most activities can be accomplished without undue risks, and as such any audit of them can be carried out as a direct function of the local quality management system. However, some activities have such potential for injury and/or legal implications as to necessitate the adoption of a far more thorough audit of the safety aspects than would otherwise be the case. The safety management system designates those activities and details the administration system to be adopted. The line management responsibility for safety is reflected in the involvement of managers at various levels in formalised checking and monitoring duties.

Activities designated for the safety management system include:

- gas testing in external structures,
- work on poles,
- pole erection,
- routine pole examination,
- handling and lifting,
- road works guarding,
- supervision of contractors,
- radio station permit-to-work procedures,
- working on radio towers,
- roof work,
- work with optical-fibre systems (Figure 8),
- motor transport workshop practices, and
- asbestos removal.

SAFETY SPECIFICATIONS

The Health and Safety at Work Act is written in such a manner that, although contractors may be employed to do work on BT's behalf, BT still retains responsibilities for health and safety under the act. Once again this responsibility primarily rests with line management. In order to assist managers who are charged with the responsibility to write, place and administer contracts, a series of safety specifications is to be made available. Safety specifications have been produced for contract works dealing with subjects and activities that require monitoring and procedural control, so that safety management is applied during work. Safety specification will be introduced into BT tenders and contracts by Generic Technical Standard GS11 which identifies the key safety management standards required of suppliers. The prime safety specification will be SFY10000 - Contractor Safety, which must be used when selecting and monitoring contractors' safety performance. Other safety specifications appropriate to the contract work activity can be selected and quoted with the invitation to tender and the contract documentation.

Contracts should only be let to suppliers who are assessed by BT as being competent and suitable for the work and who agree in writing to comply with the safety specifications.

While the subjects in the safety specification series are wide and cover a range of activities likely to be encountered within the company, they cannot be regarded as exhaustive. New subjects and amendment of existing safety specifications will be a continuing responsibility of BT Safety Unit, but contract managers and managers in the field will need to ensure that the content of any safety specification quoted in an invitation to tender or contract is suitable and adequate for the work to be put in hand.

Figure 8
Working with optical-fibre systems is one of many activities covered by the safety management system

Procurement duties will be responsible for ensuring the relevant safety specifications are included with the documentation to the tenderer/contractor.

At contract completion, the contractor's safety performance must be reviewed and consideration given to the contractor's suitability to be invited to perform future contract work. It is important that good as well as poor safety performances are recorded.

SAFETY STRATEGY

So far, this article has outlined the broad legal framework within which BT must operate, and has detailed the organisation and arrangements. However, to achieve the safety goal of being an accident-free company requires a strategy embracing these aspects and with a focus on accident reduction. This ultimate objective can only be achieved in stages. Recognising this, the company has set a medium-term objective of reducing the lost-time accident incidence rate (lost-time accidents per 1000 employees) by 50% by the end of 1995. This is a stretching target but is nonetheless achievable.

The safety strategy also includes safety awareness plans with safety talks and videos in team briefings, and the proper distribution of safety instructions through the company's instruction system (ISIS).

CONCLUSION

To be an accident-free company is an objective worthy of achieving for both moral and commercial reasons. BT has in place a strong safety organisation and a committed management team working within a framework which should ensure that the objective is achieved.

ACKNOWLEDGEMENTS

The author would like to acknowledge the assistance of the following people in the drafting of this article: Sean Conry and Eric King, BT Safety Unit; David Smith, Safety Manager, Home Counties; and Graham Nurse, Safety Officer, Home Counties.

Biography

Ken Clark is BT's Chief Safety Officer and leads the BT Safety Unit, which is in Group Personnel. Ken is a Chartered Engineer, being a member of the Institution of Electrical Engineers and a member of the Institution of Occupational Safety and Health. He joined the Post Office as a Youth-in-Training in the London Test Section, Inspection Branch and specialised in transmission through acceptance testing work at contractors' works. Safety became a significant part of his work when he moved into the Network Planning Department's Microwave Radio Works Section in 1973 where he organised the installation of microwave towers and aerial systems, and the aerial systems for early radiophone and radiopaging systems. He eventually became the Radio Engineering Safety Officer in that section, before taking his current post in 1986.

Digital Circuit Multiplication Equipment and Systems—An Overview

EDWARD A. KESSLER†

This article discusses the contribution made by the introduction of digital circuit multiplication to the conversion of the international network from analogue to digital transmission, and gives some insight into the important systems features, the interactions with the network, and the signals carried by the network.

INTRODUCTION AND HISTORICAL PERSPECTIVE

In 1986, when digital circuit multiplication equipment (DCME) was last discussed in an article in the *Journal*[1], the subject was the first systems to go into service on the first digital optical-fibre transatlantic cable, TAT-8. With the exception of a few satellite routes, which had been converted to digital operation by using the INTELSAT* and EUTELSAT‡ time-division multiple-access/digital speech interpolation (TDMA/DSI) systems less than 5 years earlier, the international network was predominantly analogue.

It seemed likely that optical-fibre submarine cables would provide the answer to provision of digital capacity for the large routes which carry the majority of international telephone calls. This is because if the basic cost of providing and maintaining a new submarine cable can be justified, provision of extra fibre pairs is almost a marginal cost. Nevertheless, as the provision of DCMEs for TAT-8 illustrated, capacity could be enhanced even further, at relatively smaller cost. However, in 1986, most countries depended upon analogue satellite links for most of their international telephone traffic, and many such routes were too small in themselves to justify submarine-cable access within a reasonable period of time.

It seemed that international calls to most countries would have to use analogue transmission plant for at least as long as it would take for the cost of digital optical-fibre submarine cables to fall to the level where they could compete on a per-channel cost basis with analogue transmission on small routes. This would have provided customers with ample opportunity to compare the noise, distortion and other shortcomings of analogue international connections with the clear, virtually noise- and distortion-free performance of calls via BT's digital national trunk network.

The decision to use DCMEs on TAT-8 pointed the way to the means of improving transmission quality for most intercontinental calls, while minimising the cost of the extra bandwidth needed for digital transmission. Realising that there was potential for a much less expensive means of digital transmission than TDMA/DSI, INTELSAT took the bold step of introducing a new range of standard digital carriers known as *intermediate data rate* (IDR) services, for satellite transmissions.

The consequence of this enlightened policy was the very rapid migration of services from the analogue to the digital domain, not just for large routes, but also for many smaller routes. Far from being a curiosity used only on a few new cable systems, the DCME has become a commodity item for the international network planner within less than 5 years. The service and quality implications of this are discussed in a later article; this article describes the systems concepts of the DCMEs currently in use, and their general impact on the network.

ARCHITECTURE OF A DCME

The purpose of a DCME is to take a large number of digital channels, examine the signals carried on those channels, and recode them as efficiently as possible, consistent with minimal added degradation. This enables a much smaller number of transmission channels to be used. For example, a silent channel can be recoded very accurately with very few bits indeed. Conversely, a signal with a high information content, such as a high-bit-rate voice-band data signal, needs either to have certain known characteristics which can be extracted and transmitted explicitly, or else must have more bits allocated to it to ensure satisfactory performance.

In practice, the removal of silent intervals is carried out by the process known as *digital speech interpolation* (DSI), whereas the recoding of signals according to their information content is carried out by using adaptive-differential pulse-code modulation (ADPCM). These pro-

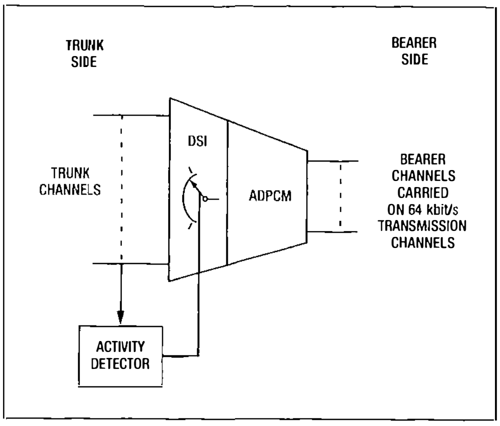
---

† BT Worldwide Networks

* INTELSAT: International Telecommunications Satellite Organisation

‡ EUTELSAT: European Telecommunications Satellite Organisation

Figure 1
DCME conceptual diagram

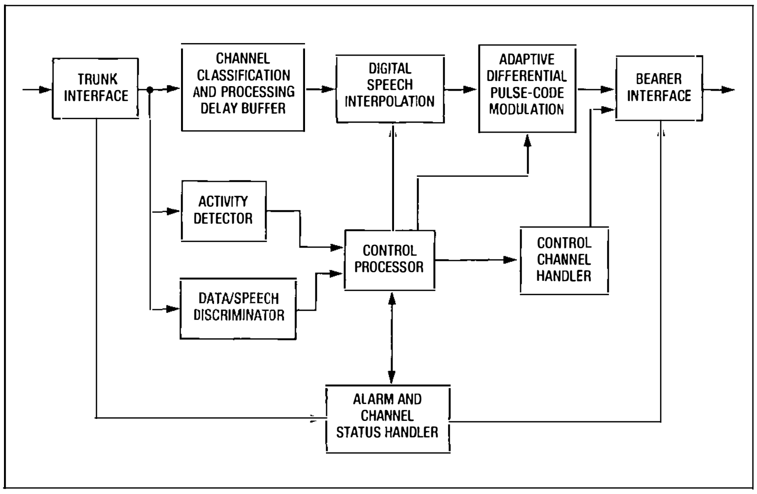


ADPCM: Adaptive differential pulse-code modulation
DSI: Digital speech interpolation

cesses are shown in conceptual form in Figure 1. The channels which the network presents to the DCME for processing are known as *trunk channels* (TCs), whereas those which link the DCME transmit side to a distant DCME's receive side are known as *transmission channels*. The actual order of the DSI and ADPCM processing is dependent on the particular manufacturer's implementation.

A block diagram of the transmit side of a typical DCME terminal is shown in Figure 2. It contains the following blocks:

Figure 2
DCME transmit side



Trunk Interface

The trunk interface converts between pulse-code modulation (PCM) line code and the internal logic levels of the system. It may interface up to ten 30-channel systems and, depending on the manufacturer's implementation, may provide the means to re-order or extract from each system a certain number of channels for transmission. It also extracts alarm and status information.

Activity Detector

An activity detector is used to make a decision as to whether the channel is ACTIVE or SILENT. In principle, the decision could be based on power level alone, since only very rarely does speech on the network fall below –30 dBm0, but simple threshold detectors may misoperate in an obtrusive manner in the presence of noise, echo, or music-on-hold.

Data/Speech Discriminator

In addition to determining whether a channel is active, a classification must also be done on the basis of the type of activity—speech, voice-band data, or signalling—so that the appropriate bit rate reduction technique can be used. The data/speech discriminator does this by examination of the energy level, envelope peak-to-mean ratio and signal spectrum. It may look for specific tones associated with signalling systems, and the calling tone (1100 Hz) and echo-control disabling tone (2100 Hz) used by most modems. By matching characteristic frequencies and spectral distributions, it may also be possible to differentiate between high-speed and low-speed modems.

Channel Classification and Processing Delay Buffer

The main signal path contains a buffer of approximately 25 ms duration, in order to allow sufficient time for reliable classification. Some time is also required for processing the channel-state information in the central processor, queuing for a free channel, and formatting the output channel and control information.

Control Processor

The control processor:

- stores the maps which indicate which TCs are connected to which bearer channels in the system at a given time (the bearer channels are the reduced-bit-rate channels which carry the traffic between the DCME terminals);
- receives channel state information and allocates an appropriate 'hangover time'—dependent on the signal classification—to bridge short breaks in activity;
- initialises the ADPCM encoders if required;
- requests appropriate paths to be set up in the DSI block, according to the type of channel;
- generates a control message to update the DSI connection map kept in the receive side of the distant terminal; and
- reacts to and generates alarm, status and statistical information.

Digital Speech Interpolation

The object of the DSI process is to connect to bearer channels only those TCs which are active (that is, which have a valid signal on them at a given instant). Speech is a valid signal, which occurs in bursts lasting approximately 0·6 s, separated by intersyllabic pauses of comparable length, and much longer pauses when the other party is being listened to. Voice-band data is also a valid signal, and may occur in bursts of almost any length. On average, a channel is active only about 40% of the time. This means that for typical route sizes, a given number of TCs require about half as many transmission channels. In such a case, the DSI process is said to give a gain of two.

In the DCME terminal receive side, bearer channels are connected to TCs in a complementary fashion to that in the distant DCME terminal's transmit side. When a TC is not connected to a bearer channel, it is connected instead to a noise generator, so that the customer is not misled into thinking that the connection has been lost.

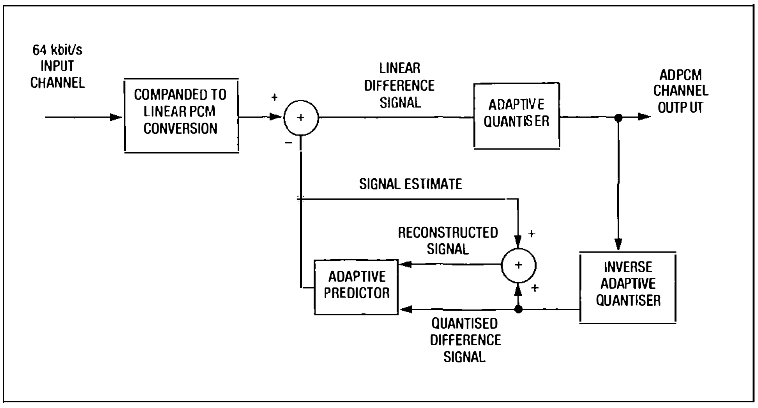
ADPCM

ADPCM relies upon the fact that for speech there is a high degree of correlation between successive samples; though the speech spectrum extends to 3·4 kHz, it changes relatively slowly, corresponding to an information rate of only a few hundreds of bits per second. ADPCM operates on a linear PCM signal, and therefore the first processing stage is the conversion from A- or μ-law logarithmic companding (see Figure 3). This is followed by a stage in which an estimated value based on several previous signal samples is subtracted from the current value. The difference signal is then processed by an adaptive quantiser.

The purpose of the adaptive quantiser is to improve the signal-to-quantisation-noise ratio for the reduced number of bits available for transmission. In order for the difference signal to cover the maximum possible dynamic range with as few bits as possible, the 'quantised' value transmitted to the distant decoder is made adaptive. This is a form of companding, akin to the A-law companding used for PCM (which reduces a 14 bit linear representation to an 8 bit logarithmically-quantised representation). The adaptation is done on the basis of both the magnitude of preceding values of the difference signal and its rate of change. This signal forms the basis of the signal transmitted to the decoder to enable it to update its adaptive filter coefficients.

Within the encoder, the re-linearised adaptively quantised difference signal is then added to the signal estimate, to produce a reconstruction of the original signal. Both are then used as the inputs to an adaptive predictor, which uses an adaptive filter to model the spectrum of the speech signal.

The operation of the decoder is complementary to the operation of the encoder, and contains similar or equivalent functional blocks, but in a slightly different configuration, as can be seen from Figure 4. The additional block, called *synchronous coding adjustment*, is intended to improve the performance for those circumstances where multiple transcodings occur between ADPCM and PCM transmission in digital networks.



ADPCM: Adaptive differential pulse-code modulation
PCM: Pulse-code modulatiom

Figure 3
ADPCM encoder

Speech can be encoded with ADPCM by using only 4 bits, as compared to the 8 bits required using companded PCM, for similar quality. The penalty is that by using only 4 bits, ADPCM does not provide adequate quality for voice-band data signals[2] at greater than 4·8 kbit/s, particularly if the signal has already suffered analogue network impairments such as noise and distortion[3].

In Recommendations G.726[4] and G.727[5], the CCITT has specified ADPCM algorithms appropriate for use in DCME and packetised systems respectively.

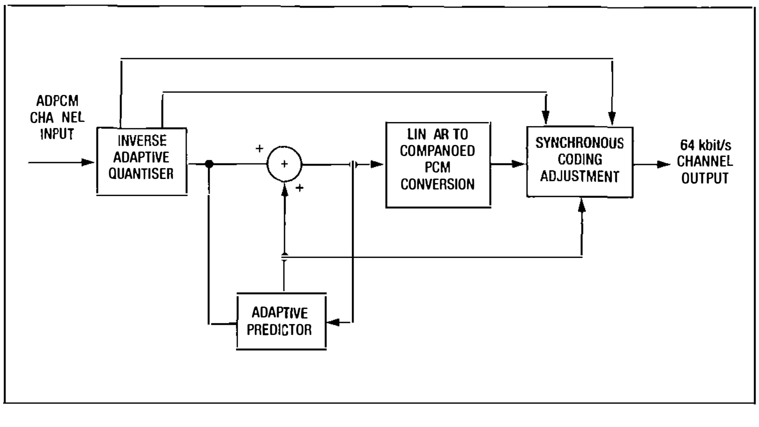
Alarm and Channel Status Handler

The alarm and channel status handler recognises alarms and other conditions occurring on the trunk interfaces, and ensures that any necessary conditions are applied at the bearer interface and the return direction of the trunk interface.

Control Channel Handler

The control channel handler takes the messages passed to it by the central control processor,

Figure 4
ADPCM decoder



ADPCM: Adaptive differential pulse-code modulation
PCM: Pulse-code modulation

assesses their order of priority, orders them and applies forward-error-correction (FEC) coding for their transmission to the distant terminal.

Bearer Interface

The bearer interface assembles the transmission channels, control channel and synchronisation information into the format required for transmission using the appropriate line code, to the distant terminal.

IMPROVING PERFORMANCE FOR VOICE-BAND DATA

There are four possible solutions to ADPCM's limited voice-band data capability. They are:

- Improve the quality of the adaptive filter model, and the dynamics of the coefficient adjustment and quantisation. This requires use of a more complex filter, and some interesting control theory problems have to be solved to maintain stability under all conditions. Nevertheless, one manufacturer has solved the problems sufficiently well to demonstrate adequate performance at 9·6 kbit/s voice-band data rate[6] for at least a single ADPCM link.
- Recode voice-band data at 5 bits/sample instead of 4 bits/sample. This is a simple and effective solution, offering good performance to voice-band data at up to at least 14·4 kbit/s (the remainder of the connection permitting), even when a call passes through more than one ADPCM link. The disadvantage is the extra bearer capacity required if the percentage of voice-band data is high on a particular route. Three manufacturers have chosen to use this method, and it is the method specified in CCITT Recommendation G.763[4, 7].
- Recode voice-band data at 5 bits/sample, but change the sampling rate from 8 kHz to 6·4 kHz, giving a 3·1 kHz channel bandwidth. In effect, bandwidth is being traded for resolution. This exploits the fact that to avoid the more extreme variations in amplitude and group delay response which analogue channelisation filters sometimes introduce, most modems do not use the full channel bandwidth. This method offers good performance up to at least 9·6 kbit/s, but the bandwidth restriction means that 19·2 kbit/s is the maximum rate that is likely to be passed. One manufacturer has used this method.
- Demodulation to baseband, and transmission as a digital bit stream. This method appears to offer the best of both worlds, in that it combines the best performance and the greatest transmission capacity saving. Unfortunately it is also the most complex, and has as yet only been used for the most widespread application of voice-band data in the network, namely facsimile. Five manufacturers either offer, or propose to offer this option[9]. It will be discussed in more depth in a later issue of this *Journal*.

Voice-band data is relatively easy to corrupt; the aim in implementing DCME has therefore been to give it greater protection than speech. A good example of the way that this has been done is the technique known as *silence elimination*, which works as follows:

By far the majority of voice-band data calls use half-duplex transmission, in which only one direction of transmission is active at any particular time. The direction of transmission normally changes at the end of each burst of activity, so that modem B is only likely to transmit when modem A has been silent for at least some tens of milliseconds.

When the call is set up, each DCME terminal will initially classify the activity as voice-band data, probably on the basis of the tonal exchange, and will allocate capacity accordingly. Let us assume that only the B-to-A direction remains active. As soon as activity ceases in the A-to-B direction, a 'data hangover' timer is started, during which time any new activity in that direction will automatically be initially classified as 'data'. If no new activity is detected in that direction before the data hangover expires, the bearer channel in that direction may be released, but the 'data' classification for the TC will be maintained. When activity then ceases in the B-to-A direction, the A-end DCME will immediately classify the TC as data, in anticipation of the A-to-B direction next becoming active. This means that the new activity in the A-to-B direction will have a higher priority for connection than new speech activity. This reduces the possibility of corruption of the modem training sequence, due either to freeze-out, or to the initial allocation of a channel which might be operating with less than 4 bits per sample.

HANDLING OF 64 kbit/s ISDN CALLS

In order to handle 64 kbit/s calls on demand, a means must be provided to distinguish such a call from a normal analogue telephone originated call. The ISC must examine the common-channel signalling information which it receives through the national network, in order to ascertain whether a call requires 64 kbit/s clear channel capacity. If it does, the ISC uses signalling in time-slot 16, as described in CCITT Recommendation Q.50[10] to instruct the DCME to allocate a 64 kbit/s channel without either DSI or ADPCM.

DCME OVERLOAD

One feature that on-demand 64 kbit/s calls and voice-band data have in common is that they reduce the gain of the DCME as compared to speech. For on-demand 64 kbit/s calls, the gain is 1, and for voice-band data, even with silence elimination, it rarely exceeds 3, whereas for speech it is about 4 for typical route sizes. Hence, if there is a large percentage of data traffic of either sort, more transmission channels will be required than if the traffic is mainly speech. The variability of the bearer side loading is also likely to be much greater.

The DSI process is a statistical multiplexing process, which depends upon the number of simultaneously active TCs being less than the number of available bearer channels, if there is to be no loss of channel content. In some circumstances the number of active TCs will exceed the available bearer channels. This will result in new activity suffering from initial clipping, unless steps are taken to prevent it. There are two ways of dealing with the problem, which are:

- To reduce briefly the number of bits per sample allocated to individual speech channels—this is inaudible provided that it does not last too long and is not done too often. The number of bits per sample allocated to voice-band data channels is not changed, as that might seriously corrupt modem communications at the higher bit rates.
- To signal to the international switching centre (ISC) to prevent the setting up of additional calls via the DCME suffering the overload. This is referred to as *dynamic load control* (DLC), and is usually carried out by exchange of messages in time-slot 16 of a 2 Mbit/s system, as specified in CCITT Recommendation Q.50. The main disadvantage of this method is that it is slow to show any real benefit, because the load is only reduced as calls clear.

It is found in practice that these two solutions are complementary; variable-bit-rate ADPCM is useful for dealing with overload due to normal statistical fluctuations, whereas DLC is of most benefit in limiting the busy hour loading.

DIMENSIONING AND MANAGEMENT

The gain in capacity of digital systems which DCME provides is not without some costs of its own, perhaps the most significant being the need to monitor the performance of each system, and adjust its gain to that of the traffic profile, so that performance criteria for each type of traffic are not transgressed. This is not straightforward, because there is some interaction between the relevant criteria and the number of TCs that the system carries. For example, if the number of TCs is large, say over 100, then the most significant subjective criterion for speech calls is likely to be the average number of bits/sample, which generally should not fall below 3·7. If on the other hand the number of TCs is small, say less than 30, then the most significant subjective criterion is likely to be initial clipping (this is because there are less bearer channels on which activity can cease, so that a TC which is newly active may suffer an increased probability of waiting for a longer than acceptable time for a bearer channel). Interpretation of system performance statistics, and system dimensioning has to take account of these factors.

FUTURE DEVELOPMENTS

The DCMEs currently in service are generally not used at a gain of more than four. This is in

TABLE 1
Performance of LD-CELP Algorithm

Parameter	Requirement	Objective	Test Result
Speech quality in quantisation distortion units (qdu) for nominal input level and bit error rate (BER) $\leq 10^{-6}$	$\leq$ 4 qdu		4 qdu
Speech quality for BER $\leq 10^{-3}$	Not worse than G.721		Significantly better
Speech quality for BER $\leq 10^{-2}$	Not worse than G.721		No significant difference
Speech quality dependency on input level	Not worse than G.721	As low as possible	No significant difference
Tandeming capability for speech	3 asynchronous $\leq$ 14 qdu	Synchronous	14 qdu, no synchronous tandeming property
Capability to transmit information tones		Minimal distortion	Meets objective. For all tones tested, average degradation was just detectable but not annoying. No condition worse than slightly annoying
Capability to transmit music		No annoying effects	None found

order to safeguard the transmission quality while minimising the dimensioning and management overhead for a wide range of traffic mixes. Systems now under development offer the potential for increased gain, with similar or better quality. These benefits come in part from the use of facsimile compression, but also from the use of '16 kbit/s' encoding of the speech. ADPCM cannot achieve sufficiently high quality for public network use at such a low bit rate. Other constraints, which rule out many algorithms capable of high speech quality at the required bit rate, are the need for low delay (ideally less than 1 ms) and the need for transparency to signalling tones and low-speed voice-band data.

The only algorithm which has so far been able to satisfy all the requirements is known as *low delay code excited linear prediction* (LD-CELP), which is in the process of being standardised by the CCITT as Recommendation G.728[11] for a fixed rate of 16 kbit/s. The performance achieved by this algorithm is summarised in Table 1. For use in DCMEs, the basic algorithm would be extended for operation both at higher bit rates up to about 24 kbit/s (to provide greater data transparency), and at lower bit rates down to about 12·8 kbit/s (to provide graceful degradation in overload).

CONCLUSION

Since 1988, DCME has been extensively deployed in the international network. It has enabled the benefits of digital transmission to be extended to cover a much larger number of international routes than would otherwise have been possible in the short term, whilst containing the costs of network modernisation. The benefits seem likely to grow as newer DCMEs appear in the international network.

References

1 COTTERILL, D. A. User Requirements and Provision of Digital Circuit Multiplication Systems for TAT-8. *Br. Telecommun. Eng.*, Jul. 1986. **5**, p. 158.

2 DEMOLITSAS, S., CORCORAN, F. L., ONUFRY, M., and SUYDERHOUD, H. G. Evaluation of ADPCM coders for DCME. *COMSAT Tech. Rev.*, Fall 1987, **17**(2), p. 323.

3 COMSAT Evaluation of ADPCM Coders for DCME. Final Report on Task TTA-22, CTD 87/125, Aug. 1987, 1 to 7. (Available from COMSAT Labs, Records Department.)

4 CCITT 40, 32, 24, 16 kbit/s Adaptive Differential Pulse Code Modulation (ADPCM). Recommendation G.726, Geneva, 1990.

5 CCITT 5-, 4-, 3- and 2-bits Sample Embedded Adaptive Differential Pulse Code Modulation (ADPCM). Recommendation G.727, Geneva, 1990.

6 CCITT STUDY GROUP XV Special Rapporteur on bit stream manipulation. Detailed description of the COM101/XVIII ADPCM algorithm. Temporary Document 5(XV/2), Geneva, May 1992.

7 CCITT Digital Circuit Multiplication Equipment Using 32 kbit/s ADPCM and Digital Speech Interpolation. Recommendation G.763, Geneva 1990.

8 CCITT STUDY GROUP XV G.726 COM 102 Algorithm Specification. Temporary Document 43 (WP XV/2), Geneva, Nov. 1991.

9 CCITT STUDY GROUP XV Facsimile Demodulation for DCME. Draft Recommendation G.766, contained in Report R69 (WP XV/2), Geneva, Dec. 1991.

10 CCITT Signalling Between Circuit Multiplication Equipment and International Switching Centres. Recommendation Q.50, Melbourne, 1988.

11 CCITT STUDY GROUP XV Coding of Speech at 16 kbit/s using Low Delay Code Excited Linear Prediction (LD-CELP). Draft Recommendation G.728, contained in Report R67 (WP XV/2), Geneva, Dec. 1991.

Bibliography

AT&T Overview of CCITT ADPCM Algorithms. CCITT COM XV D.449, Geneva, May 1992.

Israel Signal classification for facsimile demodulation in DCME/PCME. CCITT COM XV NJ-5, presented at the Eatontown NJ joint rapporteurs' meeting, Dec. 1990.

CCITT Software tools for speech and audio coding standards. Draft Recommendation G.191 (in preparation).

KESSLER, E. A. Digital Circuit Multiplication Equipment and Systems. IEE Second National Telecommunications Conference Proc., 309, 1989.

BARDOULEAU, D. A. Time Assignment Speech Interpolation Systems. A Review of the Circuit Multiplication Systems used by BTI. *Br. Telecommun. Eng.*, Oct. 1985, **4**, p. 139.

Biography

Edward Kessler joined the External Telecommunications Executive of The Post Office in 1975, after obtaining a B.Sc. in Applied Physics at the University of Sussex. He worked first on the introduction of digital switching systems, and later on research and development coordination and network optimisation. He then spent some years working on measurements and theoretical analysis of interference effects in satellite communications. His involvement in DCMEs dates from this period, when he played a part in setting the functional requirements for equipment to be used in the INTELSAT and EUTELSAT systems. Since then his work within International Networks has become progressively more network rather than systems orientated, particularly as regards transmission quality.

Fibre Campus Networks

KEN W. COBB†, PETER D. JENKINS†, IAN MACKENZIE*, and DAVE J. STOCKTON†

Blown fibre is an ideal method for installing an inter-building campus area network (CAN), offering remarkable flexibility and many environmental benefits. The blown-fibre technique allows a pneumatic link to be made up of tube assemblies compatible with their local environment. By using range-extension techniques and adopting simple handling methods with a rugged fibre-bundle design, long-haul spliceless optical-fibre links are possible. This article describes the marriage of external access network and in-building local area network disciplines to satisfy the customer-led demand for provision of optical-fibre CANs. In-building, underground and overhead issues are discussed. Typically, these cover temperature performance and fire hazards of the fibre bundle and tube assemblies. This article is based on a paper presented at EFOC/LAN 91‡.

INTRODUCTION

The last decade has seen an explosion in the amount of data communications carried out in a large office network. Initially, isolated office networks were integrated through the advent of common sets of data transport protocols (for example, IEEE 802.3 and 802.5) and a physical wiring scheme to form a local area network (LAN) made up of a mixture of copper wire and optical fibre[1,2]. Now, there is a growing demand for a communications network service which is physically larger, serves more nodes, and thus has to handle a faster throughput of data than before. These criteria form the basis of a campus area network (CAN).

Optical fibre, with its low optical loss and high transmission bandwidth, has been integrated increasingly into the data communications market. The fibre distributed data interface (FDDI) is one communications system which uses the advantages of optical fibre and addresses the needs of a CAN. In-building wiring practices have tended to be star or tree-and-branch wired from a central hub, but CAN designs are increasingly using an inter-building ring plan. The CAN's physical layer has to be flexible to allow ease of maintenance and reconfiguration, have a high immunity to cable damage over a wide site, and be easy to upgrade. As a link may pass through many different designs of cable to reach important outlying buildings, either the cables must be designed to be flexible in their use or, as in the case of BT, a technique must be used to match the cable to the environment in a cost-effective manner.

BT has adopted the blown-fibre technique to install optical-fibre infrastructures for data communications networks within buildings and, now, between buildings. The technique combines the benefits of low installation strain on fibres, with the flexibility of reconfiguration and the possibility of proofing against uncertain fibre count and specification. This article discusses elements of a CAN optical-fibre infrastructure.

Blown-Fibre Technology

The blown-fibre installation technique was invented in 1982[3]. The first reported use in a CAN was in a trial to link three BT buildings together with both multimode and singlemode fibre bundles[4].

The major system components are:

- a 1·6 mm diameter fibre bundle (four optical fibres of 125 μm outside diameter, primary coated to 250 μm diameter held together by a polypropylene skin, and foamed polyethylene covering),
- a blowing head and control box,
- compressed air, and
- the tube network (a network of interconnecting polyethylene tubes held together with a suitable sheath material).

The first stage in constructing any blown-fibre network is to install tube assemblies connecting the communications nodes. This tube network is terminated at tube flexibility points which allow tubes to be interconnected as desired. The tube assembly is run to the final terminating positions situated in racking, under-floor or wall-mounted utility points. Once the dedicated tube network has been defined, continuous fibre links can be blown in end-to-end. Finally, the optical fibre can be terminated by use of in-situ field-terminable connectors. Thus, an inexpensive reconfigurable splice-free optical cable network is provided.

---

† BT Development and Procurement

* BT Products and Services Management

‡ The Installation of Blown Fibre Campus Networks. European Fibre Optic Communications and Local Area Network Conference, London, Jun. 1991.

CAMPUS AREA NETWORKS

The blown-fibre technique has now been adapted to provide inter-building communications in the form of CANs. All aspects of the physical layer have been addressed from connector style and termination techniques to fibre performance over a wide range of temperatures and topologies.

Singlemode fibre, or 50/125 μm, 62·5/125 μm graded-index multimode fibre, is supplied in blown-fibre bundles consisting of four fibres. Within 3·5 mm or 6 mm bore tubes, a fibre bundle can be blown up to 400 m and 1 km, respectively. These bore sizes meet the requirements of local and campus network's optical-fibre infrastructures. The tube routes are terminated in a range of hardware to provide a secure environment for the fibres, their connectors, and to ensure personnel have maximum cover for optical safety. The system can support the major optical-fibre connectors and any design of 125 μm diameter optical fibre.

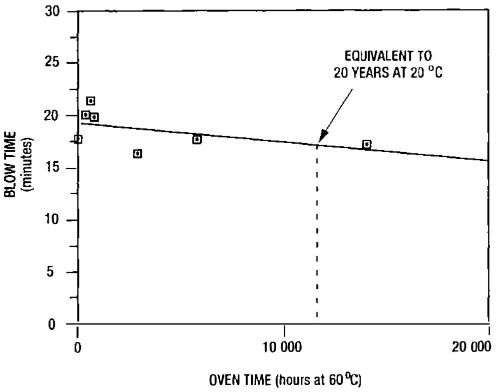
TUBE ASSEMBLY DESIGN

The use of blown fibre enables the design of the tube assembly to match, in a cost-effective manner, the hazard of its surrounding environment. When required, the fibre is blown in to form a spliceless link. New tube-assembly designs are evolving to meet future national standards. All designs are subject to a range of basic tests to satisfy uniformity of performance.

Blowing Performance

The design of the tube assembly has to satisfy a number of issues. A requirement is for a stable performance over the temperature range +60°C to -40°C throughout a lifetime exceeding 20 years. An accelerated aging test has confirmed the blowing performance which is shown in Figure 1.

Figure 1 Blowing performance of aged blown-fibre tube



Samples of tube assembly were aged at 60°C for over 12 000 hours and, at predetermined intervals, the blowing performance was assessed in terms of the time to blow 500 m. The graph shows there is little change in blowing performance.

Mechanical Properties

Designs are subject to tensile loading, crush and bending tests detailed in British Standard BS6558 (Part 1). The criterion for the tensile test is that the tube assembly is subjected to an applied force equivalent to 1·5 km in weight of the sample under test. The bend test requires that the sample is wound for five turns round a mandrel whose radius is twelve times the outer radius of the sample. In each case, after the test, the tube assembly should recover its geometric dimensions without permanent deformation.

Campus Designs

For underground installation, two methods can be used. The most common method is to pull an empty tube assembly into previously installed underground duct by using standard cabling techniques. Typically, a 6 mm bore 7-tube assembly is used. The second method is to bury directly the tube assembly.

Trials have been made on the direct burial of a 6 mm bore, 7-tube assembly. By using a tractor and standard mechanical mole-ploughing techniques, demonstrations have taken place in ground varying from sandy soil to heavy clay with large flints and chalk stones. After installation, the tubes were checked for deformation by blowing through a 4·76 mm ball bearing. The design of a directly-buried cable requires the cable to be made rodent proof. This arises because the action of the mechanical mole plough loosens the earth in such a way that is ideal for burrowing rodents. These rodents gnaw through the cable, so a stainless steel barrier is incorporated into the cable to give protection.

Designs for overhead cable work enable the tube assembly to be run on overhead gantries, cleated to an outside wall, and hung as an aerial cable. In all cases the designs meet recognised standards in the area of ultra-violet performance. Whereas standard underground tube assembly can be used for the overhead gantry and outside wall environments, an aerial tube assembly required a new design. This has resulted in a collaborative project between BT and BICC for drop cable for the passive optical networks (PONs) used in BT's optical field trial at Bishop's Stortford, UK[5,6].

Within the network, the ingress of water into a conventional cable structure is to be avoided. The recognised techniques are to fill the cable's interstices with petroleum jelly or to apply air pressurisation. This requirement is because installed cables retain a small amount of strain which, in the presence of water, can lead to premature failure. Investigations have shown residual strain in blown fibre to be negligible[4]; thus, since the fibre is under no strain after installation, the presence of water is not of great importance.

Techniques have been developed to recover the blowability of empty tubes which have been

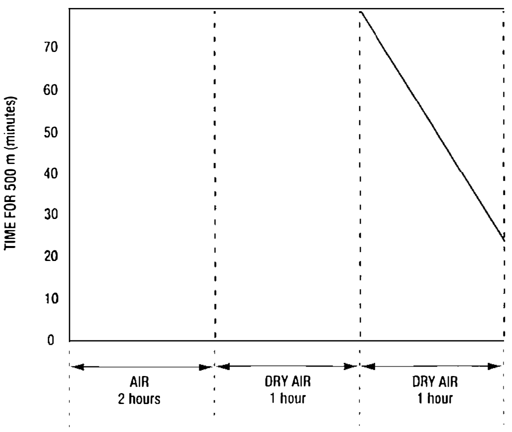


Figure 2—Recovery time of blowing performance

flooded prior to installation of a fibre bundle. After the tube has been emptied of water, it is purged with dry air. The graph in Figure 2 shows the blowing performance of a 500 m length of tube treated by this method. From the graph, the blowing performance has been restored after purging with dry air for four hours.

FIRE PERFORMANCE

Greater attention is being paid to the performance of building components in terms of fire hazard. In the case of blown fibre, the tubed fibre assembly constitutes a cable in most instances. It is therefore important to describe the performance of the combination in any fire test.

Fire standards vary markedly across the world. In the USA, a high emphasis is placed on a reduction in fire propagation tendency, hence the adoption of large-scale burning tests such as UL 1666 and UL 910. In the UK and Europe, there is a higher importance attached to the hazard presented by combustion products, smoke and fumes. The information in Table 1 represents the performance for a European type product recently developed by BT Laboratories.

In order to prevent the ingress of toxic and flammable gasses into a building, it is standard practice to block all cable interstices at the building's external/internal boundary.

FIBRE BUNDLE DESIGN

BT's design of blown-fibre unit, or fibre bundle, consists of four individually-coloured fibres with two Kevlar ripcords sealed in a polypropylene skin and covered in polyethylene foam to reduce the overall density and to increase the surface area. Since the four fibres are lightly bound together, the resulting fibre-bundle structure offers a degree of ruggedisation against fibre buckle and eases general handling. A low-technology pan system is used to store and dispense the fibre bundle, which negates the use of complicated fibre-pay-off equipment. In use, the single bundle enables the blowing equipment to have an integral speed control, whereas a separate constant-speed capstan is required to regulate the speed of blown single-fibre variants. Blowing equipment is therefore simple, compact and easy to set up. It has an added advantage that range-extension techniques can be easily used. Theoretically, these techniques enable infinitely-long spliceless links to be installed by the technique of blow-store-blow etc.

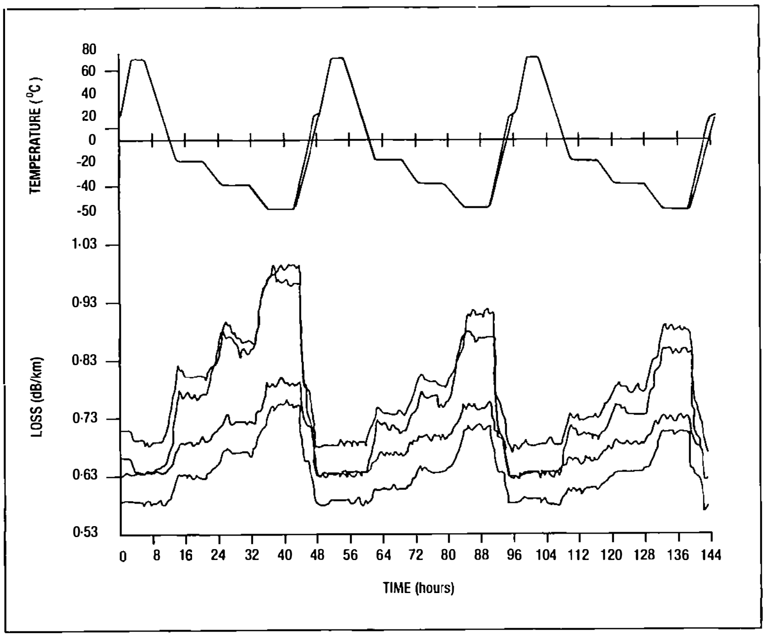
The fibre bundle accommodates any design of fibre with an outside diameter of 125 μm. For instance, within the BT access network, singlemode fibre is used, whereas within local area and campus networks, 62·5/125 μm fibre is preferred, although 50/125 μm can be supplied.

BT Laboratories has succeeded in designing a fibre unit with excellent low-temperature performance. In Figure 3, the temperature against loss performance of the four fibres in a 50/125 μm fibre bundle is shown over a temperature range of +70°C to -60°C. Development work on multimode fibre-bundles is being conducted on 50/125 μm fibre, rather than 62·5/125 μm fibre, because that fibre design is more susceptible to higher microbend losses when subject to any coating process. At 1300 nm, the graph shows a 0·15 dB/km change in performance between the temperatures of +70°C to -40°C, and between -40° to -60°C the loss increases by a further 0·1 dB/km. For most

TABLE 1
Fire and Fume Performance

Property	Test	Result
Flame Spread (small scale)	IEC 332Part 1	Pass
Vertical Burning	IEC 332 Part 3	Pass
Smoke Emmission	BS 6724	Pass
Toxicity Index	NES 713	Pass to level required in NES518
Smoke Index	NES 711	~30
Oxygen Index (sheath)	IEC 332 Part 3 Appendix A	35 Pass to level required in NES 518
Temperature Index (sheath)	NES 715	270°C

Notes
1. All tests refer to 3·5/5·0 mm tube containing four fibre unit, unless otherwise stated.
2. The results from testing to NES 711 are variable. This is believed to reflect the test method rather than the sample.
3. NES: UK, Naval Engineering Standard.



Upper trace shows temperature range (+70°C to –60°C) applied to a four fibre bundle. Lower part of the graph shows attenuation performance of the four fibres when subjected to this temperature range.

Figure 3 Temperature/loss performance

campus systems where a 2 dB maintenance margin is planned in over a 2 km link, the fibre unit performance is satisfactory.

INSTALLATION

Addressing Planning Guidelines

Tube assemblies are used with single, four or seven tubes where the tube bores are 3·5 mm or 6 mm. In order to ensure consistent blowing performance throughout the length of the route, the bore should be uniform. The smaller tube is limited to the boundaries of a building, but the larger tube is used for both internal and external routes. Future investigation will be undertaken to determine the permissible blowing lengths where routes have a mixture of bore sizes.

An analysis of horizontal and vertical blowing performances of 4-fibre bundle into 3·5 mm bore tube has been made for planning purposes. In the horizontal plane, 16 right-angle bends of minimum bend radius were added to a straight route to simulate real installations. Although up to 800 m was blown, to ensure consistent performance, a guaranteed limit of 400 m is set. For the vertical test, a helicopter was used to lift one end of a 400 m long tube assembly to incremental heights up to 200 m (650 ft). At each height a fibre bundle was blown through from the ground up to the helicopter, after which the fibre bundle was recovered and the test repeated at a new height. Figure 4 shows the resulting planning graph where the x and y axes represent the sums of the horizontal and vertical elements respectively.

A study has been made of the strain performance of fibres in a 4-fibre bundle when hung

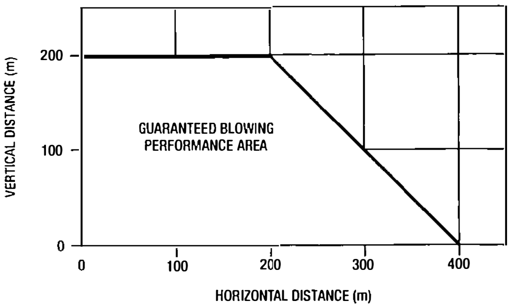


Figure 4—Horizontal and vertical blowing limits used during planning stage.

vertically up to a height of 400 m (1300 ft) as part of an analysis to check for a compromise in fibre lifetime. This arises since the fibre bundle hangs freely within the tube. The maximum strain would take place in the bend at the top of the vertical riser where the tube assembly passes from the riser onto the floor. An experiment was set up to simulate the condition by hanging a range of weights onto a short length of 4-fibre bundle whereby the fibre bundle was routed round a range of different radii bends. Fibre strain was measured by using optical phase shift techniques[7]. Figure 5 is a graph of strain in a single fibre against height for different riser/floor bend radii with curves showing theoretical (dotted line) and measured values. The measured results suggest that the fibres support an equal portion of the load. The theoretical line shows the increase in strain caused by a straight length of fibre bundle in the riser. It represents an equal load distribution over each fibre. Additional theoretical strain due to the curvature of the fibre bundle at the top of the riser is not plotted here for clarity of presentation.

As can be seen, even with the tightest installation radius (100 mm), at the top of a riser, coupled with the maximum drop (400 m), the strain level of 0·2% maximum is observed. Calculations indicate that fibre will survive a minimum service under these conditions with a negligible risk of failure (1 in 10^5). The graph shows most tall buildings can confidently have fibres in their risers without the use of intermediate strain relief mechanisms.

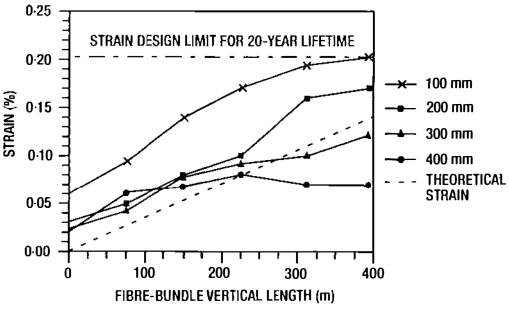


Figure 5—Graph of single fibre strain against vertical height for a range of bends

When 6 mm bore tube is used, the maximum blowing distance for 4-fibre bundle is 1 km. For longer route distances, serial tandem blowing and mid-point blowing range-extension techniques are used[8]. Both these methods have been used successfully during March 1991 when two 4-fibre spliceless links were blown in over a 14 km route between Gloucester and Painswick.

Fibre Management and Termination

In order to take full advantage of spliceless links enabled by the blown-fibre system, field-terminated optical-fibre connectors are used on fibres broken out from the fibre bundle. The standard connector is the ST style, but FSMA and most other connector styles can be used. Since both 50/125 μm and 62·5/125 μm multimode fibre is used, the transmission performance of both types of fibre round a range of bends of different radii has been analysed to confirm reported[9] differences in performance. The objective was to determine the losses induced by these bends and, furthermore, to use this information in developing a new patching facility. For typical in-building routes up to 50 m in length, the graph in Figure 6 shows the increase in loss at both 850 nm and 1300 nm after the addition of ten bends of different diameters into a straight length of fibre. For longer fibre routes, the severity of the effect is reduced since the guided light is reaching a state of equilibrium mode distribution.

From this information, guidance about a link's optical performance was determined and designs of suitable housings for the patching system were possible. The new patching facility has been designed to route fibre bundle and fibres behind the connector in a highly-organised and easy-to-install manner. This facility is part of an integrated patching system which can be used to terminate optical-fibre links in an aesthetic housing on a wall, inside standard trunking, under the floor, or as part of a comprehensive patch panel.

FUTURE

BT is committed to the global supply of telecommunication products and services. A necessary element of that commitment means the developed products shall meet international standards. In order to accommodate worldwide campus markets, it will be necessary for the blown-fibre system and fibre-management techniques to have the capacity to blow longer lengths and to pass round tighter bends. With the increasing value of real estate, the system will have to address higher packing densities by increasing fibre count within fibre bundles and by reducing tube sizes.

CONCLUSION

BT, in its commitment to its blown-fibre technology, continues to meet its objective of providing a universally applicable optical-cabling system.

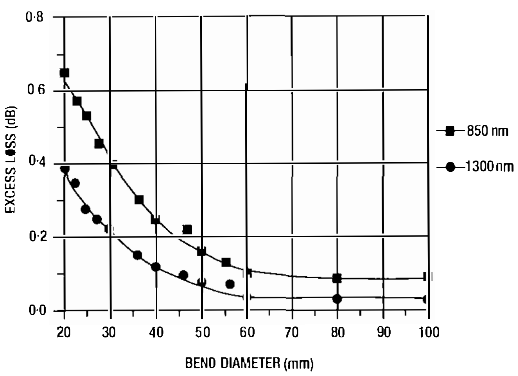


Figure 6—Graph of excess loss against applied bend diameter

The developments outlined in this article provide a positive step towards achieving that aim. The technology has been shown to be readily adapted to the challenging environments found in campus network applications.

References

1 Quarmby, J. H., *et al.* Structured cabling for in-building and data communications. *Br. Telecom Technol. J.*, **9**(1), Jan. 1991.

2 Bishop, K. W., *et al.* A novel optical solution to office cabling. EFOC/LAN 89, *LAN Proc.* No. 1.3.3, p. 109, Amsterdam, Jun. 1989.

3 Reeve, M. H., and Cassidy, S. A. Installation of optical fibre units using viscous drag of air. ECOC 83, Technical Digest, p. 239, Geneva, 1983.

4 Hornung, S., *et al.* The blown fibre cable. *IEEE J. on Selected Areas in Communications*, **SAC-4**(5), Aug. 1986.

5 Stern, J. R. *et al.* Passive optical local networks for telephony applications and beyond. *Electron. Lett.*, **23**(24), 19 Nov. 1987.

6 Beaumont, A. R., *et al.* Passive optical networks for telecommunications. EFOC/LAN 91, London, Jun. 1992.

7 Barlow, A. J. Quadrature phase shift technique for measurement of strain, optical power transmission, and length in optical fibres. *IEEE J. of Lightwave Technol.*, **7**(8), p. 1264, Aug. 1989.

8 Freeman, R. A., *et al.* Advances in blown fibre installation methods. *Br. Telecom Technol. J.*, **5**(3), Jul. 1987.

9 McIntosh, T. Selecting the optimum fiber design for LAN applications. EFOC/LAN 89, *LAN Proc.* No. 1.3.4, p. 114, Amsterdam, Jun. 1989.

Biographies

Kenneth Cobb graduated from the University of Bradford with a B.Eng. in Electronic Engineering, and from University College, London with an M.Sc. in Microwaves and Modern Optics. He joined BT's Trunk Transmission Department in 18981 where he was involved in trials of initial optical 140 Mbit/s transmission systems and the measurement of optical fibre parameters. He moved to BT Laboratories to lead a development team whose field is the design and application of optical-fibre cables, structures and components, including the use of blown fibre, for local and campus area networks.

Peter Jenkins joined BT Laboratories in 1958 as a Trainee Technician (Apprentice). In 1960, he joined the Submarine Cable Division where he introduced many innovations to both analogue- and optical-cable technology. In 1988, he was appointed Head of the Optical Cables and Structures Group, and his responsibilities included research and development of the blown-fibre system. He is now Head of the Optical Plant and Processes Group and is responsible for the implementation of passive optical network technology plant in BT's local access networks. He is the BT Laboratories' technical coordinator for optical plant and holds many patents for products now in current use throughout BT.

Ian MacKenzie currently leads a team with technical responsibility for all aspects of optical-fibre cabling installed on customers' premises, within the Local Area Systems business unit of Products and Services Management. He joined BT in 1970, as a Trainee Technician (Apprentice) and progressed on into network transmission installation and maintenance. He later joined a data transmission installation and maintenance group responsible for customer premises equipment and, on promotion, joined a regional data support group, later to become Customer Advanced Networks, and provided system engineering support to Field Sales and National Account personnel. During this period, he was actively involved in the initial trials of IDA with customers, and worked closely with both customers and development personnel. He has been involved with blown fibre from its earliest trials inside buildings and, with his team, is developing all-fibre cabling solutions to meet different business needs.

David Stockton joined BT in 1978 as a Trainee Technician Improver in the London Materials Section. His work included polymer materials analysis and identification, using spectroscopic techniques. He obtained a BT Major Award in 1982 and was awarded the Graduateship of the Royal Society of Chemistry in 1983 and, subsequently, the Diploma in Management Studies. In 1984, he joined BT Laboratories working principally on the effects of atmospheric corrosion on new designs of cable connectors. Since 1987, he has worked in the optical cable field, including the development of the blown-fibre system. Currently, he leads a group concerned with the plant aspects of optical-fibre and cable-system performance.

The Transmission and Connectivity Tester

DEREK NASH, ALAN GOBEY and JONATHAN BARNES†

As competition in the telecommunications field increases, the importance of the quality of the service as perceived by the customer increases as does the ability to measure it. This article describes the development of equipment to carry out these measurements.

INTRODUCTION

In an increasingly competitive world, products and services can be sold only if there is a market for them and the cost is justifiable. This may be in absolute terms or in comparative terms (where direct competition exists).

One of the major factors which determines whether a particular product or service will be chosen in preference to others is its quality. This applies to telecommunications as much as any other industry. It will therefore become increasingly important that BT has cost-effective methods of measuring the quality of its services. For the speech and data services provided by the public switched telephone network (PSTN), not only is this an important commercial consideration, but effective management of the BT network requires objective measurement of the quality of the network as perceived by the customer. In this way, customer perception can become a direct influence on the network operation.

The transmission and connectivity tester (TACT) is a system for automatically testing, over dial-up routes on the PSTN, the network performance element of quality of service as perceived by the customer.

The equipment modules comprising TACT are connected to PSTN lines and automatically dial up similar modules with the purpose of conducting end-to-end tests across the established path.

WHAT DATA IS REQUIRED?

The recommended parameters essential to measure objectively the quality of service as perceived by customers for speech calls and low-speed data services are categorised into two areas^1:

- call connectivity, and
- transmission quality or call clarity.

The questions to be asked are thus:

'How easy was it to establish a connection to a far-end destination?'

and, having made the connection:

'What was the quality of the circuit provided?'

There is another element, relating to charging and billing integrity, which is not addressed by TACT.

Call Connectivity

The connectivity parameters to be measured are:

- time to dial-tone,
- post-dialling delay, and
- call-failure rate.

The time to dial-tone measures the delay between the customer's first action to stimulate a call and the response from the network.

The post-dialling delay measures the elapsed time between a customer completing dialling and the network indicating to the customer that a call has been delivered by the return of ring tone or that there is a problem by the return of another tone or recorded announcement.

The call-failure rate is the percentage of calls placed that were not successfully completed. The reason for failure will be categorised as:

- misrouting,
- number unobtainable,
- network-equipment engaged, and
- destination engaged.

The connectivity measurements place a requirement on TACT to recognise a large range of British and international network information tones, including the presence of automatic announcements. It is not proposed, however, that TACT should interpret automatic announcements.

Transmission Quality

The transmission-quality or call-clarity parameters to be measured are:

- transmission loss,
- total distortion,
- attenuation distortion,
- idle-channel noise,
- group-delay distortion, and
- impulsive noise.

---

† BT Development and Procurement

These are electrical measurements of the network performance and were selected for two main reasons. The first is simplicity, which relates directly to cost of implementation. The measurement techniques are well known[2] and can be readily implemented. Secondly, BT's digital exchange equipment is design tested against these parameters. The exchange-to-exchange performance can therefore be predicted and measured results correlated with a known benchmark.

INTERNATIONAL REQUIREMENTS

Making quality-of-service measurements on international circuits has a number of problems not encountered on the BT national network. Transmission paths may be longer and include types of equipment such as digital circuit multiplication equipment (DCME)[3] and echo-control devices not found elsewhere. Circuits may go via cable or satellite. There are thus a number of factors which may contribute to degradations in quality of service not found on shorter inland circuits.

Thus, international routes require additional measurements to characterise:

- round-trip propagation delay,
- echo-control device performance, and
- clipping.

Delay

The effects of delay are particularly noticeable in speech calls. Delay alters conversation behaviour. It effects how long people wait for information, who interrupts and who controls the conversation.

Echo

Echo is intrusive in a speech call when the speech-to-echo ratio drops below about 45 dB and becomes more apparent to the customer as the delay increases. Echo also degrades the performance of data calls by corrupting signals at the physical level. The echo heard by a customer is made up of a number of components, representing points of mismatch at each two-to-four and four-to-two wire conversion along the route. The echo from the near-end local exchange is perceived as sidetone. The far-end echo, however, may be delayed by anything up to 1·6 s depending on the length of the transmission path, and it is this signal that is significant in degrading the quality of service.

It is usual on international circuits, therefore, to include devices to control the level of far-end echo.

These may be echo suppressors[4] or echo cancellers[5]. The effect of these devices is to reduce the level of far-end echo returned to a user by, typically, 40 dB. By measuring the effectiveness of these devices, TACT can provide data from which the echo level experienced by the customer can be deduced.

Clipping

Clipping, here, is defined as the loss or distortion of the leading edge of a signal, as distinct from amplitude clipping. As the direction of propagation changes, echo-control devices take a finite time to switch to the new direction, possibly causing a portion of the signal to be lost or attenuated. This manifests itself as the loss of the first syllable(s) of words as a conversation alters direction.

Similar effects are introduced by DCME used on international routes. The clipping measurement has been designed as an objective measure of these phenomena.

These are three new measurements for which new measurement techniques have been developed for TACT. There are no antecedents in the CCITT Recommendations.

SYSTEM OPTIONS

Having established the broad requirements for the measurements that should be made, the potential systems for making these measurements were examined.

The types of solutions considered fell into two broad categories:

- devices at the customer's network terminating equipment (NTE), and
- test-call systems at the main distribution frame (MDF).

The attraction of a device at the customer's NTE is that it offers a true end-to-end measurement potential which includes local line plant as well as the network.

Provisional analysis showed, however, that these types of systems suffered from a significant disadvantage; namely, that the cost would be dominated by an unacceptable cost of deployment.

A conventional *test call* architecture was thus adopted. This uses test equipment at local exchanges connected either to a dedicated test number or to individual customers' exchange line equipment via metallic test access.

A comprehensive picture can then be derived from MDF to MDF, while relying on the data provided by the line test system[6] for the performance of the local line plant. Network management schemes are evolving to correlate this data[7].

IMPLEMENTATION OPTIONS

The first and simplest option is to buy proprietary equipment. However, a close examination of the presently available systems shows a number of technical and commercial drawbacks.

No single system is capable of carrying out all of the required measurements. With the exception of the international requirements, each of the measurements appeared to be offered by at least one system. However, detailed investigation showed that the methods used for identically-named measurements differed between manufacturers. Thus, the data produced by these systems are not directly comparable.

An option would be to standardise on equipment from a single manufacturer. This, however, does not permit competitive procurement and allows a manufacturer to impose a *de facto* standard which is also his commercial offering.

It is additionally restrictive for international testing where cooperation is required with other administrations. They may have chosen to standardise on equipment from other manufacturers. Results would not be comparable and this could have implications for performance agreements.

Discussions with the manufacturers revealed that they found the absence of a single agreed standard to be as much as a problem to them as it was to their customers. Not only were the measurement methods different, but there was no standard to facilitate interworking between different manufacturers.

It was decided, therefore, the approach would be to produce a standard that:

- ensures comparability of results, and
- enables interworking between different manufacturers' equipment.

The cooperation of manufacturers of existing test systems was sought and positive efforts made to involve them from the earliest stages. This ensured that they were aware of the evolving requirements and had the opportunity to input to them. This also permitted the derivation of a highly practical standard.

THE TACT ARCHITECTURE

Although BT's developing network management systems are very powerful, it was deemed necessary to add TACT controllers which effectively act as element managers for their subordinate test equipment. In order to reduce the complexity of control, a single-ended approach was adopted, whereby only the call-originating equipment has a direct control interface to the element manager, the call-receiving equipment being controlled indirectly over the PSTN connection under test. This is possible because of the dial-up nature of the PSTN.

This approach provides a control strategy for a nationwide, and potentially international, testing system.

Figure 1 illustrates the hierarchy of equipment and clearly identifies the interfaces involved.

PROPOSED TACT SYSTEM OPERATION

The use of the TACT system falls into two categories:

- quality-of-service testing, and
- maintenance testing.

For quality-of-service measurements, a testing schedule is downloaded over the I3 interface to the appropriate controller. This schedule consists of originating numbers (customer numbers or dedicated test numbers), their intended destination test number, and the tests required between them. The schedule is split into sub-schedules and loaded into the call-originating equipment (transponder) which has access to the appropriate originating numbers. This is performed over the I2 interface. The transponders then proceed autonomously with their sequence of calls, passing back batches of results to their associated controller. After post-processing, the results from all transponders under the jurisdiction of a particular controller are forwarded to the BT management system for correlation and trend analysis.

Maintenance activities require an ON-DEMAND mode of access which can interrupt an active sub-schedule if required. Once access is gained to the required transponder, test calls and subsequent test sequences can be initiated with results being passed back immediately to the user for analysis.

Having outlined the methodology, architecture and basic operation of TACT, the following gives a more detailed description of its various interfaces.

THE I1 INTERFACE

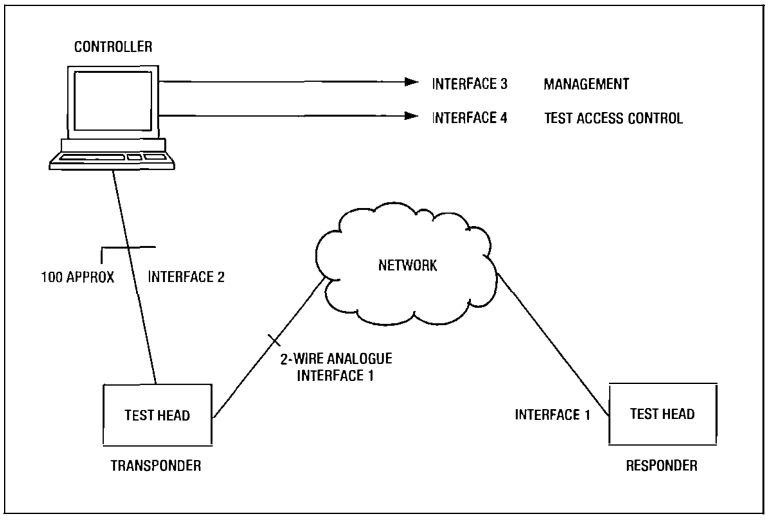
The I1 interface is the connection between the TACT transponder and the TACT responder as shown in Figure 1. The connection is established across the PSTN by means of a TACT transponder dialling up a TACT responder. This connection not only provides the test path, but also the control circuit to the responder.

The test path is subjected to a suite of transmission tests. These measure the parameters outlined previously in a way which is independent of network characteristics[8].

The control circuit provides the following:

- control of bi-directional parametric testing,
- an enquiry service for responder test capability and status, and
- a path for operational software upgrades; that is, configuration.

Figure 1
TACT architecture



Once a connection has been established for test purposes, a set sequence of phases follows:

- *Phase 1* A negotiation phase where the identification of the responder is established and the types of tests it is possible to carry out using the transponder/responder pair are identified.
- *Phase 2* A test-download phase where the tests that are to be carried out across the connection and the sequence in which these tests will occur is downloaded to the responder. (The capability to perform these tests was established in phase 1.)
- *Phase 3* The testing phase where the test sequences identified in phase 2 are performed across the connection.
- *Phase 4* The results phase where all results, including those of bi-directional tests, are returned to the originating (transponder) end.

These phases can be carried out between any transponder/responder pair regardless of their manufacturer.

THE TACT PROTOCOL

The above phases demonstrate the need for a clearly defined and comprehensive communication protocol between transponder and responder, carried across the PSTN.

To reduce development time and costs, and to facilitate acceptance, it was decided to use standard protocol elements.

An extensive survey of potentially suitable existing protocols was carried out, but none had all the desired characteristics. Therefore, it was necessary to develop a custom BT protocol using, wherever possible, off-the-shelf elements.

Previous experience in the testing and development of digital protocols led to a specification corresponding to the first three layers of the Open Systems Interconnection (OSI) model (physical, data-link and network layers).

A feature peculiar to the I1 interface is that it must allow for the protocol to be suspended while the transmission tests are performed across the link. The protocol must then be reinstated to allow the responder test results to be recovered.

The following sections outline the elements chosen for each layer of the protocol specification.

Physical Layer

V.22*bis* [9] was chosen for the physical layer. This is a robust and well known standard that provides for an adequate data rate—1200/2400 baud. Hardware implementations are also readily available.

Data-Link Layer

V.42[10] LAPM was chosen for the data-link layer. A number of the optional parameters were optimised for BT's use.

Although fairly new, V.42 has been primarily developed to provide a robust error-correcting link for normal modem communication. Proprietary chipsets are readily available at moderate cost, so that implementation should be cheap.

The Network Layer

This was a full BT custom development as no suitable existing network layer could be found. Because of the complex nature of the protocol and to prevent different interpretations occurring, it was essential to use a rigorous method of specification. To this end the graphical form of the Specification Description Languagc (SDL 88)[11] was used and the structure of the data within each message defined by using Bachus-Naur Form (BNF).

The protocol works in a similar fashion to most message-based protocols. Specific types of message are exchanged by each end of the link, the data contained within these messages determining types of test, duration of parameters, test results etc.

The message set for this layer is shown in Table 1.

TABLE 1
Testing Layer 3 Message Set

GENERAL COMMUNICATION	
Message Name	Message Function
RIM	Responder Initialisation Message
CIM	Clear Indication Message
CCM	Clear Confirmation Message
TESTING	
Message Name	Message Function
TIMI	Testing Intention Message Incomplete
TIMC	Testing Intention Message Complete
TAMI	Testing Acceptance Message Incomplete
TAMC	Testing Acceptance Message Complete
TCMI	Testing Command Message Incomplete
TCMC	Testing Command Message Complete
TSM	Test Start Message
RRM	Results Request Message
TRMI	Test Results Message Incomplete
TRMC	Test Results Message Complete

Sequence of Events across I1

Figure 2 shows a typical sequence of events across I1 to set up a test suite, execute the tests, retrieve the results and clear the connection.

Note that because the I1 interface is required to drop out of and return to the control protocol, to enable the quality-of-service tests to be run, a mechanism for delimiting test schedules was necessary. This uses multi-frequency (MF4)[12] tones to coordinate the start and direction of tests, and to return to the protocol.

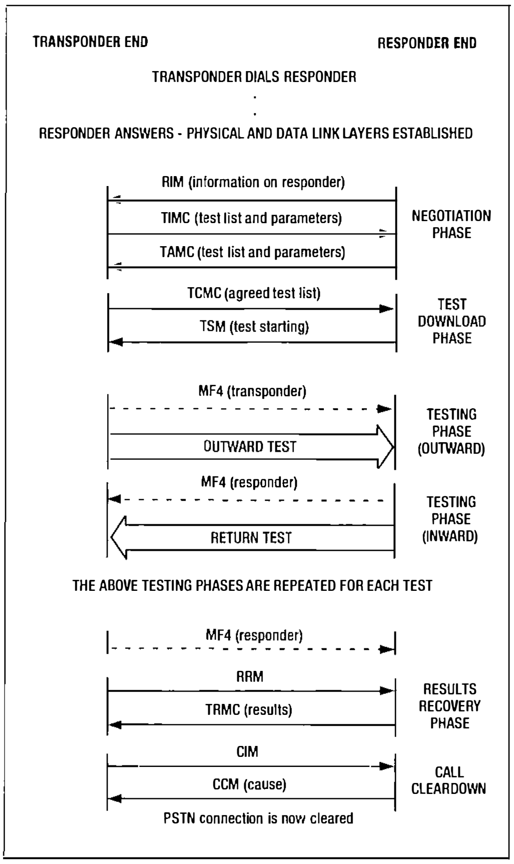


Figure 2—Typical protocol usage

Responder Status/Configuration

The status/configuration part of the I1 interface supports a self-test capability as well as the upgrading or replacement of responder software, considerably reducing the need for site visits. The latter function, however, can only be supported between equipment from the same manufacturer.

The messages used for these activities are given in Table 2.

TABLE 2

Status/Configuration Layer 3 Message Set

MAINTENANCE	
Message Name	Message Function
MCM	Maintenance Command Message
MRM	Maintenance Response Message

SOFTWARE UPGRADE	
Message Name	Message Function
SUTM	Software Upgrade Transfer Message

THE I2 INTERFACE

The I2 interface is the control interface between a controller and its managed transponders. It is a PSTN dial-up link which uses an OSI compatible protocol at layers 1 to 3, with V.22*bis* forming the layer 1[9]. It allows for transponder maintenance as well as test-schedule downloads, on-demand testing, and responder-software upgrade downloads.

THE I3 INTERFACE

I3 is an evolving interface which initially supports manual control of the TACT system through a human–computer interface (HCI). In later phases this will migrate to control via management information systems through a generic test interface (GTI).

The HCI is based on the industry-standard X Windows™product using the Motif™style for a consistent look and feel across the menus and forms which it employs. The visual aspects of the interface are being developed by the TACT team as a standard offering, under which the manufacturers build their application functions. This approach saves testing effort and ensures that all TACT controllers look the same without placing undue constraints on manufacturers implementation of the required functionality.

The GTI is a specific implementation of the testing management interface identified as part of the TAMS study[7]. The TACT GTI port is the agent node end of the OSI standard, object-oriented interface[13]. It allows for the creation, manipulation and termination of managed objects. These objects are the outsider's view of the implementation of the set of tests outlined earlier. The underlying communication path is via X.25[14].

The open, standard and international nature of this interface enables connection to any appropriate network management system. This potentially removes the BT-specific aspects of the network control level interface into the TACT system.

THE I4 INTERFACE

This interface controls the test access relays and allows a metallic or transmission bridged (speech only) connection to be made from external equipment to:

- the exchange analogue port,
- the customer's local access, and
- the customer's line in a monitoring mode.

Its intended use is for connection to the exchange analogue port of individual customers for routine testing.

I4 uses an existing, ASCII character, message-based interface. This is operated over a V.24 interface into the associated local exchange or concentrator unit. An important feature is its ability to inform the 'user' if a busy line is accessed, thus allowing for prevention of intrusion into existing calls.

CONCLUSIONS

The TACT project has created a series of specifications and a protocol that permit the inter-operation of test equipment from a variety of manufacturers. The standardisation of measurement methods means that test results obtained from different manufacturers equipment can be directly compared. This contrasts sharply with the usual situation of incompatible operation between different manufacturers' equipment and test results from one manufacturer's system which cannot be compared with those from another manufacturer.

The process of creating a level playing field has been actively supported by the equipment manufactures who see interworking and competitive procurement as an aid to their commercial aspirations.

It seems likely that the initial deployment of TACT will use standalone controllers, programmed via the HCI, but the future promises a much closer integration with BT's management information systems via an electronic I3 and the inclusion of ISDN in the test repertoire.

ACKNOWLEDGEMENTS

The authors acknowledge the contribution of all of the TACT team.

References

1 CCITT Draft Recommendation E.434: Subscriber to subscriber measurement of public switched telephone network. SG2 Sept. 1991.

2 CCITT O-Series Recommendations: Specifications for measuring equipment. CCITT Blue Book, 1988.

3 INGHAM, A. R., and COPE, G. A. The Performance of Digital Circuit Multiplication Equipment (DCME). IEE Eighth UK Teletraffic Symposium, 1991.

4 CCITT Recommendation G.164: Echo Suppressors. CCITT Blue Book, 1988.

5 CCITT Recommendation G.165: Echo Cancellers. CCITT Blue Book, 1988.

6 FALCONER, J. R., HEMMINGS, C. P., POTTS, S., BLAKE, I. F., and VANNER, N. J. Automated Line Testing for the BT Repair Service. *Br. Telecommun. Eng.*, Apr. 1991, **10**, p. 75.

7 REED, C. F. Network Test Management Systems. *ibid.*, Oct. 1991, **10**, p. 239.

8 NASH, D. J. Measuring speechband transmission parameters in a complex impedance environment. *Br. Telecom Technol. J.*, Apr. 1992, **10**(2), p. 9.

9 CCITT Recommendation V.22*bis*. CCITT Blue Book, 1988.

10 CCITT Recommendation V.42: Error correcting procedures. CCITT Blue Book, 1988.

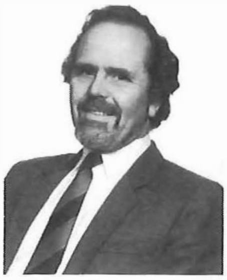
11 CCITT Recommendation Z.100: Specification and description language (SDL). CCITT Blue Book, 1988.

12 British Standards Institute BS6305:1982. General requirements for apparatus for connection to BT PSTN.

13 OSI/Network management forum: Application Services, Testing Management Function. Issue 1.0, Forum 012, Aug. 1991.

14 CCITT Recommendation X.25. CCITT Blue Book, 1988.

Biographies



Derek Nash graduated from the Polytechnic of Central London, in 1967, with a B.Sc. in Electrical Engineering and has been a member of the IEE and a Chartered Engineer since 1973. He worked on a number of MoD projects at Marconi Research before joining BT, in 1980, to work on System X line cards. Currently working in Digital Services Division, he is involved in a number of aspects of interface measurement and protocol validation.

Alan Gobey joined the Quality Assurance Division of BT as an apprentice in 1975. He gained full City and Guilds Certificate and an HND in Micro-electronics. He worked on fibre optic and acoustic device evaluation before transferring to Teleprove. At Teleprove, he worked on PBX evaluation for three years before transferring to BT Laboratories in 1987, where he joined the Interface Protocol Evaluation Group specialising in ISDN protocols. He is currently a team leader on the TACT project.

Jonathan Barnes graduated from the University of Bath with a B.Sc. in Electrical and Electronic Engineering in 1987. He immediately joined BT Laboratories working primarily on real-time software design for an embedded system. In 1989, he gained an M.Sc. in Telecommunication and Information Systems at the University of Essex. He is now involved in a system design aimed at improving the quality-of-service monitoring within BT networks.

Glossary

DCME	Digital circuit multiplication equipment
GTI	Generic test interface
HCI	Human–computer interface
ISDN	Integrated services digital network
MDF	Main distribution frame
NTE	Network terminating equipment
PSTN	Public switched telephone network

Analogue Signalling Integrity in the Access Network

JOE (R. A.) STARTIN†, DAVID M. GIBSON†, and ADRIAN J. LEE*

Advanced technology is being applied more and more to the access network. Customers with analogue ports will generally be using traditional signalling to and from their equipment, but the access network will be passing the signalling on via a digital interface of some sort. It is important that the integrity of the signalling is preserved, and BT needs to check conformance appropriately on all new network equipment. This article describes the testing process, and in particular a tester that was specially developed to support it.

INTRODUCTION

Fibre is migrating from the core network into the access network, an obvious step which is presenting many challenges[1,2]. The copper in the existing access network is an asset which must be continually exploited, and there are interesting new ways of doing this[3]. Such developments enable new and better services to be supported, but at the end of the line most customers still need ordinary analogue ports into which to plug their telephones or analogue PBXs.

Allowing technology to grow in the access network has certain drawbacks. However, equipment for the access network can be developed faster than for the local exchange[4], and this attraction is difficult to resist. As the access network develops, it is vital that signalling integrity is preserved. Interfaces must be stable, clearly defined, and capable of being rigorously tested. The Digital Access Signalling System No. 2 (DASS2) interface[5] is currently playing a key part[1,2], not just for ISDN services but for analogue services as well. Figure 1 shows a typical case of signalling from one telephone to another.

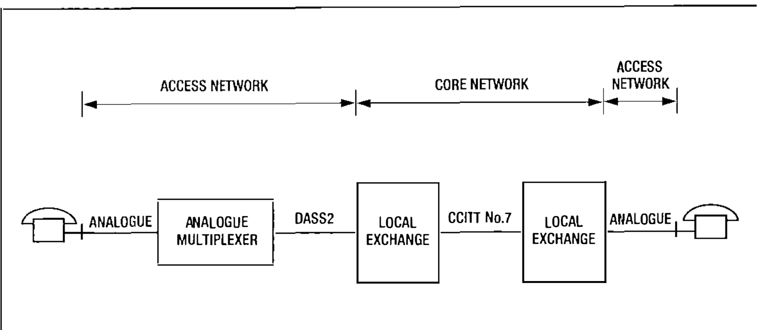
The protocol afforded by the DASS2 interface includes a definition of how it maps to and from analogue signalling. Any equipment supporting this mapping must be proven to do it correctly if interworking problems are to be avoided later. This article explains how the proving is being done. It will be evident how protocols other than DASS2 could be handled in a similar way.

INTRODUCING NEW EQUIPMENT

BT is facing more and more competition in the access network, and there is a drive for improved quality, increased functionality, lower costs, faster service provision and shorter fault repair times. Consequently, BT has embarked on several initiatives to exploit the potential of new delivery mechanisms available in the access network. Many of these initiatives include multiplexers providing analogue (public switched telephone network (PSTN)) and/or digital (integrated services digital network (ISDN)) services connected to digital exchanges via a 2 Mbit/s interface port, employing DASS2 signalling techniques.

Multiplexer equipment is available from an increasing number of manufacturers, providing various levels of service capability and performance. Implicitly, this equipment will vary in shape, size and functional realisation and although this is not desirable, it is not a prime consideration. BT is more concerned with the cost benefits that can be achieved through competitive procurement, while protecting itself from 'lock-in' to an initial supplier. It follows therefore that the specifications for such equipment are *black-box* specifications, based around the required customer and network interfaces, qualified by maintenance, performance and environmental requirements. Most of these interfaces are specified and are defined as BT Network Requirements (BTNRs)[5,6] and CCITT standards (typically V, G and I-Series).

Before any new equipment can be introduced into the network, BT must be confident that it is fit for purpose. It is essential that the functional integrity of the network is maintained and that service characteristics to customers are



DASS2: Digital Access Signalling System No. 2

Figure 1
An example of signalling across the network

---

† BT Development and Procurement
* BT Worldwide Networks

consistent, whichever network elements are deployed. Testing and *connection approval*, therefore, are key parts of the procurement process, which must be fully defined and rigidly performed, to ensure that results obtained are reproducible and above reproach.

The level of testing performed needs to be carefully pitched to ensure that confidence of conformance against all the specified requirements is attained, while the cost and time overheads incurred are kept to a minimum. This is normally agreed with the relevant specification authorities within BT, as are the results. These results may require analysis where, for example, incidents of non-compliance may not be critical to the intended application.

ESTABLISHING CONFIDENCE

Connection approval for network equipment requires conformance against functional, performance, electromagnetic compatibility and environmental specifications. Conformance testing is undertaken in full by the supplier, and the results obtained are reflected in formal responses made against the relevant specifications. It is likely, however, that functional testing is performed on the equipment in isolation, or in a simulated network environment, so it is incumbent upon BT to verify conformance statements under network conditions. Approval testing performed by BT, leading to connection approval, is designed to provide such verification. The functional testing stage would include parametric and transmission performance testing of the electrical interfaces, and signalling protocol conformance, work normally performed early in the approval testing programme. The penalty for failure here can mean expensive rework and retesting for the supplier, followed by regression testing by BT.

Testing of the analogue signal mapping to the DASS2 digital signalling channel on multiplexers supporting PSTN services forms a major part of approval testing, and proven conformance at this stage gives a high degree of confidence on the functional aspects. The range and critical timing of these requirements are such that testing has to be automated to provide the necessary level of accuracy and efficiency. An existing protocol tester, the Digital Communications Tester (DCT)[7], was chosen to fulfil this need, using test scripts developed by BT Laboratories. These scripts perform thorough and comprehensive test routines on the equipment under test to ensure correct interaction between customer equipment and the network. The size and complexity of the DASS2 protocol, which this article will be illustrating, make the speed, fault analysis, test-repeatability and selective regression test capabilities of the DCT an invaluable test facility.

OVERVIEW OF THE PROTOCOL

For good practical reasons, data communications protocols are defined in terms of layers. The 7-layer ISO Reference Model[8] provides a useful common way of talking about protocols, and the signalling protocols used in the access network correspond well with the lower three layers of the model. Layer 1 (the *physical layer*, concerned with passing bits over a suitable transmission medium) and layer 2 (the *data link layer*, that uses the physical layer as a way of transferring messages correctly and in the right order) are relatively self-contained. They are aspects of the protocol that can be related to an individual interface port without the need to involve any other port. Given adequate means of setting up the port, layer 1 and layer 2 can be tested on that port in isolation.

At layer 3, the *network layer*, the personality of a protocol shows more clearly. The protocol is used within a system to support a certain functionality, and this functionality is stamped all over layer 3. Where the protocol terminates on a black box within the system, the behaviour on at least one other port on that black box will map to layer 3 in a particular way.

The DASS2 protocol is no exception, and BTNR 190[5] handles the mapping of its layer 3 to an analogue interface. The black box is treated as a state machine, interacting with both the customer's analogue signalling and the DASS2 digital signalling on the exchange side. Using plain English and formalised CCITT Specification and Description Language[9,10], generally known as *SDL*, a high degree of rigour and low level of ambiguity can be achieved through a diagrammatic representation that protocol engineers can easily follow. Figure 2 shows a small part of the SDL, with one of the paths through it highlighted. Most of the terminology can be ignored here, but *normal current* refers to an analogue signalling condition that is applied as a type of line feed, and *ISRM(I)* means initial service request message (incomplete), the name of a DASS2 message. Alongside it is a message sequence chart for that SDL path.

To validate the mapping on a particular black box, a test specification is first drawn up that translates all possible paths in the SDL into message sequences. For test purposes, practical message sequences will need to ensure the black box is returned to its IDLE state (state 0) before the following test can start. Given a suitable tester, the black box can then become a unit under test (UUT) that is exercised with every sequence and checked for the correct behaviour.

As mentioned above, the tester chosen for this was the DCT[7], but it still needed a way of handling the analogue interface. Signalling and termination conditions as if from customer apparatus must be applied to the UUT, and the exchange signalling and termination conditions from the UUT must be detected and recognised. The DCT analogue interface subsystem (DAISY) was developed to solve this problem (see Figure 3). It has its own special message set for talking to the DCT, using a conventional RS232 data link.

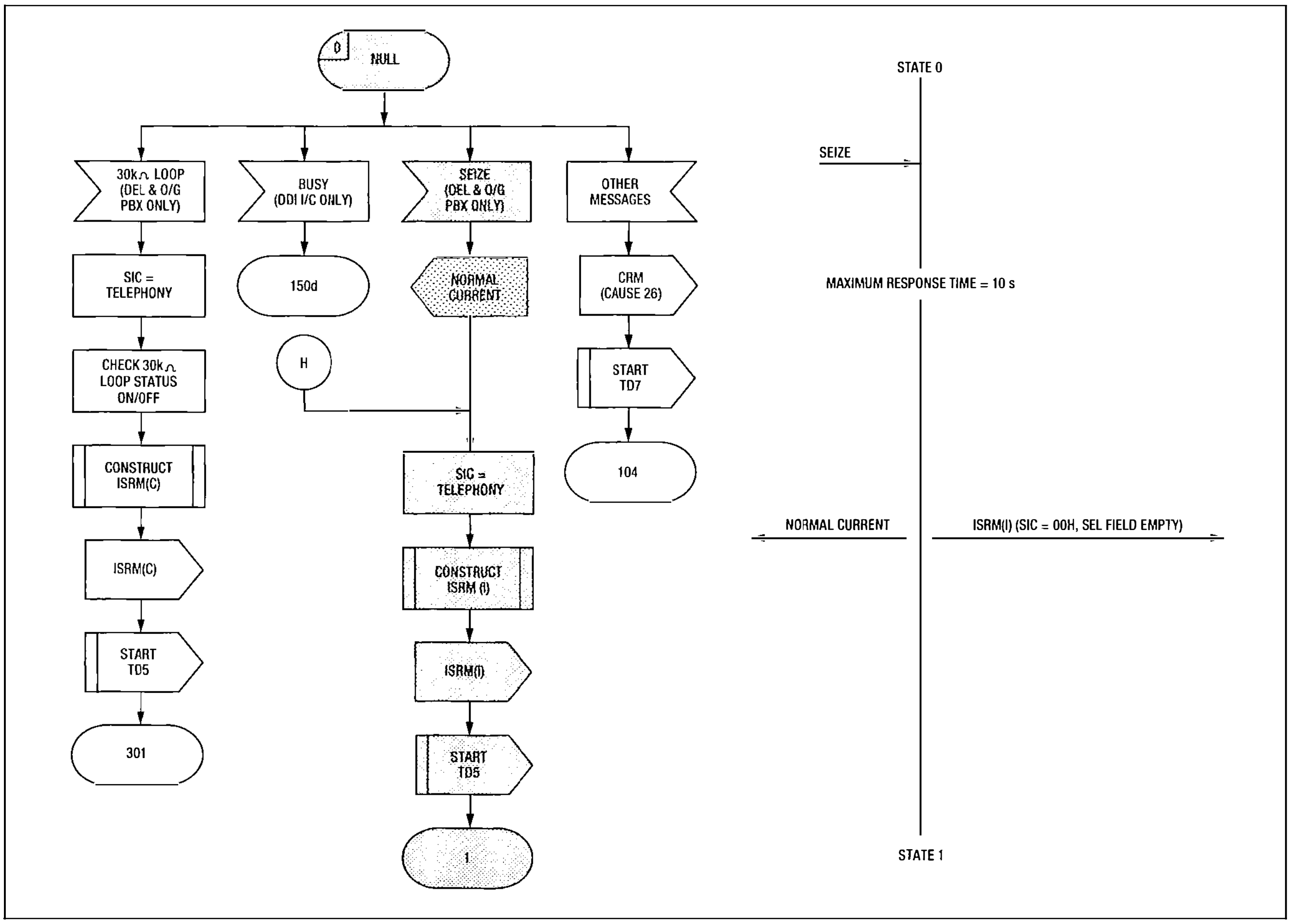


Figure 2—Example of SDL, with an associated message sequence

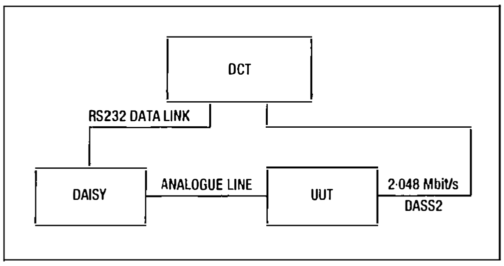
THE DAISY TESTER

An analogue connection supplied by BT is expected to work to any customer apparatus that conforms to BS6305[11] and BS6317[12] (for telephones) or BS6450[13] (for analogue PBXs). These standards are not directly suitable as specifications for procuring network equipment. This need is met by two BTNRs. One of them deals with transmission performance over a connection that has already been set up, and is not immediately relevant. The other, BTNR315[6], deals with the signalling interactions between the customer equipment and the network.

BTNR190[5], which describes the DASS2-to-analogue mapping, references BTNR315 in order to characterise the interactions that occur on the analogue side. DAISY is therefore specified to test connections that are to BTNR315. A summary of the customer apparatus conditions DAISY can provide and the exchange conditions it can recognise is given in Table 1.

All these conditions are specified in terms of electrical parameters and, where necessary, timings. When it comes to validating the mapping, the parametric limits are not of immediate concern and should not be allowed to interrupt the flow of testing.

DAISY handles this in two ways. Firstly, when acting as a customer's terminal, it consistently produces electrical signals that are close to the mid-points of the parametric bands prescribed by BTNR315. Secondly, when recognising conditions from the exchange, it uses parametric limits somewhat wider than those in the BTNR. Then, if a test fails, it is because the mapping is wrong or there is a very distinct deficiency in the parametric performance of the UUT.



DAISY: DCT analogue interface subsystem
DASS2: Digital Access Signalling System No. 2
DCT: Digital Communications Tester
UUT: Unit under test

Figure 3—Test configuration using DAISY

Although DAISY is necessarily a complex piece of equipment, the key architectural features are quite simple. Figure 4 illustrates this for the case of testing an ordinary telephone line. The microprocessor card deals with messages to and

TABLE 1
Termination and Signalling Conditions which DAISY can Apply or Recognise

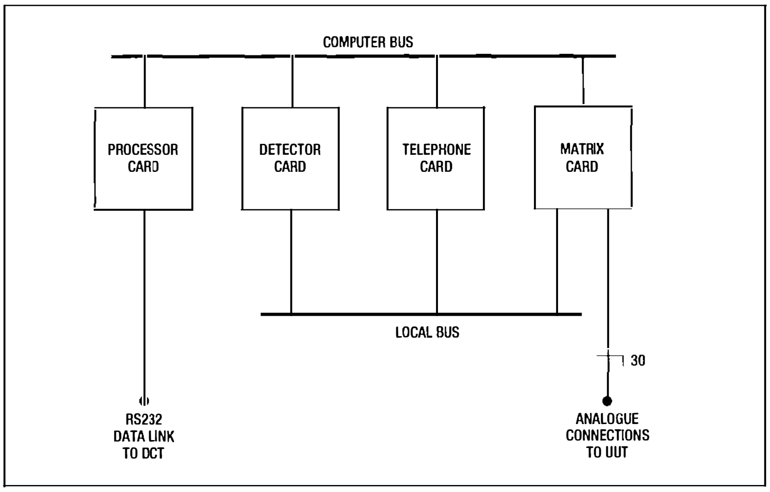
Customer Termination	Customer Apparatus Conditions that can be Applied	Exchange Conditions that can be Recognised
Direct exchange line (normal telephony)	Seize Answer Clear Dialling digits (loop-disconnect or MF4) Register recall and malicious call indication Earth fault on A and/or B leg 30 kΩ loop Charging current loop	Normal current feed Idle voltage feed Zero current feed Parked current feed Ringing (4 distinguishable cadences) Exchange released/ end of call 50 Hz SPM pulses 16 kHz SPM pulses
Analogue PBX	Seize (loop calling) Seize (earth calling) Answer Clear Dialling digits (loop-disconnect or MF4) Earth fault on A and/or B leg 30 kΩ loop Charging current loop	Normal current feed Idle voltage feed Zero current feed Parked line feed Ringing (4 distinguishable cadences) Reverse current feed Exchange released 50 Hz SPM pulses 16 kHz SPM pulses
Direct dial-in (DDI) PBX	Application of appropriate line feeds Busy signal Answer Clear	Seize Digit Exchange released Idle

SPM: Subscriber's private meter

from the DCT, controls the matrix card and telephone card, and interprets measurement information from the detector card. Thus, the DCT can select the appropriate analogue connection, and instruct the telephone card to apply customer conditions. The detector card is equipped with an analogue-to-digital converter, and periodically measures the voltage and current for each leg of the UUT line. The microprocessor card samples the measurements every 10 ms, and analyses them in real time to determine what the current exchange condition is. Any changes in condition are reported autonomously by the DAISY to the DCT.

At any given instant, the most recent 256 sets of measurements are available in the memory on the microprocessor card. If required, the DCT can halt the test and get this information passed back to it as a dump.

Figure 4
Basic architecture of DAISY



DCT: Digital Communications Tester UUT: Unit under test

To provide the facilities of Table 1, the complete DAISY is equipped with additional hardware that works between the computer bus and the local bus (see Figure 4).

The circuitry within DAISY that has a metallic connection to the UUT is kept to a minimum. This electrical isolation is not for safety reasons, but to avoid potential problems with earth loops.

TEST SCRIPT DEVELOPMENT

A *test script* is a description of the steps which a tester, either a person or a machine, should go through in order to execute a test. The DCT, being a computer, responds to computer instructions, but is provided with a high-level language specially designed for writing test scripts. The language allows specific conditions to be set up by sending messages to the unit under test, and the response to be read back and checked against expected results. As with any high-level computer language, the intention is to let the programmer create instructions in the terms which the programmer understands, rather than in the low-level computer instructions. For these test scripts, this process has been extended by using the 'macro' facility of the language to create a library of action routines which match the actions defined in the state description language used within the BTNR. The test scripts are then written with these macros, in terms which are the same as those used in the specification. Figure 5 is the

```
/*****************************************************************/
/*                                                               */
/* MSD Reference: 0_DEL_3                                        */
/*****************************************************************/
!
Start(0_del_3,del)
!
sprint ’MUX in state 0’
!
sprint ’Send SEIZE message to DAISY’
send_daisy_msg(SEIZE)
!
sprint ’Receive NORMAL-CURRENT message from DAISY and’
sprint ’Receive ISRM(I) message from DASS2 port’
sprint ’Sequence is not important. Max wait time is 10 seconds’
rcv_2_msgs(ETCON,NORMAL_CURRENT,ISRMI sic=#00 sel=’’,t10s)
!
sprint ’MUX in state 1’
!

* More script for other messages *


!
sprint ’MUX in state 0’
!
finish(0_del_3)
```

Figure 5
Test script

actual test script used to cover the SDL and message sequence chart shown in Figure 2.

The scripts, when run on the DCT, make the DCT perform like the telephone exchange on one side, signalling with DASS2, and a telephone on the other via the DAISY unit, as in Figure 3. It runs through the state transitions defined in the specification, exercising the multiplexer, and checking that the responses match those specified. There are 350 test scripts to cover the analogue mapping in the specification.

A major problem with the development of any test system is to prove that the test system itself is correct. For example, an oscilloscope should be calibrated before it is used to measure voltages or time delays, but for the DCT and its scripts, there is no equivalent to the digital voltmeter or timer to compare it against. Instead, a separate team at the Belfast Engineering Centre, working completely independently, developed a second set of test scripts which would make the DCT function exactly as a multiplexer. These *anti-scripts* were run on a second DCT connected back-to-back with one running the proper test scripts, to validate them. This exercise showed a number of deficiencies in both scripts and anti-scripts, but after four weeks work, they successfully ran against each other, and gave confidence that the scripts correctly interpreted the specification.

USING THE TESTS

When starting to test a new piece of equipment such as a multiplexer, there is always some new script development required so that the unit can be automatically set up, loaded with configuration data and set running from a known start point. In the real world, this would be done partly by the exchange as the unit is brought into service, and partly from the operations and maintenance centre (OMC) as lines are brought into service. With no exchange or OMC in the test set-up, many of these actions have to be done by the DCT. Another important script is the *reset* script, which ensures that, as far as possible, the unit under test can be returned to its IDLE state. It is needed because if a test finds an inconsistency between what actually happens and what is expected, the script terminates at that point, leaving the unit in an unknown state. The reset script is then run to restore it to the IDLE state.

Once the unit is set up and running in the test environment, the test scripts are run through in batches and the results kept in a log file on the DCT. The results of each test are then analysed, and the cause of any premature script termination, arising from a discrepancy between expected and actual result, is investigated. Typically it takes about three weeks to run through this process, but it can take as little as two days if no inconsistencies occur. The golden rule in the investigation has to be ‘assume nothing’, as the cause could be in any combination of:

- the unit under test,
- the test script,
- the test equipment, and
- the specification itself.

There have been examples of inconsistencies from all four of these areas, but it is not appropriate to give details here. However, as more testing takes place the number of test-script problems has decreased.

The main result has been to gain confidence that the unit being tested is fit for its intended purpose, and will perform correctly in service. Several tested units are now in service in the field, and as experience builds up, they can be shown to be consistently interworking correctly with the exchange end, implying that both exchange and multiplexer have correctly implemented the protocol. This indirectly demonstrates the integrity of the underlying specification, as by rigorously checking the conformance to the specification through these tests, and successful field service, the specification is shown to be a correct and sufficient description of the signalling protocol.

CURRENT POSITION

Development of the test scripts is now complete, and they cover the full range of analogue line types. Most are concerned with the direct exchange line providing ordinary telephone service, but there are scripts to cover PBX working (both earth calling and loop calling), DDI PBX, payphones, 50 Hz SPM and 30 kΩ loop signalling.

The first real use of the scripts to test the mapping of analogue to digital signalling was on the multiplexer equipment used for the Canary Wharf fibre scheme in London's Docklands. The full set of tests has now been run on samples of analogue multiplexers from different suppliers, one for use on the fibre access network programme and another for rural modernisation schemes. New releases of these are now tested as a matter of routine. These tests are in addition to others checking the transmission performance, the safety and operational features such as installation, maintenance, call handling capacity etc.

The scripts have also been used to check the equipment used to supply telephony service for the Bishop's Stortford optical-fibre trial[2]. The results helped to build confidence in the trial equipment, and to demonstrate that it was good enough to connect to the existing network, before connecting it to the live exchange at the trial site.

OTHER APPLICATIONS

The 2 Mbit/s DASS2 interface on the exchange is seen as a suitable connection point for a number of systems which could be used to provide analogue telephony to customers. The analogue multiplexers and the optical-fibre trial equipment have already been mentioned, but the tests can in principle be applied to any system with a DASS2 exchange interface which supports analogue telephony. The tests are also expected to be used on equipment providing analogue telephony to be supplied under the business TPON initiative.

One system which has been tested was a signalling converter unit to be used for a Centrex service which converted between the DASS2 protocol and the conventional channel-associated signalling, both carried in time-slots on 2 Mbit/s PCM circuits. For the purposes of testing, the channel-associated side of the converter was turned into a plain telephone interface by using a small proprietary PBX. The DAISY was connected as an extension telephone, and a call set up to the exchange line over the PBX, which then exercised the signalling converter unit in much the same way as it would in service.

Another possible application may be the digital access carrier system, which will provide multiple telephone lines over a single pair, using digital coding and multiplexing techniques. This may be connected to the exchange via the 2 Mbit/s DASS2 interface, and so could be conformance tested in the same way as the analogue multiplexers.

CONCLUSIONS

The traditional analogue style of service will be around for a long time to come. The equipment in the access network will become more diverse and elaborate, so that fibre can be deployed and digital techniques can make more cost-effective use of the existing copper. This equipment will be procured competitively. The integrity of the signalling path is potentially at risk, and this can be avoided only by good specification and reliable testing techniques.

In the future we can expect to see protocol specifications become more formal, while progress is made towards automating the error-prone and laborious process of test specification and test script writing. Testers such as the DCT can readily support such changes, so long as the particular test language they use is included in the process. If the analogue interface changes, or variants develop, the DAISY can handle most eventualities with a straightforward software change. The testing architecture has the flexibility to cope as and when different changes are needed at different times.

ACKNOWLEDGEMENTS

Among the large number of people who have worked in this area, the authors would like to acknowledge particular technical contributions from Barry Trawford (DAISY tester), Juan Harrison (test specification) and Alan Rain (multiplexer testing).

References

1 OAKLEY, K. A., GUYON, R., and STERN, J. Fibre in the Access Network. *Br. Telecommun. Eng.*, April 1991, **10**, p. 40.

2 HOPPITT, C. E., and RAWSON, J. W. D. The United Kingdom Trial of Fibre in the Loop. *ibid.*, April 1991, **10**, p. 48.

3 LISLE, P. H., and ADAMS, P. F. Exploiting the Copper Network. *ibid.*, April 1991, **10**, p. 26.

4 MARSHALL, J. F., and WELSBY, F. A Multiplex Solution for Initial ISDN Provision. *ibid.*, Jan. 1991, **9**, p. 253.
5 BTNR190: Digital Access Signalling System No 2 (DASS2).
6 BTNR315: Analogue Customer Line Interface for Digital Local Exchanges.
7 RISBRIDGER, J. N. A., and STEWART, D. W. A Protocol Tester for Message-based Signalling Systems. *Br. Telecom Technology J.*, Apr. 1987, **5**(2), p. 19.
8 JENKINS, P. A., and KNIGHTSON, K. G. Open Systems Interconnection—An Introductory Guide. *Br. Telecommun. Eng.*, July 1984, **3**, p. 86.
9 CCITT Recommendation Z.100: Specification and Description Language SDL.
10 BELINA, F., HOGREFE, D., and SARMA, A. SDL with Applications from Protocol Specification. Prentice Hall, 1991. ISBN 0-13-78590-6.
11 BS6305: General requirements for apparatus for connection to the British Telecommunications PSTN.
12 BS6317: Simple extension telephones for connection to PSTNs run by certain Public Telecommunications Operators.
13 BS6450: Private Branch Exchanges for connection to PSTNs run by certain Public Telecommunications Operators.

Biographies

Joe Startin joined the Post Office Research Department in 1969 after receiving a B. A. in Engineering from Cambridge University. He worked on high-speed logic and gallium-arsenide devices, and was awarded a Ph. D. in 1975 after research at University College, London. In 1977, he transferred to head a group which worked on various aspects of System X local exchange development. Since 1984, he has led a number of projects concerned with testers for commissioning or signalling conformance of network equipment.

David Gibson graduated from Imperial College, London, in 1969 with a degree in Electrical Engineering and joined the Telecommunications Development Department in what was then Telecommunications Headquarters of BT. There he worked on the crossbar switch and on the acceptance of the Stag Lane crossbar international exchange. In 1972, he transferred to the Research Department working on aspects of stored program control of switching systems, and then on the processor system for System X; this was followed by further work on processor control techniques. In 1986, he became head of a group which specialises in the testing of systems containing computer and switching elements; this group is now part of the system Engineering Assessment unit within the Network Management Department.

Adrian Lee joined the then British PostOffice as an apprentice in 1971. He was initially employed on exchange construction and clerk of works duties, moving on to a group responsible for installation and commissioning of PCM/X-Stream services equipment in his latter years as a technician. On promotion to Assistant Executive Engineer, he joined a KiloStream technology group and was involved in the specification and development of the fourth-generation KiloStream multiplexer and associated equipment. His current responsibilities include managing the testing and approval programmes for the PSTN and flexible multiplexers deployed in the access network.

Glossary

BTNR	BT Network Requirement
DASS2	Digital Access Signalling System No. 2
DAISY	DCT analogue interface subsystem
DCT	Digital Communications Tester
DDI	Direct dial-in
ISDN	Integrated services digital network
OMC	Operations and maintenance centre
PSTN	Public switched telephone network
SDL	Specification and Description Language
SPM	Subscriber's private meter
TPON	Telephony passive optical network
UUT	Unit under test

The Use, Benefits, and Potential of Space Telecommunications

In his message for World Telecommunication Day, the Secretary-General of the International Telecommunication Union introduced the theme 'Telecommunications and Space: New Horizons', and recalled the unceasing progress made by man in the conquest of space over the past 35 years by outlining key events in space history from the launch of Vostock 1 on 12 April 1957, the first commercial telecommunications satellite, Early Bird, in April 1965, and the Moon landing by Apollo XI on 20 July 1969. These early achievements formed an integral part of modern telecommunications.

The following article by John Hampton, Acting Director General of the International Telecommunication Satellite Organisation (INTELSAT), continues this theme and discusses the role satellites are playing in bringing more and better communications services to all nations.

INTRODUCTION

The impact of space telecommunications permeates every aspect of global society— political, economic, cultural. Space telecommunications has stimulated not only the global marketplace for goods and services, but also the marketplace of views and opinions. We need only review the major political events of 1991 to grasp how much the availability of instantaneous global communications affects what we do and how we think. The ravages of war, the jubilation of the victors in the struggle for political freedom, the triumphant smiles of victorious athletes—all are captured on television screens and played to global audiences.

The availability of space telecommunications makes it possible for any area of the world, no matter how remote, to be accessed in seconds via INTELSAT's comprehensive satellite and earth station network. Satellite communications technology has fostered universal, high quality, cost-effective international telecommunications services. As a result, satellite communications has been an equaliser by offering the same calibre of communications service to developed and developing nations alike. Even more important, satellite communications has been a catalyst for many nations in augmenting and enhancing growth and development.

INTELSAT has played a major role in providing expanded telecommunications services to all areas of the world on a global and non-discriminatory basis. INTELSAT has successfully met the goal of harmonising global requirements while rising above political differences among nations. INTELSAT's 17-satellite global system serves more than 180 countries, territories, and dependencies via more than 2200 pathways and a wide variety of earth stations (Table 1).

The interconnectivity provided by the INTELSAT system, combined with an outstand-

Table 1
Choice of Earth Stations

Standard	Antenna Size (m)	Service Range	Frequency Band (GHz)
A	15–18	International voice, data and TV, INTELSAT Business Services (IBS) and Intermediate Data Rate (IDR)	6/4
B	10–13	International voice, data, TV, IBS and IDR	6/4
C	11–14	International voice, data, TV, IBS and IDR	14/11
D1	4·5–6	Vista	6/4
D2	11	Vista	6/4
E1	3·5–4·5	IBS	14/11, 14/12
E2	5–7	IBS and IDR	14/11, 14/12
F1	4·5–5	IBS and IDR†	6/4
F2	5·5–7	IBS and IDR	6/4
F3	9–10	International voice, data, TV, IBS and IDR	6/4
G	All sizes	International lease services	6/4, 14/11, 14/12
Z	All sizes	Domestic lease services	6/4, 14/11, 14/12

† IDR subject to approval on a case-by-case basis.

ing standard of service—99·00% reliability—is a valuable global communications resource.

Since INTELSAT began providing service in 1965, use of the system has grown exponentially, and the variety of services available has expanded in response to market demand. For example, growth in public switched telephony traffic has increased more than 800-fold. Full-time leases carried on the system continue to grow at a steady pace and, at the end of 1991, there were more than 170 such leases. Most of these leases are for domestic and video services. Indeed, about one-third of INTELSAT's members use the system for domestic as well as international services.

SPACE COMMUNICATIONS VERSUS OPTICAL FIBRES

The nature of INTELSAT's market share is likely to change over the years, with the implementation of optical-fibre cable systems. Overall, however, the amount of traffic carried on the system will continue to grow significantly, as reflected in traffic forecasts provided by members and users (Figure 1). Implementation of optical-fibre cable systems will have an impact on INTELSAT traffic patterns and, on some routes, there will be significant changes in the percentage of international traffic carried on satellite and cable, respectively. However, while on some heavy traffic routes INTELSAT will carry a smaller percentage of the total international traffic, it seems clear that all routes will retain a segment of the traffic on the INTELSAT system. All of the other intercontinental communication links in the world where cables do not exist, and these comprise greater than 70% of the INTELSAT links, will continue to experience heavy growth on INTELSAT.

FUTURE GROWTH

To accommodate growth in service requirements in the near term, INTELSAT has seven INTELSAT VII/VII-A satellites on order. The first of these satellites is anticipated to be launched during 1993. For additional capacity in the post-1995 era, INTELSAT's Board of Governors, in December 1991, authorised the issuance of a request for proposal (RFP) for the construction and delivery of up to three satellites of different design. The Board will decide during 1992 on the acquisition of additional satellites, with a range of options which could include both more INTELSAT VII/VII-A and satellites selected for the response to the RFP. In addition, the INTELSAT K, a higher powered, all Ku-band (12·40 GHz–18·00 GHz) spacecraft, will be launched in the second quarter of 1992 for service in the Atlantic Ocean region. During May 1992, an INTELSAT VI satellite, stranded in low earth orbit as the result of a launch failure, was fitted with a new rocket motor by an astronaut team on the space shuttle *Endeavour*. It was then reboosted to geostationary orbit and is now being deployed for service. These spacecraft will augment INTELSAT's existing network of INTELSAT V, V-A, and VI satellites.

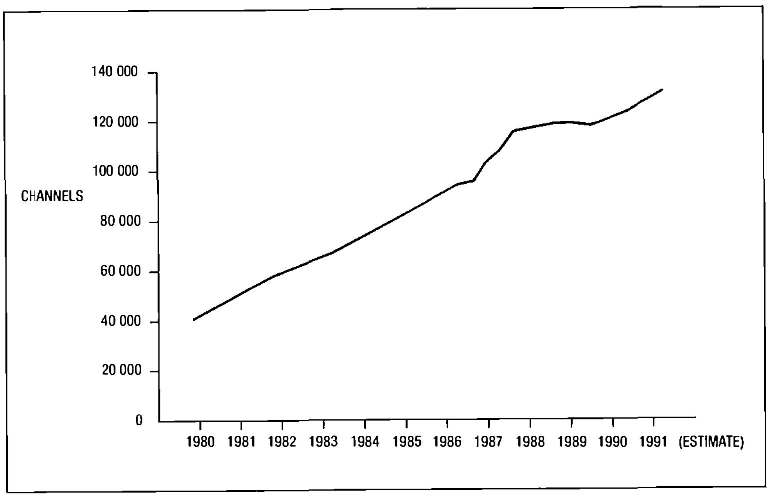


Figure 1 Growth in full-time use of the INTELSAT system

While the INTELSAT system and the amount of traffic carried on the system have grown substantially, the cost of service has declined dramatically. The cost-of-living index has soared upwards, yet INTELSAT charges have consistently been reduced (see Figure 2). For example, the cost of a voice channel has declined in real terms over a hundred-fold over the past quarter of a century, and a voice channel, spanning oceans, can now be obtained for as little as US$1·00 per day. This productivity has been achieved through technological innovation, the economies of scale made possible by increasing usage and system growth, and responsiveness to changes in the market-place.

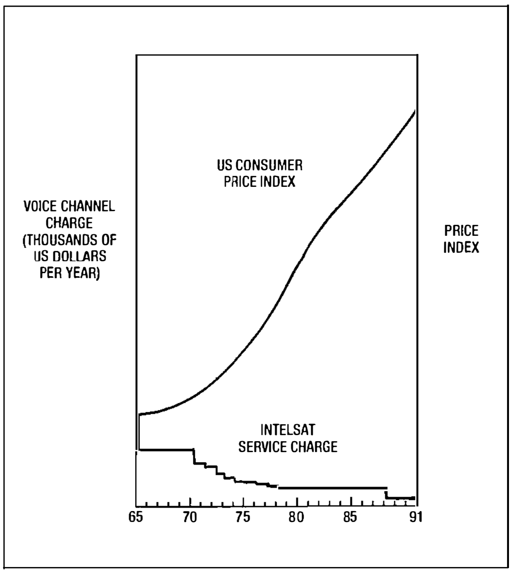


Figure 2—INTELSAT productivity

Space telecommunications technology has made global communications easier by bringing the means of access closer to the user. Microterminals 1 m, or less, in diameter transmit financial, news, point-of-sale, and other data around the world.

Small transportable satellite-news-gathering terminals are routinely clustered at the site of major news or sporting events for broadcast of these events, as they happen, to global audiences that easily can number in the billions. New developments in space-telecommunications technology are making it possible for an individual to be in constant touch with the rest of the world no matter where the person is—in a car, a ship, a plane, a jungle, or on the top of a mountain.

REGIONAL SYSTEMS: COMPLEMENTARY TO THE INTELSAT GLOBAL NETWORK

Easy access to communications facilities that are cost-effective and indifferent to both distance and geography have stimulated the implementation of domestic and regional networks. INTELSAT provided its first domestic satellite offering almost twenty years ago to a member nation that has continued the service to this day. Several domestic INTELSAT networks, in turn, are evolving into multipurpose regional systems. In December 1991, INTELSAT's Board of Governors authorised proposals for implementation of two major regional communications networks in the INTELSAT system. The first of these networks, the ASETA project, will provide domestic and regional communications for the Andean countries of Bolivia, Colombia, Ecuador, Peru, and Venezuela. Most of these nations already use the INTELSAT system for domestic services (see Figure 3). The second network, the Regional African Satellite Communications (RASCOM) project, would consolidate INTELSAT capacity already used by African nations for domestic services and expand such use for a mixture of domestic and regional services.

Consolidation and incremental growth of domestic and regional networks via INTELSAT, such as contemplated by ASETA and RASCOM, is a practical and economic alternative and results in more efficient use of orbital resources.

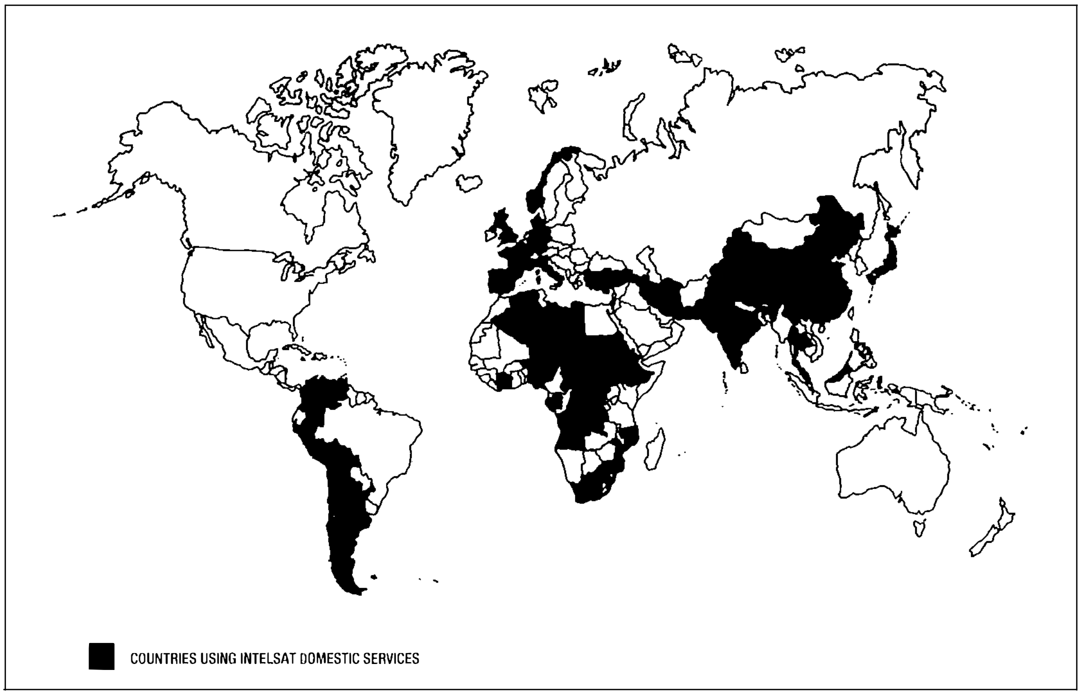
NEW AND EXPANDING APPLICATIONS

The combination of easy-access higher-powered satellites, the expanding use of microterminals, and low costs will enhance the role that space telecommunications and INTELSAT play in extending services to rural and remote areas. Both satellite and earth-station technology are making it possible to offer a wider range of services for thin-route communications to rural and isolated areas. INTELSAT anticipates that satellites will become a major source for provision of these kinds of services. Thus, they are a service area where INTELSAT anticipates significant growth in the future.

Space telecommunications has also played an important role in disaster and peace-keeping operations. Because the technology continues to make access to space communications links easier, the role played by space telecommunications in disaster and peace-keeping operations will expand in the years to come.

INTELSAT has provided leased capacity for telecommunications service to the United Nations since 1983 for peace-keeping, emergency/disaster relief and security of UN personnel. INTELSAT also provided emergency services after the 1988 Armenian earthquake, the 1990 earthquake in Iran, and the 1991 flooding

Figure 3
Domestic users on the INTELSAT system



disaster in Bangladesh. In these instances, transportable earth stations were flown to the devastated areas so that vital communications links could be established with the outside world.

Future technology trends in space telecommunications are in the direction of smaller earth stations and more powerful satellites. The use of smaller earth stations within INTELSAT continues to proliferate and is very much a part of the system today. Spurred by technological breakthroughs that have reduced costs and increased portability, VSATs and microterminals have become accessible to an increasingly wide range of INTELSAT users. The future only promises smaller and more sophisticated terminals accommodating virtually any application imaginable.

PROMISES OF THE FUTURE: FLEXIBILITY, UBIQUITY AND LOW COSTS

The services and technology of today hold the seeds of promise of what is to come tomorrow. Significant progress has already occurred in the field of personal communications systems. The technology is in place for telephone calls directly to a person as that individual walks down the street, commutes to work, or dines in a restaurant. Global data networks for financial, industrial, and research information are in place that transmit information around the world in seconds, oblivious to national boundaries.

Future space telecommunications technology trends are focussed on enhancing the ability to communicate anywhere, to anyone, at anytime at lower costs. INTELSAT is examining several advanced technologies for incorporation on future spacecraft conducive to this goal. One of these is ion propulsion—an electric as opposed to chemical method to manoeuvre satellites. The use of this technology would conserve spacecraft mass, enable greater concentration on communications packages, and extend spacecraft life.

Another application is more on-board processing. Greater use of on-board processing will enhance flexibility and connectivity and help achieve a cheaper ground segment and higher overall capacity.

LOW EARTH ORBIT SATELLITES (LEO) AND INTER-SATELLITE LINKS

Another technology that may enhance flexibility and connectivity is the use of inter-satellite links. This has some application for satellites in geostationary orbit, but it has more interesting applications for satellites in low earth orbit or for linking satellites in low earth orbit and those in geostationary orbit. INTELSAT is looking at augmenting its geostationary satellite system with satellites in low earth orbit. Satellites in low earth orbit accessed at optical frequencies and linked by optical inter-satellite links as a complement to INTELSAT's geostationary satellites can offer interesting options for expanded services; for example, very high bit rate multi-point transmissions. Such optical transmission links could offer many advantages for increasing capacity while eliminating some of the technical limitations of geostationary spacecraft.

CONCLUSION

The time periods between major developments in communications technology and space telecommunications have become increasingly compressed. The International Telecommunication Union had its beginning in 1865. One hundred years later, in 1965, the world's first commercial communications satellite, Early Bird, was launched. Just four years after that, in 1969, the first global satellite communications system was in place. Today, in 1992, we take for granted the fact that we can call virtually anyplace, and that we are participants, via global television, in events around the world.

Developments in space telecommunications have a momentum that has brought more and better communications services to all nations. INTELSAT has played a vital role in this process and plans to continue to play a major role in providing innovative, high-quality cost-effective satellite communications services. The benefits that have flowed from space telecommunications have exceeded the expectations of even the most optimistic of communications prognosticators. Achievements in this field augur well for a sustained and enhanced contribution to global society in the future.

Journal Awards for Volume 10

At its third annual congress and dinner held in June, the Institution of British Telecommunications Engineers (IBTE) again honoured authors from *British Telecommunications Engineering*. IBTE President Dr. Alan Rudge presented awards to authors of outstanding articles from Volume 10 (April 1991–January 1992).

The prize for best article this year went to Roger Garrison, Adam Spector and Peter de Groot for their article 'The BT Network Traffic Management System: A Window on the Network' published in the October 1991 special edition on Network Management Systems. The team received a crystal bowl inscribed with the Institution's insignia, and a cash award of £300; each author also received an IBTE crystal paperweight.

The article covers many aspects of network traffic management. In its introduction, it takes the readers' imagination by describing how the subject was first raised by being added to the agenda during an AT&T Conference in 1960, after delegates experienced difficulty in making calls home owing to widespread network problems following Hurricane Donna. It then moves on to describe the features that network traffic management offers, why BT needs it, and how it has been implemented technically, and finally looks at what the future holds.

The reader is constantly brought back from the world of technology into the real world of people, where problems caused by unplanned local radio phone-ins are described, and the need to plan for major events like 'Children in Need' and 'Comic Relief' is considered.

The Board considered it to be an interesting, balanced, well-written article which will appeal to a wide range of *Journal* readers, and therefore very deserving of the award for 'Best Journal Article' of Volume 10.

Runners-up

This year, three runner-up prizes were awarded comprising cash awards of £100 for each article, together with an IBTE crystal paperweight for each contributing author.

The first was to Keith Oakley, Ray Guyon and Jeff Stern for their article 'Fibre in the Access network' published in the April 1991 special edition on the Access Network.

The local network is the lynch pin of future development both in relation to new products and services and in the drive for improved quality of service. It is therefore particularly appropriate that this article discusses how BT can develop its local network in a cost-effective manner utilising the benefits of research and technology to maintain its competitive edge.

The article is well constructed, beginning with an explanation of the early methods of fibre usage and exploring the progress made through to the present-day developments which will ensure that the introduction of fibre into the local loop is a reality. This highly-readable and clear article achieves that fine balance of depth and readability providing for the needs of both the technical reader and those who wish only for a 'where are we now' update.

The second runner-up prize was awarded to Peter Robins and Jim Liness for their article 'Heathrow Airport Optical-Fibre Network' published in the July 1991 edition.

The authors describe how a customer's need for improved communications led to the installation of an optical-fibre network at Heathrow Airport. This informative and well-structured piece gives readers an insight into how BT is serving a customer by providing a secure, cost-effective, minimal-maintenance solution. The activities are clearly documented and cover all aspects of BT's involvement from the initial requirement through to the delivery of a flexible network with a manageable future evolution. The article describes how new technologies are being used to complement existing equipment instead of replacing it completely.

Dr. Alan Rudge with recipients of the prize for best *Journal* article from Volume 10 (Left to right: Roger Garrison, Peter de Groot, Alan Rudge and Adam Spector)

Finally, Geoff Clark and Alan Bealing were awarded a runner-up prize for their article 'BT's Energy Use'.

In the light of increasing global concern about the conservation of the world's resources, this article gives a timely review of BT's energy management activity. It provides the layman with a comprehensive, but easily understood, analysis of the ways in which BT uses energy in its day-to-day operations, and highlights the many steps that can and are being taken to conserve energy and hence minimise the effect of BT's operations on the environment.

The *Journal* Award Scheme was introduced by the Board of Editors in 1990 to encourage readers in furthering the role of the *Journal*, and to give authors due recognition for an outstanding contribution. Prizes are awarded to the authors of articles which, in the opinion of the Board, demonstrate excellence in content and presentation and which enhance the quality and range of contributions published. Each year a prize is awarded for the best article published in a complete volume, together with a number of prizes for runners-up.

BT News

High Scores for Customer Satisfaction as BT Quality of Service Continues to Improve

BT's new-style Quality of Service Report, published in May, provides more information than previously, reflecting improvements made in measuring and targeting customer service performance, and BT's commitment to continuous improvement. More comprehensive customer-focused performance measures are used in the new report, measuring average performance over the past six months. Customer satisfaction results are included for the first time.

The report shows that using the new, more comprehensive measures, fewer than one call in 250 fails to get through because of faults or congestion on the BT network. The corresponding figure for the same period a year ago was one call in 120.

Continuing overall improvement, with surveys finding 85% of business customers and 87% of residential customers expressing satisfaction with the company's service, is demonstrated in the report. Investment in modern systems and preventive maintenance have continued to boost service to BT's customers. The trunk network is now completely digital and local exchange modernisation continues with, on average, 38 000 customer lines transferred from mechanical to digital exchanges each week.

For the period of the report, more than 99·7% of local calls and 99·6 of national calls were connected first time. Other results in the report include:

- For business customers, more than 92% of orders were completed by the date agreed with customers, while for residential customers, BT achieved over 96%.
- 85% of residential customers' faults were cleared within nine working hours or with successful appointments.
- For business customers, 87% of faults were cleared within five working hours or by successful appointment.
- More than 96% of private circuits were installed in standard lead time or by dates arranged with customers.
- 93% of calls to BT's Directory Assistance Service (192) and 94% of calls to BT's Operator Assistance Service (100) were answered within 15 seconds.
- More than 96% of public payphones were working at any one time.

Michael Hepher, BT's Group Managing Director, said: 'This is a better overall performance than we achieved during the corresponding period a year ago, and we are determined to go on improving the general level of service to all our customers.'

BT Expands Global Network Services Coverage and Announces New, Faster Data Service

BT has unveiled a multi-million pound investment programme for its Global Network Services (GNS). The programme includes a substantial geographical expansion of the services and the introduction of new high-speed frame relay connections for data applications such as the interconnection of local area computer networks.

By 1994, it is planned to more than double the number of countries in which GNS is fully managed by BT, from 23 to more than 60. The geographical expansion will cover all regions and, in particular, concentrate on Europe (including Eastern Europe) and Asia Pacific over the next year.

The new high-speed frame-relay connections will allow customers to transmit data at rates up to 2 Mbit/s. BT already offers a 56/64 kbit/s transatlantic frame-relay service—the first company to do so—and plans to make the new high-speed service widely available throughout Europe, Asia Pacific and North America. The service will be tested in the third quarter of this year with the intention of providing a commercial service by the end of the year.

The GNS expansion programme will give BT a significant advantage over its competitors. GNS will now provide customers with direct access to the widest range of data services in the largest number of countries.

The announcement puts BT in a good position to address multinational customer requirements for high-bandwidth services and expanded geographic coverage in key markets such as Europe and the Asia Pacific well in advance of US carriers which are now establishing their initial networks in their regions.

The expansion of BT's network is in direct response to customer requirements for increased global connectivity and the need for bandwidth on demand services—all from a single service provider. This expansion is an important step in meeting these requirements and is in line with BT's strategic drive to become the world's leading telecommunications group.

A Better Bill from BT

BT has unveiled a completely redesigned bill that will go out to customers in the Autumn. Setting all the information out in clearer, simpler terms, the bill is designed to be much more easily understood and reduce confusion about charges.

Confusion about the content of a bill is the single most common reason why customers contact BT. Often the problem is caused by a simple misunderstanding of the information given.

BT has undertaken a great deal of research with customers as to how the information could be better presented, and the new design is the result. BT sends out 100 million bills a year, and the redesign has been a massive operation. Including the extensive market research with customers, the project has lasted two years, drawing in people from all parts of BT's organisation.

BT and IBM UK Lead the way in PC Videoconferencing

At a recent press briefing, BT Visual and Broadcast Services (BTVBS) demonstrated technology that will enable people to see, speak and work with each other through their PCs. The technology, which uses BT's integrated services digital network (ISDN), is designed to operate in conjunction with software from IBM for its PC and PS/2 computers.

Steve Maine, Director of BTVBS, speaking at the press conference, at which BT demonstrated its complete portfolio of visual services, said: 'The main benefits to users will be faster decision making, speedier and more efficient use of scarce human skills, cost and time savings from reduced travel and improved corporate communications.'

BT's PC videophone hardware working along with IBM software will dramatically enhance all forms of desktop interworking, including personal videoconferencing, file transfer and access to remote databases.

The applications will operate using BT's ISDN 2 service. At the moment, potentially 86% of UK businesses have access to ISDN 2 through over 4000 modern telephone exchanges.

These developments open up a whole range of opportunities to improve corporate management. Some of the areas that will be affected are: senior management conferences, remote expertise access, project management support, customer support, staff training, teleworking and multimedia information services.

BT envisages that the early users will be existing 'information intensive' PC users, working with medium- to large-sized companies, their customers and suppliers.

BT's new PC-based videophone, due to be available from the beginning of 1993, is set to revolutionise business communication in the next decade

The technology uses the recently agreed international set of standards (ratified by the CCITT and known as the *H.320 series*), which cover H.261 video compression, with synchronised voice and simultaneous information transfer over one or more ISDN channels.

The development advances prototyping and research work, using industry standard workstations, as exhibited by IBM at the Telecom 91 exhibition in Geneva.

Standards have paved the way for rapid growth in this market. IBM's Networking Strategy Manager Chris Frost said: 'Early work completed by IBM's Hursley laboratory and by BT at Martlesham, together with the openness and accessibility of the UK's modern digital public network, makes this an area in which the UK may well lead the world.'

The two companies plan to publish, at an early date, specifications and application programming interfaces (APIs) so that engineering directions are fully open, thus permitting other manufacturers and network providers to work to the same standards and allow users to connect equipment manufactured by different companies.

Other visual products which were on display at the event included roll-about and desk-top videoconferencing units, and digital and analogue videotelephones.

Eastern Promise from BT

Businesses in Britain aiming to win custom in Eastern Europe without large-scale investment can now call on BT's International 0800 service. Three key destinations, Czechoslovakia, Poland and eastern Germany, have been introduced.

International 0800 services link UK firms to all our major trading partners. And the list of countries is growing. In addition to the Eastern European countries, other newcomers are Cyprus, Thailand and Taiwan. BT is now the world's second largest supplier of international freephone services with 41 countries on offer.

By using existing telephone lines, an International 0800 number allows overseas customers to call the UK direct for free or at local call rates. The service can also be linked to a fax machine so customers can fax their orders free of charge.

BT Expands Scope of Messaging Services

At the European Electronic Messaging Association conference in Paris recently, BT announced the expansion of BT Messaging Services into the UK and Continental Europe. This is the latest stage in a programme of enhancement and consolidation of BT's electronic messaging services around the world and gives users a portfolio of services which improve the speed, efficiency and effectiveness of their business processes.

BT Messaging Services, which are delivered over BT's Global Network Services (GNS), were launched in the US in September 1991.

Martha Hanlon, Director, Applications Services, explained: 'The emergence of a global economy means that businesses need to communicate on a worldwide basis, often between dissimilar electronic messaging systems. BT Messaging Services now provides companies throughout the world with a one-stop-shop for all their messaging requirements.'

Notes and Comments

INCREASE IN SUBSCRIPTION RATES

The price of the *Journal* to employees of BT will be increased to £9·00 per annum (£2·25 per copy) from October 1992. Members of the IBTE should also note that the membership subscription will be increased to £16.20 per annum to reflect the increase in price of the *Journal*.

CONTRIBUTIONS TO THE JOURNAL

Contributions of articles to the *Journal* are always welcome. Anyone who feels that he or she could contribute an article (either short or long) on a telecommunications engineering topic is invited to contact the Managing Editor at the address given below. Guidance notes for authors are available and these will be sent on request.

NOTIFICATION OF CHANGES OF ADDRESS

IBTE Members and *Journal* subscribers who change their address should ensure that they notify the *Journal* office on the address-label slip provided with every copy of the *Journal*.

All enquiries related to distribution of the *Journal* should be directed to the IBTE Administration Office (see below).

BTE JOURNAL/IBTE ADMINISTRATION OFFICE

All correspondence and enquiries relating to editorial matters ('letters to the editor', submissions of articles, requests for authors' guidance notes etc.) and distribution of the *Journal* should be sent to: *BTE Journal* Editorial Office/IBTE Administration Office, Post Point G012, 2–12 Gresham Street, London EC2V 7AG. (Telephone: 071–356 8050. Fax: 071–356 7942.)

THE INSTITUTION OF BRITISH TELECOMMUNICATIONS ENGINEERS

(Founded as the Institution of Post Office Electrical Engineers in 1906)

RETIRED MEMBERS

The following Members have retained their membership of the Institution under Rules 11 and 16.

Members wishing to contact retired colleagues should write to the Administration Office, Post Point G012, 2–12 Gresham Street, London EC2V 7AG.

Bushell, A J
Caves, D T
Dookie, R J
Dudley, L J
Hotchkiss, D V
Jackson, R
Jenks, A W
Leakey, D M
Lowder, W D
Medcraft, D W F
Murray, R
Palmer, D
Rogers, T G
Smith, G
Spicer, F V
Wall, H J B
Young, J W A

DECEASED MEMBERS

It is with regret that we report the death of the following Members:

Alcock, H
Baker, A C
Bryan, G A
Cave, K H
Clayton, A D
Coulstick, E A R
Crouch, P W
Farrell, B P
Feather, F F
Forbes, P S F
Goodship, D
Haley, G
Lowenhek, J N R
Llewellyn, R A
McFarlane, H A
Meed, B L
Mitchell, J S D
Preston, A G
Rendle, F R
Root, J M
Rossiter, G E
Vranch, L
Willis, R C

IBTE LOCAL-CENTRE CONTACTS

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.

Centre	*Local Secretary*	*Membership Secretary*
Aberdeen	Jim Martin (0224 752688)	George Cameron (0224 752857)
Bletchley/South Midlands	Jim Coley (0234 274840)	Keith Sanford (0234 274043)
East Anglia	Terry Birdseye (0702 373330)	Keith Phillips (0206 717244)
East Midlands	Dave Bostrom (0533 534212)	Ian Bethell (0602 478587)
Lancs & Cumbria	Trevor Hughes (0706 40840)	John Nicholson (0254 666237)
Liverpool	David Bowe (051–229 3723)	Clive Maude (051–229 4074)
London	Mike Burgess (071–587 8147)	Peter Martin (081–456 6007)
Manchester	John Halton (061–200 9216)	
Martlesham Heath	Kevin Rose (0473 647534)	Ian Gilbert (0473 645500)
North Downs	Nick Smith (0227 474823)	
North East	Pete Barrett (091–222 2304)	
North Wales & Marches	Peter Clay (0743 274205)	
Northern Ireland	David Elliott (0232 240353)	
Scotland East	Graham Neilson (031–668 5878)	Alan Dickson (031–345 5011)
Severnside	Ian Davis (0272 206701)	Dean Shephard (0272 206457)
South Downs	Graham Lindsay (0273 222234)	
South Wales	Peter Coleman (0222 691622)	Keith Voyce (0443 480033)
Staffordshire	Ray Piper (0785 813483)	Paul Field (0785 762419)
Thames Valley	Stephen Graham (0252 337104)	Dave Prout (0734 501244)
West Midlands	Gary Chattaway (0203 228396)	Paul Jervis (021–233 8162)
West Scotland	Graham Wellby (041–220 3997)	Jill Maxwell (041–220 5837)
Westward	Rob Rand (0392 212681)	Chris Gould (0392 212663)
Yorks & Lincs	Steve Wood (0532 378316)	Paul Horncastle (0532 376548)

BRITISH TELECOMMUNICATIONS ENGINEERING

BACK ISSUES

Back issues of *British Telecommunications Engineering* are available. The following is a list of the contents of recent issues. Issues from July 1991 include instalments of *Telecommunications Engineering: A Structured Information Programme*. An application form is printed overleaf.

April 1992: Special Issue on Managed Recorded Information Services

Foreword by Andy Green and Alan Rudge
The Need for BT's Managed Recorded Information Services
Managed Recorded Information Services—An Overview
Sourcing Voice Services
  Voice Services Equipment, Auxiliary Switch and Voice Applications
RIDE: Recorded Information Distribution Equipment
Opinion Poll Registration Application
Managed Recorded Information Services—Control and Management
Managed Recorded Information Services—Project Planning and Installation
Managed Recorded Information Services—Customer Interface Processes
Managed Recorded Information Services—Network Operations
Successes and Future of Managed Recorded Information Services

***Structured Information Programme*:**
Telecommunications Markets
An Introduction to Transmission
Quality of Service and Network Performance

January 1992

Guest Editorial by John Ziemniak
The Global Challenge: BT People Overseas
The Haves and Have Nots of the Information Age
Programme and Project Management in BT
Development of the National Code Change
Implementing the National Code Change
BT Energy Overview
BT's Energy Use
Keeping Account of BT's Energy Use by Means of a Personal Computer
Beyond the Second-Generation Mobile Radio Systems
Skyphone
Adaptive Quality Management Systems

***Structured Information Programme*:**
Telecommunications and the World Economy (Reading List)
An Introduction to Process Management
Switching Principles
International Networks
Customer Premises Equipment

October 1991: Special Issue on Network Management Systems

Foreword by Chris Earnshaw
Network Management Systems: Introductory Overview
Cooperative Management: The Key to Managing Customer Networks
Service Management Systems
Switch Management: The Operations and Maintenance Centre
Transmission Surveillance in BT Worldwide Networks
Work Management System
Local Access Network Management
Alarm Management
The BT Network Traffic Management System: A Window on the Network
Data and Configuration Management
Performance Assessment Tools
Network Test Management Systems
National Charging Database
Network Management Workstation
Electronic Document Retrieval System
Network Management for RACE
Future Challenges for Network Management
30th European Telecommunications Congress

***Structured Information Programme*:**
Signalling in Telecommunications Networks
Basic Network Planning
Telecommunications Regulation in the UK

July 1991:

The New CCITT Synchronous Digital Hierarchy: Introduction and Overview
SDH Multiplexing Concepts and Methods
Defining Network Architecture for SDH
Equipment for SDH Networks
Managing SDH Network Flexibility
Meridian Norstar Keysystem
A 29 GHz Radio System for Video Transmission
Delay and Echo Control in Third-Generation Mobile Systems
Heathrow Airport Optical-Fibre Network
Distribution Networks in France

***Structured Information Programme*:**
Telecommunications and the World Economy
Network Structure
Why Standards and Architectures?

April 1991: Special Issue on the Access Network

A Personal View of the Local Loop over 30 Years
Planning the Access Network in a Changing Environment
External Engineering
Digging up the Roads—Providing BT's Duct Network
Exploiting the Copper Network
Radio in the Access Network
Fibre in the Access Network
The United Kingdom Trial of Fibre in the Loop
Local Network Resource Plan—The Introduction of Total Quality in the Local Access Network
Towards a Hassle-Free Access Network
Keeping the Records Straight
Automated Line Testing for the BT Repair Service

Continued overleaf...

Practical Network Planning—A Day in the Life of a Local Line Planner
Deployment of Optical Fibre into Subscriber Networks in Japan
Deutsche Bundespost Telekom Network: Current and Future Requirements for Copper and Optical-Fibre Cables

January 1991

ServiceDesk—A Help Desk Support System
Electronic Trading: The Development of Electronic Data Interchange Services for British Telecom
Management of Information Technology Services
ISDN for the 1990s
A Multiplex Solution for Initial ISDN Provision
Telecommunications Engineering Staff College
Future Directions in Long-Haul Optical-Fibre Systems
Corporate Directory Systems
First Operational System X Permanent Building in the UK
The Modernisation of a Rural Network

October 1990: Special Issue—Network Administration for the 1990s

The Development of Network Administration in British Telecom
A Network Administration Implementation Programme—Its Evolution and Management
Project Management and its Application to the Network Administration Implementation Programme
The Selection of Support Systems for Network Administration
Network Administration Support System Development
The Network Field Unit—Its Role, Definition and Operation
The Practical Issues of Network Operations Unit Piloting
Realising British Telecom's Network Administration Policy in London
Preparation for National Roll-Out of New Network Administration Developments
Future Developments in Network Administration
British Telecom's Worldwide Network Management Centre

August 1990: Extra Issue—Papers from the 1990 FITCE Congress, Glasgow

Meeting Customer Needs in a Changing Environment
Telecommunications Today and Tomorrow: Trends and Opportunities
Modernisation of the London Network
New Telecommunications Services by Means of Increased Intelligence in Networks
A New Regulatory Framework for Telecommunications in the European Community
Private Communication Consultancy Towards the Year 2000
Message Handling Services Offered by the RTT (Belgium)
Video Communications in an ATM IBCN
British Telecom's ISDN Implementation
The ICEberg Project—A Pilot Broadband Network in Ireland
A new Acronym for ISDN: It Suits Diversified Needs
Network Management in a Multi-Supplier Environment
Network Node NK2000—A Controllable Multiplexing and Distribution Facility for Transmission Networks
Operation, Administration and Maintenance of Advanced Services Networks
The Introduction of a Service Switching and Control Point in the Telecom Ireland Network
CCITT Signalling System No. 7—A Test Equipment Manufacturer's Perspective
GECAV—A Computer System for the Maintenance of Submarine Cables
Personal Communications in the Intelligent Network
Mobile Communications: Channel Modelling
Prospects for Personal Communications in France During the 1990s
Personal Communications Services and the Intelligent Network
Vehicle Location in the Netherlands Trunking Network
The New Telecommunications Network: Architecture and Development Criteria
Fibre in the Local Loop
Broadband and Wideband Network Service Provisioning in the 1990s
Deployment Strategy for Transmission Networks Based on the Synchronous Digital Hierarchy
Remote Rural Modernisation in the UK
Satellite Communications Using Very Small Aperture Terminals (VSATs)
SIMNET Simulation System
Network Management of Broadband Networks
FibreWorld Network Architecture
Expert Systems for Customer facing Environments (ESCFE): Improving the Customer Interface

July 1990

Loading the Digital Trunk Network
The Competitive Challenge in World Communications Markets
Voice Processing Systems in British Telecom
Digital Cordless Communications—CT2
CT2 Common Air Interface
The Cashless Services System
Recent Developments in Silicon Design: A BT Viewpoint
Technical Publications
AXE10: Ready to Connect
AXE10: Interworking to Analogue Exchanges

APPLICATION FORM

To:
IBTE Administration Office
Post Point G012
2–12 Gresham Street
London EC2V 7AG

Please supply the following back issues of *British Telecommunications Engineering* (tick appropriate boxes).

☐ April 1992
☐ January 1992
☐ October 1991
☐ July 1991
☐ April 1991
☐ January 1991
☐ October 1990
☐ August 1990
☐ July 1990

Name________________ Address____________________

____

______________________________ Post Code:_______

I enclose a cheque/postal order for £______ payable to 'BTE Journal'. (***Price per copy*** BT employees: £1.20. Companies, libraries, universities and other bodies: £5.75 (UK), £7.00 (overseas). Private individuals (non BT-employees): £4.25 (UK), £5.50 (overseas)).

IBTE SALES ITEMS

The Institution now has a range of special IBTE items for sale. Members wishing to place an order should photocopy this page and on completion send it to the Institution Office located at PP: G012, 2–12 Gresham Street, London EC2V 7AG.

Please supply the following items:

ITEM	COST	QUANTITY	TOTAL COST
Notebooks	£3·50		£
Notebook Refills	£0·30		£
Personal Organiser	£16·50		£
Money Manager	£15·00		£
Key Case	£2·50		£
Credit Card Case	£3·25		£
Silk Tie, Plain Blue Design	£13·50		£
Silk Tie, Blue Chevron Design	£13·50		£
Polyester Tie, Plain Blue Design	£4·00		£
Polyester Tie, Blue Chevron Design	£4·00		£

Name ______________________________

Address ______________________________

____

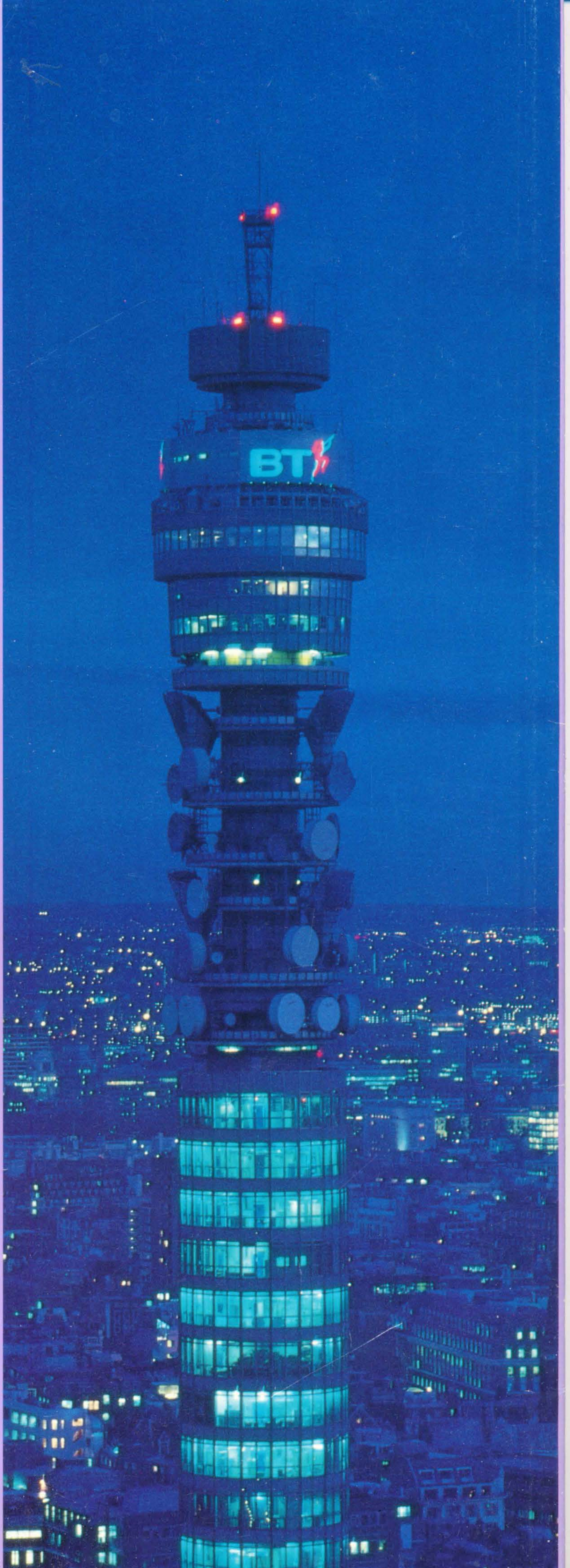
______________Postcode ______________

I enclose a cheque for £____________

(cheques payable to 'IBTE')

Signed ______________________________

VOLUME 11 PART 2 JULY 1992



Contents

The Journal of The Institution of British Telecommunications Engineers