VOLUME 12 PART 1 APRIL 1993

# BRITISH TELECOMMUNICATIONS ENGINEERING


*Marketing Customer Service*

*Offshore Digital Line-of-Sight Radio Service*

*BT's Telex Network*

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*Robotic Testing of Payphones*

The Journal of The Institution of British Telecommunications Engineers

# BRITISH TELECOMMUNICATIONS ENGINEERING

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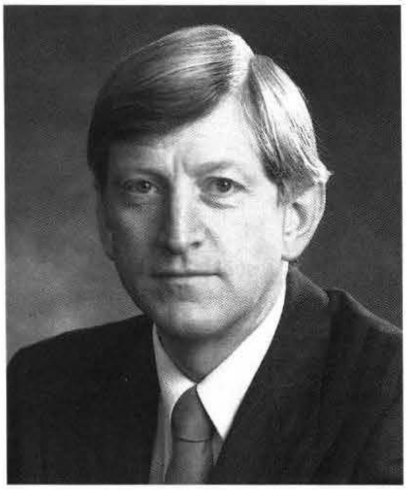
## Regular Features

*Alfie Kane*

# The Engineering Challenge



Technological developments, regulatory changes, competitive threats, a prolonged recession and the ever-increasing expectation of our customers are all factors which have contributed to a sea change in the traditionally stable telecommunications world.

This sea change will continue to pose significant new challenges for telecommunications engineers in the supply industry, in the PTTs and in the telecommunications/IT departments of large businesses. Responding successfully to these challenges will require a major expansion of the well-established skills and experience which have for decades served these engineers very effectively.

The traditional areas of expertise in the past included the copper access network, voice and data switching, transmission, and in-band signalling. In the future, these same engineers will have to master the complexities of optical-fibre access networks, resilient synchronous digital hierarchy (SDH) and asynchronous transfer mode (ATM) networks, intelligent network services, global virtual networks, digital mobile radio systems, and ever more complex billing systems.

But probably most challenging of all will be the development and deployment of computer-based network management systems, operations support systems and service management systems essential to control and exploit the massive potential of this new technology.

Achieving a critical mass of knowledge and expertise in these key areas would be difficult enough in the past traditional stable business environment. However, to do so in a multi-national, multi-vendor, competitive environment with an uncertain regulatory framework will stretch the most able engineers in this dynamic industry.

Success at the end of the day can, of course, only be judged by the key stakeholders: the customers, the shareholders and the employees. And a prerequisite to the achievement of that success will be the ability to meet the requirements of local, national and multi-national customers, first time, every time and at lowest cost. Such will be the challenge facing a total quality, global telecommunications business of the 1990s. Telecommunications engineers have a major role to play in responding to that challenge.

*Alfie Kane*

**Director Operations**
BT Worldwide Networks UK Operations

*Adrian Mahon*

# Marketing Customer Service: the Differentiator for the 1990s

*As competition in telecommunications intensifies into the 1990s, the role of service will take on increasing importance. In particular, this will be the case where price and product offerings tend toward uniformity. BT is well placed to develop a market position based upon service, and this article sets out the key elements of developing a service-based marketing strategy and describes some of the initiatives already under way to understand customers' real service needs.*

## Introduction

There is a theory that by the year 2000, the telecommunications market will be dominated by two or three really-powerful global suppliers, with a number of 'also-rans' fighting for the crumbs. It is not BT's intention to be an 'also-ran' as BT's Vision statement states:

*To become the most successful worldwide telecommunications group.*

But if BT is to be the world's most successful telecommunications supplier, how is it to be done? Companies that hope to survive beyond the millennium will have to create a strong and sustainable position in their chosen markets, and BT is no exception. BT's chosen market position must be capable of withstanding the challenges of not only MCL, Cable and the newly licensed UK network operators, but also the challenge of other operators such as AT&T, NTT and Deutsche Bundespost, which will also be fighting to be the most successful global supplier.

## Establishing a Market Position

So, what is the market position, the high-ground that will differentiate BT from the rest? Differentiating on price is one option, but not a viable, or desirable one in the long-term, since price is so easily copied. BT's price-packaging programme, Options, has shown how MCL's price-based market position can be challenged successfully. BT can certainly differentiate on product offerings by ensuring that it anticipates customers' requirements and is the first to offer solutions that meet these needs. If BT wants to be market leader, then it must invest accordingly in new product and solution development, and bring these to market quickly. This is particularly important as technology lead-times become shorter, given that the new entrants to the market are often coming in on the back of modern technology. But AT&T *et al.* are also investing heavily in new product development, and products will be replicated or leap-frogged quickly.

As price and product become copied more easily, the role of service takes on an increasing significance as a potential differentiator and as a means of securing customer loyalty and repeat business. At the simplest level, a call is a call and, if they are similarly priced, what makes a customer choose one call supplier over another? Ultimately, it will be how the customers are handled and treated as individual customers that will determine their intention to repeat the purchase with the same supplier. We can all recall instances where the service received from a supplier was so delightful that we would never consider going anywhere else. Sadly, or perhaps inevitably, for every such case, there are many more occasions where the service was so abysmal that we would never consider going back again.

## BT's Service Package

BT can create a sustainable and competitive positioning in its markets on a service platform if it gets all components of the service package working in harmony. By service package is meant the whole service offering: from initial pre-contact information, through to post-purchase support, and ongoing use of BT's products and services. It is about the way BT makes it easy for customers to contact them; how BT tells its customers about the portfolio offerings and benefits; how BT delivers, installs and maintains the customer's purchase, be it network based or hardware based; how BT offers a choice in methods of payment and billing facilities; and it is about how customers are kept informed. In the delivery of service, you are as good as your weakest point: one poor component undermines the whole package. It is essential, therefore, to get everything right, first time. But when things do go wrong, and even with the best processes they will, it is also essential that recovery is rapid and any appropriate recompense is made promptly and without quibble.

## Developing a Service Differentiation Strategy

If service is to be used as a point of differentiation upon which BT will pursue its Vision and Mission, then it is essential that:

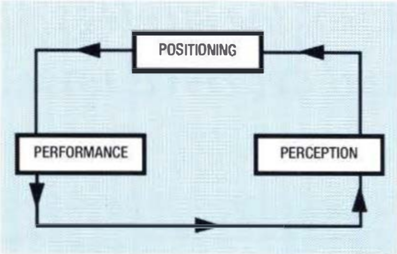



*Figure 1—Position, perception, performance virtuous circle*

- the total service package is clearly defined for customers in each market segment; that is, BT makes a clear statement (a commitment) of what its customers can expect in their dealings with the company (POSITIONING),
- BT delivers upon that commitment consistently (PERFORMANCE).

By delivering on performance, BT will ensure that customers regard BT as <u>the</u> supplier of communications services with which they should do business (PERCEPTION), rather than just another utility to be sourced at minimum cost. BT can then reinforce the virtuous circle of positioning, performance and perception as in the model shown in Figure 1. The positioning, or brand image which BT chooses to pursue will direct the development of the service package such that daily activities and interactions with customers constantly reinforce the positioning and their (customer) perceptions of BT's service *vis-à-vis* other competing suppliers.

In developing a quality service package, it is essential to ensure that the strategy is underpinned by:

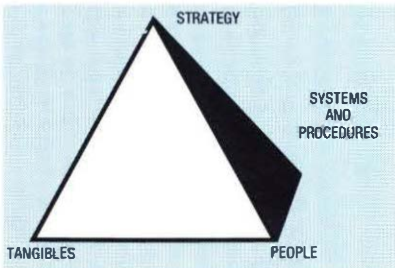
- the TANGIBLE elements; what customers actually receive (for example, fault-free connections),
- the behaviour of PEOPLE; what customers experience in dealing with BT people (for example, professional and helpful responses from named individuals),
- the SYSTEMS and PROCEDURES to ensure that BT delivers a seamless service to customers in the most efficient and effective way which supports BT people in the delivery (see Figure 2).

Weaknesses in any of these key components will leave BT in a vulnerable position when it comes to the race for market supremacy. Just imagine a restaurant which has imported the best chef from France and whose culinary expertise is out of this world. This might be a significant competitive advantage in the restaurant's catchment area. But if, when you go there: the table is not ready for the time you booked; the waiter is surly; the decor is inappropriate; and your order takes an hour to reach the table, you are unlikely to return, even if the food is excellent. You are also likely to tell your friends not to go.

So it is with BT's service package. There is no point in having a superb new fax machine if systems cannot identify which customers are likely to use it, if sales teams do not have the information about it, and if

> Praise has been pouring in for the way BT people responded when an exchange fire in Liverpool destroyed cables and wiped out phone service for 13 000 customers, leaving them without 999 cover.
>
> The city's Lord Mayor, Councillor Rosemary Cooper, visited the exchange in Wavertree when — only a week after the suspected arson attack — virtually all customers had had service restored.
>
> She said: 'There has been a crisis and everyone has pulled together. I have been very impressed. Logistically for BT this must have been a nightmare and to have the whole exchange back on in a week is magnificent. Everyone is to be congratulated. They have done a super job'.
>
> People gave up rest days and postponed courses and extra help was brought in from other areas.[1]

*Figure 2—Key components of the service strategy*



*All the key elements of the strategy must be considered and delivered upon.*

engineers who go out to install it have not been trained to do so or be able to show the customer how it works. All the key elements of the strategy must be considered and delivered upon.

## Developing Market-Driven Customer Service

The starting point in developing a quality market-driven customer service is to understand thoroughly the customers' service requirements and expectations. These will be driven by past experience, personal need and feedback from colleagues, acquaintances and relatives, and will vary by segment. But it is very easy for company managers to assume that they know what their customers want, and to miss the point. For example, many companies, BT included, place great emphasis on speed of response to incoming calls. Unfortunately, speed of response is the only measured target in many such company customer reception centres, and yet all the available market research indicates that this is just one small element in customers' requirements in contact handling.

Attributes of contact handling such as empathy, understanding, courteousness and responsiveness are not targeted or measured and, therefore, not monitored or managed. Consequently, customers sometimes feel that receptionists are abrupt, off-handed, show no consideration for their individual needs and cannot wait to get them off the phone in order to take the next call.

There is often, therefore, a gap between customer expectations and management perceptions of those expectations. Figure 3 shows this gap (Gap 1) in a service model along with other possible gaps[2]:

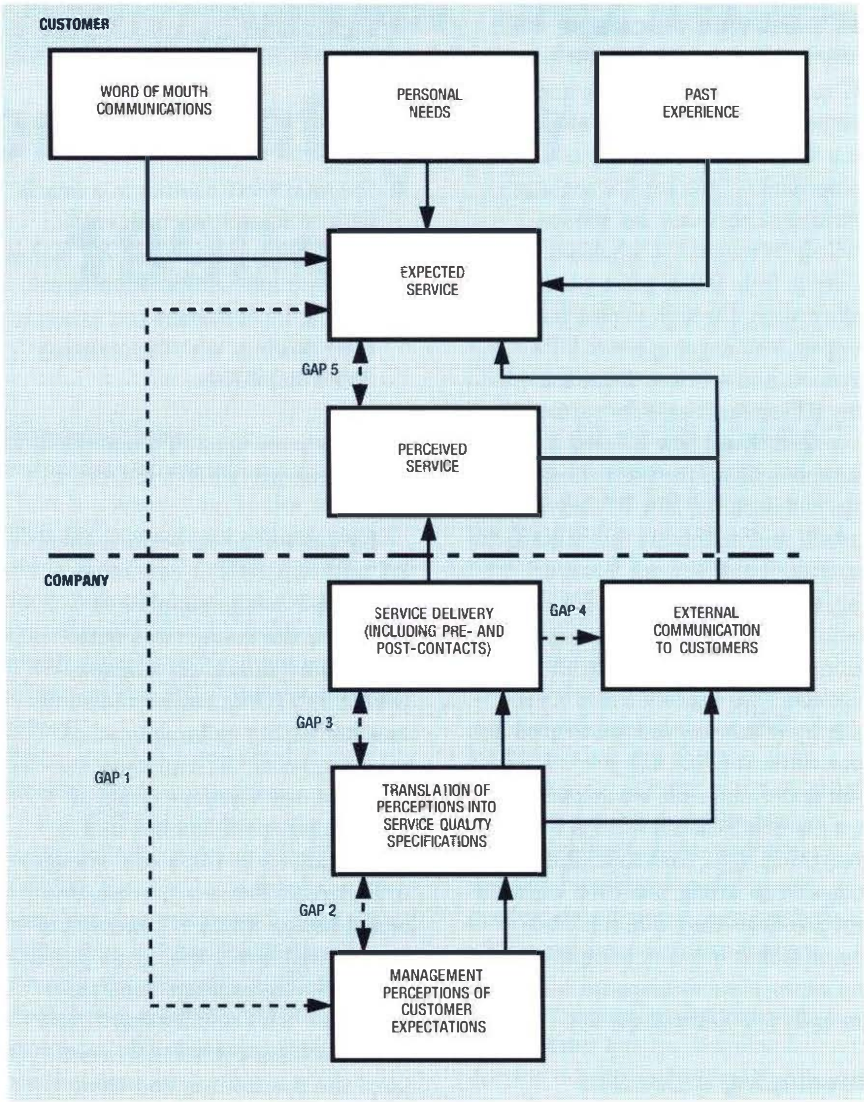



*Figure 3—Service quality model*

Gap 1 Between what customers expect, and what managers perceive them to expect/desire.

Gap 2 Between management's perceptions of what is important, and the specifications and targets set.

Gap 3 Between targets and specification, and what is actually delivered.

Gap 4 Between what communications to customers position the service to be, and what is actually delivered.

Gap 5 Customers' perception of service against what they expected to receive.

It is the job of marketing and customer service management working together to ensure that these gaps do not develop. The aim is deliver to the customers' expectations every time. The classic case study of British Rail's 'We're getting there' campaign demonstrates the point when the gap between what is actually delivered to customers and what they expect is compounded by inappropriate advertising.

## Customer Expectations and Requirements

The work which the team in BT's Business Communications (BC) National Customers Service Marketing unit has undertaken has focused on understanding the real service

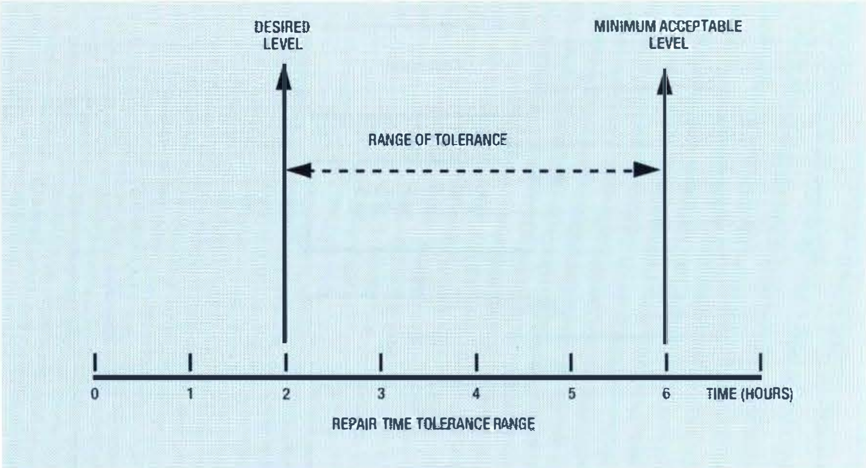



*Figure 4—Repair time tolerance range*

needs of customers and then working with the customer service team to translate these requirements into measures, procedures and targets. The work has identified that customers usually have a range of tolerance about particular service attributes. For example, take repair service: a customer phoning to report a fault might be reasonably satisfied if the fault is repaired in, say, six hours. This would be the minimum level of service they would tolerate. However, what they would really like is for the fault to be fixed in, say, two hours. They therefore have a tolerance range of six hours at the upper level to two hours at the desired level (Figure 4). Service performance then needs to be positioned competitively within this range.

We can all think of our own personal circumstances when this has applied. We might accept the taxi we ordered to be up to five minutes late, although we would prefer it to be on time. We are happy to wait 15 minutes for our table in the restaurant whilst we have a drink in the comfortable bar, but if we are not sat down at the table in half an hour we start to get impatient, and after an hour we are angry.

The service marketing team has identified the key service attributes for customers from an in-depth analysis of all service-related market research over the past few years and, via further research, has established the tolerance ranges for these key attributes. For the more tangible performance-related attributes such as speed of repair and provision, the findings are built into the BT's measurement and targeting system as part of the annual quality plan and budget process. For the less tangible attributes, such as provision of information and contact staff behaviour (sometimes called *soft attributes*), the team has reviewed the regular event-driven customer satisfaction surveys and revised questions or introduced new questions to cover these attributes. Targets are also being introduced for operational managers' handling of these soft attributes.

## Service Delivery Process

In any business environment, products or services are delivered to customers via a sequence of events starting with the customer's buying process, through ordering, collation and despatch to delivery and after-sales service. In a service-based business, the service delivery chain is the heart of the company operation. Success in service delivery will dictate whether or not customers will stay with the company and generate profitable revenue over time.

In tandem with the research-based analysis of customer expectations and requirements, the service marketing team has reviewed BC's service delivery processes to assess how well they match up to the customers' expectations identified from the research. The market research analysis has identified what customers expect at each point in the delivery chain and these requirements are then fed into the procedures and measurements for each stage in the chain.

Figure 5 shows a simplified version of BT's service delivery chain and highlights the various key service encounters along the way. Such service encounters must contribute positively to customer satisfaction and provide a seamless delivery for customers. Each service encounter is a moment-of-truth when customers interface with an element of BT's service process and BT people, and can truly judge commitment to putting the customer first.

Whether it is the initial contact at the Customer Service Centre, or the engineers who call to install the product, or the entry in the Phonebook, or the receipt of the bill, any failure at these critical points will reflect upon the whole process and on whether or not the customer repeat purchases.

Such close relationships between service management and marketing are of what successful service companies are made. In fact, in a service organisation, everyone is a marketeer in that they must live the marketing philosophy of focusing on the customer. Even those people not directly facing customers have to appreciate their role in meeting customers'

Colin Marshall of Hewlett Packard thanked BT teams after his firm's London office move. This involved a complicated removal and reinstallation of a digital switch over a weekend.

He wrote: 'The engineers worked to resolve the problems they had and handed over a fully-working switch.

'I was also pleased to see several of them on site early on the Monday morning to ensure everything was working to my satisfaction'.'

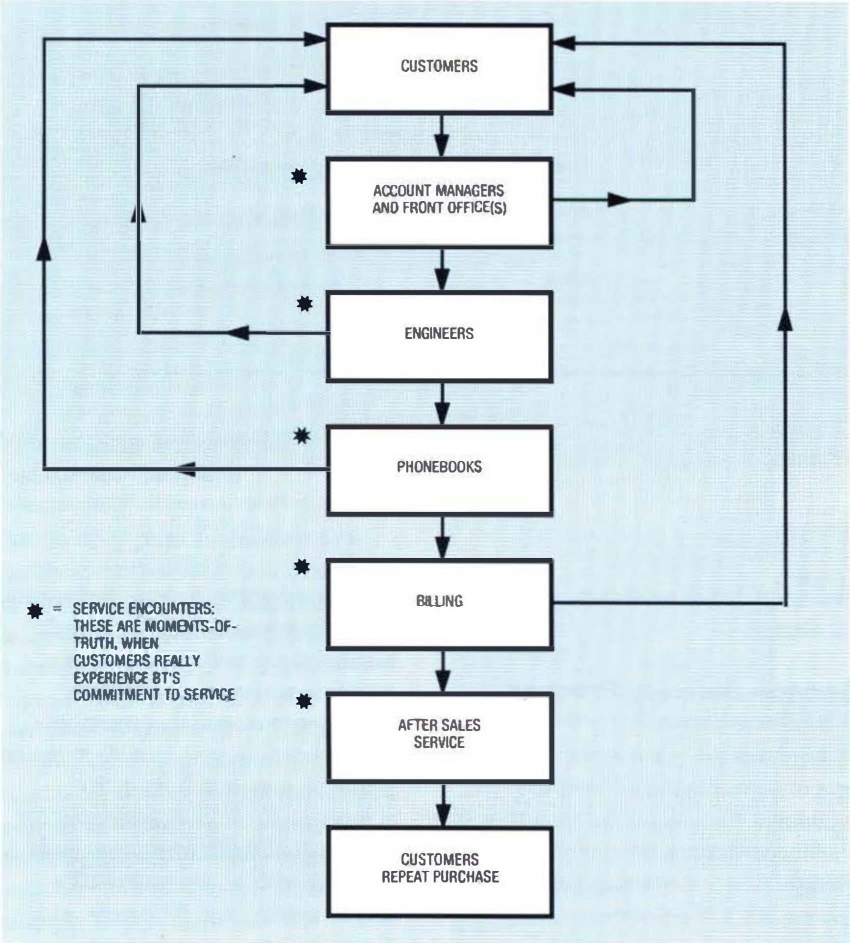



*Figure 5—Simplified service delivery chain*

requirements through the support they provide to those directly in the front-line.

## The Importance of People in Service

No service company can deliver its vision and mission if it ignores the needs of its own people and fails to market to them. Such internal marketing programmes must provide the commercial tools to enable people to handle customers professionally, courteously and with an eye to the opportunity to generate more value to the business. This can be either in retention of existing customer loyalty (which ensures future revenues) or in the identification of new sales opportunities.

The BC service marketing team is leading a number of key internal marketing programmes, not only for BC itself, but also across BT. In the latter case, the Winning Matters programme is being driven on behalf of the Group Managing Director and has included such initiatives as:

- setting up a Group-wide sales lead system and single 0800 number;
- establishing a 0800 hot-line number for competitor intelligence;
- producing briefing leaflets and articles for internal publications; and
- providing a commercial input to key training programmes both at the management level (for example, the Leadership Programme) and at operational level (for example, the Involving Everyone quality programme and engineers' product training).

## Adding Value from Customer Relationships

Within BC, the service marketing team is working closely with customer reception management and sales management to clarify the roles and responsibilities of the respective channels and to provide programmes to enhance the value of the regular contact with customers. And when it is remembered that in BC alone, customers call the 152 enquiry number over one million times every month, then the opportunities to add value are enormous. The team is also providing the catalyst for the development of service-based account management which extends the concept of sales account management into service to create virtual account teams across both functions. This is in response to customers' desires to experience a total integrated approach.

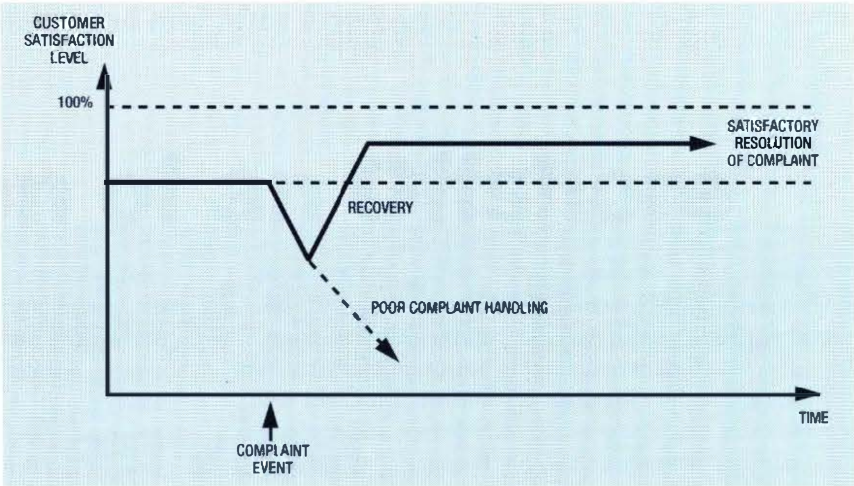
These initiatives will contribute to BT's positioning in the market as a service-based supplier. They will also develop and strengthen BT's relationships with its customers, a critical success factor if the company is to achieve its Vision.

## Recovery

With even the best systems, the best procedures and excellent people, things can go wrong. When they do, it is an opportunity to demonstrate to customers that the company really does put them first by fixing things quickly, professionally and at minimum inconvenience to the customer. If service is BT's key market positioning, then the company must demonstrate this when recovery is required.

Opportunities for service recovery are frequent. Any problem which someone close to the customer identifies and resolves is a chance to go beyond the norm and retain the customer for a long time into the future. Often, petty problems can escalate into Chief Executive correspondence with all the associated costs and recriminations, to say nothing of the lost customer. No business can afford to lose a customer: it takes, on average, five times more to replace a customer than it does to retain one. A complaint quickly resolved can reinforce a customer's positive attitudes towards the company and even push

*Figure 6—Impact of complaint handling on satisfaction*




satisfaction levels above the previous levels. A complaint badly handled can have long-term consequences for the customer's loyalty (Figure 6).

However, few service delivery systems are prepared for dealing with exceptions, and companies do not often allow their people to step outside the procedures to recover a situation. The successful service companies in the future, whether telecommunications or other services, will be those which empower their people to act appropriately when there is a failure, train them and support them in how to do so and recognise initiative when it is applied. The company should listen to its customers to anticipate complaints, facilitate speed of action and let the customer know when their complaint or suggestion has led to a change of procedure or improvement. The company should also measure the costs of failure and recovery. Thorough analysis of complaints is an excellent means of identifying what is going wrong and generating action to resolve such problems before they create dissatisfaction for other customers. The BC service marketing team is working with Customer Service to improve the analysis and reporting of complaints to meet this very objective.

## Learning From Experience

The examples quoted in the highlighted boxes give a good illustration of what service is all about. Be it first-time delivery or recovery, every incident is an opportunity to examine what was right and what was wrong. Companies often have processes in place for failure analysis and take action to put things right. But very few companies pay as much attention to analysis of success so that excellent performance can be used as models to reinforce things done well. Case studies can be used in training and development of customer-facing people which must be both theoretical and practical. Support people too will benefit from exposure to relevant material which reinforces the principles of effective teamwork.

## Conclusion

The role of service is widely recognised as providing excellent opportunities for supplier differentiation, particularly as pricing and product offerings tend towards uniformity. Those companies who want to be key players in their markets into the future will have to identify the role service will play in their market positioning and then communicate and deliver consistently against that positioning.

BT has recognised the vital role of service in the telecommunications market and is already well on the way to developing and delivering a service-based strategy from the work being led by its Business and Personal Customer Service marketing teams.

The strategy requires a wholly integrated approach with all elements of the service package fully considered and configured. This is being underpinned by refocused measurements and targets on operational units, revised operational procedures and supporting, internal marketing programmes.

But in the final analysis, 'the battle for market share will be won, not by analysing demographic trends,

When the City of London was, in April '92, hit by its biggest bomb blast since World War Two, BT swung into action to ensure as many companies as possible could get back to business. Scores of BT people worked round the clock to deal with the effects on telecommunications in one of the world's largest business commercial centres. Where possible, service was restored or diverted but repairs were hampered by loss of power and restricted access, especially near the centre of the explosion in St Mary Axe, where more than 140 companies are located.

Caravans housing telephones and fax facilities were operating in the area by the Monday morning after the Friday night blast, offering free calls for customers. By the end of the day, 800 lines had been diverted and 500 new direct exchange lines and 61 private circuits provided. Customers were then contacted to assess their needs including those forced to move premises.

BT's Croydon Service Centre worked over the weekend to re-direct communications links to Commercial Union's Whyteleafe, Surrey, office. Transfers included Meridian switches, MegaStream circuits and five ISDN 30 integrated services links.

As a result Commercial Union was able to answer more than 95 per cent of its calls by the Monday morning[1].

Consider how Club Med-Cancun, part of the Paris-based Club Mediterranee recovered from a service nightmare and won the loyalty of one group of vacationers.

The vacationers had nothing but trouble getting from New York to their Mexican destination. The flight took off 6 hours late, made 2 unexpected stops and circled for 30 minutes before it could land. Because of all the delays and mishaps, the plane was en route for 10 hours more than planned and ran out of food and drink. It finally arrived at 2 o'clock in the morning, with a landing so rough that oxygen masks and luggage dropped from overhead. By the time the plane pulled up to the gate, the soured passengers were faint with hunger and convinced that their vacation was ruined before it had even started. One lawyer on board was already collecting names and addresses for a class-action lawsuit.

Silvio de Bortoli, the general manager of the Cancun resort and a legend throughout the organisation for his ability to satisfy customers, got word of the horrendous flight and immediately created an antidote. He took half the staff to the airport, where they laid out a table of snacks and drinks and set up a stereo system to play lively music. As the guests filed through the gate, they received personal greetings, help with their bags, a sympathetic ear, and a chauffeured ride to the resort. Waiting for them at Club Med was a lavish banquet, complete with mariachi band and champagne. Moreover the staff had rallied other guests to wait up and greet the newcomers and the partying continued until sunrise. Many guests said it was the most fun they'd had since college.

In the end, the vacationers had a better experience than if their flight from New York had gone like clockwork. Although the company probably couldn't measure it, Club Mediterranee won market share that night.[3]

ratings points and other global measures, but rather by pleasing customers one at a time'[3]. This is the challenge for companies in the nineties and beyond.

## References


1 *BT Today*. Extracts from various issues.

2 Berry, L.L., Parasuraman, A., and Zeithamal, V. A. Delivering Quality Service: balancing customer perceptions and expectations. Free Press, 1990, p. 46.

3 Hart, C.W.L., Heskett, J.L., and Sasser Jr., W.E. The Profitable Art of Service Recovery. *Harvard Business Review*, Jul.–Aug. 1990. (This is an excellent article on service recovery and is highly recommended.)


## Biography


**Adrian Mahon**
BT Business Communications


Adrian Mahon is Manager, Customer Service Development, in BC's National Customers Marketing Division. He joined BT as District Marketing Manager in Manchester in 1985 following 12 years experience in sales and marketing in fast-moving consumer goods and the automotive after-sales business. In 1989, he took responsibility for Business and Residential sales operations in the District before moving to Headquarters as BC's Marketing Operations Manager at the Sovereign reorganisation. He took up his current role in July 1992. He has an honours degree in Economics from Manchester University and a Masters Degree in Business Administration from Warwick University.

*David Elliott and Mike Freeman*

# Provision of an Offshore Digital Line-of-Sight Radio Service

*This article details some of the technical aspects associated with a BT contract to provide communications to two offshore gas platforms, situated approximately 64 km off the Lincolnshire coast. It details the factors leading to the decision to use digital line-of-sight radio, and outlines some of the technical complexities associated with the service implementation.*

## Introduction

During 1990, the Offshore Services team of British Telecommunications plc (BT) was approached by ARCO British Ltd, an offshore hydrocarbons operator, to provide high-speed digital communications to two new offshore gas platforms planned to operate off the Lincolnshire coast. The Offshore Services team is a specialist unit within BT's Worldwide Networks which was set up to provide and operate customised telecommunications services for the hydrocarbon industry. In this case, the two new platforms under consideration were to be situated in the Pickerill field, approximately 64 km due east of the Humber estuary, and would be used to collect and pump gas from the surrounding fields to reception facilities situated at Theddlethorpe, Lincolnshire.

A notable feature of these platforms was that they were to be operated on a 'not-normally-manned' basis. This was of significance since UK legislation and customer strategy constrained both the number of people working offshore and the telecommunications facilities provided on the platforms. The Cullen report, which followed the Piper Alpha offshore explosion in July 1988 (with the loss of 167 people including three BT personnel), sought to reduce the risk of a similar incident occurring again by emphasising the need for good telecommunications systems and reliable remote-control and monitoring facilities.

Consequently, ARCO had digital communications requirements which were in excess of those currently operational in the North Sea. This article summarises some of the options considered to meet ARCO's requirements, the factors leading to a BT contract to provide a digital line-of-sight radio service, and some of the technical considerations associated with the design and subsequent service implementation.

## Customer Requirements

### Network requirements

Figure 1 illustrates a schematic of the customer's operational network. The principal nodes on this network are the Pickerill A and B offshore platforms, the Viking Gas terminal at Theddlethorpe and the ARCO control centre at Great Yarmouth. Gas is pumped from the offshore platforms to the Viking Gas terminal where the pipeline terminates and the gas is processed. Management of the pumping operation is controlled from the ARCO control centre at Great Yarmouth.

ARCO's requirements were for a minimum of one 2 Mbit/s communications link to be provided between its onshore communications control point at Great Yarmouth and each of the Pickerill A and B offshore platforms. In addition, a low-speed data link was required to the Viking gas terminal at Mablethorpe for monitoring purposes. A separate 13 GHz digital radio system interlinking the Pickerill A and B platforms (spaced approximately 6 km apart) would be provided by ARCO.

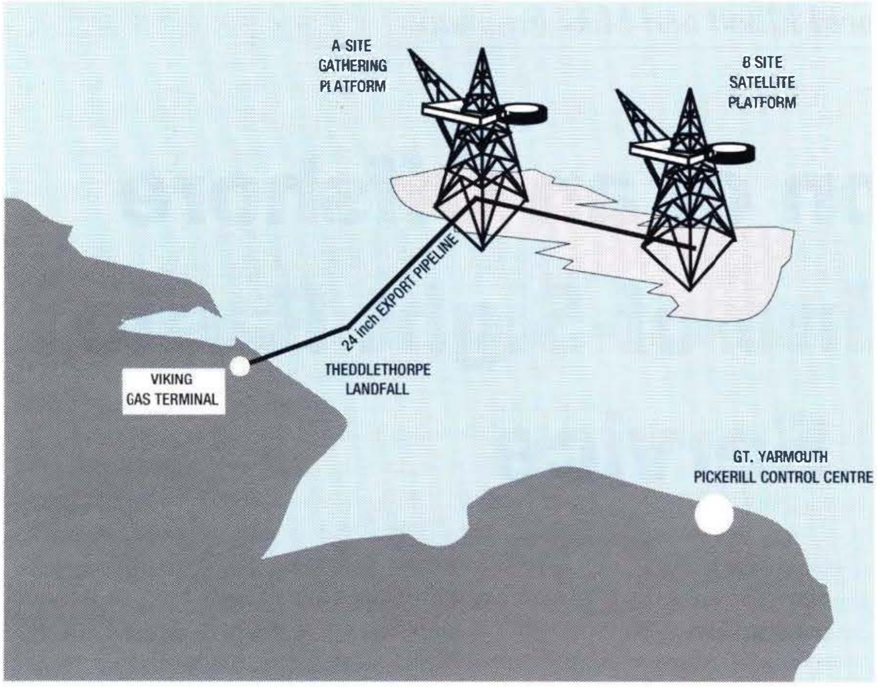



*Figure 1—Network schematic*

An important requirement from the customer's standpoint was the ease with which the system could be expanded to support additional voice and data traffic requirements. It was also essential that the service solution should be capable of supporting third-party traffic so as to provide communications to neighbouring gas fields via line-of-sight radio extensions. The two platforms were expected to commence operations in mid- and late-92 respectively, and the telecommunications facilities were a prerequisite before pumping operations could commence.

### Service availability

For the reasons outlined above, a high end-to-end service availability was essential. The customer's requirement was for a minimum availability of at least 99·9% of the time. This was to include all sources of failure including hardware failures and backhaul failures, as well as the propagation characteristics of the transmission system and the repair times of the not-normally-manned equipment on BT's onshore premises. This availability equates to a service downtime of not more than 8·8 hours per year.

BT was also required to assess the implications of meeting an upper design target for the end-to-end service. This was to achieve an end-to-end availability of better than 99·99% of the time, and equates to a service downtime, from all sources, of not more than 53 minutes per year. This is an extremely demanding target particularly when considering the not-normally-manned status of the onshore equipment and the target availability criterion of a single BT landlink (99·85% of the month).

## Technical Options

When considering this service requirement, consideration was given to four different types of transmission system; namely, optical-fibre cable, digital troposcatter, digital satellite and digital line-of-sight radio. The relative merits of these are briefly summarised below.

### Optical-fibre cable

The use of an optical-fibre cable system would have had the benefits of accommodating large network capacities (for example, 34 or 140 Mbit/s) and providing a simple means of network expansion. Optical-fibre systems are also well known for the very high performance they can provide. However, because of the stringent availability criteria, and the risk of damage to the cable by ships in the North Sea, it would have been necessary in this case to provide either a separately routed cable to both offshore nodes, or an alternative means of restoring service quickly in the event of a failure; for example, by satellite. Further significant drawbacks were the costs and difficulties associated with securing agreements with the operators of neighbouring fields to permit the provision and maintenance of such a system. As a consequence of these difficulties this approach was not adopted.

### Digital troposcatter

Troposcatter is a transmission system commonly employed in the North Sea and remote areas to communicate over distances of several hundred kilometres. The troposphere extends to 8–10 km and is the region where the air is in permanent motion. Radio signals passing through this region are refracted in very small amounts in all directions and permit beyond-the-horizon communications to be carried out when employing large radio antennas (typically 9 m) and sensitive receiving equipment. In recent years digital troposcatter systems have also been developed to permit digital communications at rates of between 2 and 8 Mbit/s, and would have provided the capacities required.

A significant disadvantage of troposcatter systems is the high level of power that is required to be radiated for large proportions of the time. Studies performed with the UK Radio Agency revealed that for the site under consideration, interference to other radio services would be a major problem unless transmissions were in a north–south direction. While potential sites were identified in North Norfolk, the costs of purchasing a new site, together with the high costs of providing digital troposcatter systems meant that this transmission system was commercially less attractive than other options.

### Satellite

Satellite links to offshore platforms are now regularly used by offshore oil operators in the North Sea to provide

*Note*: In accordance with CCITT definitions, unavailability is defined as those periods where a bit error ratio (BER) of 1 in 1000 is exceeded for 10 or more consecutive seconds.

digital communications at rates of between 64 kbit/s and 2 Mbit/s. These links are most commonly provided by means of the satellite multi-services payload on satellites at 7 and 10 degrees East. These satellites are owned and operated by EUTELSAT, the European Satellite Organisation, of which BT is the UK signatory and a major shareholder. BT Offshore Services presently operates two teleports in Scotland to access these satellites for the benefit of the oil industry, at Aberdeen and Mormond Hill, near Fraserburgh. BT also accesses these and other international satellites from its teleports at North Woolwich in London, Goonhilly Downs in Cornwall and Madley in Herefordshire.

Diverse satellite communications links from two of the BT teleports to each of the Pickerill A and B platforms, together with redundant and diversely routed terrestrial backhauls to the customers's premises, could have provided the high end-to-end availabilities required for the service. However, a satellite system would also have introduced certain constraints when attempting to expand the network above the initial requirements. For example, the offshore satellite terminals would have had to be designed from the outset to cater for the maximum traffic requirements, with the associated cost implications. Also, the availability of suitable space segment capacity for network expansion could not be guaranteed without incurring significant recurring costs, or risking significant changes to the operational configuration at a later date. As a consequence of the shortfalls identified, this option was also not selected.

### Digital line-of-sight

The distances from the mainland to the offshore platforms (59 km and 64 km respectively) indicated that a direct line-of-sight radio link to each of the platforms was perhaps feasible, provided that the antennas were raised to sufficient heights to overcome the curvature of the earth and that the system link budget ensured an adequate fade margin. Initial studies indicated that antenna heights of the order of 130 m above sea level onshore and 90 m above sea level offshore would be required, which would necessitate building substantial supporting structures both on and offshore.

An advantage of digital line-of-sight radio was its capability of providing relatively high information rates, for example, 8 Mbit/s, which could meet the customer's requirements for network expansion and third-party traffic. The high availabilities achieved by modern digital radio systems also meant that an end-to-end service availability close to the upper design target was feasible when employing a triangulated radio system offshore and redundant and diversely routed terrestrial backhauls onshore.

A disadvantage of this scheme was the requirement to identify (and obtain planning permission for) a suitable site for the onshore facility. A further drawback was the lack of reliable information on the performance of high-order digital systems on such links over water in the North Sea. Despite the increased technical complexities, it was concluded that this transmission system most closely met ARCO's communications needs and was selected for detailed consideration.

## Radio Link Design Considerations

When designing a line-of-sight radio system, special attention has to be given to a number of factors, including the antenna siting and the radio link budget, to ensure that propagation effects are fully addressed. In the case of links over water, care must be taken with the assumptions made for the refraction of microwaves in the air and the roughness factor assumed for the water surface, since these affect the resultant performance and availability.

### Antenna considerations

BT computer models, developed over many years of engineering design for mainland systems, were used to predict the antenna heights required, given the projected gains, losses and sensitivities of the radio equipment. An important consideration was the 'k-factor' assumed. This is a commonly used term to describe the amount of bending undergone by the microwave beam as it propagates through the medium. In the case of links over inland areas, a figure of 1·33 is typical and denotes a tendency for the microwave to curve towards the earth.

With links over water the atmospheric density can, on occasions, increase with height instead of decrease with height. As a consequence, there is a tendency for microwave links over water to bend away from the earth for certain percentages of the time, and requires antennas to be situated higher than would otherwise be expected to provide a reliable communications path. A k-factor of 0·8 was selected based on BT experience and available CCIR information.

Figure 2 illustrates typical path profiles computed for different antenna heights and k-factors for the Pickerill A link. From these it was concluded that antenna heights of 124 m and 130 m above sea level were required onshore to access the Pickerill A and B platforms respectively, based on an antenna height of 90 m above sea level for the offshore platform. The latter was determined by the maximum practical height considering the available space on the platform for supporting such a structure.

To overcome the affects of multipath fading, whereby changes in the propagation medium cause signal fades in excess of 40 dB to occur, a space diversity radio system was proposed. This is a commonly used technique whereby two receiving antennas are spaced a half wavelength distance apart along the propagation path from the principal

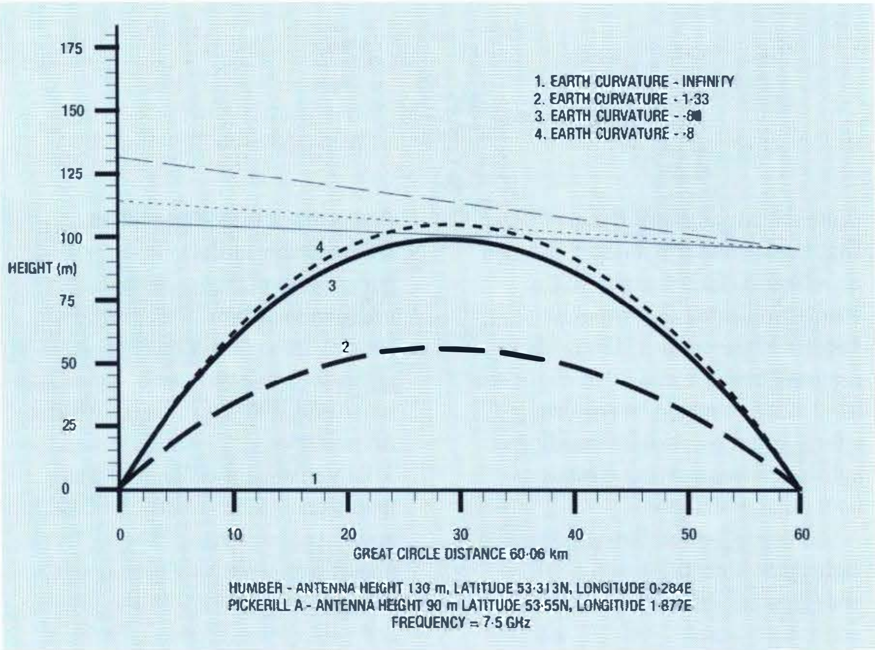



*Figure 2—Path profile for Pickerill A link*

sources of interference; for example, reflections. This increases the probability of a strong signal being received from one of the two antennas under varying atmospheric conditions. Studies concluded that space diversity antennas were required onshore at heights of 114 m and 118 m above sea level for the Pickerill A and B platforms, and at 83·2 m above sea level on the offshore platforms.

### Link budget

To achieve the required quality, consideration had also to be given to the specific characteristics of the link budget, taking into account the gains and losses in the system. This was dependent on the modulation type and frequency, which for this system were proposed to be 8 Mbit/s quadrature phase-shift keying (QPSK) operating at a frequency of 7·5 GHz.

Link calculations carried out using the characteristics of available radio equipment and projected antenna heights, concluded that 3 m antennas with 2 W transmitters would be sufficient to comply with the relevant radio specification, MPT1407, and to ensure that a flat fade margin in excess of 40 dB was provided.

A consideration in the above study was the roughness factor assumed for the surface of the water between the transmitter and receiver. This affects the signal reflected into the receiver, which in turn impacts on the projected performance and availability. Performance predictions for links over water are notoriously unreliable due to the potential presence of strong reflections from the water surface. However, the results of the above study, using a roughness factor of 10 mrad, were sufficient to conclude with a high degree of confidence that the availability in excess of 99·972% of the worst month could be achieved on each of the onshore-to-offshore links.

### Overall quality of service

An assessment of the overall end-to-end availability had to take into account many factors including the requirement for diverse and separated backhauls, the reliability of the radio equipment, the reliability of shared facilities (for example, power supplies) and the response times of support staff both on and offshore. In addition, because of the limited separation of the platforms (approximately 4 degrees as seen from onshore), assumptions had to be made about the correlation between the propagation effects observed simultaneously on both the Pickerill A and B systems, and the resultant impact on the triangulated system.

Consideration of all of these factors led to the conclusion that on average an end-to-end service availability of 99·97% of the worst month could be achieved, taking into account all possible failure mechanisms. This figure was very close to ARCO's most stringent design target, utilising what were believed to be conservative assumptions. In practice, the availability of the radio system is expected to exceed BT's theoretical projections, because of the assumptions made for the roughness factor, k-factor and the correlation factor for simultaneous fades on two sections of the triangulated system.

## Implementation Considerations

### Site Considerations

As a consequence of the preference to use digital line-of-sight radio, a feasibility study was carried out to locate suitable sites for an onshore communications facility. The Lincolnshire coast was the preferred area, since this offered the shortest line-of-sight distance to the Pickerill field, and several potential sites were identified. However, as BT Worldwide Networks already operated a Maritime Coast Radio Station at Mablethorpe (Humber Radio), this location was selected because of cost considerations.

Planning application for a 135 m (450 feet) stay-supported mast and equipment building on a remote receive site, situated approximately 1 mile inland from the main Humber Radio station, was approved. Consideration of a 135 m self-supporting tower on the main station site was rejected due to the environmental impact such a large structure would have on the neighbouring residential area.

After planning permission had been granted in May 1991, a contract was awarded to BT, by ARCO, for the provision, operation and maintenance of the onshore service. Operational requirements for gas production dictated that the service to Pickerill A commence June 1992, with the service to Pickerill B commencing late-1992/early-1993.

### Mast Considerations

Soil surveys carried out at the proposed site showed the ground stratum to be varied, having layers of soft, hard and glacial clay up to depths of 24 m, and that pile foundations would be necessary for the main column and stay blocks. As the equipment building would still be under construction during the mast foundation work, conventional pile-driving techniques could not be used. A method of drilling and fluid injection, to prevent soil collapse, was employed for the pile foundations. A 1·8 m diameter augur was used to drill the holes to a depth of 20 m, with a cage of steel reinforcing lowered into each hole followed by approximately 50 m³ of concrete. Figure 3 illustrates the onshore foundations under construction.

The onshore mast was restrained by three sets of three cables fixed to the mast at three stages and to inner (45 m) and outer (94 m) stay anchor blocks buried in the ground. One of the most stringent design criterion for the mast was that it maintain the four 3 m dish antennas to within ±0·5 degrees for at least 99·99% of the time, with winds gusting at 45 m/s (162 km/h). Figure 4 illustrates the stay support arrangements used while Figure 5 illustrates the completed mast together with the microwave antennas.

The onshore construction phase was complicated by the fact that the foundations, mast and equipment building had to be built during the winter, when there are fewer hours of daylight and weather conditions are at their worst. Safety considerations further restricted the number of activities that could be carried out simultaneously on both the mast and the equipment building because of the danger of falling objects.

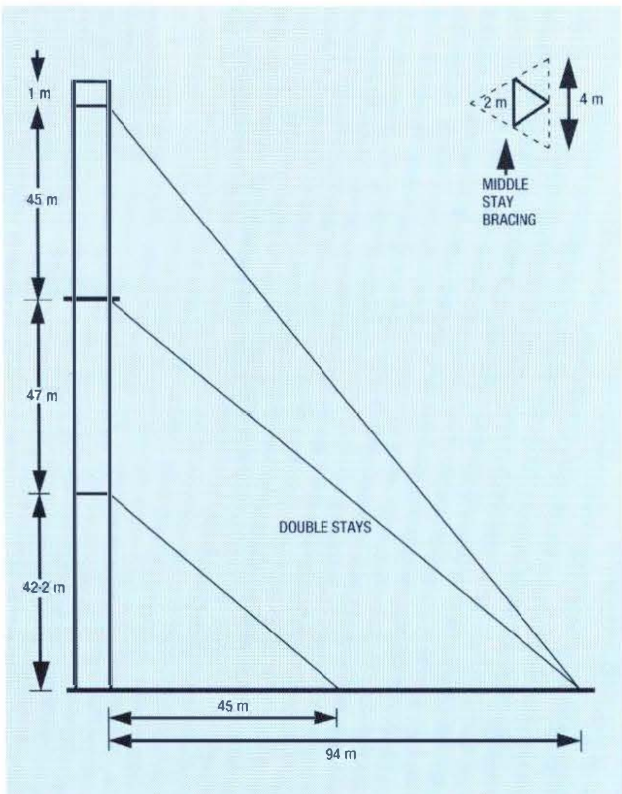
On the offshore platform, a 60 m self-supporting tower was provided which, together with the platform height of 30 m, gave the required antenna heights. This tower was constructed onshore prior to floating the platform out to the proposed drilling site. Figure 6 illustrates the tower on the Pickerill B offshore platform prior to the installation and panning of the antennas. The scale of the platform and tower can perhaps best be judged from the size of the personnel and lifeboats seen on the lower front decks.

## Equipment

Ferranti RT24 8 Mbit/s radios were selected for use in this system as these offered a number of facilities including a hot stand-by transmitter, hitless receive switching, and maximum output power of 2 W. The radios were also conformant with the necessary radio specifications (MPT1407) for operation in the 7·5 GHz private-user band; no other supplier at the time was identified as being able to offer a radio to these requirements. An important feature of the radio system was the ability of the processing unit to monitor both receivers at the 8 Mbit/s transmission rate and to initiate a changeover if the online path degraded to a BER of worse than 1 in 1000. Changeovers are synchronised so as not to introduce errors into the data streams.

*Figure 3—Onshore mast foundations under construction*


*Figure 4—Onshore mast design parameters*

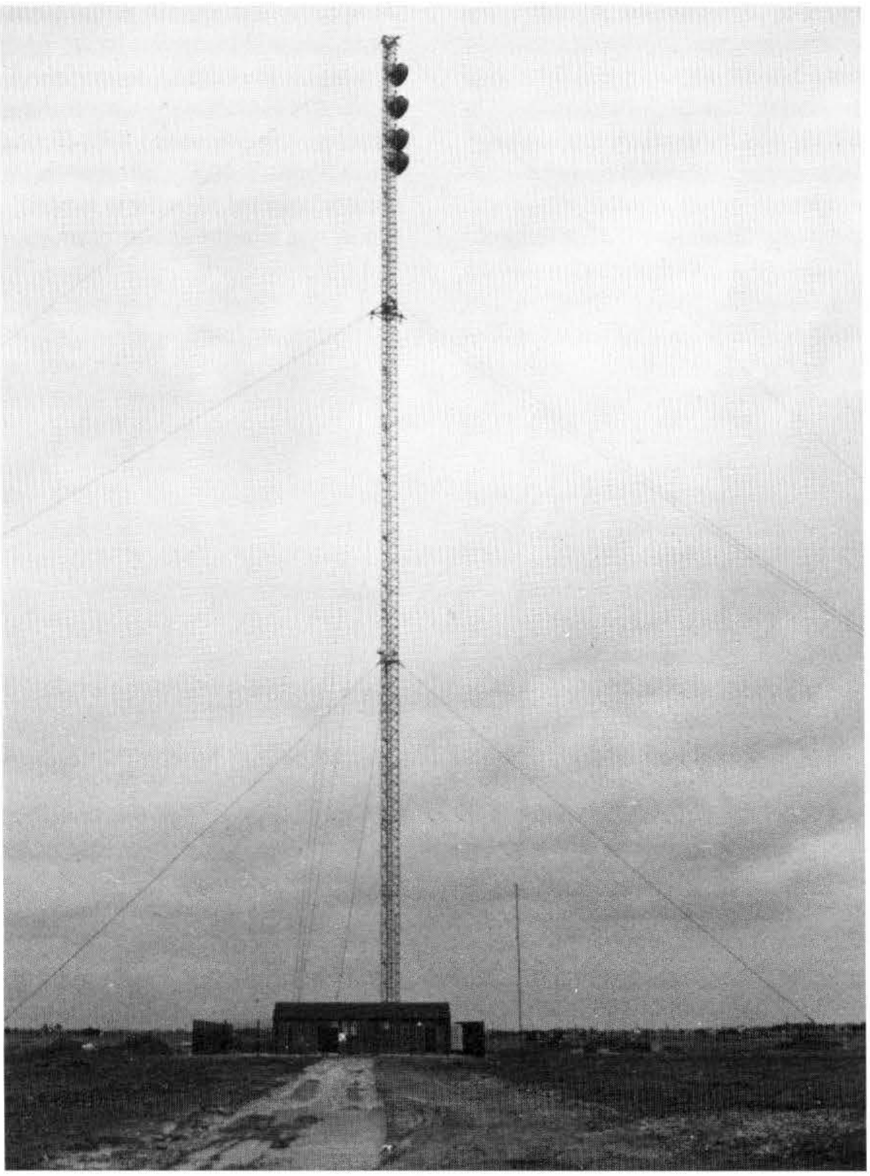


The multiplexers selected for the network were DSC CP4000 Nodal processors. This is an intelligent networking multiplexer which provides voice and data communications at a wide variety of data rates from 1·2 kbit/s asynchronous to 2 Mbit/s synchronous. Its integral X.25 port permits remote error-free control and connectivity to the network management system, which in turn enables the status and performance of any node on the network to be assessed. Multiplexers are located at each major node of the network and perform the operation of switching the 2 Mbit/s trunks. The Humber multiplexer is the master node which holds the routing tables, and provides the timing for the whole network.

Typical communications requirements conveyed over the multiplexer to each of the offshore platforms include a Hotline channel (64 kbit/s), a process control channel to monitor and control the offshore pumping and platform facilities (256 kbit/s), an emergency shutdown control channel (9·6 kbit/s), telephone extensions (32 and 64 kbit/s) and a number of 9·6 kbit/s data channels for passing equipment supervisory information.

The offshore equipment facilities include a *three-generator* system; that is, main, stand-by and emergency generators feeding an uninterruptable power supply (UPS) that ensures mains power is available at all times. The generators will continue to run unless the protection system that monitors the total platform shuts down the generation system. In such an event, the UPS can supply full load for two hours. The onshore equipment facilities are similarly provided with a UPS and stand-by generator to ensure that the system can continue to operate in the event of a mains-power-supply failure.

*Figure 5—Onshore mast at Humber Radio Station*



The status of both the communications network and the supporting facilities are constantly monitored from the main Humber node. Any equipment failures or performance degradations on the network are monitored locally as well as being reported via a remote control and monitoring system over the public switched network to BT's Offshore Network Control Centre at Mormond Hill, Scotland. The backhauls were provided by means of 19 GHz digital line-of-sight radio systems which were fed to exchanges in Sutton and Mablethorpe.

## Network Integration and Management

In common with many offshore projects, the final integration and testing programme, both for the platform and the communications system, were dependent on the weather conditions. Despite this, the trials to the Pickerill A platform commenced on schedule in June 1992. A notable feature during this phase of the project was the cooperation and teamwork shown by the BT and ARCO personnel in ensuring that the exacting communications requirements were implemented in the required time-scales.

The final communications network configuration is illustrated in Figure 7, and has been designed so that it is resilient to failures on any one section. The performace of all of the links is monitored by the multiplexer, such that in the event of a failure or

*Figure 6—Pickerill B platform*

high BER alarm being detected, the information is alternately re-routed. For example, a failure or degradation on one of the offshore radio links causes the data to be re-routed via the alternate working link and the interplatform link, all under the control of the multiplexer system. The terrestrial links are similarly monitored and re-routed.

In the event that there are major problems which can not be overcome using the in-built equipment and network redundancy, BT provides a rapid maintenance response which ensures that trained staff are on site within one hour to identify and resolve the problem. In the case of the major faults offshore, maintenance teams can be dispatched and available on the platform within 4 hours, subject to weather conditions.

## Network Performance

To confirm the radio link availability, measurements were carried out for a period of one month in accordance with CCITT recommendations. After commissioning of the Pickerill A system in June 1992, pseudo-random bit sequence (PRBS) tests were carried out on 2 Mbit/s tributaries, in both directions, using data analysers. The result for the offshore-to-onshore direction was an availability of 100%, while in the other direction an availability of 99·985% was obtained.

Commissioning of the B platform commenced in November 1992, after the siting of the platform. Short-term tests on the tributaries to date (December 1992) suggest that the availability targets will again be met, although further testing is currently in progress. Tests on the complete triangulated system are scheduled for early-1993, after which the service will be monitored to assess the ongoing performance and availability.

## Summary and Conclusion

This article has outlined some of the technical factors associated with the custom design and implementation of a BT digital line-of-sight radio service for ARCO operating to two new gas platforms in the North Sea. At the time of writing, the commissioning of the triangulated network is nearing completion and the early indications are that the service will meet or exceed the very high levels of end-to-end availability required for the network.

While initially just one of the 2 Mbit/s tributaries on the 8 Mbit/s radio links will be used by ARCO, BT has already contracted with a neighbouring operator for a service utilising a further 2 Mbit/s capacity on the network. This requirement will be integrated by means of digital line-of-sight extensions to neighbouring platforms to form a further triangulated system which will commence operations in early-1993.

Given the clear commercial and technical benefits that this type of service can provide to operators, BT Offshore Services is investigating the potential for similar digital line-of-sight services to other platforms in the North Sea.

## *Acknowledgements*

The authors wish to acknowledge the assistance and cooperation given by ARCO British Limited in the preparation of this article.

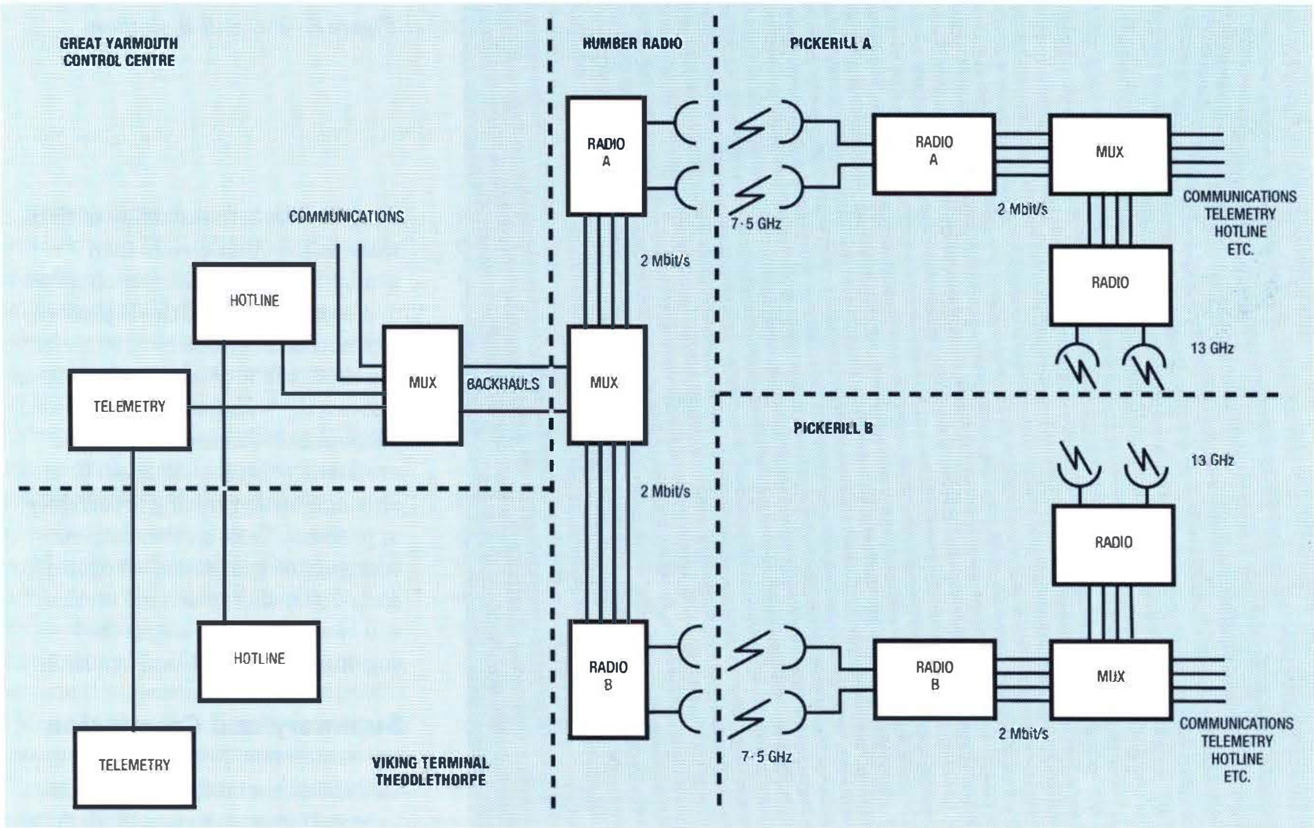
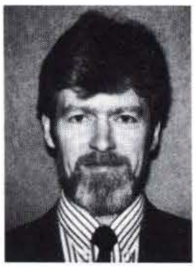



*Figure 7—Overall network schematic*

## *Biographies*

**David Elliott**
BT Worldwide
Networks

David Elliott heads a group which provides project management and technical support to BT's Worldwide Networks Offshore Services team. He studied Electrical and Electronic Engineering at Queen Mary College, London, where he obtained a first-class Honours degree. He subsequently carried out research on the tuning properties of piezo-electric devices, obtaining a Ph.D in 1981. Since joining BT he has worked on a wide range of telecommunications projects, including the specification of international satellite systems, evaluation of digital satellite modem/coding techniques, and providing international consultancy on satellite systems on behalf of BT. He has represented BT internationally at CCIR meetings concerned with the specification of satellite performance in the ISDN, and managed teams responsible for the provisioning of a range of BT services; for example, Satstream, SatStar and Offshore.



**Mike Freeman**
BT Worldwide
Networks

Mike Freeman is a senior project manager in BT's Worldwide Networks Offshore Services team, and the BT project manager during the implementation phase of the ARCO project. After joining BT, he worked for several years on the provision of MF/VHF systems for Maritime Radio Services. He then worked overseas, on behalf of BT, for a period of 4 years on planning and implementation of microwave radio systems and rural subscriber networks for the Government of Vanuatu. On his return to the UK in 1983, he joined BT's Offshore Services team. Since then he has project managed a wide variety of projects, including the provision of troposcatter, line-of-sight and satellite radio systems.

*Chris Drewe*

# BT's Telex Network: Past, Present—and Future?

*One of BT's less-publicised services—the Telex system—is now fully software-controlled, improving quality and opening up some interesting opportunities. Here is the story of how it was done and a view of what the future may hold.*

## Introduction

BT's public telephone system modernisation programme has been well publicised, but behind the scenes another of BT's traditional services—Telex—has been quietly brought into the computer age. The UK's last Strowger Telex exchange was closed in August 1992, and now BT's whole inland network is under the control of Canadian Marconi Company CMA-755 data exchanges, plus a Plessey 8660 unit in London. Cross-divisional teamwork played a major role in successfully progressing the project through its various stages, and the professional approach of central and field people in BT Worldwide Networks and Business Communications ensured that customers' interests were put first.

Mention of 'Telex' usually conjures up images of clattering mechanical teleprinters and bundles of paper tape, but the aim of this article is to show that such associations are no longer appropriate. A full description of the CMA-755 computer-controlled Telex exchange was included in the April 1989 issue of the *Journal*[1], and the paragraphs which follow are intended to provide a potted history of the UK Telex service.

## Historical and Technical Review

### History

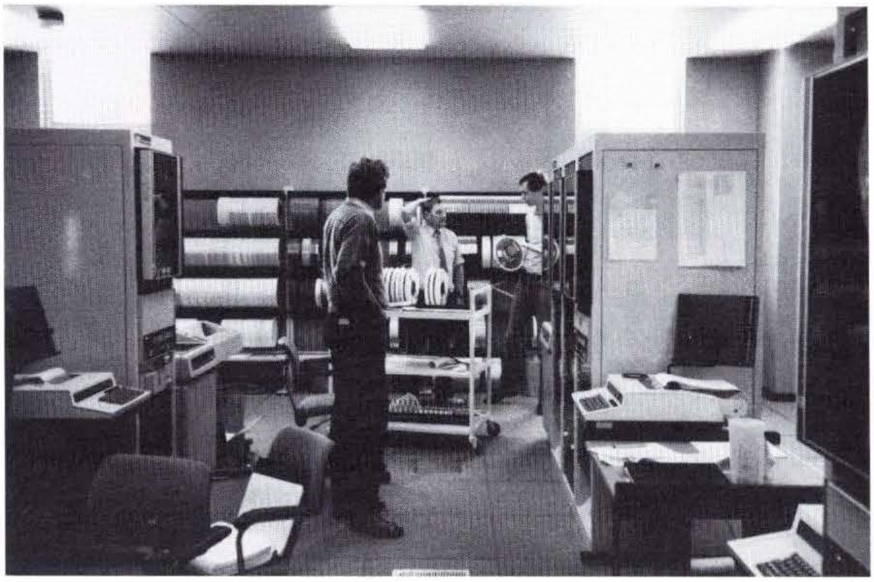
Various types of apparatus for transmitting printed messages over wires, both as graphic images and printed characters, were invented in the last century, but practical teleprinters did not arrive until the 1920s and 30s. They were mainly used for point-to-point transmission, though businesses requiring more versatility were offered teleprinters which worked over the telephone system: users made a telephone call in the usual way, and then switched the line at each end over to the teleprinter—not unlike sending a fax today. The Post Office then set up a manually-switched network just for teleprinters, and during the 1950s converted it to automatic operation, using telephone-type Strowger technology. The term *Telex* comes from TELegraph EXchange.

### Into the 1980s

As the years rolled on, the Strowger Telex network suffered from the same problems as the Strowger telephone network—high maintenance costs, difficulty in introducing new facilities, expensive and hard-to-obtain spare parts, etc. In the 1970s, it was decided to buy in proprietary computerised stored-program-controlled (SPC) equipment to replace all the Strowger exchanges, both international gateways and customer switches. Contracts were awarded to GEC for an exchange system designed by its subsidiary, the Canadian Marconi Company (CMC) of Montreal, and to Plessey (now GPT) and ST&C (now NTE). These contracts were for exchanges at main centres around the UK, including London international gateway units, which were duly opened in the mid-1980s, and most have since been extended to cope with subsequent growth.

Telex transmission and terminal technology has advanced too. Customers' local ends have changed from ±80 volts DC signalling to modems, and links between exchanges and transmission nodes now use standard time-

*Figure 1—Routing and billing centre (RBC) computers in a CMC exchange. Note the 'computer room' environment*



division multiplex (TDM) techniques over digital bearers. Modern 'teleprinters' are special-purpose desk-top computers, featuring cathode ray tube or liquid crystal display screens and text-editing software for message preparation, with floppy disks taking the place of punched paper tape storage. They also have RS232 serial ports, for direct connection to local area networks, mainframe, mini and desk-top computers, dial-up modems, etc. There are even 'Telex' cards for PCs.

### Character sets

Until the 1970s, teleprinters were entirely mechanical in operation, so the character transmission codes had to be simple. The adopted standard was the International Telegraph Alphabet No. 2 (ITA2 or Murray Code). Each character is transmitted as a start bit, 5 code bits, and a stop element which is at least 1½ bits long; hence ITA2 is known as a *7½-bit code*. Five code bits allow 32 combinations, just enough for the alphabet, so a 'shift' feature provides a second character set for numbers and punctuation marks. The standard transmission speed is 50 bit/s (= 50 baud in traditional telegraphy parlance), or just under 7 characters per second. When computers came along they brought with them the familiar ASCII 8-bit code (plus start and stop bits gives 10 bits per character). Various transmission speeds are used for different applications, 300 bit/s being common for low-speed data communication—equivalent to 30 characters per second, or 4½ times the standard Telex character rate.

Modern Telex terminals and SPC exchanges, being microprocessor-controlled, use ASCII internally, but are usually configured to send and receive ITA2 to line. They can also send and receive ASCII characters to line at the normal 300 bit/s rate; apart from the advantage of higher speed, terminals can therefore exchange documents containing the full ASCII character set, including printer-control sequences, or even binary files. The exchanges can perform speed-and-code conversion if a call has an ITA2 terminal at one end and an ASCII one at the other, using X-ON/X-OFF flow control if necessary. SPC exchanges also recognise ITA2 and ASCII characters as selection digits, which is much quicker than using a dial.

### Exchange operation

All of the inland SPC exchanges are products of the Canadian Marconi Company (CMC), except one of the London installations, which is a Plessey design. They are fitted in an air-conditioned computer-room environment, with air ducted through the false floor and suspended ceiling. All cable runs are under the floor, so there are no Strowger-type overhead cable grids. Both exchange designs take power from conventional −50 V DC supplies; DC–DC converters produce logic voltage supplies for slide-in cards, while the CMC exchanges feature static inverters to generate normal 240 V 50 Hz 'mains' for mini-computers and peripherals. CMC exchanges use standard 19-inch-type equipment cabinets, whereas the Plessey exchange cabinets are their own design. Both designs employ card cages within the cabinets, with a 'mother board' at the back and slide-in circuit cards.

Both exchange types are entirely software controlled. In CMC's CMA-755 exchanges, all the external lines or 'ports' are connected to microprocessor-controlled front-end processors (FEPs), and the exchange is operated by routing and billing centre mini-computers (RBCs). See Figure 1. All FEPs and RBCs are interconnected by a high-speed time-division multiple-access (TDMA) data bus. Each RBC has a set of magnetic tape drives, and a hard disk drive which stores all the information required to run the exchange (software and database). The exchange features fully distributed processing; the RBCs share the call set-up and clear-down effort between them, unlike the traditional 'main/stand-by' arrangement. If an RBC fails in service, only calls being set up by it are lost, and no calls in progress are affected.

When a customer makes a call, the FEP acknowledges the call signal and accepts the selection digits, while alerting an RBC via the TDMA and passing the selection digits on to it. The RBC determines where the call needs to be routed to—either another customer, or more usually, an outgoing trunk—and directs the call to the appropriate FEP. If the call is successful, the RBC records the call start details on magnetic tape, and then plays no further part, while the two FEPs communicate directly over the TDMA. When the call is cleared, the FEPs notify an RBC so that the end-of-call details are recorded on tape. Calls from incoming trunks are routed in the same way. An interesting feature of the exchange is that it is completely non-blocking, as the TDMA bus has sufficient capacity for all lines to make or receive calls at once, while the call-handling capability of the RBCs is about 12 call attempts per second each.

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INTERNATIONAL CALLS FOR BILLING NUMBER 8956254

| CALL DATE | TIME | ORIGINATING NUMBER | DESTINATION COUNTRY | DESTINATION NUMBER | CALL UNITS | CHARGE RATE | CALL FACILITIES | FACILITY CHARGE | TOTAL CALL COST |
|---|---|---|---|---|---|---|---|---|---|
| 26/10/92 | 1218 | 949201TLXHQ G | HONG KONG | 080283235 | 19 | 0.090 | | 0.000 | 1.71 |
| 26/10/92 | 1219 | 949201TLXHQ G | JAPAN 5 DIGITS | 0722292383 | 20 | 0.115 | | 0.000 | 2.30 |
| 26/10/92 | 1224 | 949201TLXHQ G | JAPAN 5 DIGITS | 0722292383 | 15 | 0.115 | | 0.000 | 1.73 |
| 26/10/92 | 1231 | 949201TLXHQ G | PHILIPPINES 5 DIGITS | 07527695 | 18 | 0.115 | | 0.000 | 2.07 |
| 26/10/92 | 1536 | 949201TLXHQ G | SAUDI ARABIA | 0495470292 | 26 | 0.132 | | 0.000 | 3.43 |
| 26/10/92 | 1542 | 949201TLXHQ G | W GERMANY | 041410282 | 18 | 0.026 | | 0.000 | 0.47 |
| 26/10/92 | 1553 | 949201TLXHQ G | W GERMANY | | | | | | |
| 27/10/92 | 0750 | 949201TLXHQ G | GIBRALTA | | | | | | |
| 27/10/92 | 0830 | 949201TLXHQ G | W GERMANY | | | | | | |
| 27/10/92 | 0832 | 949201TLXHQ G | GIBRALTA | | | | | | |
| 27/10/92 | 1337 | 949201TLXHQ G | FRANCE | | | | | | |
| 27/10/92 | 1343 | 949201TLXHQ G | FRANCE | | | | | | |
| 27/10/92 | 1455 | 949201TLXHQ G | LUXEMBOURG | | | | | | |
| 27/10/92 | 1458 | 949201TLXHQ G | W GERMANY | | | | | | |
| 27/10/92 | 1500 | 949201TLXHQ G | NETHERLANDS | | | | | | |
| 27/10/92 | 1552 | 949201TLXHQ G | GIBRALTA | | | | | | |
| 27/10/92 | 1559 | 949201TLXHQ G | BELGIUM | | | | | | |
| 21/10/92 | 1824 | 945588BTLHQ G | JAPAN | | | | | | |
| 23/10/92 | 1757 | 945588BTLHQ G | JAPAN | | | | | | |
| 26/10/92 | 1749 | 945588BTLHQ G | JAPAN | | | | | | |
| 27/10/92 | 1827 | 945588BTLHQ G | JAPAN | | | | | | |
| 21/10/92 | 1054 | 9419453TXHLPG | HONG KONG | | | | | | |
| 27/10/92 | 1627 | 9419453TXHLPG | HONG KONG | | | | | | |
| 23/10/92 | 1656 | 935119TELEX G | HONG KONG | | | | | | |

PROGRAM ID: E8701 FILE ID: E89707 RUN NUMBER: 282 DATE 23/11/92

DESTINATION ANALYSIS SUMMARY FOR BILLING NUMBER 8956254

FOR PERIOD 06/10/92 TO 27/10/92

| COUNTRY | TOTALS CALLS | TOTAL COST |
|---|---|---|
| AUSTRALIA | 1 | £ 1.54 |
| BELGIUM | 6 | £ 14.85 |
| CANADA CNCP | 1 | £ 1.47 |
| DENMARK | 1 | £ 0.62 |
| FRANCE | 26 | £ 61.61 |
| GIBRALTA | 3 | £ 1.54 |
| HONG KONG | 15 | £ 25.83 |
| IRISH REPUBLIC | 4 | £ 7.26 |
| ITALY/VATICAN CITY 6 | 2 | £ 0.67 |
| JAPAN | 7 | £ 62.58 |
| JAPAN 5 DIGITS | 37 | £ 177.42 |
| KOREA SOUTH | 1 | £ 1.84 |
| LEBANON | 1 | £ 3.83 |
| LUXEMBOURG | 19 | £ 14.06 |
| MALAYSIA | 1 | £ 1.07 |
| NETHERLANDS | 6 | £ 26.01 |
| PHILIPPINES 5 DIGITS | 1 | £ 2.07 |
| SAUDI ARABIA | 4 | £ 36.17 |
| SWITZERLAND | 8 | £ 10.87 |
| USA ALL OTHERS | 2 | £ 11.79 |
| USSR | 1 | £ 0.57 |
| W GERMANY | 25 | £ 16.71 |
| INTERNATIONAL | 172 | £ 500.60 |
| NATIONAL | 290 | £ 71.35 |
| TELEX-PLUS | 11 | £ 20.22 |
| GRAND-TOTAL | 473 | £ 571.95 |

*Figure 1—Example of Telex call itemisation output*

As the call starts and ends are recorded separately, the exchange staff regularly run a simple routine (the accounting and statistics package (ASP)) to match the 'heads and tails', which are recorded as complete records on another tape for despatch to the billing system. Call details include date, time of start and clear (recorded by RBCs), chargeable duration in seconds (recorded by FEPs), calling-line answerback (from exchange database), selection keyed, and codes for identifying facilities used, inland or international calls, etc.

The Plessey 8660 exchange in London has a different design philosophy. The exchange is assembled from mini-computer sub-systems; each sub-system is a miniature exchange in itself and performs all call routing and recording functions independently of the others. Each sub-system is dual-redundant with twin processors in the usual main/stand-by mode. In the event of a 'main' processor failure, switch-over to the 'hot stand-by' is automatic, and calls in progress are affected by the loss of less than one character. Data links pass cross-exchange traffic, database updates, etc. between them. Each mini-computer does all call recording itself, and complete call records from all mini-computer sub-systems are forwarded to a data collection unit, where they are written to tape. These tapes are then processed on an off-line system to extract chargeable call records, which are written to another tape for the billing system.

## Billing

Tapes containing call records from all the exchanges go to a computer centre, where a mainframe software suite called *INSPECTA* (Inland

Stored-Program Exchange Centralised Telex Accounting) calculates the cost of each call and accumulates the total charges for individual customers, before passing details to billing offices each month for bills to be made up. (Customers are billed monthly, or quarterly in three 'phases', so each month the billing offices receive totals for monthly-billed customers, and quarterly-billed customers whose bills are due that month.) Marketing and statistical information is also produced. A big advantage of having a centralised billing software suite, under the control of a dedicated support team, is that tariff revisions and software enhancements can easily be implemented.

After requests from several high-volume users, a recent development enables customers to receive fully-itemised details of their calls on 3½-inch 1·44 Mbyte floppy disk, so that they can use their own spreadsheet software to analyse the data for inter-departmental accounting, etc. The disk files include details of every call, listed in date and time order, and totals by calling line and destination country, in the form of comma-separated columns of text. The files are compressed into one file and password-encrypted for security, and the disks are checked for viruses and immediately sealed after production. The recipient keys a simple one-line command, including the password, to 'explode' the files, normally onto a hard disk. An uncompressed, un-encrypted README text file on the floppy disk gives general information about the disk files, and includes instructions on how to uncompress them.

There is also a paper output option, giving the same information as the disk files but split into pages and with column headings, etc. added (see Figure 1). For low-usage customers, an exchange-based facility enables call detail statements to be transmitted weekly to their Telex line.

## Where We Are Now

During the 1970s and 1980s, many commentators confidently predicted the imminent demise of Telex as a result of advances in computer communications, as part of the 'paperless office' revolution. However, although techniques for transferring text and data between computer terminals have been around for many years, the lack of accepted and easy-to-use standards has restricted this activity to data communications specialists and computer buffs, and 'file transfer' usually means sending a floppy disk through the post. Telex remains the only established worldwide system, though its low transmission speed and restricted character set, intended for mechanical terminals, have limited its usefulness for computer communications. By contrast, facsimile technology has also been around for decades, but in recent years the ready availability of inexpensive terminals, combining push-button convenience with the ubiquity of the telephone, has enabled fax to become the text communication method of the early 1990s.

The 'anyone-can-use-it' convenience of fax now means that most people do, and as a result, Telex traffic has declined worldwide. However, the recent downturn has presented BT with the opportunity to exploit the capabilities of its modernised network for new service applications.

### Telex and low-speed data into the 1990s

BT now has a secure, software-controlled public switched Telex network covering the whole of the UK, with access to the worldwide Telex service, and providing low-speed data facilities. The network already provides many customer-friendly features, such as fast call set-up, user groups (closed or open), broadcast calls, traditional Telex or 300 bit/s using ASCII transmission (with speed and code conversion for interworking with Telex), call redirection, pre-recorded message, line identity (answerback) stored in exchange database, etc., as well as versatile billing options.

Unlike existing electronic-mail systems, this network does not depend on the telephone switching system, but offers users a reliable, hacker-proof, digital end-to-end service. And unlike fax, it transmits text as characters, not graphic images, so they can be sent and received as normal computer data, not patterns of dots. At 300 bit/s, a full A4 page of text takes about two minutes to send, similar to a high-resolution fax transmission.

*this network ... offers users a reliable, hacker-proof, digital end-to-end service*

### Foreign affairs

One topic which has generated considerable interest is providing Telex (and low-speed data) service to other countries on an agency basis from the UK. Effectively, foreign customers are very 'long lines' on a BT exchange, although their details are recorded separately in the database so they retain their own line identities, numbering range, etc. Overseas administrations can therefore offer their customers a high-quality service with the benefits of an all-digital network without the heavy capital expenditure and maintenance costs of their own exchange equipment.

Providing Telex service for another country from the UK is more logical than it may appear, as much traffic is between countries anyway (about 40% for the UK), and the number of calls which are routed half-way around the world and back via satellite to get to the next street is likely to be small. Country codes for international calls are standardised to CCITT Recommendation F.69 for use in all countries, so foreign customers making international calls use the normal BT codes (and the UK code, 51, for calls into the UK). It is quite easy for the mainframe billing software to extract foreign customers' call details for billing and accounting purposes, and fully-itemised listings can be supplied to the foreign administration. BT currently provides Telex service to Liberia on this basis, and other administrations have also expressed an interest.

### Alarm systems

The SPC exchanges' closed-user-group and broadcast facilities have been put to good use by a consortium of Teesside chemical and oil-refining companies and the local emergency services—if any of them experiences a spillage or fire involving hazardous substances, all interested parties can be notified immediately, by a 300 bit/s broadcast call, to enable appropriate action to be taken. The network's transmission reliability is exploited to minimise the possibility of confusing the names of chemicals which sound similar but may need totally different treatments (nitrate and nitrite, for instance), while the closed user group ensures confidentiality and security.

A well-known public utility, which operates all over Britain, is also evaluating the SPC network for a national alarm signalling system; the network offers a secure and reliable service to uniform standards to the whole of the UK, including Northern Ireland and the more remote parts of Britain (even the Shetland Islands), not just the major business centres, making it attractive to national organisations.

### Other possibilities

The Telex network's ability to transmit data reliably and securely has led to proposals that it would be a suitable system for electronic document interchange (EDI), and for such uses as credit card validation in retail outlets; for instance, filling stations. X.400 interconnection can be provided by BT's inter-operability network (ION), which demonstrates open systems and standards.

## Conclusion

Despite expectations, Telex is not yet dead, though not as popular as it was. BT's all-digital network and software-controlled exchanges were originally intended simply to modernise the existing UK Telex system, but now offer wider opportunities for circuit-switched low-speed data transfer applications.


## *Acknowledgements*

Thanks are due to members of Telex Networks, BT Worldwide Networks, who assisted with the preparation of this article.


## *Reference*


1 KITE, P. CMA-755 SPC Telex Exchange. *Br. Telecommun. Eng.*, Apr. 1989, **8**, p. 11.


## *Biography*


**Chris Drewe**
**BT Worldwide Networks**


Chris Drewe joined the Preston Area of Post Office Telecommunications in 1971, and moved to the Telex section of the Network Planning Department, Telecommunications Headquarters, in 1979. He has worked on various aspects of the SPC Telex programme since then, and is currently part of the billing support team.

*Ted Rook and Steve Green*

# BT's Internal Network

*One of the greatest challenges facing BT is to bring together the multiple sources of information and systems and migrate them into a coherent global network. The consolidation and integration of systems and information can be a powerful catalyst to achieving increases in efficiency and customer satisfaction. This article outlines the network services provided over BT's internal network and looks at how the many elements of this network are evolving to meet this global service.*

## Introduction

Leading companies today recognise that it is no longer satisfactory in the corporate environment for information and systems to be deployed in a disparate way. One of the greatest challenges facing BT is to bring together the multiple sources of information and systems and migrate them into a coherent global network.

The past two years have seen rapid progress to achieving this objective, and many parts of the business are benefiting from dramatic improvements in the voice and data networks. The consolidation and integration of systems and information can be a powerful catalyst to achieving increases in efficiency and customer satisfaction. Responsibility for this wide range of activities rests jointly with BT Development and Procurement (D&P) and BT Worldwide Networks (WN).

Group Computing Services was created in D&P and made responsible for computing applications. Internal Networks (IN) was created in WN to deliver other communications services, primarily those for voice and videoconferencing, and with the responsibility for the management of a wide range of other services, applications and ancillaries needed by BT for it to operate and be competitive in the telecommunications market.

As the need for rapid communications increases, it is important that the user has an insight into one of the largest private voice, data and video networks in the world.

## WN/Internal Networks — Service and Network Management Systems

This article concentrates mainly on the network aspects of the WN/IN portfolio, but the other services delivered cannot be ignored as they provide a significant demand for service and network management system functionality. In addition to the network services described in this article, IN manage on behalf of the BT Group the provision for internal use of 70 000 BT Chargecards, 14 000 mobile cellphones, 56 000 pagers, and 18 000 private mobile radio stations.

WN/IN manages BT Headquarters switchboard services which handle over 360 000 calls per year, and the BT Headquarters Message Centre which handles 1 000 000 messages per year

WN/IN manages the supply of many thousand exchange line connections which are used for a wide range of internal applications.

The supply for each of these services is monitored to ensure that authorised internal customer requirements are met at least cost to the business.

The service and network management systems for supporting the internal network are still evolving. Many of the elements exist, but are still to be migrated into an integrated solution. In parallel, the previous management structures are migrating to functional working and the number of locations is being reduced.

Users requiring service call a standard Freephone number 0800 800 190. These calls are delivered by using the Advanced LinkLine service to an IN front office (INFO). Each INFO has an automatic call distribution (ACD) system staffed by service agents. The INFOs handle 110 000 calls per year, resulting in 160 000 orders being passed into the BT ordering systems.

Service agents are supported by a computerised order taking and problem management system, and have access to local and remote databases. Limited access to some BT

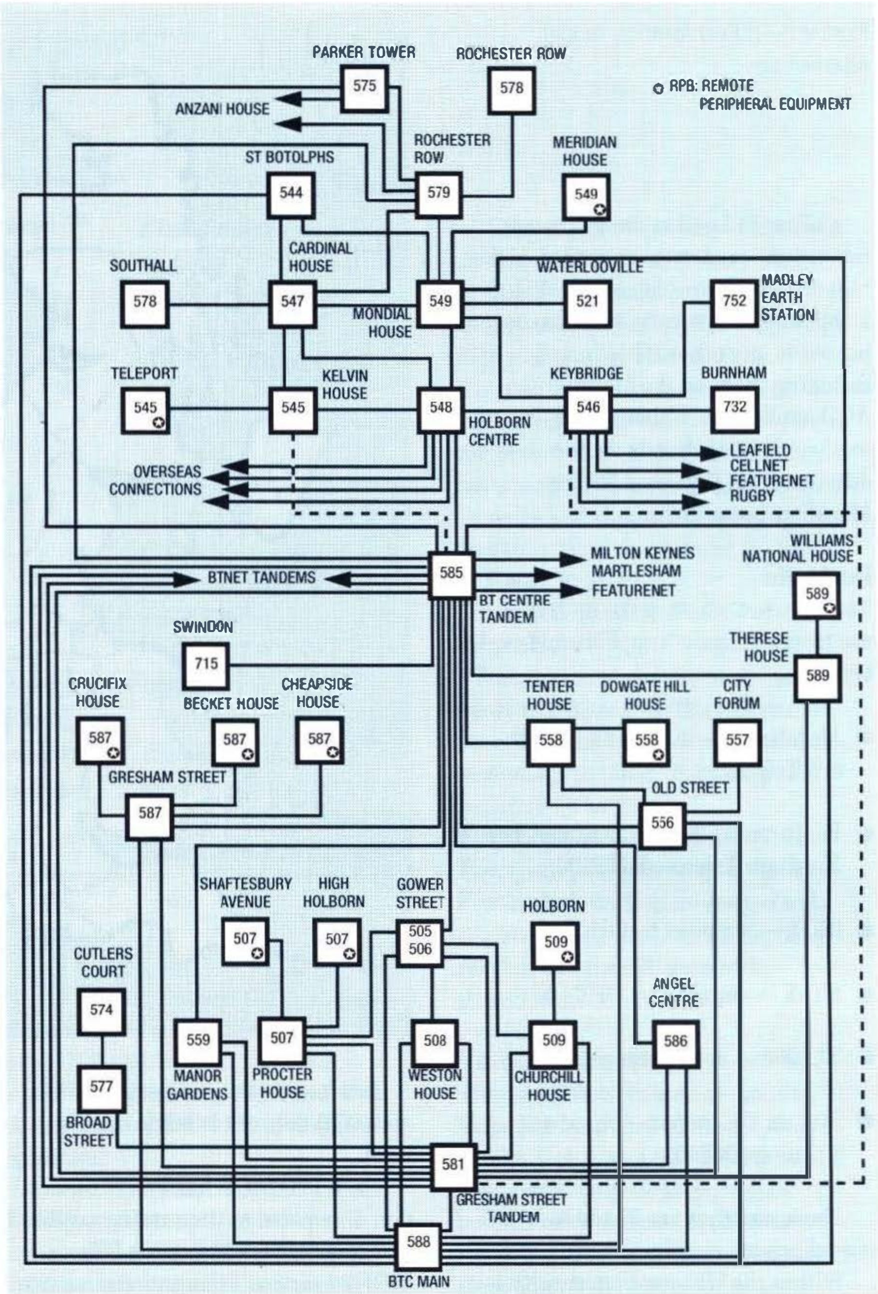



*Figure 1—BTnet for London Headquarters*

Group computing applications is also provided. Most calls can be handled directly by the service agent, but if necessary they can be transferred for specialist assistance to an IN back office.

The computer support systems are migrating to centralised locations which have 24-hour support, and the hardware and software platforms which range from personal computers (PCs) to mainframes are being rationalised.

### Migration

Currently, there are five INFOs operating on a geographical basis, although the target is to reduce this to two. In the future, INFO ACD systems will be networked to ensure most efficient call handling.

The benefits of providing voice response units which automatically answer the telephone and can interact with the caller for simple service requests (for example, Chargecard renewal) are being evaluated. The potential for using computer-integrated telephony and interactive voice-response units to carry out even more sophisticated functions will be evaluated during the coming year.

Network management activities are being focussed on a single centre located at Pontefract.

## BTnet — The Corporate Voice Service

### Service Description

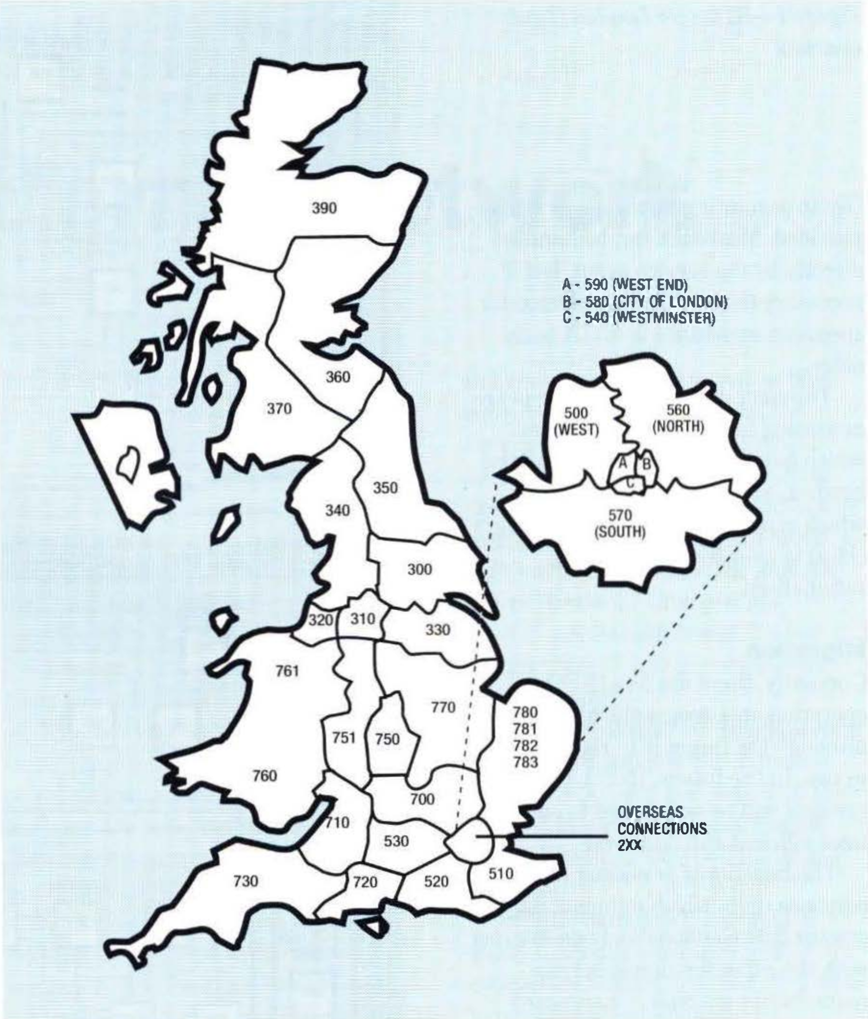
BTnet interconnects 280 of BT's major locations in the UK and overseas with a fully digital private voice network. A total of 180 000 extension connections are deployed. In addition to plain telephony, a range of supplementary services is offered both locally and on a network basis.

The network is tailored to meet the needs of each user. The majority application is for inter-office communications, but in addition more highly functional specialised applications are supported. BTnet delivers communications to BT's customer-facing front office and the supporting back offices. Remote operator services are provided throughout to facilitate efficient deployment of expensive people resource.

The part of BTnet supporting the London-based headquarters installations is illustrated in Figure 1. Some 38 000 users in 41 locations have their telephone service delivered by a network of 31 PABXs. For economy, some buildings are serviced by remote peripheral equipment. Remote peripheral equipments are apparatus racks loaded with extension line cards operated remotely from the core switching function of the PBX.

The largest specialised application is the service provided for BT's Customer Service Centres. With the exception of London customers, calls to BT for sales, billing and repair enquiries are taken from the PSTN into a 'nationwide' ACD application based on 47 locations equipped with Northern Telecom Meridian 1 apparatus. These calls are networked on a zone basis to ensure that callers are answered promptly. If necessary, calls can be passed on to any other BTnet user. The application is supported by a comprehensive call-management information system. This network is the largest virtual ACD in existence anywhere in the world.

*Figure 2—BTnet location (node) numbering*




Callers in London are delivered into a public network embedded ACD based on Northern Telecom DMS100 technology. These calls may also be passed to any other BTnet user, including those on the Meridian 1 ACD application, although the method of connection is rather different from that used for the Meridian 1 application.

## Portfolio

The switches which make up BTnet are from a range of suppliers and types:

- Meridian 1 — supplied by Northern Telecom
- Featurenet 5000 — based on Northern Telecom DMS100
- iSDX — supplied by GPT Ltd
- BTeX — supplied by GPT Ltd
- SX2000 — supplied by Mitel
- System Y Centrex — based on Ericsson AXE10.

These switches are linked by digital private circuits.

Within the UK, most bandwidth is provided by MegaStream links. Outside the UK, international private leased circuits (IPLCs) are used at varying speeds (dependent on capacity required). As overseas circuits are normally shared with data applications and video-conferencing, the service to BTnet is delivered from the internal backbone transmission network (IBTN), for economy and to give flexibility of utilisation.

## Topology

The design of BTnet requires that each zone has both the PBX and ACD networks connected as rings, supplemented by direct links between sites where required by capacity. The zone rings are then linked at two points to the adjacent zones to provide a national network.

Interconnection between the PBX and ACD network is made at zone level.

Each PBX/ACD has PSTN connection dimension as required by traffic. PSTN is delivered by using BT's ISDN30 service. International service is parented on a single location to economise on the requirements for 24-hour support.

## Numbering Strategy

All the network extension numbers are seven digits, generally of the form *aaa bbbb*, where *aaa* is a 3-digit PBX/ACD location and *bbbb* is a 4-digit extension number. Exceptionally, six digit extension numbers are supported in the form *a bbbbbb*. To avoid excessive use of number capacity in these cases, the first two digits of the extension number are chosen to avoid clashes with other location codes.

Within a PBX, users dial only the extension number and this facility is extended across groups of PBXs which share a close community of interest.

PBX/ACD locations are numbered on a geographical basis, as illustrated in Figure 2.

Traditionally, private voice networks implement full linked-numbering schemes. BTnet is too large to take this approach. A feasibility study concluded that a numbering scheme similar to that of the PSTN could not be implemented because of the technical limitations of PBX call routing tables, and the resulting complexity of management in an environment where constant changes are made to the network.

Access to PSTN is generally by keying the digit 9, but where this cannot be achieved (for example, typically where historically 9 has been deployed as the first digit of an extension number) *9 is used.

For access to BTnet, users dial *7 or 00 (dependent on PBX/ACD type) followed by the network address.

A policy of service number standardisation has been introduced. Users requiring a service (for example, Internal Networks Help Desk) dial 0190 and, regardless of location, the call is delivered to the office which manages that PBX/ACD. To call the office which manages other PBXs, the user would dial *7 *aaa* 0190, where *aaa* is the identity of the PBX location about which the query is to be made.

## Synchronisation

The synchronisation strategy is designed to maintain synchronisation for the network in both normal operation and under failure conditions.

The first choice is always to synchronise to BT's ISDN30 service which is directly connected to the PBX. The second choice is generally to synchronise to a link which is connected to a nominated PBX within the zone which in turn is connected to ISDN30 service. To minimise the potential for creating a mutual synchronisation loop, this nominated PBX takes as a second choice a link from a PBX outside the zone, but with an ISDN30 connection.

Special arrangements exist for overseas locations and for where PBX functionality limits this general approach.

## Signalling

Extensive use is made of Digital Private Network Signalling System No. 1 (DPNSS1) between PBXs, including some overseas links. DPNSS1 provides users, attendants and network operators with a wide range of functionality. The services supported on a network-wide basis are listed in Table 1.

Between ACDs, Northern Telecom's inter-PBX variant of Q.931 signalling is deployed. This signalling system supports many of the DPNSS1 features used between PBXs, but in addition provides the additional functions needed to operate geographically distributed ACDs. A highly-functional gateway between DPNSS1 and Q.931 signalling system is maintained to ensure that both systems can co-exist without loss of user functionality.

BTnet was the first commercial application of DPNSS1 within the UK, and commissioned the first ever international link (to New York) using DPNSS1 in 1989. It is the largest all-digital private network in the world using DPNSS1 and Q.931 signalling.

| Table 1 | BTnet Features |
|---|---|
| User Functions | Fast calls set up (voice) |
| | Data call (partial) |
| | Call back when free |
| | Call back when next used |
| | Three-part services |
| | — Enquiry |
| | — Shuttle |
| | — Transfer |
| | — Conference |
| | Call-forward services |
| | — Unconditional |
| | — On busy |
| | — On no reply |
| Attendant Services | Centralised attendant |
| | Night service |
| Controlling Services | Class of service (partial) |
| | Trunk access (partial) |
| | Alarm reporting (partial) |
| | Route optimisation (partial) |

## Management

A range of tools is used for network management for design and support.

Computerised support for BTnet design is provided by Micronap, an application produced by TML Ltd. The tool is capable of network modelling and can accept usage information direct from capacity management tools. The detailed configurations are manually designed. To ensure consistent operation, standards have been developed for essential configuration channels for each PBX.

Alarm monitoring is carried out centrally by using Concert™ ServiceView. The network operations centres are provided with network status information from BT's remote access of customer equipment (RACE) centres. This method has the advantage that both network operator and maintainer share a common view of problems.

Capacity management is achieved using an Orbitel Call Management System purchased from SRL Ltd. Call detail information is collected at each PBX and transported over the internal X.25 data network to a central computer at Pontefract. Users are provided with local terminals and have access to a considerable range of capacity and usage information analysis. The arrangement is shown in Figure 3.

## Migration

BTnet must deliver the most cost effective solution to BT's communication needs, and must keep pace with technology to allow this to happen.

## FeatureNet Services

There will be greater deployment of FeatureNet, particularly when the requirement is for simple telephony service, and for cutting cost in transmission.

## Voice processing

The deployment of services such as Voice Mail, and call filtering using similar technology has already begun. These will continue to grow and become more complex applications requiring the interaction of voice with computing (offers interactive voice response — Call IVR) will be required.

## Computer integrated telephony

Applications requiring the voice call processing and data applications to work together have already been specified although not yet deployed. In the future, specialist applications will require this functionality.

## Consolidation

Change in BT will lead to the requirement for a reduced number of buildings with a greater occupation density. This will alter the BTnet requirement and affect its shape.

## Service management

Provision will move to a basis on which service on demand will require computerised support.

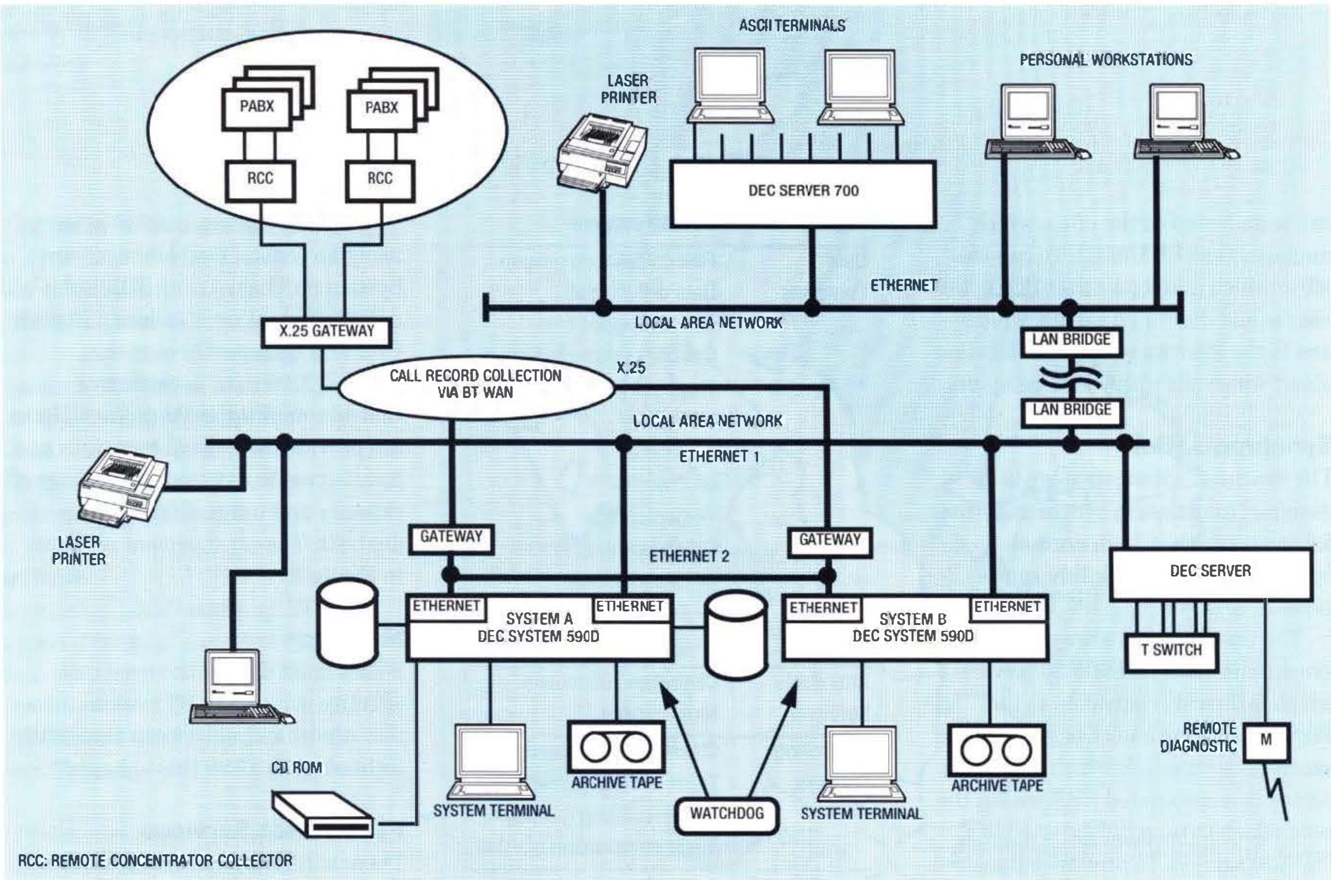



*Figure 3—BTnet call management system*

## VCnet — The Corporate Videoconferencing Service

### Service description

VCnet offers managed video-conferencing facilities between 29 locations in the UK, USA and Europe (see Figure 4) with onward connections to public studios in 55 countries. The service is built round dedicated studios which can hold up to six people. Point-to-point and third-party conference are offered. In addition to the video units, each studio is equipped with:

- graphic tablet
- telephone service
- facsimile
- white boards.

A central booking service is provided.

### Quality of service

#### *Architecture*

Each studio is equipped with a double (or exceptionally a single) video cabinet. These cabinets are connected to line by using BT's VC2100 range of CCITT H.261 compatible video codecs. Each codec has available 384 kbit/s bandwidth from the IBTN managed bandwidth service (reviewed later in this article). This is pre-emptable bandwidth normally lying spare to protect against the disruption which could occur if it became necessary to fall back a BT computer centre.

Switching is achieved by using the functionality available from IBTN multiplexers. At strategic locations within the IBTN, 8-port multi-party conference units are provided. These units provide multi-party (up to eight locations) capabilities using voice-controlled switching for video control.

Interconnection with the ISDN at 128 kbit/s and 384 kbit/s is used to serve locations where fixed bandwidth is not readily available.

A centralised booking system available from IN front offices is in place.

Connection to video studios operated by BT Europe, Tymnet and Syncordia is achieved by providing linkage at channel bandwidth level between IBTN and Syncordia/Tymnet networks.

#### *Management*

End-to-end management visibility is maintained by providing IBTN multiplexers at the remote locations. Video codecs and MCUs are managed from the IBTN service centre at Pontefract using dial-up modems.

#### *Migration*

A number of service enhancements are planned in addition to meeting normal demand for service growth.

- ISDN—The ability to communicate with ISDN connection desk-top video units is envisaged. A future migration towards total ISDN connection is also being considered.
- Booking system—A fully integrated booking system providing connections on demand is being specified. It is expected that this will be delivered as part of BT's Concert™ programme.
- Management—A higher functionality management package is to be specified, targeted to improve service availability.


*Figure 4—Videoconferencing studio locations*

In addition, VCnet will migrate to become the internal element of BT's global visual services initiative.

## IBTN — A Managed Bandwidth Network

### Service description

The IBTN provides a national and international managed bandwidth service. Support is provided for voice, data, and videoconferencing applications.

Approximately 4000 user channels are supported. The primary use is for data, with the largest application being the provision of networked fallback service for BT's computing locations.

Voice is supported at a range of speeds from 4·8 kbit/s to 64 kbit/s. Internal applications restrict use to adaptive differential pulse-code modulation at 16 kbit/s and 32 kbit/s together with A-law and m-law encoding at 64 kbit/s. Clear channels at 64 kbit/s are available for signalling.

For data channels, speeds supported range from 9·6 kbit/s to 1544 Mbit/s, with most users now migrating from 9·6 kbit/s to 64 kbit/s. A range of user interfaces is available.

Videoconferencing is supported by channels working at 384 kbit/s.

The IBTN is designed for fast service provision and very high availability. The design of the network and the way that it is operated overcome the effect on users of single and multiple element failures.

### Portfolio

The IBTN is constructed from BT DM7532 and DM7560 multiplexers, linked in the UK by MegaStream, and overseas by appropriately dimensioned $n \times 64$ kbit/s IPLCs. The BT KiloStream service provides a reliable clock source for synchronisation.

### Topology

The current IBTN design is an incomplete mesh. The mesh has become increasingly more complex as the number of network nodes has grown, particularly in the past two years. As there is known demand for 1000+ additional user channels, a network design enhancement is being implemented which will change the network to have a core and access structure.

This new design will give improved availability as well as simplifying planning and support of the network.

The core consists of six DM7560 multiplexers linked in a complete mesh by MegaStream circuits. The access network consists of DM7532 multiplexers linked into rings (normally triangular) radiating from the core.

The migration to the new design is a complex project, as it must not jeopardise service. When complete, it will provide a more efficient network with improved availability.

### Numbering

Each multiplexer has a 3-digit location identity. No attempt is made to structure the allocation of these identities as each location is configured to have full knowledge of all other locations on the network.

### Synchronisation

For synchronisation, the network is divided into three geographical zones. Each zone is independently synchronised from multiple KiloStream sources.

Multiplexers not directly connected to KiloStream circuits are arranged in a master/slave arrangement with no more than two links between a multiplexer and a KiloStream source. Use of multiple KiloStream circuits, and highly-accurate internal clocks are used to protect against loss of synchronisation.

### Signalling

A channel for signalling management information is extracted from the bandwidth provided between multiplexers. This channel is used for the transport of alarm and supervisory information to and from the management centre.

### Management

The design tool for IBTN is NETMOD, a BT Laboratories development specifically targeted at the design of networks using DM7500 series multiplexers. In addition to basic modelling of the network and testing 'what if' scenarios, the tool produces the configuration tables for the multiplexers, and has the capability of storing alternative configurations for use in disaster situations and for major redesigns. NETMOD is used to download remotely configuration changes from the network management centre.

Alarms are monitored by using the multiplexer manufacturer's proprietary system called *GNMS* (global network management system). Status information is gathered from the network and displayed. Alarms can be interrogated remotely to determine their cause, and action can be taken to restore service without going to site.

## D&P/Group Computing Services

### BT internal data networks

The current technologies employed for data networking in BT are diverse. The primary reason for this is historical. In the past, no single authority was responsible for providing data communications and hence the resulting infrastructure evolved from geographically-based business units called *Districts*.

The current network technologies deployed are:

- T-NET Plus based on Digital Equipment Corporations (DEC) DECnet suite of products. T-NET Plus supports over 27 000 users and was originally designed to provide multiple host access from a single terminal (M1779). The primary use is for user access to the Customer Service System (CSS).
- System networking architecture (SNA) is primarily used for access to International Business Machines (IBM) based applications. These networks are usually geographically-based utilising point-to-point multiplexer technologies for wide area connectivity. SNI is used principally for host-to-host access.
- The IBTN is a nationwide network of DM7500 multiplexer technology used for terminal access to remote computer centres.
- Regional DM7500 multiplexer transmission networks are used for onward connection of user-to-host terminal traffic.
- The internal core network is a nationwide router network based on DEC products. Only DECnet protocols are routed. The network is used for terminal-to-remote host access.
- BT Tymnet Europe X.25 networks are a rented service used to connect remote terminals to hosts and are used in conjunction with T-NET Plus networks.
- District X.25 DM3000 transmission networks, sometimes called *private X.25 networks*, are used for linking remote sites to T-NET Plus networks.
- The administration data packet network (ADPN) is an X.25-based network utilising KiloStream circuits to support host-to-host data of digital telephony exchanges.
- District-based DM5500 time division statistical multiplexer networks are used primarily for onward connection of asynchronously connected terminals.
- The group data centres WAN/LAN allows both connectivity of dumb terminals and PCs using a variety of multiplexer and router technologies.
- The BoaT Intermail network is used for electronic mail transfer between existing host office automation systems such as PROFS, HOST and All-in-1.

Most of the above are used for onward connection of terminal (user) connection to remote mainframe-based business applications. The two most significant network architectures are SNA and DECnet based.

Most of the end-user devices are dumb terminals connected to terminal servers or cluster controllers. There is a wide variety of terminal types and network components.

The principal access requirement for most data networks in BT is the CSS. CSS is an IBM mainframe-based application widely used throughout most BT business divisions.

Group Computing Services is rationalising all of the above networks using the computer centre consolidation programme as the driver to provide a common bearer network using shared high-speed WAN circuits for access to all business applications. Figure 5 shows the current topologies of existing networks. It is worth noting that most terminals have access to only a single service.

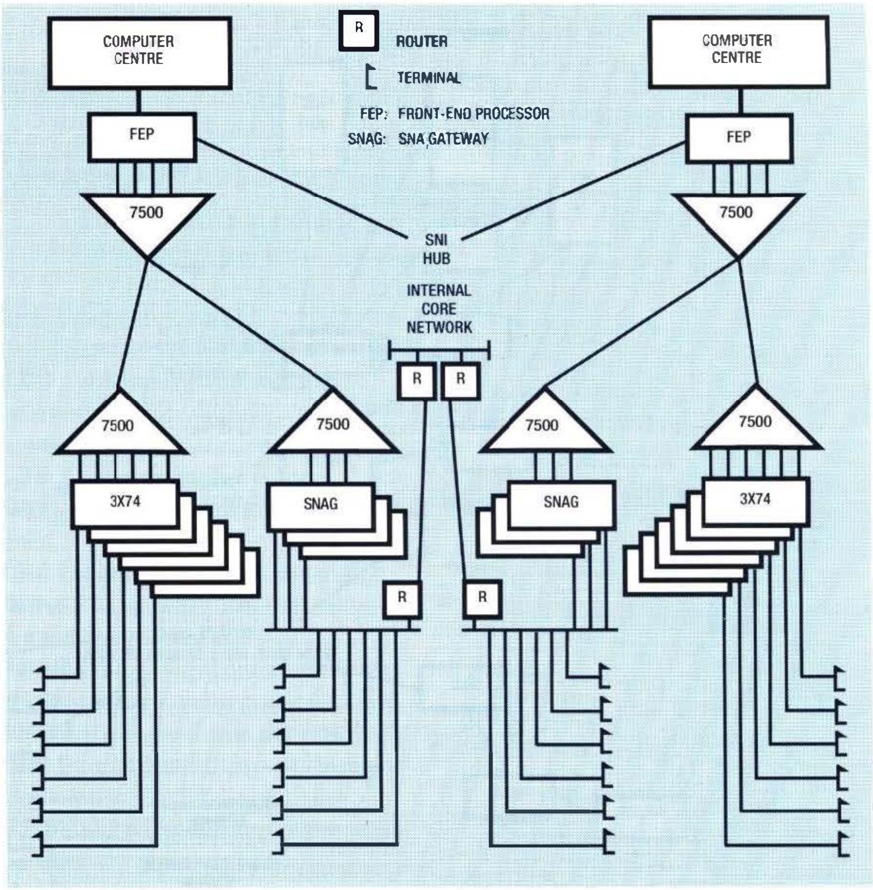
## Business Requirements for Data Networking

As previously stated, the pre-Sovereign District-based business structures precluded the need for anything other than geographically-based network infrastructure. Each of the user networks deployed were 'parented' on a computer centre based within the District.

The need for nationwide networking was limited to systems such as sales, line plant and personnel. There were also limited requirements for management information systems and integration of business information from CSS.

This has now changed. BT has been restructured into an international

*Figure 5—Existing network topologies*




organisation and hence the need for integration of BT's business information has become a prime requirement. Management information systems are a fundamental requirement for sales and resource forecasting.

Not only has there been a need to integrate and manage data more centrally, but the computer applications currently being implemented are far more complex than in the past. This has meant that requirements for more complex security and access facilities are much more sophisticated than those required in the past. More applications are being developed on UNIX and Open Systems, coupled with a growth in distributed processing. Thus there is a requirement for more flexible 'any-to-any' networking rather than the traditional fixed 'user-to-host' and 'host-to-host' configurations.

The above has impacted on the requirements in both local and wide area networking environments in the following way:

- To protect the investment in existing network infrastructure it has been necessary to implement a nationwide multi-protocol network environment.
- To reduce bandwidth costs the deployment of a shared wide area network is seen as a fundamental requirement.
- To ensure that demand for reduced user response times, a high-speed networking infrastructure is necessary.
- To guarantee high availability and reduced provisioning times a structured LAN cabling infrastructure and meshed WAN topology is required.
- To reduce operational costs, a more sophisticated and automated service management environment is a pre-requisite.

The above changes to requirements have led to the development of a strategy to rationalise and improve significantly the current networks deployed in BT.

The computer centre rationalisation programme is reducing the number of data processing sites from over 40 to just nine. This programme will also functionalise computer operations, by concentrating common data processing environments together. For example IBM, DEC, UNIX and systems development workloads will be placed at the optimum site nationally, rather than replicating the entire suite of computer applications at each regional site. Specialist activities, such as batch printing, will also be re-located to dedicated print factories.

## Future Data Networking in BT

Before deciding on a technical/business strategy for internal BT data networks, it is necessary to understand fully not only the existing and medium-term business requirements, but also how the existing networks can be migrated.

In August 1991, Group Computing Services Data Communications published a strategy based on a business model developed to assess the cost impact of the implementation of any technologies on the existing networks.

From this business model, it has been possible to do an impact analysis of various technical strategies. The most cost effective and technically viable strategy has been assessed as:

- A local area network utilising Ethernet and token ring physical media. The transport protocols utilised will be OSI, DECnet, SNA (or APPN) and TCP/IP.
- A shared-bandwidth high-speed wide area network utilising frame relay technology.

The new technologies have all now been trialled and have been planned to be implemented to provide a single shared network providing any-to-any connectivity. This network has been called the *corporate data network* and comprises the following components:

- High-speed data network (HSDN) comprising 2 and 34 Mbit/s circuit switch technologies connecting all major user populations and compu-

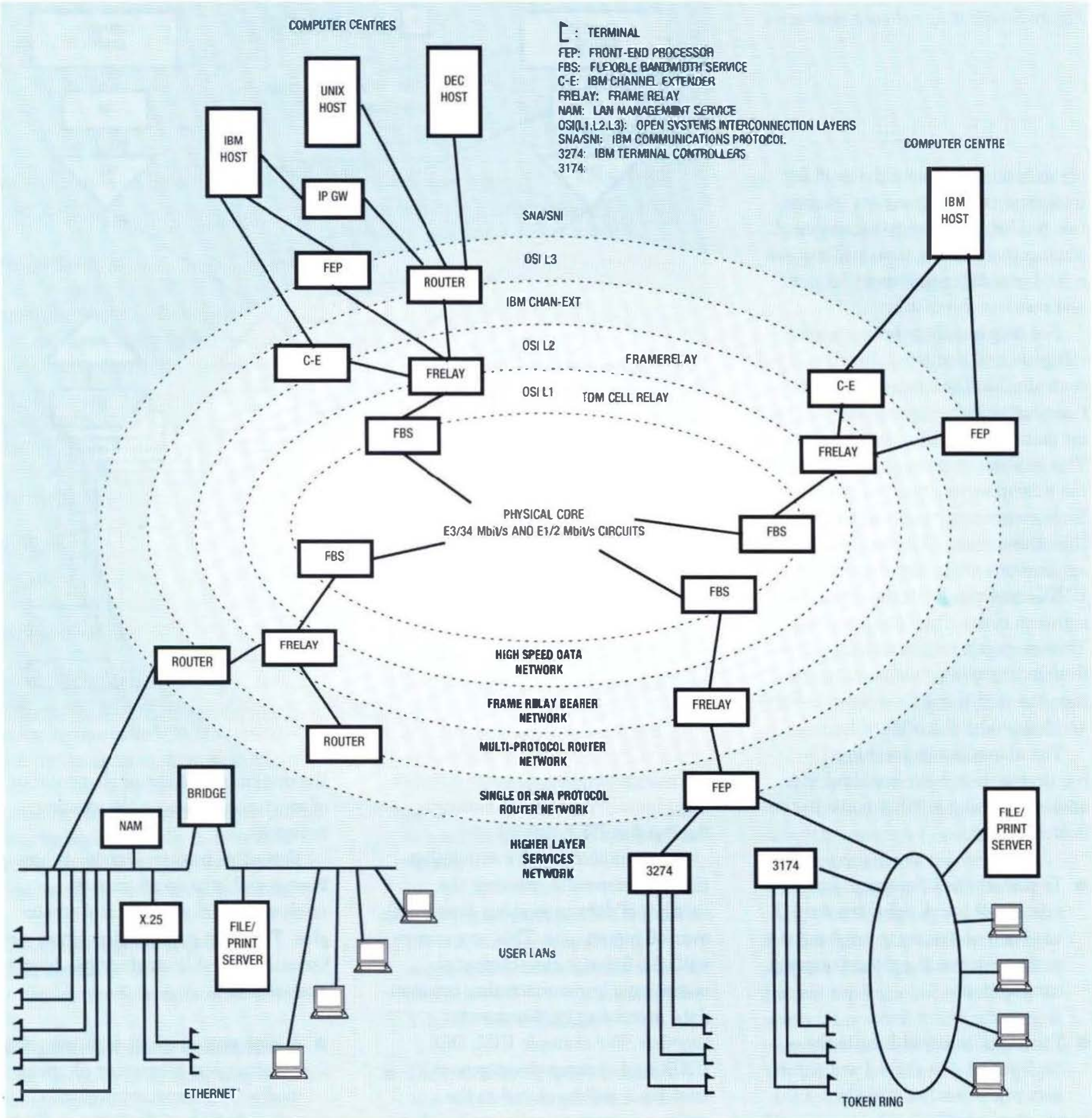



*Figure 6—BT corporate data network*

ter centres in a flexible and resilient mesh topology. This network is essentially a shared-bandwidth national network with major network nodes based in core sites and points of presence at major user sites and computer centres.

- Frame relay bearer network (FRBN) comprising 2 Mbit/s frame relay technologies acting as a feeder network to the HSDN. This network provides the most efficient means of consolidating high volumes of data traffic from a wide range of other network types onto single physical trunks.

- Multi-protocol router network (MPRN) comprising multi-protocol routers based in user sites, core sites and computer centres and is closely integrated with the FRBN. This network will add the transport and network-level switching intelligence to route to remote applications.

- Single (or SNA) protocol routing network (SPRN). Current multi-protocol router technologies do not allow for efficient and flexible transmission of SNA, an imperative for BT due to the scale of BT's IBM computing base. The SPRN will also support the efficient management of the very large terminal networks through the implementation of IBM configuration management centres. The SPRN will be complementary to the MPRN and again tightly integrated with the FRBN. The use of APPN in the future will further integrate the SPRN and MPRN.

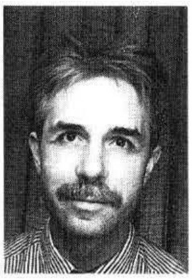
- Higher-layer services network (HLSN) is the operational and service management network which overlays all of the above networks allowing closely coupled service capabilities and gateway management to all BT business applications.

Figure 6 shows the proposed any-to-any connectivity of the corporate data network.

## Biographies

**Ted Rook**
BT Worldwide Networks

Ted Rook joined the BPO as an apprentice in 1964 in City Telephone Area. Since then he has worked on a range of tasks mainly in the area of customer premise equipment design, management and support. He has spent the last two years with WN/ Internal Networks where he is now responsible for Network Operations.



**Steve Green**
BT Worldwide Networks

Steve Green obtained a B.Sc. in engineering while working for British Rail. During this period, he was responsible for the design, procurement and installation of a computer-aided engineering system which was used for railway rolling stock design and manufacture. In 1986, he joined BT, initially working for BTAT on the CHOTS project, and subsequently took responsibility as Program Manager for the roll-out of T-NET Plus. Steve joined Group Computing Services in 1990, and currently has responsibility for data networking strategy.

## Glossary

**ACD** Automatic call distrubution
**ADPN** Administration data packet network
**CSS** Customer Service System
**D&P** BT Development and Procurement
**DEC** Digital Equipment Corporation
**DPNSS1** Digital Private Network Signalling System No. 1
**FRBN** Frame relay bearer network
**HLSN** Higher-layer services network
**HSDN** High-speed data network
**IBM** International Business Machines Corporation
**IBTN** Internal backbone transmission network
**IN** Internal Networks
**INFO** Internal Networks front office
**IPLC** International private leased circuit
**ISDN** Integrated services digital network
**LAN** Local area network
**MPRN** Multi-protocol router network
**OSI** Open Systems Interconnection
**PBX** Private branch exchange
**PC** Personal computer
**PSTN** Public switched telephone network
**RACE** Remote access of customer equipment
**SNA** System networking architecture
**SPRN** Single (or SNA) protocol router network
**WAN** Wide area network
**WN** BT Worldwide Networks

*John Hartill, Alan Marshall and Chris Davis*

# Robotic Duty Cycle Testing of Payphones

*This article discusses the need for, and describes the development and function of, a robot-based test cell for payphone products. The benefits of automated, realistic whole-product tests during climatic stressing are discussed together with the reliability and whole-life cost improvements achieved.*

## Introduction

The continuing development of payphones in BT, including a description of the new range of payphones being introduced, was featured in a previous issue of the *Journal*[1].

The theme of the new range is improved customer features and reliability for the 1990s.

The Product Evaluation: Payphones unit, of BT Development and Procurement's Group Technical Facilities (GTF), based in Birmingham, provides specialist support to BT Payphones via the Payphones Procurement Team of Group Procurement Services. This support is primarily in terms of proposing technical and reliability requirements for product specifications, together with product design and performance evaluations.

The core objective is to minimise whole-life costs by means of clearly defined reliability and performance requirements evaluated against realistic and meaningful test and evaluation programmes. The test programmes are required to realise a minimum cost benefit to BT of 5:1.

In view of improved customer facilities, increased complexity and sophistication from the new payphone product range, taken together with stringent reliability targets, a cost-effective, flexible, realistic and robust evaluation process is required.

This article describes the development and use of a robotic test cell for payphone products in order to satisfy the above requirements and criteria.

## Group Technical Facilities—Quality and Reliability Involvement

GTF's quality and reliability support to payphone development involves interfaces at appropriate points in the payphone life cycle (see Table 1). The scope of specialist services involved is given in Table 2.

The life cycle as represented in Table 1 is idealised and invariably is not stringently followed for real-life, practical reasons. The target launch date is sensibly the driving force for the project. Tasks and evaluations may take place in parallel or out of logical sequence, with the objective of concentrating as much evaluation and

**Table 1** Idealisation of Payphone Product Life Cycle

| GTF Involved In: / Product Options | Specification | Design Reviews with Suppliers | Proto-types | Field Trials | Supplier Audits | Supplier Tests | In-Service Problems | Recovery |
|---|---|---|---|---|---|---|---|---|
| Existing Products | | | | | | | ● | ● |
| Redesign of Existing Product | ● | ● | ● | ● | ● | ● | ● | ● |
| Proprietary Product | | ● | | ● | ● | | ● | ● |
| Clean-Sheet Design and Development | ● | ● | ● | ● | ● | ● | ● | ● |
| Product Concept | Design and Development | | | | | | Production and Service | Withdrawal |

*the cost of rectifying a design fault during production and/or service can be 10 or 100 times the cost of correcting the problem during design and development*

necessary redesign work as possible into the design and development phase. It is an accepted fact that the cost of rectifying a design fault during production and/or service can be 10 or 100 times the cost of correcting the problem during design and development.

The time between the design and development phase and the product launch phase may be only a few months. GTF is conscious of this fact as a prime customer requirement and therefore provides differing levels of evaluation which match the necessary urgency. Providing the client with informed, quantified information regarding design and reliability risks is vital. All work is agreed by the client prior to commencement for a forecast minimum of 5:1 return on resource expended.

It is normal for a BT payphone supplier to be contractually required to demonstrate, by testing, that his product meets the specification. In practice, this involves a minimum of two separate test programmes:

- a qualification test programme, and
- a reliability test programme.

The results of these two sets of tests taken together with the field-trial results provides BT with a level of confidence for the product performance.

The real-life scenario of product development provides a complex set of conflicting requirements for the product team and project manager in meeting the desired launch date, yet having sufficient test and performance data to allow launch to occur at minimal failure risk to BT. It is not unusual for suppliers' reliability test programmes to be scheduled well into the production/in-service phase. The scope of suppliers' tests may also be less than the ideal requirement and will depend directly upon the range of facilities which he has available and the costs which he is prepared to incur in sub-contracting tests and building test models. These factors are in turn directly related to the unit price which BT is prepared to pay for the payphone.

It is to this environment that the Product Evaluation: Payphones team within GTF has designed and integrated its duty cycle and climatic test programmes. The objectives are summarised as follows:

- to provide realistic payphone operation for coins, BT phonecards (debit cards), credit cards and management system reports for a sensible number of simulated calls;

**Table 2 Typical GTF Activity**

| |
|---|
| *GTF Reviews:* |
| Design proposals |
| Qualification and reliability test plans |
| Reliability predictions |
| Component list |
| Materials and finishes |
| Safety |
| ESD/EMC risk |
| Mechanical integrity |
| Environmental issues |
| Build standards and quality |
| Dry-cell performance evaluation |
| *GTF Performs:* |
| Test facility audits |
| Quality of design and build audits of printed wiring boards |
| Component supply and qualification audits |
| Component quality and tolerance audits, especially polymers |
| Coin and card tests if a risk is identified |
| Software functionality and provocative tests |
| EMC/ESD tests if a risk is identified |
| Environmental tests if a risk is identified |
| Field-trial technical support |
| Post field-trial evaluations |
| Reliability trials |

**Table 3 Product Ranges to be Tested in Terms of Facilities Required for a Representative Test**

| | |
|---|---|
| **Public Call Office (PCO)** | Use and quantity logging for:<br>● Coins: £1, 50p, old 10p, new 10p, 20p (maximum of 12 coins in escrow*).<br>● BT phone cards.<br>● Credit cards; for example, VISA, American Express, BT Chargecard.<br>● Coin rejection and refund.<br>Handset lift and replacement.<br>A controlled sequence of meter pulses (SPM).<br>Controlled connection to the BT network for management system reports.<br>Temperature and humidity sensing internal to the payphone.<br>Tones for test and operational reasons.<br>A line simulator which provides conditions matching self-test routines. |
| **Renters and Private Payphone** | Use and quantity logging for:<br>● Coins: £1, 50p, old 10p, new 10p, 20p (maximum of 12 coins in escrow*).<br>● Credit cards; for example, VISA, American Express, BT Chargecard.<br>● Coin rejection and refund.<br>Handset lift and replacement.<br>A controlled sequence of meter pulses (SPM) with the alternative option of self-contained metering.<br>Controlled connection to the BT network for management system reports.<br>Tones for test and operational reasons.<br>A line simulator which provides conditions matching self-test routines. |

* *Escrow* is a legal term which means that although the deed has been delivered it will not become effective until the specified condition has been fulfilled[2]. Its use in payphones is as an alternative term for coin store—coins may either be refunded to the user or cashed when in store or *escrow*.
SPM: Subscriber pulse metering

- to provide quantified performance data for coin validation, fraudulent coin rejection, coin mechanisms, BT phonecard readers and credit card readers;
- to provide the above during realistic climatic conditions;
- to avoid duplication of suppliers' test programmes;
- to provide test results for any BT payphone within sensible (that is, acceptable to client) time-scales;
- to have the capability for monitoring voltages, currents and signals within the payphone during duty cycle and climatic tests; and
- to provide the above on a cost-effective basis.

## GTF Payphone Product Evaluation Tests

There is little benefit to BT in repeating tests which a supplier is contractually required to carry out and which can be witnessed by BT personnel if considered to be necessary. The benefit from BT Product Evaluation payphone test programmes accrues from investigating and quantifying the product performance beyond the scope of the standard test regimes but within the specified operations envelope. In this respect, realistic usage (that is, duty cycle) tests are an important feature. Within the scope of the authors' experiences of BT payphone suppliers' test programmes, there is a concentration of effort in terms of testing coin and card mechanisms and keypads, for example, but little emphasis on 'whole product' tests during typical service usage combined with climatic stressing. These two features combined are paramount to a payphone's perceived operation and reliability. In fact, suppliers' reliability tests are normally conducted during ambient conditions.

Within the philosophy of reduced whole-life costs by a concentration of effort at the design and development stage, there is clearly an opportunity for BT to reduce its purchasing risk by supplementing the suppliers' tests and evaluation with a whole-product test during simultaneous climatic stressing. This provides additional data to the field trials and supplier-test programmes and gives the product team and project manager an informed evaluation during realistically simulated service conditions. Additionally, it provides data for input to the supplier's quality-improvement programme and possibly even a stimulus for investment by the supplier in similar test equipment.

The product requirements to be considered in designing such a test facility are detailed in Table 3.

Clearly, a test facility designed around the public call office (PCO) requirements with switchable options for subscriber pulse metering (SPM) or self-contained metering would satisfy both sets of requirements.

## Design Strategy

The criteria identified as key features of the design are listed in Table 4.

| Table 4 | Key Design Features |
|---|---|
| Human Interaction | Different product layouts |
| | Coin selection |
| | Coin supply |
| | Call type |
| | Call duration |
| | Follow-on call |
| | Coin reject and refund |
| | BT phonecard supply |
| | BT phonecard call duration |
| | Response to liquid-crystal display messages |
| | Credit card calls via 144 and swipe |
| | Dialling a selection of numbers |
| | Local, national and international calls |
| Network Simulation and Switching | SPM pulses and specification |
| | Line length |
| | Transmission characteristics |
| | Earthing |
| | Switch from simulation to network |
| Tones | Operator |
| | 1600 Hz for 144 service |
| Monitoring On-hook and Off-hook | Line conditions on- and off-hook |
| Climatic Stressing | Realistic conditions |
| | Sensible time-scales |
| | Apparatus-under-test-to-chamber volume ratio |
| | Operation of test rig |
| | Correcting faults at extremes |
| | Transportability of test rig |
| Data Recording | Climatic conditions internal to the payphone |
| | Number of calls of each type |
| | Number and denomination of coins presented |
| | Number of BT phonecard erasures |
| | Number of credit card calls |
| | Number and classification of failures |
| | Number of SPM pulses sent |
| | Payphone identification details |
| | Test identification details |

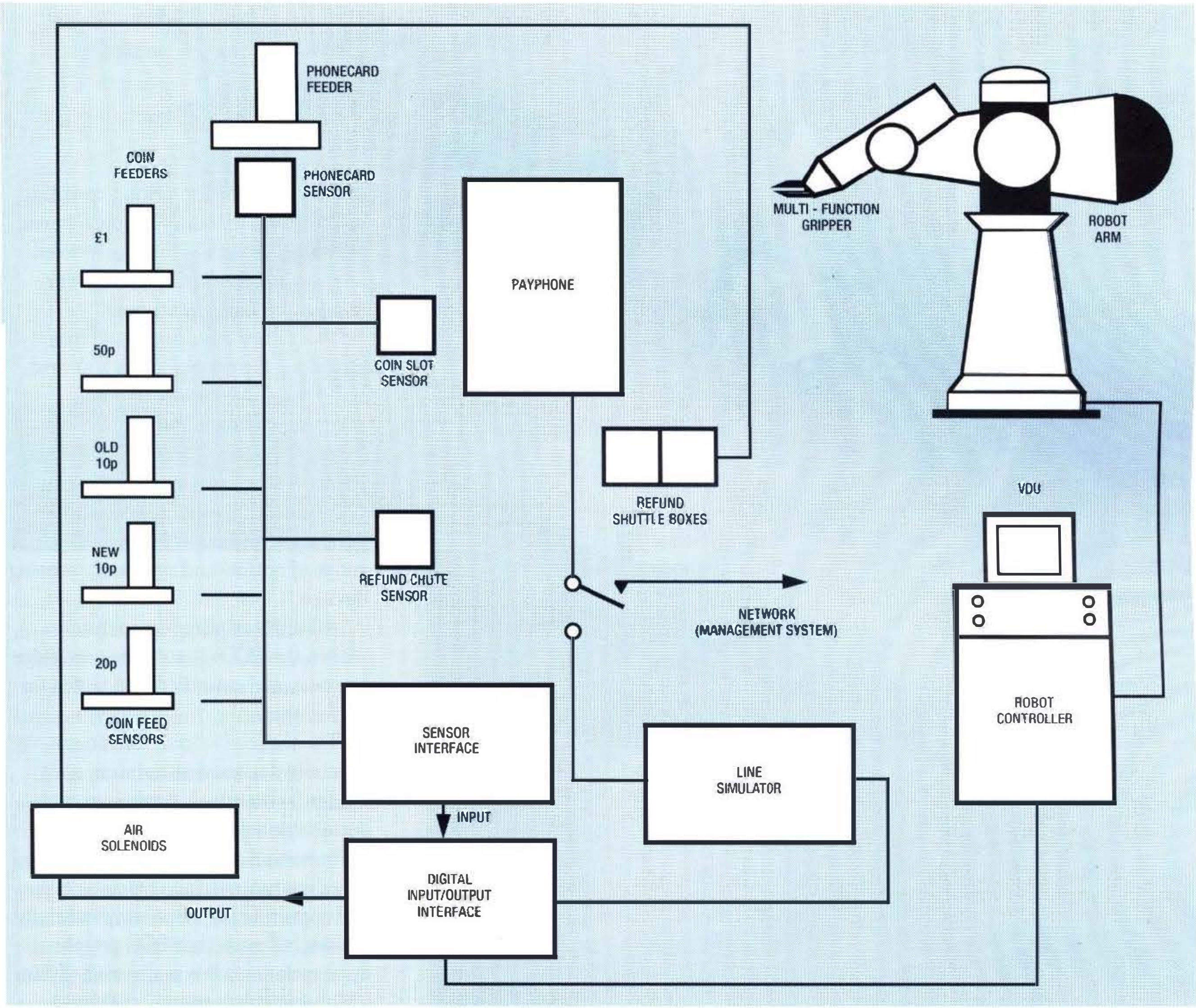



*Figure 1—Schematic diagram of payphone robotic test cell*

## Test Cell

The test cell is based around a Staubli Unimation, PUMA 560C robotic arm (see Figures 1 and 2).

Test programmes are effected under master control from the robot controller. A generic test programme has been developed using the resident VAL II software. Control of peripheral devices and sensor feedback signals is handled by the extensive digital input-output facilities available from the controller.

The generic design of the software programme was carefully considered in order to supply a rapid reconfiguration for different products. Subject to mechanical configuration, a product change can be effected within 2 hours, including redefinition of robot arm positions. The level of programme editing required is minimal, the necessary product changes being made by resetting variables within a menu-driven set-up routine.

Network conditions are simulated from a unique design of simulator. Payphone metering pulses, tests for on- and off-hook conditions, together with a transmission network, dial tone, operator and cashless service tones are effected from within the VAL II programme by using this simulator. For payphones which can make routine and fault reports via the network, a switch is operated under software control switching from the line simulation unit to the network for the necessary period. Metering pulses are switched off for tests on self-metering payphones.

Coins are presented from tubular stacks of 250-coin capacity for selection and transfer by the robot gripper to the payphone coin entry slot (see Figure 3). Coin presentation is reliably performed by a polytetrafluorethylene (PTFE) slider under the control of a pneumatic actuator. PTFE provides excellent low friction and wear properties combined with chemical and dimensional stability across the operational temperature and humidity range of PCO payphones ( +50°C to –20°C, with 30% of test duration at condensing conditions). Coin selection can be set to fixed or random sequences with variable weighting factors for higher-usage coins.

Call duration, number of coins per call, percentage of coins refunded, and meter rates are variable between test runs. Discrimination between non-validated and refunded coinage is available by means of a rodless cylinder which shunts two separate boxes across the refund chute at appropriate points in the programme (see Figure 4).

The robot gripper is a multi-function device capable of picking and placing

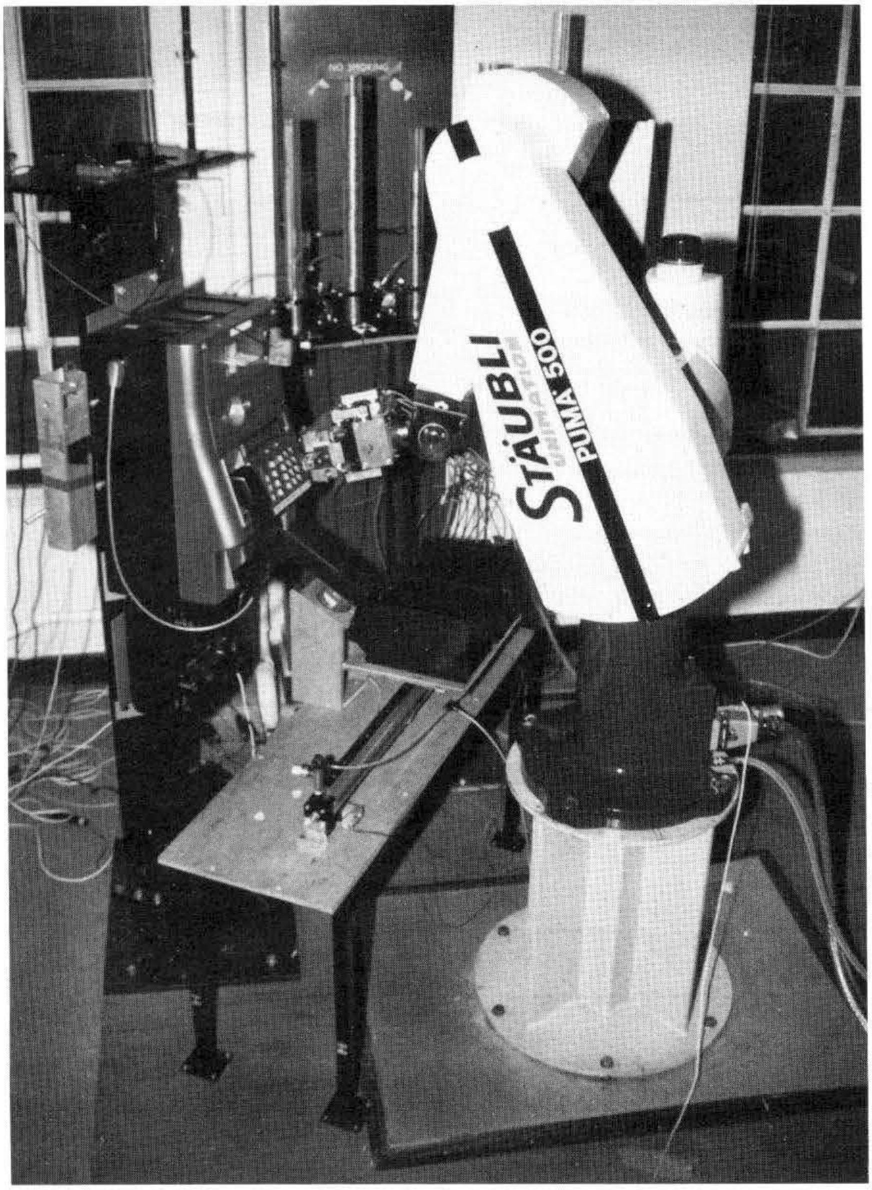
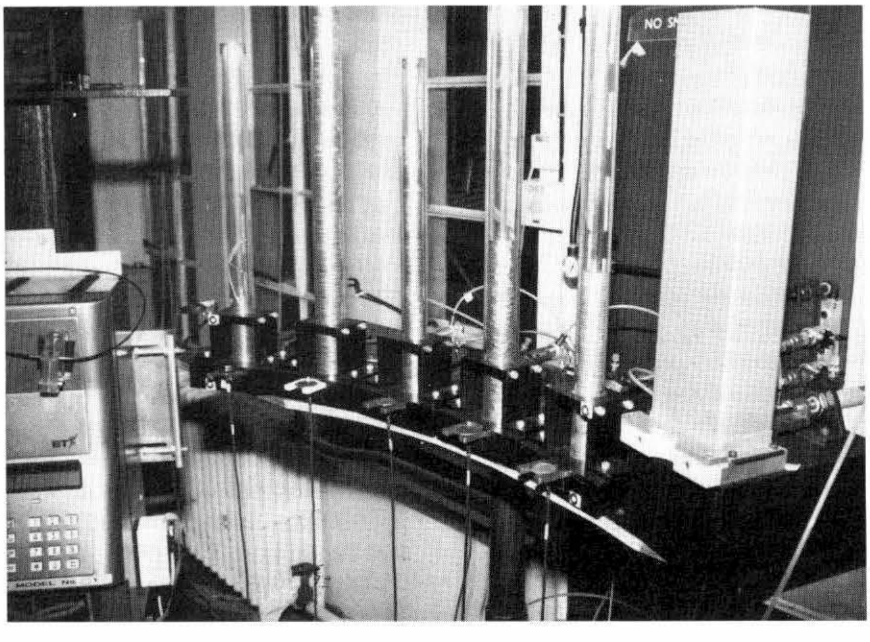



*Figure 2—Robotic test cell during evaluation of Payphone 2000*

*Figure 3—Pneumatically operated coin stacks*



the full UK coin set; picking, inserting, latching and withdrawing phonecards; controlled credit card swipes at most orientations; keypad operation and handset lift and replacement.

Phonecards are presented by a slider arrangement from a 200-card magazine. Any denomination phonecard may be used.

Feedback of critical actions within the test (for example, coin presented, coin picked up, coin in refund chute, phonecard in gripper) is provided by a range of optical and proximity sensing devices.

All units required to operate within the PCO climatic test envelope are designed, specified and tested for performance.

The test cell is mounted on a specially designed aluminium alloy ladder frame which combines an acceptable weight for handling with stiffness and environmental stability. The dimensions of the frame and the cell operating envelope were carefully considered such that PCO payphone duty cycle tests are performed within a climatic stress chamber; this is a unique test capability, representative of service conditions yet exceeding the minimal functional requirements of standard climatic stress tests.

## Future Development

A vision system is currently being commissioned for the test cell to enable the monitoring of liquid crystal display messages during tests.

An integrated instrumentation system will be added to permit automated measurement and recording of voltage, current and signal parameters during the test programme.

Consideration is also being given to multi-product testing within the same test cell.

## Conclusion

This robot test cell has been utilised with considerable success during the BT phases of product evaluation for recent payphone developments. It

*Figure 4—Rodless cylinder 'shuttles' collection boxes to refund chute for mis-validated and returned coins*

provides direct support to GTF's commitment not only to improve the reliability of products but also to support continuous improvement of BT suppliers.

Coin jams, phonecard reader malfunctions, software defects and reliability shortfalls have been identified and fed back into the supplier design loop. By performing realistic duty-cycle tests during representative climatic conditions and taking advantage of the consistency, productivity and data handling capacity of industrial automation techniques the reliability of BT's payphones is being improved and whole-life costs reduced.

## *References*


1 EMPRINGHAM, JOHN B. Developments in Payphones, *Br. Telecommun. Eng.*, July 1992, **11**, p. 77.

2 Law made simple : Colin F. Padfield 1973 edition


## *Acknowledgements*


The authors acknowledge the contribution of Steve Carter, BT Group Technical Facilities, for valued software-development advice and expertise; and Phil Need, BT Group Technical Facilities, for design and construction of the line simulation unit.


## *Biographies*


**John Hartill**
BT Development and Procurement


John Hartill joined the then British Post Office as a TT(A) in 1967. He worked as a Technical Officer and Assistant Executive Engineer on test equipment servicing and calibration. He gained supplier liaison experience as a quality assurance officer and was a technical manager for eight years of the mechanical and safety testing laboratory, BT Group Technical Facilities. He is currently senior quality and reliability engineer for payphone product evaluation within BT Group Technical Facilities. He was awarded an honours degree in mechanical engineering at Birmingham Polytechic during 1992 together with the I.Mech.E project prize.


**Alan Marshall**
BT Development and Procurement


Alan Marshall joined the then British Post Office as a TT(A) in 1978. He was a Technical Officer in the mechanical and safety testing laboratory for ten years. He is currently a quality and reliability engineer concerned with software product evaluation within BT Group Technical Facilities. He is in the final year of study for a B.Sc. in Applied Science at Wolverhampton University.


**Chris Davis**
BT Development and Procurement


Chris Davis joined BT as a TT(I) metallurgist in 1977 providing analysis of field failures. He worked for 4 years as a Technical Officer on payphone product evaluation within BT Group Technical Facilities. He is an Incorporated Engineer.

*Edward Kessler and Alistair Farquharson*

# Transmission Quality of Digital Circuit Multiplication and Low Rate Encoding

*This article explains the factors which affect the quality of speech and voiceband data transmissions through digital circuit multiplication equipment and low rate encoding. The means which may be used to assess degradations and the overall quality perceived by the customer are viewed in a real network context.*

## Introduction

Previous articles have outlined the general principles of digital circuit multiplication equipment (DCME), and low rate encoding (LRE) using adaptive differential pulse-code modulation (ADPCM)[1]; the methods used to test the correct functioning of DCME[2], as a piece of transmission equipment in the network; and the special techniques now being introduced in order to improve the quality of facsimile transmissions[3]. This article examines in a little more depth the possible impairment mechanisms and their effects when DCME is used. It also considers some practical methods for assessment of the transmission quality, and the quality likely to be experienced in real network situations. Finally, an Appendix (Appendix A) is included which clarifies the relationships between the various LRE algorithms.

## Factors Affecting Transmission Quality

For DCME, the factors which affect the transmission quality divide logically into two classes, namely those which are the result of the interpolation processes, and those which are the result of the encoding processes. The two classes may then be further subdivided into speech impairments and voiceband data impairments.

### Interpolation process impairments

Two possible types of impairment can occur in the interpolation process:

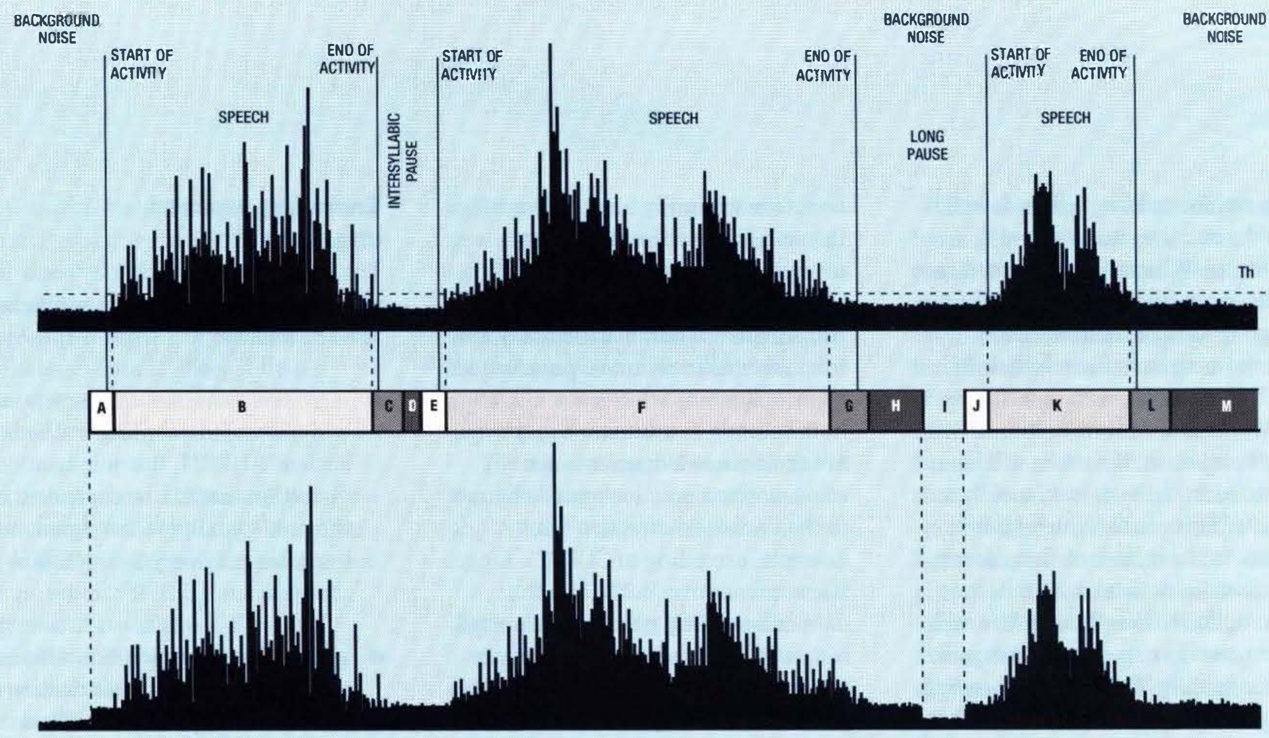
- competitive clipping, which results when the active trunk channel capacity exceeds the available bearer channel capacity; and
- impairments related to activity detection.

Competitive clipping, or *freezeout*, can easily be reduced to imperceptible levels by ensuring that the DCME is correctly loaded in terms of the number of channels for a given set of channel occupancy characteristics. This is extensively discussed in the supplements to CCITT Recommendations G.763 and G.766, and will therefore not be discussed further here.

Impairments related to activity detection result from a number of different causes:

(*a*) Noise, echo, crosstalk and extremes of level may result in misoperation, so that speech or voiceband data is clipped, or a silent background is punctuated by bursts of noise or interference.

(*b*) The finite detection time of the activity detector requires buffering to be inserted in the main signal path to compensate. This has the benefit that competitive clipping and recognition failures may also be slightly reduced, but the disadvantage that noise contrast effects may be increased. A considerable disadvantage is the increase in the propagation time: echo control is definitely required.




## Effects of the interpolation process

The diagram above shows what happens to speech that is subjected to interpolation. The top trace represents the sequence of events on a particular trunk channel input, the left-hand side of the page being earliest time. The vertical bars show the short-term average power level (arbitrary scaling). The line labelled Th is the threshold above which the activity detector registers that speech is present. The thick irregular line at the bottom of the trace represents the background noise.

The second trace shows when a bearer channel is allocated to the trunk channel and, by means of different types of shading, for what reason.

The third trace shows the reconstituted trunk channel output, incorporating some artefacts of the interpolation, in the form of the noise contrast (exaggerated for clarity) prior to the period A and between H and I, and I and J.

As the DCME loading is increased, less bearer channel time is allocated to the trunk channel. This occurs by the progressive erosion first of the periods D, H and M (when there is really no need for the bearer channel to be allocated to the trunk channel) and then of periods A, E and J ( which are provided to give the activity detector sufficient time to operate correctly). At this stage, depending upon the quality of the activity detector, critical listeners may notice some clipping. Finally, when the DCME is operating in severe overload, periods B, F and K, and their associated hangover periods C, G and L will be affected.

*Figure 1—Explanation of interpolation*

(c) Quantisation distortion is increased at the start of the activity due to the fact that the LRE decoder (and possibly the encoder as well) has to be reinitialised for each new assignment. This is because after the decoder (and encoder) are connected to the channel it takes some time to collect sufficient samples to model the signal characteristics accurately, typically about 200 ms. This also means that for speech, synchronous tandeming (see Appendix B) is only likely to be achieved when the DCME is lightly loaded.

### *Interpolation process impairments for speech*

A known characteristic of speech is that it has a high peak-to-mean ratio (though this is affected by the characteristics of the transducers used in the telephones, among other things). Furthermore, speech consists of a mixture of voiced sounds, which have strong tonal components, and unvoiced sounds, which are noise-like, and generally quieter. It also has a syllabic structure, within which individual syllables have a duration of about 300–800 ms, with intersyllabic pauses of about 30–100 ms.

Since most detection methods are unreliable when working on less than about 10 ms of speech, it is usual to provide 15-30 ms of buffering for the main-path signal, while detection takes place. This means that initial low energy sounds, which themselves would not register as activity, can still be transmitted through the DCME, provided that a louder sound follows within the buffering period. This is shown in Figure 1.

For similar reasons, a form of hysteresis, known as *hangover*, is provided, to ensure that the quiet sounds towards the end of an utterance are not suddenly clipped, which would make the speech sound unnatural. When the activity detector first declares the channel inactive the hangover timer is started. The channel assignment is maintained until the timer has expired. If new activity is detected within the hangover period, the timer will be restarted from the cessation of that activity. This enables intersyllabic pauses to be bridged, so that speech sounds more natural, with less interruption to breathing noises and room noise. For speech, the hangover time is usually 30–100 ms, depending upon the equipment type. Even after the hangover has elapsed, the channel will not necessarily be reallocated immediately. For that to happen there must be sufficient demand, in the form of newly active unallocated channels. If the equipment is lightly loaded, a channel allocation may persist for several minutes after activity ceases.

The noise contrast effect, mentioned under (*b*) above, is a change in the character of the background noise on the channel when allocation and deallocation occur. It is important that if the real background noise level on the channel is high, then the listening party should receive a similar noise level, irrespective of whether the channel is allocated or not. Furthermore, the noise should ideally be of similar character (spectrum, granularity etc) to the real noise, so that a contrast is not perceived. In some cases, there appears to be benefit in reproducing a lower noise level than the real one, particularly when the level of the real noise is high enough to be annoying, or its character cannot easily be matched[13].

### *Interpolation process impairments for voiceband data*

The characteristics of voiceband data transmissions are quite different from those of speech, from the point of view of the interpolation process. For example, the peak-to-mean ratios are much smaller and the mean signal levels are generally higher. This aids the activity detector in making unequivocal decisions.

Furthermore, data tends to be transmitted in bursts which may last from seconds to minutes, punctuated by interruptions which may also last from seconds to minutes. Exceptions are the acknowledgements sent by some modems on a low-speed channel in the backward direction (for example, according to CCITT Recommendation V.23), and the data-call start-up phase, which often contains bursts of energy which are only a few hundreds of milliseconds in duration. (The protocols used by facsimile machines are a very commonly encountered special case[5,6,7].) However, modems which are intended for use on international circuits usually commence the start-up phase with an exchange of identifying signals. In the case of a called modem intended for use on international circuits, the first signal which it sends is usually 2100 Hz. The purpose of this is to set any echo control devices on the circuit into an appropriate state for the data which is to follow. In other cases, a called modem may respond with other tones such as 2225 Hz, 1270 Hz, 1650 Hz, 1300 Hz or the repetitive transmission of a predetermined set of modem states. These signals are relatively robust, and therefore make the impairments discussed in (*c*) above insignificant for voiceband data, because such impairments should only occur during the early part of the start-up phase of a call recognised as voiceband data.

There seems little likelihood of noise contrast effects affecting voiceband data adversely, because they generally occur at levels far below the signal levels required for reliable transmission in the presence of noise.

In general then, provided that competitive clipping is made negligible by correctly dimensioning the DCME, the effects of interpolation on voiceband data communications should not be significant.

## Encoding process impairments

The impairments which may occur in the encoding process may be summarised as follows:

- increased quantisation distortion: with advanced encoding methods such as ADPCM, the quantisation distortion tends to be dependent on the predictability of the signal, and therefore may vary as the signal changes;
- variable bit-rate operation: this results in increased quantisation distortion for speech (voiceband data is generally transmitted with a fixed bit rate);
- bandwidth restriction: this is a feature of one ADPCM algorithm designed specifically for voiceband data transmission; and
- level dependency effects.

### *Encoding process impairments for speech*

For speech it is difficult to derive an adequate, comprehensive model for the way the ear experiences many of the effects described above. Experience has shown that the most significant effects in most circumstances are likely to be variable bit-rate operation, and level dependency.

Subjective testing has indicated that for the CCITT Recommendation G.726 algorithms, when the transmitted bit rate is reduced, by progressively increasing the proportion of samples encoded with 3 bits, rather than 4, the degradation becomes noticeable at an average of about 3·7 bits per sample.

It has also been observed during subjective testing that ADPCM codecs perform best when the speech input level is within a certain range, and when the listening level is also within a certain range. These effects depend to some extent both upon the speaker (whether male or female, for example), and upon some non-linearities of the hearing mechanism, and are therefore not easily testable, other than through formal subjective testing.

***Encoding process impairments for voiceband data***

Voiceband data is affected by the encoding process impairments as follows:

*(a) increased quantisation distortion*

A major factor in the performance of ADPCM algorithms is the accuracy of the predictor. The function of the predictor is to estimate the next sample of the input signal based on previous values. The predictor normally comprises two or more high-order filters, the combined output of which forms the estimate of the input signal. It is the difference between this estimate and the actual input signal that is coded and transmitted. Quantisation distortion occurs when there is a difference between the input signal level and the level resulting from the transmitted code.

The distribution of the quantised levels available to code the output signal is non-linear, having smaller steps between lower levels. So, the smaller the difference signal, the smaller the quantisation error is likely to be. The size of the difference signal is controlled by the accuracy of the prediction. Future estimates can only be predicted if there is some significant correlation between successive samples in the input signal. In the case of speech, there is a high degree of correlation. For data, the degree of correlation is dependent on the data rate of the signal relative to the sampling rate and in most cases is a lot lower than that of speech. In theory, the quality of the prediction improves as the number of previous samples taken into account increases. In practice, the gain in quality after three or four previous samples is negligible[8].

The principle of adaptive quantisation is that the step size between the quantisation levels varies depending on the rate of change of the input signal. This is designed to help prevent slope overload conditions and to minimise the quantisation distortion when the signal variation is small. The available steps have a non-linear distribution and the actual values are defined for each algorithm. The adaptation is controlled by a quantiser scale factor that changes depending on the signal.

The effect of quantisation distortion is to introduce amplitude and phase jitter which is correlated to the signal.

*(b) variable bit-rate (VBR) operation*

Some manufacturers' DCMEs permit lower encoding rates to be used for low-rate voiceband data. The G.726 32 kbit/s ADPCM gives acceptable performance with voiceband data rates of up to 4·8 kbit/s. Rates of 2·4 kbit/s and below may perform adequately even with the G.726 24 kbit/s algorithm, assuming that the signal is not already significantly degraded elsewhere in the network. Allowing VBR on lower voiceband data rates depends also on being able to classify the signal as data and to detect the speed. Incorrect classification of a signal could obviously lead to high-speed data signals being corrupted by bit stealing, or encoding at too low a bit rate.

*(c) bandwidth restriction*

The sampling rate of the ADPCM coding is determined by the 8 kHz sampling of the received PCM signal. However, there is one implementation[9] that trades bandwidth for increased quantisation levels by resampling at 6·4 kHz. The input signal is band-limited to 3·1 kHz and quantised with 5 bits per sample resulting in a bearer channel rate of 32 kbit/s. The frequency spectrum of existing voiceband data modulation schemes does not extend beyond 3·1 kHz and so they suffer no adverse effects. In fact, the extra quantisation steps mean that this 32 kbit/s algorithm can cope with V.29 9·6 kbit/s and V.17 14·4 kbit/s data rates provided that the other impairments in the network are not too great.

However, improvements in modem technology have opened up the possibility of extremely sophisticated compensation and predistortion to overcome non-ideal channel characteristics. Such modems are able to adapt the characteristics of their transmissions (centre frequency, bandwidth and constellation) to the characteristics of the channel. Clearly short-distance links through the local network offer the greatest bit-rate potential, because the signal-to-noise ratio is high and bandwidth can exceed 3·5 kHz. In such circumstances, over 28 kbit/s has been achieved. In most national trunk networks, the channelisation filters of analogue FDM systems, and the anti-aliasing filters of digital PCM systems result in lower bandwidths and hence lower data rates, in the region of 24 kbit/s being possible. Further bandwidth reduction to 3·1 kHz clearly impacts even further upon the maximum possible bit rate. Recent tests[10] on the international network have shown that it results in a practical limit of about 16·8 kbit/s.

The limitations of ADPCM, for the transmission of high bit-rate voiceband data are well recognised within the CCITT. Consequently, the standardisation work for future high-speed modems, currently designated *V.fast*, is proceeding in parallel with work to standardise the protocols, so that DCMEs may use demodulation and remodulation techniques similar to those currently being introduced for facsimile calls[3,11]. This should eventually enable the use of higher voiceband data rates than would have been possible had it been feasible to provide a 64 kbit/s clear channel through the DCME.

*(d) level dependency effects*

In general, the level dependency effects for voiceband data which result from the encoding are only likely to be significant at very high and very low levels. At very high levels, clipping may occur in preceding PCM links, which would tend to reduce the correlation of the signal, thereby reducing performance still further because of the time taken to recover. Control of this phenomenon is largely in the hands of users, regulators and manufacturers, rather than network providers. For good performance in normal circumstances, maximum transmission levels need to be observed.

For very low transmission levels there may also be some performance limitations, owing to failure of synchronous tandeming of the 40 kbit/s ADPCM algorithms caused by truncation in the LOG function of the algorithm[12]. Further work is needed to establish whether such degradations are likely to occur in practice.

## Transmission Quality Assessment

When assessing equipment and techniques which are themselves of high complexity, and which moreover are deliberately interactive with the transmissions which are carried through them, it is very important to adopt a structured approach to testing. This means that long before tests are conducted with 'live' traffic in an environment which is something like the real network, a judgement must be made about which characteristics are the most critical and therefore deserving of detailed individual examination. It is then down to the skill of the test team to devise meaningful experiments which fully evaluate each characteristic within the range of likely operation. This is a very time-consuming and expensive process, but experience has shown that a more wholesale approach runs the risk of producing results which do not withstand critical scrutiny.

### Transmission quality assessment for speech

There are several problems in trying to assess transmission quality for speech, for the interpolation process and the encoding process separately. One problem is the relative transience and irregularity of some of the degradations. Other problems are the lack of comprehensive standardised test sequences which are also a convincing representation of a long segment of speech, the difficulty of maintaining subject concentration during very long subjective test sessions, and the fact that the nature of the impairments varies with the load applied to the DCME (so that the loading, together with its statistical variations, must also be stipulated and simulated). Finally, the purpose of subjective testing is to find out the opinion of a representative sample of the public-at-large on a particular set of conditions. This is a very necessary market-oriented approach, but sometimes raises as many questions as it answers, as regards the impairments which actually came into play at the instant when a particular quality judgement was made.

An approach which has been found worthwhile uses subjective tests to evaluate the overall quality for a limited range of carefully chosen conditions, with objective testing of interpolation effects, using a range of simulated and real test signals combined with expert listener evaluation.

For example, when conducting a subjective test it would be desirable to know whether the DCME loading is likely to produce noticable clipping, or whether only variable bit-rate operation is likely to be experienced. This can be determined by establishing a test loading condition using a channel activity simulator to simulate voice, voiceband data and facsimile traffic on a given number of trunk channels, while a single test channel carries a sequence of test signals to probe the transmission quality of the link. A simple example of such a test signal would be a series of tone bursts, each of duration comparable to that of a syllable, say 600 ms.

The severity of clipping of the test signal can be evaluated in two different ways. The total percentage of tone lost provides an approximation to the freezeout fraction. The percentage of bursts which were clipped by more than 50 ms is also meaningful, because 50 ms of initial clipping has been stated to be the threshold of audibility of clipping[13]. Such test results can also be useful for confirming the accuracy of statistical reports produced by DCMEs.

In practice, determining the loading of the DCME is not the only requirement, and even for that purpose the use of tonal signals is suspect. This is because real activity detectors may respond differently to speech rather than tones. To overcome this limitation, use has been made of suitable segments of the artificial voices (male and female!) available on compact disc from the CCITT[14]. These have syllabic structures and spectra which resemble speech, and therefore are a more realistic test. Noise contrast effects under various loading conditions may also be evaluated, by using various levels of mixed-in background noise on the source tape, and the reliability of the detection mechanism at various signal levels can also be evaluated. A typical test setup is shown in Figure 2.

Either listening or conversational subjective tests may be conducted, depending upon what it is desired to investigate. Listening tests are generally simpler and cheaper to perform, and may produce more consistent results because the source material is more controlled. However, there are some impairments which can only be realistically assessed for their annoyance value in a conversational situation. Noise contrast is one such impairment; it may be less likely to be noticed if it occurs just as the direction of the speech changes.

### Transmission quality assessment for voiceband data

Assessment of the effects of impairments on voiceband data transmissions is less of a problem than for speech since objective measurements can be made. The traditional methods of classifying modem performance are

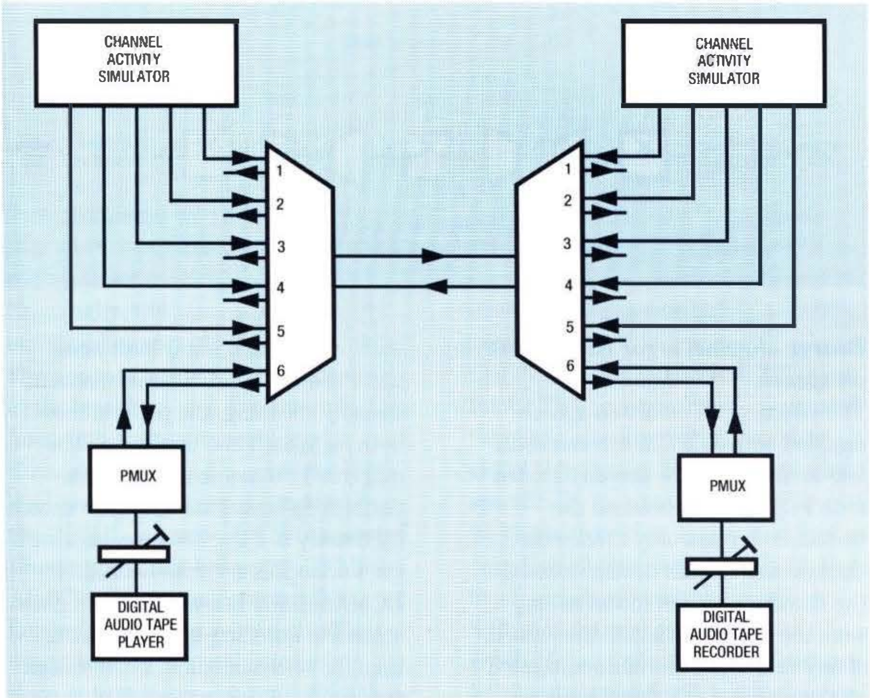



*Figure 2—Typical test setup*

bit and block error rates. The issue then becomes a question of deciding on an acceptable error rate for the transmission system concerned.

Similar problems relating to loading of the system exist as when testing speech performance. The behaviour of the system when it is heavily loaded may be much less predictable than when only a single voiceband data channel is active. There may also be differences depending on how the channels not under test are loaded. If they are all speech calls the system will be more readily able to accommodate a newly active voiceband data channel than when a large proportion of the channels are carrying voiceband data, since bit stealing is not normally allowed on data channels. (This means that less overload channels can be created and clipping is more likely.) Simulators capable of exercising the equipment with realistic protocol exchanges for a large number of concurrent facsimile and voiceband data calls are important to making meaningful bit error rate and other performance measurements.

Investigations into the performance of different ADPCM algorithms have been made on behalf of the CCITT[15]. It has been assumed that with blocks of 1000 bits, a block error rate (BLER), of better than $10^{-2}$ is required for acceptable performance. Based on this assumption, the G.726 32 kbit/s algorithm is only capable of handling voiceband data at rates up to 4·8 kbit/s (V.27ter). CCITT Recommendation G.763 recommends the G.726 40 kbit/s algorithm for DCME, which gives a satisfactory performance at 9·6 kbit/s (with the comparatively fragile V.29 modulation scheme).

A more graphical illustration of relative performance is the constellation diagram. The recently ratified CCITT facsimile recommendation V.17 has a modulation scheme that permits a bit rate of 14·4 kbit/s with a signal-to-noise ratio similar to that required for 9·6 kbit/s transmission with V.29 modulation methods. Tests carried out recently compared the transparency of different DCME transmission techniques to V.17 facsimile transmissions. The tests were made on DCME loaded by simulated speech traffic. The channel under test included a standard set of impairments[16] on the simulated analogue access network.

Figures 3, 4 and 5 respectively compare the transparency to V.17 signals of 64 kbit/s PCM, a 32 kbit/s proprietary ADPCM algorithm designed to carry voiceband data, and facsimile compression. Each of the 128 points in the constellation represents 6 bits plus 1 extra bit used by the special trellis coding. Trellis coding provides some extra error protection by ensuring that consecutive symbols never occur in adjacent locations in the constellation. (Thus although the ADPCM constellation looks blurred, the resulting BER was better than $10^{-4}$.)

The effect of errors on facsimile transmissions can, for example, be measured by the number of errored lines in the received image or the speed chosen in the negotiation process. Deciding upon the acceptable

*Figure 3—V17 through 64 kbit/s A-law PCM*

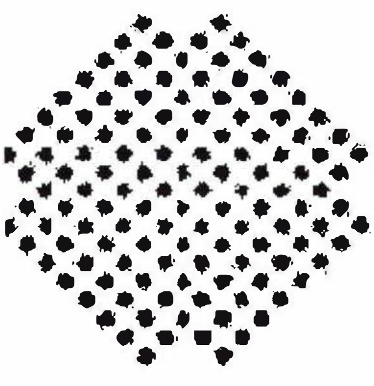


*Figure 4—V.17 through 32 kbit/s proprietary ADPCM*

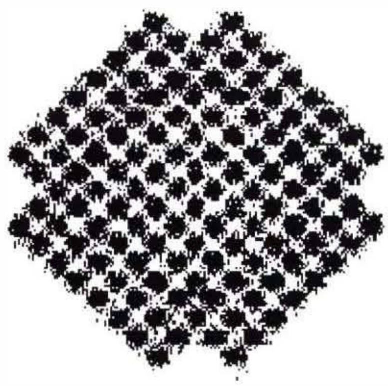


*Figure 5—V.17 through proprietary fax compression algorithm*

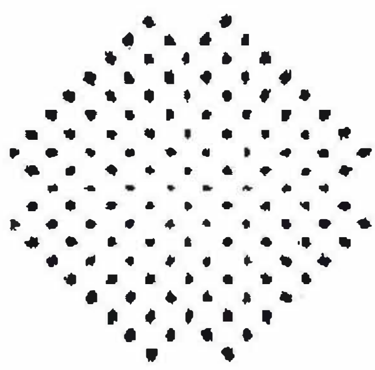
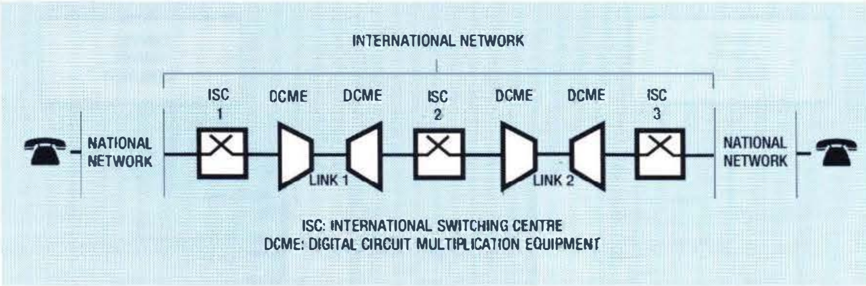


Figure 6—DCMEs in tandem




number of errored lines in a received image is a highly subjective matter. It depends on many factors, such as grouping of errored lines and the content and purpose of the image. In any case, most modern facsimile machines incorporate error correction procedures which will remove errors at the expense of a small increase in transmission time. A tester has been developed that can simulate a facsimile machine with marginal or poor performance, or which deviates from the standards; that is, levels and timings of signals can be altered to determine the limits of the capabilities of the DCME system.

## Network Quality Perspective

The primary application of DCME is on international links. For most countries, use within the national network would be ruled out by the economics of providing the necessary echo control at national centres, among other things. However, there will be instances where similar techniques (voice activation, ADPCM etc.), and therefore similar degradations will appear in national networks. It is important not to neglect these when considering the end-to-end quality.

### Performance of a single DCME link

The performance of a DCME is ultimately limited not only by the design of the DCME itself, but also by the network in which it is used. The digital network which links the two terminals will have an inherent error rate which will affect performance to some extent. The error rate will affect speech and voiceband data differently, and there will also be the possibility of incorrect assignments due to corruption of the control information passed between the two terminals. Although the background error rate in the bearer channel is generally very low (for example, of the order $10^{-8}$ for satellite), errors usually occur in bursts, and can therefore affect transmissions.

***Bearer-channel error rate effects on speech***

The effects of bit errors on speech encoded with ADPCM are markedly less serious than for speech encoded with PCM. This is because the transmission link only carries the change information needed to keep the decoder's speech model in step with the encoder's model. The effects of any errors are therefore mitigated by the model of the sound built up based on preceding samples. As a result, it may be perfectly possible to talk over an ADPCM link with a bit error rate in the region of $10^{-4}$, whereas PCM would be degraded seriously.

***Bearer-channel error rate effects on voiceband data***

Voiceband data generally suffers more seriously than speech as a result of errors affecting an ADPCM transmission link. The reason for this is that data is much less predictable than speech, which means that the correct updating of the signal model held in the decoder is of more critical importance. Error extension occurs, which corresponds to the time taken by the decoder to reconstruct an adequate signal model.

***Control-channel errors***

In order to protect the DCME control channel, it is usual to use very powerful forward error correction, with interleaving of information to reduce the effect of burst errors. Tests have shown that this works very well, and that incorrect channel assignments are extremely rare. Even if they do occur, the normal information refreshment processes ensure that the typical duration is only about 300 ms.

### Performance of tandem links

In the international network, DCMEs may appear in tandem (Figure 6). This will affect the performance to an extent which depends on the design of each, and on how many such links there are for a particular connection. Broadly speaking, the performance both for speech and for data will be marginally worse than the worst performing link. This will affect speech differently to data, however, because if the uncompressed links between the DCME terminals are digital and not subject to encoding-law conversion, then for voiceband data, synchronous tandeming may be maintained, whereas it may not be for speech, because of the interpolation process. This means that voiceband data should only see the impairments due to one link (naturally the worst!), whereas for speech, the impairments will be more cumulative.

### Performance with echo control

Use of DCME implies the use of echo control, because of the delay introduced by the DCME. Echo control itself introduces impairments, which may be subtle or not, depending on the specific echo control device design, the echo return loss from the distant hybrid, the losses in the network, the total delay and many other factors. The increased clarity of digital transmission (which on international links often means DCME) sometimes has the unwanted side effect of making echo and echo-control problems more noticeable. (This has been found particularly problematical when one talker interrupts the other. This double-talk phenomenon is an extremely exacting test for an echo control device—in echo cancellors, misoperation can result in clipping or bursts of distorted echo being produced.)

It is generally preferable to avoid network configurations which place ADPCM or voice activation in the national network between an echo cancellor and the local loop hybrid. This is because such signal-dependent devices restrict the echo cancellor's ability to model and cancel precisely the echo from the hybrid.

### Performance of DCME with low rate encoding in local and mobile networks

Essentially, the reservations already expressed as regards tandem DCMEs also apply to tandeming with devices at the local loop end. For example, the limitation to data transmissions through cellular radio networks is the quality of those networks, rather than the DCME. Likewise any future use of short-range radio links with 32 kbit/s ADPCM, for example, for cordless facsimile machines within an office, would have to live with the restrictions on maximum data rate that that algorithm would impose.

## Conclusion

This article has presented a detailed appraisal of the impairment mechanisms of concern when considering the introduction of DCME into the network, and has provided some evaluations of their effects in a range of different circumstances.

## Appendix A—CCITT LRE Algorithms

*CCITT Recommendation G.721 (Red Book)*: This 32 kbit/s algorithm was used in some early equipment. It has not been widely used because of

- problems in handling transmissions from certain FSK modems which did not employ scramblers for the data,
- slightly impaired voice quality in some circumstances, and
- use of a 16 level quantiser, which means that the '1's density requirements of ANSI* T1 line systems cannot be satisfied.

*CCITT Recommendation G.721 (Blue Book)*: This 32 kbit/s algorithm is a development of the Red Book version, which has minor modifications to overcome the quality deficiencies noted above, and has a 15 level quantiser, so that the '0000' code cannot be transmitted. The recommendation states that the algorithm is suitable for use with voiceband data at rates up to and including 4·8 kbit/s.

*CCITT Recommendation G.723 (Blue Book)*: This recommendation contains two fixed rate algorithms based on G.721 (blue book). Both are intended specifically for use in DCME. The 24 kbit/s algorithm is intended for the encoding of overload channels for the brief periods of time when sufficient 32 kbit/s channel capacity is not available, and the 40 kbit/s algorithm is intended specifically to give higher quality for voiceband data.

*CCITT Recommendation G.726 (separate volume)*: This recommendation is a rationalisation of the information contained in Recommendations G.721 and G.723 with the addition of a 16 kbit/s algorithm for DCME overload channel use. Hence it describes a family of ADPCM algorithms at 16, 24, 32, and 40 kbit/s fixed rates. In addition to its use in DCMEs, the 32 kbit/s algorithm has been chosen for use in various cordless telephone and mobile radio applications, including DECT and CT2.

*CCITT Recommendation G.727 (separate volume)*: This recommendation parallels the contents of Recommendation G.726, but uses a technique known as *embedded coding*, which permits the least significant bits to be 'stolen' periodically without the encoder or the decoder having any knowledge of the actual number of bits transmitted. This form of ADPCM is useful in packetised systems, which may need to lose bits at intermediate nodes as a form of congestion control.

*CCITT Recommendation G.722 (Blue Book)*: This ADPCM algorithm is based upon the G.721 (Blue Book) algorithm, but is intended for 7 kHz wideband speech transmission within 64 bit/s. The bandwidth is divided into a high band and a low band, each of which is encoded separately using an ADPCM encoder which is optimised for that band. Applications include audio conferencing, broadcasting commentary channels and high-quality telephony within the ISDN.

*CCITT Recommendation G.728 (separate volume)*: This recommendation describes a fixed rate 16 kbit/s algorithm using low delay code excited linear prediction, to achieve a similar level of quality to the 32 kbit/s algorithm of Recommendation G.726. It is intended that this algorithm will be used as the basis of future algorithmic developments, both to replace the Recommendation G.726 and G.727 algorithm families, and for future audiovisual use.

*Other algorithms*: Certain ADPCM algorithms have been 'recognised but not specified'[15] by the CCITT, and are used commercially.

## Appendix B—Synchronous Tandeming

The synchronous tandeming capability is an additional feature of many ADPCM algorithms, which is intended to minimise the accumulation of distortion in multiple stages of conversion between PCM and ADPCM and vice versa. An additional block in the decoder examines the values of the companded PCM output, and makes any adjustments necessary to ensure that they are nominally identical to the companded input values at the encoder. This means that it is possible to transcode many times between PCM and ADPCM without accumulating additional quantisation distortion, provided that all intermediate links are digital and that the PCM systems all use the same encoding law. Bit errors on the digital system between an encoder and a decoder will result in loss of synchronous tandeming for a period which will depend on the severity of the error and the nature of the signal carried.

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* American National Standards Institution

## References

1 Kessler, E. A. Digital Circuit Multiplication Equipment and Systems—An Overview. *Br. Telecommun. Eng.*, Jul. 1992. **11**, p. 106.

2 Hodges, R., and Barclay, S. Development and Testing of DCME Systems. *Br. Telecommun. Eng.*, Oct. 1992. **11**, p. 205.

3 Kessler, E. A. Improving Facsimile Performance for International Networks. *Br. Telecommun. Eng.*, Oct. 1992. **11**, p. 197.

4 KDD Proposal for the insertion noise level for adaptive noise matching on DCME. Contribution to CCITT Study Group XV, Working Party 2, Question 10, Sept. 1989.

5 CCITT Recommendation T.4. Standardisation of group 3 facsimile aparatus for document transmission. Melbourne, Nov. 1988.

6 CCITT Recommendation T.30 Procedures for document facsimile transmission in the general switched telephone network. Melbourne, Nov. 1988.

7 CCITT Recommendation V.25. Automatic Answering Equipment and/or Parallel Automatic Calling Equipment on the General Switched Telephone Network including Procedures for Disabling of Echo Control Devices for both manually and automatically established calls. Malaga-Torremolinos, Oct. 1984.

8 Sklar, B. Digital Communications. Prentice Hall, 1988, p. 633.

9 CCITT Study Group XV Ad Hoc Group on Bit Stream Manipulations. G.726 COM 102 Algorithm Specification. Temporary Document 43 (WP XV/2), Geneva, Nov. 1991.

10 Motorola Information Systems. 1991 PSTN survey results. Contained in document FL-145 of the CCITT Study Group XVII Special Rapporteur's meeting for Recommendation V.FAST, Florida, Feb. 1992.

11 CCITT Recommendation G.766 Facsimile Compression for use with DCME. Geneva, 1992.

12 McHarg, M. Symbionics Ltd. Private Communication.

13 Campanella, S. J. Digital Speech Interpolation. *COMSAT Tech. Rev.*, Spring 1976, **6**(1), p. 127.

14 CCITT Recommendation P.50 Artificial Voices. Melbourne 1988 (and compact disc No. CRM-1059, available from NTT).

15 Demolitsas, S., Corcoran, F. L., Onufry, M., and Suyderhoud, H. G. Evaluation of ADPCM coders for Digital Circuit Multiplication Equipment. *COMSAT Tech. Rev.*, Fall 1987, **17**(2), p. 323.

16 CCITT Study Group XVIII. Report R 28-E. Report of the meeting of working party XVIII/2. Nov. 1983, p. 45 (Table 10 and 11 are popularly known as the 'R 28 impairments', as if the report had the status of a recommendation!).

## Bibliography

Boyd, I. Speech Coding for Telecommunications. *Electronics and Communication Engineering Journal*, Oct. 1992, p. 273.

South, C., and Usai, P. Subjective Performance of CCITT's 16 kbit/s LD-CELP algorithm with voice signals. CSELT Technical Reports, XX(6), Dec. 1992, p. 537.

Onufry, M., Forcina, G-P., Oei, W. S., Oishi, T., Phiel, J. F. and Reiser, J. H. DCME in the INTELSAT VI era. *COMSAT Tech. Rev.*, Spring 1992, 22(1), p 19.

## Biographies

**Edward Kessler**
BT Worldwide Networks

Ed 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. His work since then has included digital switching and satellite communications as well as the network aspects of DCME. For approximately 6 years, he was a participant in the CCITT work on speech coding and transmission. More recently, he has stepped outside that field to work on the design of a managed path layer network within Europe.

**Alistair Farquharson**
BT Development and Procurement

Alistair Farquharson joined BT research laboratories in 1984 after graduating with a B.Sc. in Electronics and Electrical Engineering from Edinburgh University. He worked initially on IDA, BT's pilot ISDN service, and was involved with the development of a digital telephone and then a digital communications PC card for IDA. In 1990 he gained an M.Sc. in Telecommunications and Information Systems. Since then he has been developing a PC-based facsimile test tool for the testing of both customer and network equipment. Over the past two years, this has included testing of LRE equipment in the international network for transparency to facsimile traffic.

*Peter G. Clarke*

# ISDN Standards: An Overview

*International agreement on standards and protocols is essential for satisfactory and economical worldwide telecommunications, not least for facilitating the interconnection of national ISDNs. This article, the first of a series of six in the Journal, provides an overview of the contribution of regional and international bodies to the setting up of international standards for ISDN from its conception until the present time. Looking ahead, the author considers the ongoing work on producing standards for the intelligent networks of the future, with built-in flexibility to meet evolving customer demands quickly and economically.*

## Introduction

Now that the CCITT 1988–1992 Study Period is complete, and many new European Technical Standards (ETSs) for ISDNs are being published, it is appropriate to review the progress made since the birth of the ISDN concept. This is the first of a series of six articles describing the standards relevant to the ISDN. The remaining articles will cover: services, architecture, transmission and switching, access signalling and terminals, and internodal signalling standards.

## Why do we need Standards?

Communication cannot take place without standards. Animals need to know what interpretation to put on the signals received from other animals. Humans have evolved a wide repertoire of signals and can communicate complex ideas orally and in writing, but this would not be possible without the use of a standardised alphabet with standardised sounds and standardised words. However, the parochial origins of the standards for human communication have resulted in many different alphabets and a vast number of different words to convey similar meanings. If all people throughout the world were to speak the same language, personal communication would be much easier, and the time currently taken to learn foreign languages could be used more productively. Conversely, such extreme application of standards would make life rather boring. In telecommunication, on the other hand, the benefits of standards are compelling, avoiding the need for complex interworking mechanisms and compatibility checking.

In addition to the advantages to telecommunication, further benefits of standards may be gained within the communicating entities, where the communication protocols employed are specified in layers. In such cases, different upper layer modules designed for different applications may share not only a common type of underlying protocol, but also a common instance of that protocol.

The benefits of standards in the context of worldwide telecommunication may be considered to comprise the following:

- cost savings,
- clarity,
- cooperation, and
- stability.

The cost savings accrue from avoidance of functionally incompatible equipment to perform similar tasks, avoidance of developing special interworking mechanisms between functionally compatible equipment, and sharing of resources in the development of interfaces. Clarity is derived from formally agreed and documented functional and interface specifications, and from an understanding of their scope and applicability. Cooperation is ensured between systems, and between network operators and their customers, particularly if they have both been involved in the establishment of the relevant standard(s). Stability is guaranteed provided all involved are committed to the standard(s), and provided the standards are evolvable and constrain only what must be constrained to meet the basic requirements. This usually means, among other things, that the standards must be independent of the technology used to implement them.

The perennial difficulty with standards is that the requirements are not usually sufficiently clear until there is a real need and some development work has already taken place on a national basis, often in several countries independently. The more committed countries become to their own solutions, the more difficult compromise becomes, and the more difficult agreement to a single standard becomes. This introduces further delay in the production of the standard. Some countries are more inclined than others to display this 'not invented here' syndrome. To minimise the risks when new standards are required, it is important that discussion starts at the earliest possible time so that all those involved can work towards a common solution.

## Standards Bodies

### ITU and CCITT

Under the overall authority of the International Telecommunications Union (ITU), the worldwide body responsible until March 1993 for the production of standards for telecommunications (except radio transmission) was the International Telephone and Telegraph Consultative Committee (CCITT). Membership was open to operating and manufacturing companies, and to scientific organisations concerned with telecommunications. Members paid subscriptions commensurate with their size, and the proceeds are used to support a central headquarters and secretariat in Geneva.

The technical standardisation work of the CCITT was conducted under a number of Study Groups whose terms of reference were focused on the production of recommendations in different series for specific aspects of telecommunications. There were 15 Study Groups with a structure as set out in Table 1. The Study Groups of primary concern for ISDN standards are I, II, III, VII, XI and XVIII. In December 1992, the ITU Plenipotentiary Conference agreed that, as from 1 March 1993, the standardisation activities of both the CCITT and the CCIR (International Radio Consultative Committee) will be combined under a single Telecommunication Standardisation Sector (TSS). The numbering of the Study Groups has been changed from Roman to Arabic notation. The values are unchanged except that Study Groups XVII and XVIII have become 14 and 13 respectively, Study Group IX has ceased to exist and CMTT (television and sound transmission standards) has become Study Group 9.

In the past, the standards were published in the form of Recommendations in a number of bound volumes at the end of each four-year Study Period. The last to appear in this form were the 1988 Blue Books. The complexity of the recommendations and consequently the volume of paper needed have escalated in recent years, concurrently with the demand for earlier publishing. The logistics of publishing bound volumes and the practice of approving all recommendations by the CCITT Plenary Assembly are inconsistent with early publication. For this reason, it has been proposed by the Director of the CCITT (and widely supported) that approval by the CCITT Plenary Assembly of recommendations should cease from the end of the current Study Period (1992). It is proposed that formal approval by the relevant Study Group of new and amended recommendations is sufficient. This, in effect, is the practice that has been operated for accelerated approval, where there is general demand for publication of a recommendation in a shorter timescale than that permitted by the normal procedure. Assuming that the proposals are agreed, recommendations will be published separately in

**Table 1 CCITT Study Groups Responsible for Recommendation Series**

| Study Group | Terms of Reference | Recommendation Series |
|---|---|---|
| SG I | Service definitions | F..., |
| SG II | Network operations | E..., F... |
| SG III | Tariff principles | D... |
| SG IV | Maintenance | M..., N..., O... |
| SG V | Safety, protection and EMC | K... |
| SG VI | Outside plant | L... |
| SG VII | Data communications | X... |
| SG VIII | Terminals for telematic services | T... |
| SG IX | Telegraph networks and terminal equipment | R..., S..., U... |
| SG X | Software | Z... |
| SG XI | Switching and signalling | Q... |
| SG XII | Transmission performance | G..., P... |
| SG XV | Transmission systems and equipment | G..., H..., J... |
| SG XVII | Data transmission | V... |
| SG XVIII | ISDN and digital networks | G..., I... |

*Note: General recommendations concerning the organisation and working procedures etc. of the CCITT are in the A..., B... and C... series.*

*It therefore became necessary to establish the appropriate level of standardisation sufficient to ensure interworking, but not so restrictive as to inhibit innovation.*

loose-leaf form as and when they become available after approval by the originating Study Group.

### CEPT and ETSI

Even in the late 1950s it was apparent that the standardisation processes of the CCITT were too slow for some European countries. This led to the setting-up of the European Conference of Postal and Telecommunications Administrations (CEPT), membership of which was open to European Administrations, but not manufacturers. There was no central secretariat, and meetings were hosted in turn by members. Although the main objective of the CEPT in harmonising European views on key issues of the time was successful, the same cannot generally be said of the consequent efforts to gain the agreement of the CCITT to these views.

At about the time that the UK joined the EC, the impact of commercial interests on telecommunications in Europe was becoming apparent. In particular, it was recognised that full advantage could be taken of the convergence of telecommunication and information processing technologies only by liberalisation of existing PTT monopolies. It was also recognised that freer market conditions would encourage private investment in the development of new services. The EC also required the removal of restrictive trade barriers by 1992. It therefore became necessary to establish the appropriate level of standardisation sufficient to ensure interworking, but not so restrictive as to inhibit innovation. This led the EC, in 1988, to form the European Telecommunications Standards Institute (ETSI), which was given the authority to produce standards (ETSs). Membership was broadened beyond that of the CEPT to include manufacturers and research organisations. The headquarters is near Nice and an annual fee is charged for membership. The application of ETSI standards is generally voluntary, although EC legislation will make the adoption of some standards mandatory. Where this is done, the standards become Normes Européenes de Télécommunications (NETs). Several of these have been agreed in respect of terminal-network interfaces.

Now that the technical standards work formerly undertaken by CEPT is performed by ETSI, the role of CEPT has been reduced to consideration of regulatory issues.

The detailed standards work of ETSI is conducted under 13 Technical Committees (TCs), many of which are supported by a number of Sub Technical Committees (STCs). These generally meet once or twice per year. Overall direction of the work of the TCs comes from the Technical Assembly which meets three or four times per year. In addition, there are two high-level management committees. From time to time, short-term project teams are set up at the ETSI headquarters to accelerate the production of standards in areas where they are needed urgently. The present committee structure is set out in Table 2.

Those groups of specific relevance to ISDN standards are: ISM, BT, NA, SPS and TE.

### ISO

Communications comprise only a small part of the work of the International Standards Organisation (ISO). However, ISO has been responsible for the production of one very significant standard in respect of telecommunication: the Open Systems Interconnection (OSI) protocol reference model. In particular, the adoption of the principles of layered protocols has had a profound, but beneficial, effect on the way in which signalling protocols are modelled, and on the way in which their specifications are written.

### ANSI

Although the total scope of the operations of the American National Standards Institute (ANSI) is more akin to that of ISO and the British Standards Institution (BSI), in respect of telecommunications ANSI performs a function for the USA and Canada very similar to that performed by ETSI for Europe. Commercial and regulatory influence in ANSI is very strong, and often provides US and Canadian delegates with rigid briefs from which they may not deviate in the CCITT. When these are contrary to ETSI views or to those of individual members, much time can be lost in attempts to reconcile opposing views.

## Regional Initiatives

### GAP

An analysis and forecasting group (GAP) was set up by the EC to produce a plan for the coordinated introduction of ISDNs in the European Community. The standards needed to support the services required by the GAP report were generated by means of quadripartite discussions between France, Germany, Italy and the UK. This collaboration led initially to the specification of customer-to-network signalling protocols, internetwork signalling protocols (TUP+), and numbering and routing requirements

**Table 2 ETSI Technical Committee Structure**

| | |
|---|---|
| TA: Technical Assembly | |
| ISM: ISDN Services Management | |
| SRM: Strategic Review Committee | |
| **Technical Committees (TCs)** | |
| ATM | Advanced testing methods |
| BT | Business telecommunications |
| EE | Equipment engineering |
| GSM | Mobile services |
| HF | Human factors |
| IPRC | Intellectual property rights committee |
| NA | Network aspects |
| PS | Paging systems |
| RES | Radio equipment and systems |
| SES | Satellite earth stations |
| SPS | Signalling protocols and switching |
| TE | Terminal equipment |
| TM | Transmission and multiplexing |

for the support of limited ISDN service within and between European countries. The documentation of these requirements was based on the then existing CEPT recommendations. Subsequently, the group produced an exceptions document to the CCITT 1988 (Blue Book) ISUP to eliminate options not required for international interconnection.

### The European ISDN Memorandum of Understanding (MoU)

In April 1989, BT as a network operator, signed and committed itself to the ETSI 'Memorandum of Understanding (MoU) on the Implementation of European ISDN Service by 1992'. Mercury Communications Ltd. has also signed the MoU. Consequently, the UK network, along with those of the other member states, will be required to provide at least the services identified as having priority ('starred services') in the MoU, by December 1993 at the latest, and preferably by December 1992. A further requirement is that if signatories offer or provide any of the other services listed in the MoU, they must conform to the relevant ETSs. Much of the work in ETSI has been devoted to the production of these ETSs. Developments are in hand for the support of these services by the BT network.

The MoU requires that the basic access conforms to NET3, and that primary rate access conforms to NET5. The MoU additionally requires that the signalling protocols used to provide international operation of the services identified conform either to the European standard TUP+ or to the ETSI ISUP Version 1; these will be discussed in some detail in a future article on internodal signalling.

Table 3 shows the services supported by the European MoU.

### Development of ISDN Standards

The concept of the ISDN was born in CCITT Study Group XVIII as an exploitation of the capabilities of a contiguous 64 kbit/s network with integrated transmission and switching, usually referred to as an *integrated digital network* (IDN). This occurred in the late 1970s, when Study Group VII was actively generating standards for circuit-switched and packet-switched public data networks (PDNs). The benefits to the network provider of combining the infrastructure of telephone and data networks in the core of the network were fairly clear.

However, as a minimum, the ISDN needed to deliver to the customer a transparent bidirectional 64 kbit/s path, together with a versatile means of controlling the network to provide the advanced services envisaged, all over one pair of copper wires having a resistance of up to 1 kΩ and a capacitance of up to 0·3 μF. Neither the technology nor the standards existed for achieving this, and the basic requirements presented a considerable challenge. The basic access structure actually agreed by the CCITT in 1984 presented even more of a technical challenge, because it consisted of not merely one but two 64 kbit/s B-channels for voice or non-voice, and a 16 kbit/s D-channel for signalling, packet data and telemetry, making a total of 144 kbit/s in each direction of transmission.

The year 1984 saw the publication in a single volume (Fascicle III.5) of the CCITT Red Book of the first set of ISDN recommendations. These included:

| | |
|---|---|
| I.100 series | General (5 recommendations) |
| I.200 series | Service capabilities (3 recommendations) |
| I.300 series | Overall network aspects and functions (5 recommendations) |
| I.400 series | ISDN user-network interfaces (16 recommendations). |

**Table 3 Services supported by the European Memorandum of Understanding (MoU)**

| Bearer services |
|---|
| Circuit-mode speech |
| Circuit-mode 64 kbit/s unrestricted* |
| Circuit-mode 3·1 kHz audio* |
| Circuit-mode 2 × 64 kbit/s unrestricted |
| Packet-mode X.31 Case A (B-channel) |
| Packet-mode X.31 Case B (D-channel) |
| Packet-mode X.31 Case B (B-channel) |

| Teleservices |
|---|
| 3·1 kHz telephony |
| Teletex |
| Telefax (Group 4) |
| 7 kHz telephony |
| Audiographic teleconferencing |
| Videotex (alpha-geometric mode) |
| Videotex (photographic mode) |
| Teleaction |
| Videotelephony |
| Computerised communication service |

| Supplementary services |
|---|
| Advice of charge (AoC) at call setup |
| Advice of charge (AoC) during call |
| Advice of charge (AoC) at end of call |
| Calling line identification presentation (CLIP)* |
| Calling line identification restriction (CLIR)* |
| Connected line identification presentation (COLP) |
| Connected line identification restriction (COLR) |
| Closed user group (CUG) |
| Call waiting (CW) |
| Completion of call to busy subscriber (CCBS) |
| Add-on conference call (Conf) |
| Meet-me conference (MMC) |
| Direct dialling-in (DDI)* |
| Call forwarding, unconditional (CFU) |
| Call forwarding, busy (CFB) |
| Call forwarding, no reply (CFNR) |
| Call deflection (CD) |
| Freephone (Fph) |
| Malicious call identification (MCID) |
| Multiple subscriber number (MSN)* |
| Subaddressing (Sub) |
| Terminal portability (TP)* |
| Three-party service (3Pty) |
| User-to-user signalling (UUS) |

* = MoU priority

Apart from those generated by Study Group XVIII itself, this volume duplicated appropriate recommendations produced by other Study Groups. To simplify reference to these recommendations, all were assigned I... series numbers in addition to the number appropriate to the originating Study Group. These included recommendations:

| | |
|---|---|
| I.331/E.164 | Numbering plan for the ISDN era |
| I.440/Q.920 | ISDN user-network interface data link layer—general aspects |
| I.441/Q.921 | ISDN user-network interface data link layer specification |
| I.450/Q.930 | ISDN user-network interface layer 3—general aspects |
| I.451/Q.931 | ISDN user-network interface layer 3—specification |
| I.461/X.30 | Support of X.21 and X.21*bis* based data terminal equipment by an ISDN |
| I.462/X.31 | Support of packet mode terminal equipment by an ISDN |

The E..., Q... and X... series recommendations were generated by Study Groups II, XI and VII respectively.

During the 1984–1988 Study Period, considerable progress was made in extending the I.... series recommendations, particularly in respect of supplementary services and interworking with existing services and networks. The complete set of ISDN recommendations as published in the 1988 Blue Book (Fascicles III.7. III.8 and III.9) consisted of the following:

| | |
|---|---|
| I.100 series | General (10 recommendations) |
| I.200 series | Service capabilities (17 recommendations) |
| I.300 series | Overall network aspects and functions (15 recommendations) |
| I.400 series | ISDN user-network interfaces (19 recommendations) |
| I.500 series | Internetwork interfaces (9 recommendations) |
| I.600 series | Maintenance principles (5 recommendations). |

## Transmission Aspects

As stated above, the need to provide a duplex transmission rate of 144 kbit/s over existing local lines has presented a considerable challenge. Two techniques, burst-mode and echo cancellation, have been the main contenders, and much experimental development work has taken place to evaluate systems based on these principles. The early BT system to support IDA was based on the burst-mode technique, using bursts of 256 kbit/s in each direction to support a duplex transmission rate of 80 kbit/s. This system worked well up to about 3 km, which is, unfortunately, inadequate for the penetration required for ubiquitous provision of a public ISDN service. Appropriate advances in integrated circuit technology have facilitated the economical production of the rather more complex echo-cancelling systems necessary to increase the range. The current echo-cancellation system allows duplex transmission at 160 kbit/s over 98% of local lines with an error ratio of less than 1 in $10^7$.

## Functional Standards/ Profiles

The development of telecommunications equipment often takes place concurrently with the development of the relevant standards. However, the drivers for equipment development are usually commercial and local, and often impose tight time-scales. The standards development is global, may lack clearly focused objectives, and is usually slower to reach completion. By the time that the standard is agreed, it is often a compromise, may include options, may well fall short of the needs of many, if not all, of the parties involved, and may well have diverged appreciably from the needs of some. Thus the standard may be regarded as a base standard, on which national or regional standards, sometimes referred to as *functional* standards, are based. The ETSI standards for ISDNs are subsets and supersets of the CCITT standards, and may therefore be regarded as functional standards based on the CCITT base standards.

The existence of differing functional standards in America, Europe, and the Pacific areas undermines the philosophy of OSI, which aims to facilitate the mixing and matching of equipment from any manufacturer, and worldwide communication between such equipment. To address this problem, yet another international committee, the Special Group on Functional Standardisation (SGFS), has been established under the International Standards Organisation (ISO). The SGFS has introduced the concept of International Standard Profiles (ISPs). The key achievements of the SGFS so far have been the establishment of: a system for classifying profiles, a directory of profiles and procedures for developing standardised profiles. Any approved organisation, such as ETSI, may submit a profile for review.

The application of the foregoing procedure to ISDN standards to produce the ISPs for ISDN was achieved by assigning work areas to three workshops set up under the three regional standards bodies. These were the European Workshop for Open Systems (EWOS), the (American) National Institute of Standards and Technology OSI Implementor's Workshop (OIW), and the Asia-Oceania Workshop (AOW).

*aim is to establish the rights of network users, and to provide open access to the network infrastructure for competitive service providers and for other telecommunications operators.*

EWOS was assigned the circuit-mode profiles, AOW the packet-mode profiles and OIW the common parts of the physical layer.

## Regulation

The existence of international standards does not imply any commitment on the part of any network operator to implement those standards. Where there is commitment, it arises from specific regulatory or commercial agreements, which may be national, bilateral or multilateral. In Europe, the regulatory environment is characterised by two significant aspects: the liberalisation and harmonisation initiatives of the European Commission, and the existence of national regulation which may hinder progress towards the adoption of unified standards.

In 1987, the EC issued the 'Green Paper on the Development of the Common Market for Telecommunications Services and Equipment', which set out a programme of the following liberalisation and harmonisation aspects:

- liberalisation of terminal equipment;
- liberalisation of telecommunications services;
- separation of regulatory and operational functions;
- introduction of Open Network Provision (ONP);
- establishment of ETSI;
- European type-approval of terminal equipment;
- open procurement of telecommunications equipment; and
- development of a policy on satellite communications.

Some of these aspects are self explanatory but others are worthy of further comment.

### Liberalisation of telecommunications services

In 1990, a EC directive was issued on 'Competition in the Markets of Telecommunications Services'. This came into effect from January 1993, and allows other operators to offer value-added services, data services and private telephone services using PTT-provided network infrastructure. Current indications are that the take-up in respect of data services is fairly rapid, but that in respect of voice services is rather slow, partly due to lack of clarity of national legislation.

A further EC directive, still under discussion, is likely to result in the liberalisation of the international interconnection of telephony service and of provision of the supporting network infrastructure.

### Open network provision

Open network provision (ONP) is an initiative of the European Commission to harmonise basic telecommunication services throughout the European Community, and consequently to stimulate a single competitive European telecommunication services market. This is being pursued by means of a common set of principles for the provision, by European telecommunications operators such as BT, of the network infrastructure. An additional aim is to establish the rights of network users, and to provide open access to the network infrastructure for competitive service providers and for other telecommunications operators. To this end, the European Commission produced a directive in 1990 providing a framework of principles for the implementation of ONP. This lays down the essential elements of a harmonised platform for the support of telecommunications services in Europe. A draft proposal relating to telephony was issued in 1991, and adopted in June 1992 together with a directive relating to leased lines. Further recommendations relating to ISDN and to packet-switched public data services have also been adopted.

The main thrust of ONP may be considered to be threefold:

- common technical standards for the user-network interfaces;
- common conditions for the supply and usage of telecommunications services; and
- common tariff principles.

Regarding the impact of ONP on network operators, it is clear that they will be obliged to provide a minimum set (yet to be specified) of services that comply with ONP standards. Where existing services meet the ONP requirements, these can be offered unchanged. Where existing services do not meet ONP requirements, operators will need to introduce compliant services on request from potential users. However, there are concerns that the obligations may not be applied uniformly to all operators in the UK. Retrospective action to change current services in order to comply is not envisaged.

### Open procurement

An EC directive to open the market for the supply and installation of telecommunications plant came into operation in January 1993. The directive covers the procedures to be adopted by network operators when procuring telecommunications equipment, and will apply to supply contracts exceeding 600 000 ECUs, and to installation contracts exceeding 5M ECUs. One of the requirements is that the equipment must conform to European standards.

### European type-approval of terminal equipment

At one time, each European country had its own terminal attachment testing and type-approval regime. A consequence of this was that, even where the user-network interfaces in different countries were identical, terminal equipment manufacturers were required to have their equipment tested in each country of proposed use, often to different criteria.

The aims of European harmonisation were to unify the test requirements, to test equipment once only, and to ensure recognition of the results by all national approvals bodies throughout Europe. The initial step in this direction led to the development of NETs, which specified the harmonised European requirements for terminal attachment approval and testing. The common technical regulations (CTRs) provide the second step, which is for one-stop approval. This will establish a single European market for any equipment that is approved according to a CTR. Work is in hand to convert existing approved and draft NETs into CTRs.

## National versus International Standards

In advance of stable and complete international standards, BT developed and launched its public ISDN service, called *integrated digital access* (IDA), on 25 June 1985. It was based on proprietary standards and was the first operational ISDN service in the world. Soon afterwards, other network operators in Europe, North America and Japan launched their versions based on further differing standards. It was clear that, for ISDN to be successful, it had to provide international connectivity, internationally standardised services and internationally standardised interfaces.

BT's basic access, single line IDA, used BT's Digital Access Signalling System (DASS1), and was configured as follows:

| | |
|---|---|
| 64 kbit/s | B-channel for voice or non-voice |
| 8 kbit/s | B′-channel for non-voice |
| 8 kbit/s | D-channel for signalling |

Total 80 kbit/s

Only a few hundred accesses have been provided to this standard.

Primary-rate (2048 kbit/s) access for PBXs, giving 30 B-channels and one 64 kbit/s D-channel, was also offered, and used a modified version of DASS1 (DASS2).

The CCITT basic access was configured as follows:

| | |
|---|---|
| 2 × 64 kbit/s | B-channels for voice or non-voice |
| 1 × 16 kbit/s | D-channel for signalling, packetised data and telemetry |

Total 144 kbit/s

Recommendations for the CCITT Digital Access Signalling System No.1 (DSS1) were first published in the 1984 (Red Book).

## The Future

### Intelligent networks (INs)

Recent technology advances have resulted in vast increases in the processing power and storage capacity of computers, including those used to control modern telephone exchanges. This has been exploited to provide supplementary services of ever increasing variety and complexity. A consequence of this is a significant increase in the time taken to specify new requirements and to develop the hardware and software to provide support for those new requirements on existing network infrastructure. This is occurring in a commercial environment of increasing competition and ever tighter market windows for the provision of services. These factors have led to the provision of stand-alone networks; for example, the derived services network for the support of Linkline service in the UK.

In the longer term, more efficient means of supporting such innovations need to be found. Many new services require only a minimum of hardware functionality, but rely on the operation of complex software programs. By exploiting the capabilities of modern digital message-based signalling, for example CCITT Signalling System No. 7, the control of telephone exchanges to support complex supplementary services can take place remotely, provided the necessary 'hooks' are specified and provided at all exchanges. The major benefit of this is that there is no need to replicate the software at all exchanges that are required to support a service; instead, the software can reside at a single location to which reference is made as required. By this means, new services can be introduced very quickly, and any changes made can be effective almost instantaneously on a countrywide basis.

The CCITT has been very active during the 1988–92 Study Period in producing standards for IN, which will be published in the Q.1200 series of recommendations. However, this is only a preliminary set, and work is continuing on the addition of further features.

### Broadband ISDN (B-ISDN)

Major advances have recently been made in the capabilities of terminal equipment to support advanced visual services; for example, videoconferencing, medical diagnostics, and personal computers with screen-based applications. Also, the need has emerged for dynamic reconfiguration of virtual private networks, and for high-speed data services. Consequently, several countries in the world have anticipated the need for an ISDN that provides switched on-demand bearer service at a bit rate very much greater than the 64 kbit/s provided by the conventional ISDN. Such requirements cannot be met economically by paralleled 64 kbit/s connections, so the requirements for a separate broadband ISDN are being specified in the CCITT/TSS and in ETSI. Almost any transmission rate can be supported, and the initial (Release 1) bearer service offerings will be for connectionless variable bit rate service, connection-oriented constant bit rate service, and connection-oriented service with a proprietary asynchronous time-division multiplex (ATM) adaptation layer. Release 1 will also include a set of supplementary services similar to those specified for the narrowband ISDN (N-ISDN). CCITT/TSS standards relating to network aspects have already been agreed, but there are as yet no agreed international signalling standards for B-ISDN. CCITT/TSS signalling standards for Release 1 are expected to be agreed towards the end of 1993.

Later releases are expected to add connection-oriented variable bit rate service, multipoint and multimedia connections, and a variety of teleservices and supplementary services.

### Mobile communications

Historically, mobile telecommunication has been expensive, not easily available owing to bandwidth restrictions, and nationally based. Consequently, people have generally organised their affairs to avoid the need for telecommunication when travelling between continents. The majority use of mobile communication has been during travel by land. As a result, the scope for global standardisation of mobile communication has been limited, and the standards produced have been national or regional rather than global.

Technology advances and the allocation of additional bandwidth have contributed to greatly increased demand for total access communications system (TACS) service in the UK, and the system is still expanding. By the early 1980s several European countries, particularly those in Scandinavia, could see the need for mobile telecommunications that allowed international roaming. This clearly required European standardisation of the air interface including access signalling protocols and speech coding, handover procedures, and network signalling protocols. This led to the establishment of a special group under the CEPT to agree standards for a European system. The system takes its name from the group, and is referred to as the *Groupe Spéciale Mobile* (GSM) system. Although the standards are virtually complete, the system has still to be launched, and even then will not support the full range of services supported by ISDN.

Based on the GSM system, UK operators Mercury PCN, Microtel and Unitel have developed another system (DCS1800) which has been accepted by ETSI as a new pan-European standard, but still does not support ISDN service.

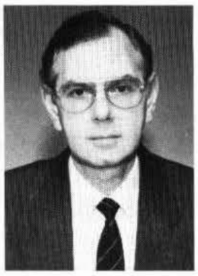
The International Maritime Satellite (INMARSAT) systems support telephony, Telex and data services only. There are plans to consider interworking, but not integration, with ISDNs. BT's Skyphone currently supports telephony only, but facsimile and packet data services are to be added soon. This may reasonably be considered to be independent of the ISDN.

There would seem to be little prospect that the full range of services supported by ISDN will also be supported by mobile communication systems until either universal personal telecommunications (UPT) or third-generation mobile systems (TGMS) come into operation, probably after the year 2000.

## Conclusion

The key to the future lies in an intelligent network with a coherent infrastructure. It must provide a variety of circuit-switched and other bearer services, with the basic call control, and some supplementary service control functions at all exchanges, and control of the more advanced supplementary services by centralised software. Customer-to-network protocols and internodal protocols must be open-ended to allow future enhancement for explicit support of any new features that are subject to international standardisation, and have the flexibility to allow support of other new features without the need for changes to the international specification. Only by these means will the network have the flexibility to meet customer needs in the short time-scales demanded, and at the right price.

## *Biography*



**Peter Clarke**
BT Development and Procurement

Peter Clarke joined the Post Office Engineering Department in 1962. He graduated from the University College of North of Wales in 1965 with a B.Sc. degree in Electronic Engineering, and is a member of the IEE. After several years of involvement with the maintenance, testing and development of Strowger switching and signalling systems, he became a member of the joint BT-Industry Advisory Group on Systems Definition (AGSD), contributing to the establishment of the basic requirements for transmission, switching and signalling for BT's integrated digital network. When the AGSD was replaced by the Telecommunication Systems Strategy Department (TSSD), he was responsible for the production of strategic network plans specifying the performance requirements for the integrated digital network. He then spent some time in Network Strategy, Network Planning and Works, and Network Systems Engineering on the specification of BT's requirements for internodal signalling. He has been involved with the negotiation of international standards for digital transmission, switching and signalling since 1977. He recently led a study concerning the evolution of internodal signalling in BT's network, and is currently working in the Architecture and Standards Department of Development and Procurement as a Standards Advisor on Signalling Systems.

## *Glossary*

**ANSI** American National Standards Institute
**ATM** Asynchronous time-division multiplex
**B-ISDN** Broadband ISDN
**BSI** British Standards Institution
**CCIR** International Radio Consultative Committee
**CCITT** International Telephone and Telegraph Consultative Committee
**CEPT** European Conference of Postal and Telecommunications Administrations
**CTR** Common technical regulations
**DASS1** BT's Digital Access Signalling System No. 1
**DSS1** CCITT Digital Access Signalling System No. 1
**DSN** Derived services network
**ETS** European technical standard
**ETSI** European Telecommunications Standards Institute
**GAP** Analysis and forecasting group
**GSM** Groupe spéciale mobile
**IDA** Integrated digital access
**IDN** Integrated digital network
**IN** Intelligent network
**ISDN** Integrated services digital network
**ISO** International Standards Organisation
**ISP** International standard profiles
**ISUP** ISDN user part
**ITU** International Telecommunications Union
**NET** Normes Européenes de Télécommunications
**N-ISDN** Narrowband ISDN
**ONP** Open Network Provision
**OSI** Open Systems Interconnection
**PDN** Public data network
**TSS** Telecommunication Standardisation Sector
**TUP** Telephone user part

*Alan Bimpson*

# Standardisation of Services for the ISDN

*The study of services for the ISDN has produced many internationally recognised recommendations and standards. This article provides an outline of the standards and the processes which have generated them. It is intended as an introduction and overview of the considerable documentation associated with the subject. Such recommendations have considerable significance as they represent the services offered to customers worldwide and form the basis of interconnection agreements between operators.*

## Introduction

The design of the technical capabilities for the integrated services digital network (ISDN) produced a realisation that there was a need to have a detailed understanding of the services to be offered to ensure that efficient use would be made of the system. As the ISDN was evolved from the 64 kbit/s digital telephony networks, many of the services are based on the capabilities of speech-based networks but due consideration was also made of circuit-switched data networks. It was also logical that the services of packet switched networks would also be incorporated thereby giving the user access through a 'simple' network interface to the widest possible range of services. Indeed, as additional switching techniques have been realised, such as frame relay and broadband asynchronous transfer mode, these too have been incorporated into the ISDN. A wide range of services has now been studied and documented in the main standardisation bodies. Standards and recommendations for the ISDN are produced by a number of organisations[1]. The sheer volume of documentation associated with the recommendations and standards from the international bodies means that only a general overview is really possible in this article.

Right from the start it was recognised that a design process was needed for the standardisation activities to ensure the capabilities and the signalling system design matched the proposals for the services to be offered by the network. It has also been a long term aim to ensure that the features and services provided in both public and private networks should be aligned as far as possible. This has the benefit of minimising the interworking arrangements needed and helping to widen the terminal equipment market.

Two international bodies are involved in the development of ISDN service recommendations and standards: the International Telegraph and Telephone Consultative Committee (CCITT) of the International Telecommunications Union (ITU), and the European Telecommunications Standards Institute (ETSI). The ITU is currently undergoing a major reorganisation and standardisation is to be focused into the Telecommunications Standardisation Sector.

## Types of ISDN Services

In the context of the ISDN, services are the communication capabilities made available to customers by telecommunications service providers. Telecommunication services providing for the transfer of information of various types between two or more users are divided into two broad categories: bearer services and teleservices. The ISDN bearer services are basic connectivity services allowing the transmission of data from one network access point to another. These may be considered equivalent to the capabilities of speech and data networks. The ISDN teleservices include high-level functions of terminals and network-based equipment to provide much more 'complete' services to be offered to users. An example of a teleservice is facsimile. The telecommunication services can be modified or supplemented by supplementary services to provide additional functions and facilities such as those found in

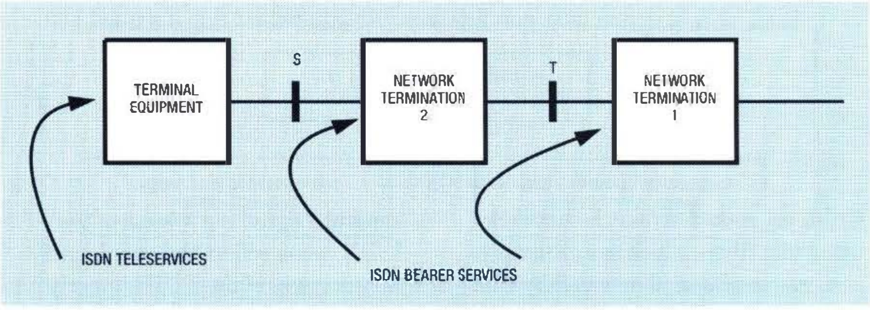



*Figure 1—Points of access to ISDN services*

private networks. Much of the standardisation effort involved has been given to the detailed specification of the supplementary services.

Both the bearer services and the teleservices use common bearer capabilities and other resources from the network. A user will select the service to be used at call establishment time. As teleservices have a rigourous definition of terminal requirements, and terminal supply in the UK is fully liberalised, BT does not always offer complete teleservices but does offer teleservice support by providing the necessary network features so that users may use a teleservice. Naturally this also allows interworking with other operators who offer the service.

The services are made available at various points in the access reference configuration (see Figure 1).

The user can access the services at a number of points dependent on the nature of the service. Bearer services are accessed at interfaces at points S or T. The choice of this point is dependent on the type of equipment the customer chooses. Terminal equipment is used to give the user access to teleservices. Specialised terminal adapter functions can convert the ISDN services to other standardised or non-standardised services to meet the user requirements. BT delivers its services to the interfaces at point 'T', the users then purchase terminal equipment, perhaps from BT, to meet their requirements. The telephony teleservice is available on ISDN interfaces so that users have access to the international telephone service.

## ISDN bearer services

### *Circuit-mode bearer services*

Three circuit-mode bearer services (services allowing a continuous passage of information) based on 64 kbit/s capabilities are well defined and established, others are still in preparation. The stable ones are:

- 64 kbit/s, 8 kHz structured bearer service—unrestricted data: this offers the capability of transferring data at up to 64 kbit/s transparently across the ISDN. The special arrangement needed for data rates less than 64 kbit/s are catered for through rate-adaptation schemes.

- 64 kbit/s, 8 kHz structured bearer service usable for speech information transfer: this offers the capability of transferring speech information (A-law or μ-law coded). The network can apply any form of processing techniques appropriate for speech (echo control, low rate encoding circuit multiplication etc) and these may not be controllable by the users. Hence users of the service will not be able to use voice bandwidth modems.

- 64 kbit/s, 8 kHz structured bearer service usable for 3·1 kHz audio information: this service offers the ISDN user the facilities of the PSTN (through the digital interface). It allows the transfer of speech and 3·1 kHz bandwidth audio information from modems, fax machines etc. Control of speech processing devices such as echo control is made through the use of disabling tones generated by terminals.

Although the above are the main categories of bearer service, a number of others have been defined. They are not widely available, however, or require much further work to produce implementable services. They include:

- alternate speech/64 kbit/s unrestricted;

- 2 × 64 kbit/s unrestricted (with delay differential between the channels restricted to 50 ms);

- 384 kbit/s, 1536 kbit/s and 1920 kbit/s unrestricted;

- multi-rate unrestricted; this is an $n \times 64$ kbit/s service which allows the user to choose the bandwidth required for the call between 128 kbit/s and 1920 kbit/s in 64 kbit/s increments.

### *Packet-mode bearer services*

To provide the services of a packet switched public data network (PSPDN) or to provide access to a PSPDN, the ISDN provides a number of services accessing packet handing functions. As the signalling channel (D-channel) of the ISDN operates using packet-mode protocols and there is considerable spare capacity, it may also be used to carry these packet-mode services. B-channels are used to provide 64 kbit/s access to the services. Two configurations are supported. Case A service uses a circuit-switched B-channel connection over the ISDN to a remote packet handler; the user then runs X.25 protocols to provide the packet switched service. This is a two-stage process: the B-channel connection is established as one phase, then the packet operations can be run over the B-channel (the packet access point is given an ISDN number as though it were a user). The second case (Case B) connects a B-channel directly, or provides the separation of data packets on the D-channel and routes them to the packet handling functions. In this latter case, as there is no separate call set up, the service request needs no additional addressing information to connect to the packet handler.

### *ISDN frame-mode services*

The lower-level protocols of packet-mode services can be used to support data transfer between users in an efficient manner especially where the error rate across the network is low (as is the case of modern networks). Blocks of data are carried in 'frames' which are routed across the network using identifiers which are either pre-assigned or allocated on a call-by-call basis. Two service types have been developed to utilise transmission and switching techniques based on these low-level protocols:

- frame-relay bearer service, and
- frame-switching bearer service.

The service offered to the user is very similar in both these cases. The main difference is in the way the network handles the frames being transported.

### ISDN teleservices

If higher-level functions of the user terminals and, if appropriate, the network are specified in addition to the bearer capabilities and other lower-level functions providing basic connectivity, then users can be offered complex services. The teleservices defined so far include:

- telephony,
- videophone,
- facsimile Group 4,
- teletex,
- videotex.

Because of the different regulatory requirements imposed on users, terminals and network operators in teleservices, they are treated slightly differently in various countries. Telephony is a particular case and in some countries it is considered as a bearer service. The protocols contain elements for handling teleservices and, through these, support of the teleservice concept may be given.

### ISDN supplementary services

A wide range of supplementary services has been defined for possible application to the ISDN. Some are designed to build on the use of the separate signalling system of the ISDN, some reflect the supplementary services of the PSTN (largely non standardised) and others reflect the facilities commonly found on private network systems. As a general rule they can be applied to any bearer service or teleservice.

The supplementary services are arranged into broad families of services. Each service is fully described and includes aspects of definition, description, procedures, interworking requirements and interactions with other supplementary services.

The main categories of supplementary services and their titles are detailed in Table 1.

Work is continuing in the standardisation bodies to add to and evolve this list. A number of the services above are actually broken down into specific versions for various phases of calls. The precise status of the standards differs slightly between the CCITT and ETSI.

## Service Description Methods

The whole of the ISDN standardisation process was designed to ensure that the network requirements would be determined as completely as possible for each service with the needs of the users also being understood. The process has been divided into a number of stages to allow specialist expertise to be applied to each part of the process. Within the standards bodies this allows separate working groups to deal with the process. This has sometimes led to consistency problems and even strong disagreements between experts (fortunately rare!). The overall process and the various stages in the process are iterative as the detailed work frequently raises problems or limitations not recognised earlier. The process itself was standardised and has proved stable and useful for a considerable period of time. As will be shown later recent developments in network capabilities are causing it to be reviewed.

The individual phases of the process analyse the following aspects

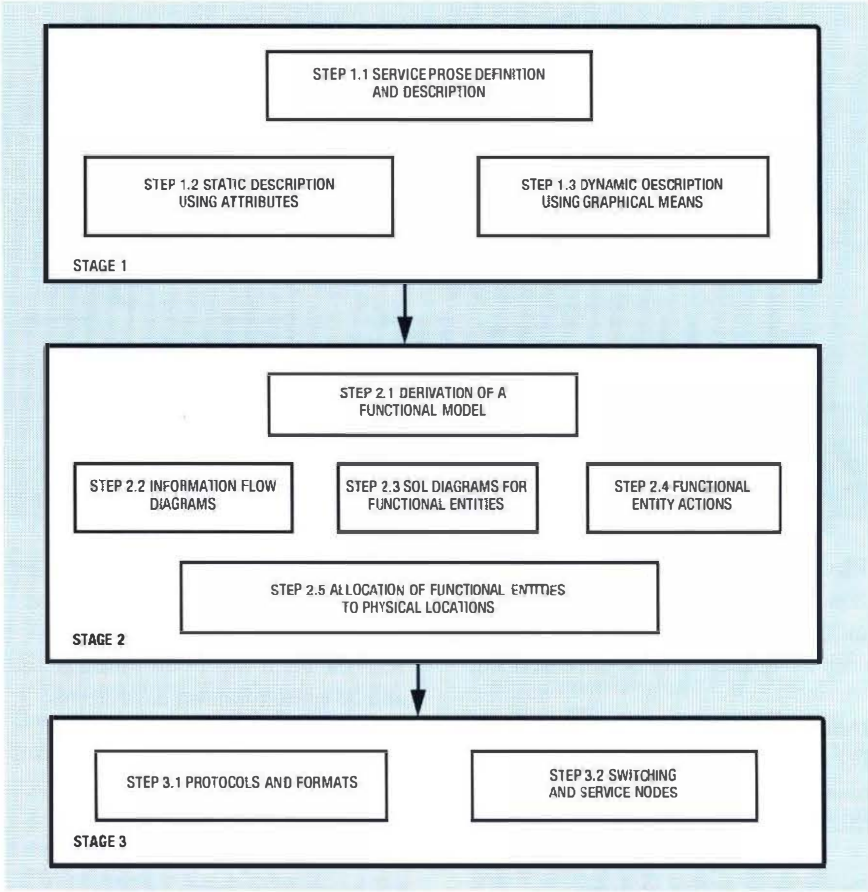
- the service definition—stage 1,
- the functional model and information flow requirements—stage 2, and
- the signalling system protocols—stage 3.

In parallel with these stages, the technical capabilities of the switching systems and interworking functions are also worked out. An illustration of the overall process may be found in Figure 2.

**Table 1 Supplementary Services**

| |
|---|
| **Number Identification Services** |
| Direct dialling in |
| Calling line identification presentation |
| Connected line identification presentation |
| Malicious call identification |
| Multiple subscriber line |
| Calling line identification restriction |
| Connected line identification restriction |
| **Call Offering Services** |
| Call transfer |
| Call forwarding busy |
| Call deflection |
| Call forwarding unconditional |
| Call forwarding no reply |
| Line hunting |
| **Call Completion Services** |
| Call waiting |
| Completion of calls to busy subscribers |
| Call hold |
| **Multiparty Services** |
| Conference calling |
| Three-party service |
| **Charging Services** |
| Advice of duration and charge |
| Reverse charging |
| Credit card calling |
| **Community of Interest Services** |
| Closed user group |
| Support for private numbering plans |

*Figure 2—Three-stage process for deriving ISDN standards*




## Stage 1—The service definition

This stage in the process results in a recommendation having two or three parts dependent on whether a telecommunication service or supplementary service is being described; that is, the prose description, the static description and the dynamic description. The prose description uses plain English to describe the service as seen by the user and to define the operational and administrative features of the service. The second part (the static description) defines the 'attributes' of the service. The network architecture gives a limited set of connection and control characteristics which can be selected to meet the requirements of the service. Because these apply to the requirements of the service rather than any specific invocation of the service, they are referred to as the *static description*. The dynamic description is an illustration of the operation of the service using a simple form of graphical system description language (SDL). The CCITT publishes these descriptions in the I series and F series recommendations.

## Stage 2—The models and information flow

This forms the next phase in translating the basic requirements of the service into the network capabilities needed to actually implement the service on a real network. It is designed to describe the functional and signalling requirements of the service in largely implementation-independent form. It has five main parts which are:

- derivation of the functional model,
- the information flow requirements between the functional entities,
- dynamic description of the operations of the function's entities contained in the functional model,
- descriptions of the actions taken by the functional entities, and
- alternative allocations of functional entities to physical locations.

The CCITT publishes these recommendations in the Q series recommendations.

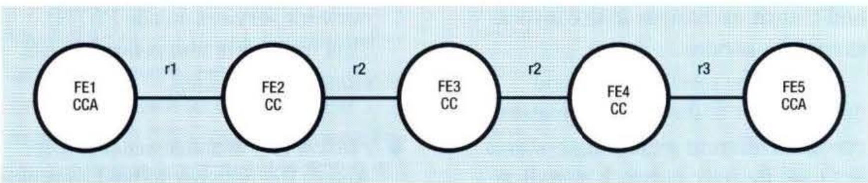
### *Functional model*

The functional model is derived from the requirements of the service. It breaks the total set of functions down into sub-sets of functions which are realistically provided at a single location. Each functional entity (FE) is then assigned a number and the relationships between the FEs are identified. Figure 3 illustrates a functional model. The FE interacting with the user is termed a *call control agent* (CCA), and the FEs concerned with providing the service by cooperating in the network are termed *call control* (CC). The relationships (r1 to *rn*) between the FEs, across which there will be an exchange of information, are illustrated in the model. Figure 3 shows the very simple model needed to describe the basic call across the ISDN.

### *Information flow*

Having identified the functional model, the information flow requirements can be defined. A diagram is constructed to identify and illustrate each interaction between the functions. When information is received by an FE, it carries out an action or series of actions; these frequently result in the generation of information to other FEs to continue the processing of the service request. Each set of actions is identified so that they may be more fully described.

*Figure 3—Functional model for the ISDN basic call*



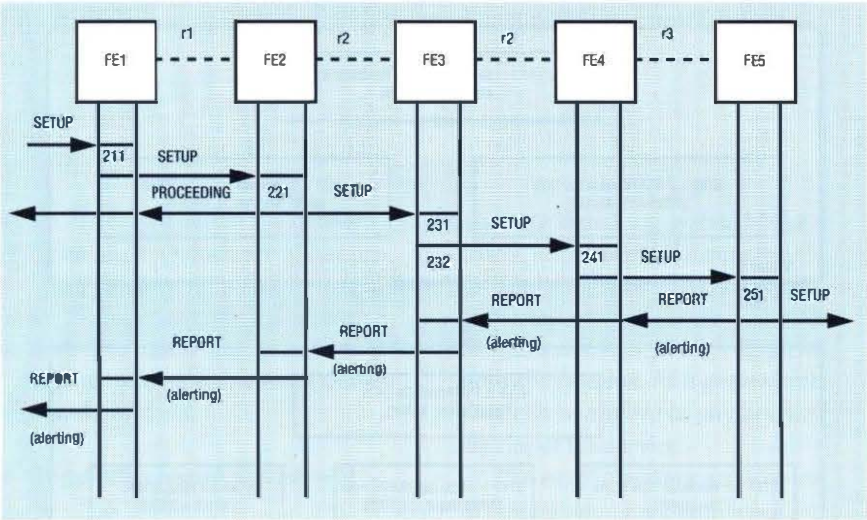



*Figure 4—Information flow for basic call*

Figure 4 shows part of the information flow diagram for the basic call. The meaning and anticipated content of each information flow is also described.

***Dynamic Description***
For each FE, an SDL diagram is constructed to show the behaviour of that part of the system.

***Functional entity actions***
For each of the FEs, actions to be taken on reception of information are listed and described. These may or may not lead to a subsequent generation of a further information flow.

***Allocation of functional entities to physical locations***
As part of the complete functional model, the functions are applied to the physical ISDN architecture and frequently this will show alternative possible implementations which are shown as scenarios. For example, there are frequently functions which could be placed either in terminal equipment or within the local exchange. The implications on signalling systems can easily be understood by examining the scenarios.

## Stage 3—The protocol definition

This last stage of the design process results in the definition of access and internodal signalling systems, and contains details of the actions to be taken by terminals, local exchanges and transit exchanges in the invocation of the service.

This is the most complex and detailed part of the standardisation process. Different signalling systems are used for user-network signalling and for the internodal (interexchange) signalling. These are message-based common-channel signalling systems with the definition of the message set and its content known as *protocols*. The complete protocol description forms a major part of the interface specification for either terminals or exchanges. More detailed descriptions of standards for these two systems will be given in future articles. Recommendations for the protocol detail are published in the Q series.

***Access signalling system***
The protocol for the Digital Access Signalling System No. 1 (DSS1) for the user-network interface description contains an overview of the system, definition of the states for the user equipment and for the network during the phase of the call and for the invocation of supplementary services, the message set and the message elements which are used to build the various messages. To complete the definition, the description of the operation of the signalling system for the basic call is also given, both in plain language and in graphical SDL. For the supplementary services, three generic protocols are described allowing various user network signalling options. These are

- *Keypad Protocol*
  Allows keypad sequences using *# and number keys to be used to control the service (similar to network services on the PSTN). This method is also referred to as *stimulus signalling*.

- *Feature Key Management Protocol*
  Allows the network to hold a service profile for the customer with the user being able to allocate functions to 'soft keys' on the terminal

- *Functional Protocol*
  Features are permanently programmed into terminals and the networks. This is an extremely rigid system but it allows the terminal to behave in exactly the same way on any network supporting the protocol.

A detailed stage 3 description is prepared for each supplementary service in respect of the functional protocol. For the other protocols, the definition of the control sequences is at the discretion of the network operators.

***Internodal signalling system***
In addition to the information concerning ISDN calls, a new user part has been added to the definition of the internodal signalling system (Signalling System CCITT No. 7). This is known as the *integrated services user part* and is to be the subject of a later article. The process for evolving this detailed description has not been standardised.

## Charging

The charges which a network operator makes on the customers for the actual use of services is definitely not a subject to be standardised. However, the general principles on which charges are based and the general principles for accounting for the services which are provided when two or more networks cooperate is considered an appropriate matter for recommendations. Recommendations in the CCITT D series describe these principles. A number of capabilities to allow charging are obviously built into networks and the protocols need to take into account the use and activation of such capabilities. In addition some services may present charging information directly to customers (for example, advice of duration and charge) and hence service descriptions and protocols need to be developed to support these services.

## Interworking

As a general rule, the ISDN services are expected to interwork with other operators' ISDNs (assuming realistic commercial implementations of the services can be put into place). They are assumed to have a high degree of commonality with private network services. In addition, it is possible to define the interworking requirements with other networks and this is explained in a future article.

## Broadband ISDN

The general principles for services in the broadband ISDN are very similar to those for the 64 kbit/s based networks. B-ISDN uses an underlying transmission technique utilising small fixed length packets of data (called *cells*) at very high data rates through the network. This technique is known as *asynchronous transfer mode* (ATM). In order to present the information to user equipment and to network functions above the basic cell handling level, adaptation functions 'map' the cell streams into continuous or variable bit rate or frame-based services. A later article will describe the operations of B-ISDN in more detail.

To date, two services for the B-ISDN have been defined; that is, the connection-oriented data service and the connectionless data service. The B-ISDN is an ISDN and may support the 64 kbit/s services directly. A number of other services are under consideration. The connectionless service is compatible with standards being produced for metropolitan area networks (MANs). Studies are continuing into the application of the broadband capabilities for advanced multi-media services.

### Connection-oriented data service

The service allows the transfer of information continuously between two users (or more if certain supplementary services or multipoint operations are invoked). The data can be at fixed or variable bit rates up to the throughput capacity of the interfaces; for example, approximately 130 Mbit/s. A call set-up or administrative procedure defines the 'connection' through the network. This is analogous to a call in a circuit-switched network.

### Connectionless data service

This service uses the connection-oriented nature of the underlying ATM network to provide a virtual path from users to a connectionless data handler. The user assembles packets of information which each contain complete addressing information and sends them to the handler. The handler then forwards the complete packet over the ATM network to the addressed recipient. As each packet is self contained no 'call' or connection exists to associate the two users hence the service is connectionless.

## Human Factors

An important area of concern in services is their presentation to the human user. Specialists in this area are consulted during the service description process to ensure that relevant factors are taken into consideration.

## Mobile Systems

The standardisation of mobile systems has used processes similar to those detailed above. A number of service standards exist for the GSM mobile systems. An active area of study at the present time is in relation to the next generation of mobile systems (termed *future public land mobile telecommunication systems* (FPLMTS)).

## Future

There has recently been adoption of a new architectural principle for networks known as the *intelligent network* (IN). This introduces capabilities and signalling functions which will offer the opportunity of creating, changing and customising services to a much higher degree than before. Network operators have the chance to provide services which are far less dependent on the dedicated facilities linked to line terminations etc. The need for detailed service specifications similar to those of the ISDN is now not at all clear and a shift in emphasis is expected in the type of service documentation needed. Several well understood services are currently being examined to assess the type of service descriptions needed. Examples include Premium Rate and Chargecard services. The requirements for these descriptions are also dependent on the regulatory and procurement frameworks in which BT and other operators have to work. The aim must be to allow the new services to utilise the flexible nature of the IN to the maximum advantage to allow operators to meet their customers' needs.

## *References*


1 Clarke, Peter G. ISDN Standards: An Overview. *Br. Telecommun. Eng.*, Apr. 1993, **12** (this issue).


## *Biography*


Alan Bimpson currently leads a group dealing with service, network capabilities and telecommunications management network (TMN) standards. He is the BT and UK coordinator for activities in CCITT Study Groups I and IV. He is also closely involved in the equivalent working groups in ETSI. Alan started as a Youth in Training in 1962 in the Liverpool Telephone Area and has been involved in a wide range of activities including Training, System X development, Systems Studies and, since 1986 international standards.

*Stanley Chia*

# Network Operational Principles for Third-Generation Mobile Systems

*In response to the needs to harmonise, internationally, the interworking between mobile networks for third-generation mobile systems and future fixed networks, the CCITT has issued a new recommendation on network operational principles for future public mobile systems and services. Within this framework, third-generation mobile systems are envisaged to be capable of providing extensive roaming and handover capabilities, high-performance speech transmission as well as efficient mobile network operations. This article reviews the key technical issues related to this new recommendation.*

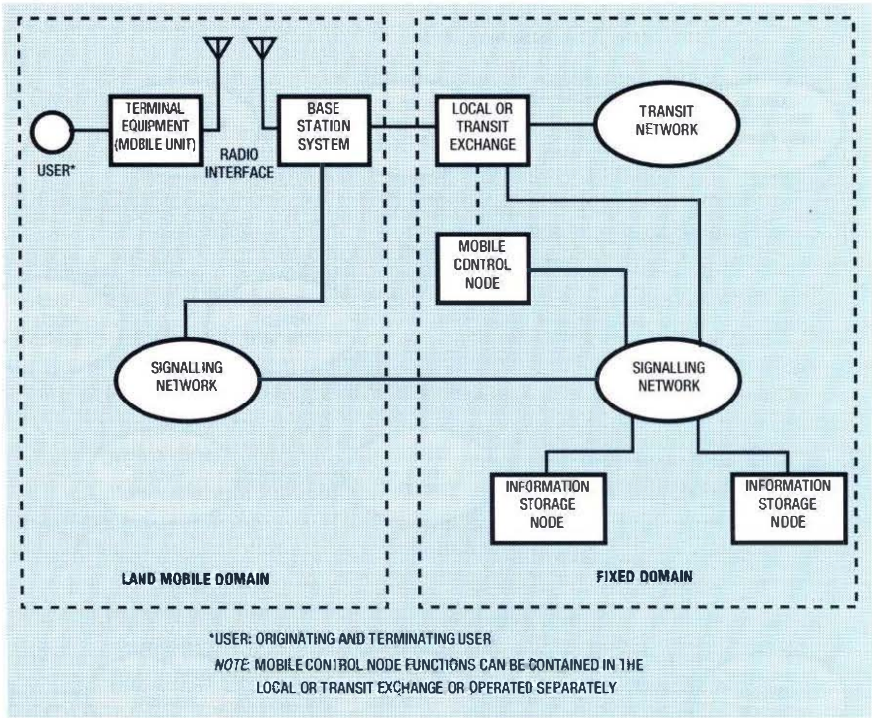
## Introduction

With the allocation of 230 MHz of spectrum between 1·8 and 2·2 GHz by the World Administrative Radio Congress (otherwise known as *WARC '92*) in March 1992, third-generation land mobile radio systems (hereafter abbreviated as third-generation mobile systems) are expected to be ready to commence services by the turn of the century. They are designed for providing access, by means of radio links, to a wide range of telecommunication services supplied by the fixed telecommunication networks and to other services that are specific to mobile users. Clearly the characteristics and requirements of these third-generation mobile systems will be dependent on their intended service offerings. Among a host of service criteria, perhaps the most important ones are dependability, universal availability and good service quality, yet these systems must remain economically viable. In addition, the provision of these service offerings will be required in a variety of radio and network environments, with the latter embedding network interconnection and integration scenarios. The competitive nature of future mobile network operations has also meant that third-generation mobile systems will be operating in a multi-service, multi-vendor and multi-operator setting. All these requirements have rendered network operations for third-generation mobile systems a uniquely challenging task in the future.

In recent years, the active multi-national collaborative research programmes on third-generation mobile systems worldwide have ensured that mobile radio communications will have a significant role in the provision of international telecommunication services. To meet the anticipated demand for mobile and personal communications, guidelines have to be established in order to harmonise the interconnection and integration of future public mobile systems with the current and future fixed networks (including public switched telephone network, integrated services digital network (ISDN) and broadband integrated service digital network), both nationally and internationally. Ideally, from the network operational point of view, it is necessary to ensure that third-generation mobile systems can be interconnected to, and integrated with, the fixed network with minimal adverse effect on overall quality of service and without the need for enhanced functionality in the fixed network. In other words, a near transparent integration and interconnection of the mobile network and the fixed network are highly desirable.

As part of the research effort on third-generation mobile systems, BT has been actively contributing to the drafting of a new CCITT recommendation on network operational principles for future public mobile system and services[1]. Indeed, this is the subject of this article, which discusses the background and the associated technical issues underpinning this new recommendation.

*Figure 1—A reference connection for integrated mobile and fixed networks*




## Network Architecture

In order to summarise the architecture of a mobile system concisely, functional models and reference connections are useful means. For third-generation mobile systems, a possible reference connection is shown in Figure 1. The figure illustrates a reference connection for the emerging scenario of integrated mobile and fixed networks. In addition, it identifies the boundary between the domains for both information and signalling traffic. In the figure, the mobile unit (or terminal equipment) is linked to the base station system via a radio interface within the land mobile domain. This base station system may be composed of a number of network elements including the base station controller, the base transceiver station, and the microcell network controller (if microcell networks are implemented). In the fixed domain, the base station system is further connected to the transit network through the local exchange and the transit exchange. These exchanges might be equipped or linked up with additional facilities which provide the functionalities associated with a mobile switching centre of the second-generation cellular radio systems. As in the second generation cellular radio systems (such as the GSM system), the switching fabric and the control fabric of the local exchange will be separated. In particular, mobility control functions for third-generation mobile systems are to be provided by mobile control nodes. These mobile control nodes will also serve as a gateway for updating location and subscriber databases, which fulfil both the functions of 'home' and 'visited' location registers in second-generation cellular radio systems.

## Service Quality

With the network architecture outlined in the previous section, the differentiation between the land mobile domain and the fixed domain in future networks may not be easily identified by end-customers, especially for those associated with the latter. For this reason, the most fundamental principle for the interconnection and integration of the third-generation mobile systems to the fixed networks is that, ideally, they should not impose any requirements for additional functionality, nor any restriction in the normal operation of the existing fixed network. To meet the requirements of future networks, a grade of service (GOS) concept is being developed that should enable independent design and implementation of functional network elements, both fixed and mobile[2]. Accordingly, in connections comprising both mobile and fixed network segments, the allocation of GOS targets for the fixed network segments should be the same as for end-to-end fixed network connections. In other words, interworking of mobile and fixed networks should not impose any restriction in the normal operation of the fixed network. It is, however, recognised that it may not be possible, in general, for mobile network segments to cost-effectively maintain some (or all) of the performance targets set for GOS parameters associated with corresponding fixed network segments. Hence a differentiation of the GOS performance with respect to the fixed network logical counterparts is introduced in principle. However, specified bounds to the end-to-end GOS parameter values should be guaranteed. Furthermore, it is expected that future advancement in technology and system design, and spectrum allocation should reduce the need for differentiation of GOS targets for mobile network segments.

## Network Operation

In general, in order to facilitate network operation and evolution, networks used to support third-generation mobile systems should be digitally implemented and compatible with the ISDN. Where appropriate, intelligent network (IN) technology should be employed and this should be compatible with the IN principles and standards produced by the CCITT. The objective of IN is to allow the introduction of new capabilities in a telecommunication network and to facilitate and accelerate, in a cost-effective manner, service implementation and provisioning in a multi-vendor environment[3]. In March 1992, the CCITT released a set of recommendations for IN, known as *IN capability set 1* (IN-CS1), which enable low-risk introduction of a wide range of advanced services with rapid service delivery and customisation capabilities. IN-CS1 mainly focuses on services that are of high commercial

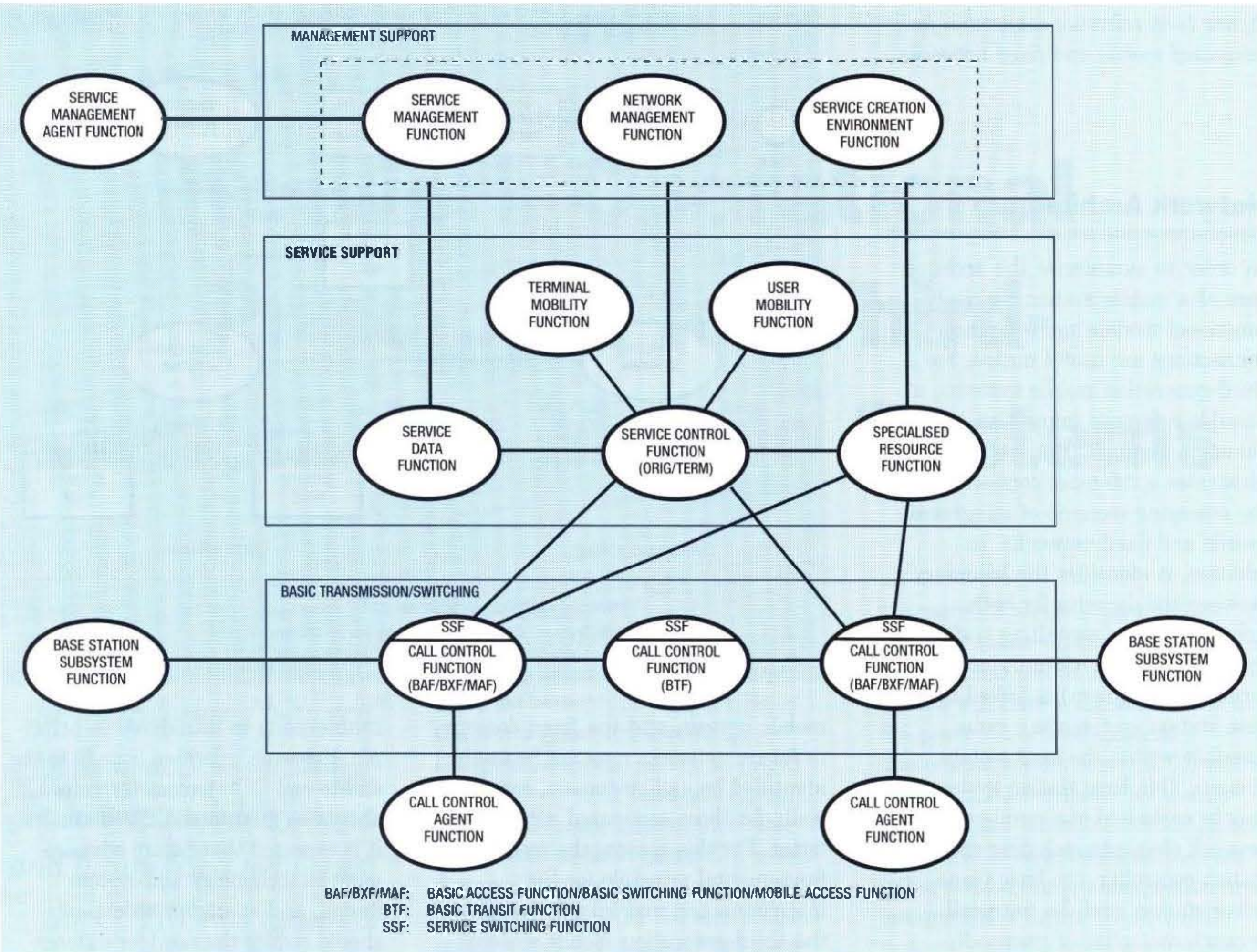



*Figure 2—A possible functional model for an extended intelligent network*

value addressing flexible routing, charging and user interactive services, and no terminal mobility capabilities have been included. To this end, there is currently a strong drive from third-generation mobile system research activities to introduce mobility-related features in future releases of the IN capabilities set. A possible scenario for the extension of the IN concept to include mobility functions is shown in Figure 2.

In addition, the signalling systems used or developed for third-generation mobile systems should be compatible with those utilised in the fixed network. Clearly, the objective should be to maximise service and feature transparency to the network, thereby reducing the need for complex interworking relationships between, and easing the integration of, fixed and mobile networks. Assuming that third-generation mobile systems are optimised to achieve spectrum efficiency, the volume of signalling traffic must be balanced with the user traffic to be carried by the fixed network especially in an integrated fixed network and mobile system. The optimum proportion of signalling traffic to the user traffic in third-generation mobile systems is a complex issue related to cell size, location registration and paging, user density, and the system level at which the control is performed; that is, locally or centrally. Thus traffic optimisation will be very much network specific.

In terms of mobility support, mobile units in third-generation mobile systems may either travel within the home public network, across or within other public networks, or private customer premises networks. To obtain services across different networks, roaming has to be supported. Roaming requires the updating of a location database for a mobile unit to provide service to the mobile unit when it is in the coverage area of a location database beyond its home network. This location management may be handled by a distributed database function.

From the location database point of view, at least three roaming scenarios are possible for third-generation mobile systems:

- inter-operator roaming (roaming between public networks);
- intra-operator roaming (roaming within one public network); and
- inter-environment roaming (roaming from a public network to a private customer premises network).

In third-generation mobile systems, all mobile units, in principle, should be able to access public networks operated by different operators as well as private customer premises networks. However, users should be able to make a choice between the networks based on parameters such as tariff structure, service quality, and network coverage whenever possible. The design of third-generation mobile systems should also take into account the possibility of occasional loss of roaming functionality, and provide for customer notification and recovery. In addition, efficient network routing should be provided to roaming mobile units. Consideration also has to be given to the trade-off between the amount of location registration and paging signalling traffic and the time to locate a mobile unit.

In future, microcells may be implemented wherever service demand justifies their deployment. A mixed cell architecture may be introduced, with microcells overlaid by macrocells in order to achieve both strategic and wide-area radio coverage, respectively[4]. In general, backward handover should normally be employed to ensure network control and spectrum efficiency. However, when a mobile unit turns a street corner, or moves into a shadowed area, the signal quality may be significantly degraded, and rapid handover may have to be effected to ensure the continuity of the connection. In this situation, the option of a forward handover may need to be executed, as the quality of the current radio channel may not be sufficient to support the required handover signalling.

Furthermore, in the design of the handover algorithm, we must also be aware of the possibility of network blocking leading to the possibility that a handover will be unsuccessful because network circuits are not available. Indeed, network blocking during the handover of high-bit-rate services, multi-media services and simultaneous multiple handover in mobile customer premises networks (for example, in buses, trains) will also have direct impact on the performance of future mobile telecommunication services.

Efficient use of network resources will be of paramount importance to future network operations. For instance, in some existing cellular radio systems, the handover between mobile switching centres requires an anchor mobile switching centre; that is, one which retains control of the call. In third-generation mobile systems, if the cell size is decreased, the number of handovers per call is likely to increase. The chance of multiple inter-local exchange handover during a call will increase accordingly. To avoid several local exchanges being held up by one call, it is desirable that third-generation mobile systems should be required to transfer both connection control and call control to the new local exchange under the supervision of the transit exchange. Indeed, the routing in the fixed network should also be optimised.

## Transmission Aspects

The end-to-end transmission performance of third-generation mobile systems is critically important if acceptable speech quality is to be achieved. However, transmission performance in a network is usually a trade-off between cost effectiveness and quality. Naturally, mobile subscribers for third-generation mobile systems will be increasingly inclined to expect good speech quality on any connection. Generally speaking, network transmissions can be impaired by a combination of a number of factors including quantisation distortion, transmission delay, and electrical and acoustic echoes.

The design of future mobile systems should, therefore, take into account the overall end-to-end transmission performance on all realistic connections. In particular, the cumulative effects of speech processing devices, both in mobile and fixed network should be considered. The one-way transmission time between any two mobile terminals, or between a mobile terminal and a fixed terminal, should be kept to a minimum. This transmission delay in a network causes the natural flow of conversation to be disrupted and echo to be more noticeable. It is recognised that not all possible user application and network configuration can be predicted. Some user applications and network arrangements may combine processing and propagation delays such that the transmission time exceeds the recommended value for the fixed network. To this end, the CCITT recommendation on transmission delay, G.114[5], should be adhered to whenever possible. Currently, the maximum of this transmission delay recommended for any international connection should be within 400 ms. For the speech quality, it is recommended that, for third-generation mobile systems, speech quality should be comparable to the 32 kbit/s adaptive differential pulse-code modulation standard with approximately 3·5 quantisation distortion units (QDUs) between analogue interfaces. Specifically, one QDU of coding distortion corresponds to a transition from analogue to 64 kbit/s A-law digital and back to analogue again. In addition, echo protection should conform with CCITT Recommendations; in particular, E.220[6]. Furthermore, due consideration should be given to acoustic echoes in hands-free operating environments. With the roaming facilities that will be offered by future mobile systems, the echo path of a connection may vary during the duration of a call because of inter-environment handover. Echo control devices, therefore, should be able to converge on new echo paths without injecting subjective impairments on calls.

## Concluding Remarks

The CCITT Recommendation, E.202, on 'Network Operational Principles for Future Mobile Systems and Services' has its scope restricted, initially, to public land mobile services. However, it may potentially be extended to cover other mobile issues including satellite mobiles.

The Recommendation is still undergoing evolution within the CCITT. Liaison on this Recommendation has already been set up with the CCIR Task Group 8/1 (charged to study future public land mobile telecommunication systems) in order to harmonise viewpoints on third-generation mobile system operations. In addition, the Recommendation has also incorporated views from the RACE mobile project which is working towards the technology for creating a European third-generation mobile system standard: the Universal Mobile Telecommunications System.


## Acknowledgements

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## References


1 CCITT: Draft Recommendation E.202. Network Operational Principles for Future Public Mobile Systems and Services. SG II R-30, Geneva, February, 1992.

2 CCITT: Draft E.750 Series of Recommendations, 'Traffic Engineering Aspects of Mobile Networks', SG II R-31, Geneva, February, 1992.

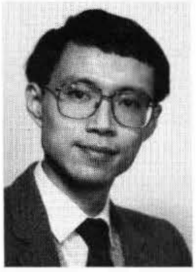
3 Duran, J. M., and Visser, J. International Standards for Intelligent Networks. *IEEE Communication Magazine*, Feb. 1992, 1(2), pp. 34-42.

4 Chia, S. T. S. Mixed Cell Architecture and Handover. IEE Colloquium on Mobile Communications for the Year 2000, 8 June 1992.

5 CCITT: Recommendation G.114. Mean One-way Propagation Time. Blue Book, Volume III, 1990.

6 CCITT: Draft Recommendation E.220. Interconnection of Public Land Mobile Networks. SGII, Geneva, February, 1992.


## Biography

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*John Lysaght*

# Is the Telco Engineer an Endangered Species?

*This article examines professional development for engineers in the evolving telco career market, discussing professionalism as one dimension of a telco career; the effect of business strategy on the telco internal labour market; and hence, the relevance of the profession to telco engineers. It concludes that professional development is becoming more attractive and proposes that FITCE, the Federation of Telecommunication Engineers of the European Community, is an appropriate forum for a continuing debate on the issues identified.*

## Introduction

Historically, engineers enjoyed the benefits of the monopoly conferred on the PTTs, the public administrations charged with providing national telecommunications infrastructures. While not quite a conveyor belt, the conventional PTT engineering career was predictable and secure, and allowed the technically-minded to devote themselves to their vocation.

In the new telcos, the commercial successor organisations to the PTTs, there has been career stagnation, redundancy and early retirement for engineers. One solution which has been advocated is for engineers to train for and seek general management assignments. Depending on one's viewpoint, this is either a decision to fight for work in the telco, or to flee from the profession of engineering. This 'fight or flee' situation brings to mind the dilemma faced by many natural species: the threat of extinction. Is the telco engineer now an endangered species?

This article looks at the telco engineer's habitat and the ways in which the species feeds and reproduces itself, and identifies issues in which professional engineers must take an active interest if the species is to survive.

This article is based on a paper presented by the author at the 31st European Telecommunications Congress, held in Granada and Seville, Spain, 27 September–2 October 1992. The author, from the Association of Telecommunications Engineers in Ireland, received the award for Best Paper.

The first step is to distinguish between the professional and other aspects of a career.

## Career Dimensions: Rank, Results and Reputation

Kanter[1], offers a conceptual model which helps us to focus on the distinction between professional and other forms of career development. She identifies three basic types of career:

- In a conventional or 'bureaucratic' career, all the elements of opportunity—responsibilities, challenge, influence, training and compensation—are tied to rank within an organisation.
- In an 'entrepreneurial' career, progress is achieved not by moving up within an organisation, but by making the managed unit grow in value—achieving results.
- The third type is the 'professional' career where growth is measured by reputation rather than rank. Whereas the bureaucrat's career is controlled by the judgement of hierarchical superiors, the professional depends on the esteem of clients and peers who may be outside the employer organisation.

While Kanter's model was originally developed to distinguish between career types, it is clear that an individual's career in an organisation can have all three dimensions. The bureaucratic dimension is self-evident, and often dominant. Within organisations, jobs are often designed to offer entrepreneurial elements—from participation in decisions to a share in the profits of success. It is quite feasible to develop a professional reputation—that is, to be recognised from outside—while employed by an organisation.

For PTT engineers, career development was one-dimensional: quite firmly bureaucratic. There were vestiges of professionalism, but these had little to do with careers. In the telcos to date, there is a growing emphasis on a second dimension, the entrepreneurial. A side-effect of this is to reduce the emphasis on professionalism: the individual becomes more concerned with developing a reputation as a manager than as an engineer.

In order to decide whether this is a good or a bad thing, it is necessary to have an overview of what is happening within the telcos.

## Career Structure: Competition and Openness

This section will first take a structural look at the telco organisation's internal labour market and then discuss the issues which arise.

Sonnenfeld[2] suggests that two structural factors determine labour market conditions within a business. Sonnenfeld's two criteria are:

- Is the company open to the external labour market; that is, does it hire people from outside in mid-career?
- How competitive is the selection process: in other words, how important are selection decisions to the success of the company?

They define four characteristic types of environment:

- The 'hire and fire' (open, non-competitive) company is familiar: hotels and building sites are examples.
- The PTTs operated 'fair' internal markets with little external recruitment. Selection was not considered critical to business success.
- The 'proprietary' company is more selective about its promotion decisions, but remains closed to the external market—the telcos are currently operating in this way.
- The 'professional' company looks carefully for talent in the external market. Hospitals and football teams are examples.

Sonnenfeld analysed the internal labour market structure in many businesses and found strong links with the well-known typography devised by Miles and Snow[3,4], which classifies businesses into four strategic types:

- 'Defenders' are firms which seek to maintain a stable environment and concentrate on operating efficiency. Sonnenfeld found that they tend to be closed to the outside labour market and have a low level of internal competition. Promotion tends to be by seniority, with emphasis on fair treatment.
- 'Prospectors' are firms which depend on locating and developing new opportunities, and therefore need operating flexibility. In career terms, these are the opposite to defenders: open to the outside labour market, with high internal competition. Employment depends on performance, and external talent is often bought in.
- 'Analysers' aim to locate new opportunities while maintaining a firm core product range. They have to manage the competing requirements of operating efficiency and flexibility. Sonnenfeld found that they are closed to the outside labour market, but have high internal competition. There is rapid progress to senior management for a limited few.
- The fourth strategic type is the 'reactor', the firm with no strategy. These are open to the outside market and have low internal competition. Employees are a commodity, hired and fired in reaction to market conditions, and little effort is put into the development of individuals.

This indicates that the increase in competition within telcos is no accident, nor is it a personnel policy *per se*. It is driven by a strategic necessity to increase the competitiveness of the firm—'selection of the fittest'. This is borne out in less academic literature such as Mayo[5].

Competitive selection has been likened to a tournament, where only the winners of lower-level competitions are eligible to compete at higher levels. The tournament theory emphasises the importance of early success and frequent moves. This poses problems for graduate engineers who expect to enter organisations as apprentices, with initially slow advancement. Those unsuccessful in early competitions are unlikely to progress as far as the winners, especially as the latter are given better development opportunities. Successful careerists, because they move jobs frequently, will have a strong attachment to the organisation, but a weak attachment to the job and the work group—the inverse of the approach promoted at university.

Competitive selection leads to an increased number of 'steady staters', people whose careers have reached a 'plateau'. Bardwick[6] is adamant in her assertion that this is not a manifestation of the Peter Principle (the idea that one is promoted until one's job performance becomes unsatisfactory), which was observed in an era of expansion, where people tended to be promoted too rapidly. In the PTTs, with seniority as a significant factor, plateauing tended to indicate unsuitability for promotion. In the new telcos, this is not the case, and telcos face the difficult problem of maintain-

## EurIng

The 'EurIng' professional engineering qualification is well-defined throughout Europe by FEANI, the European federation of professional engineering institutions. The EurIng requirements are specified in terms of a generalised 'formation package': in each country, the national institutions specify detailed variants based on the FEANI model. The version familiar to this author is used in Ireland and the United Kingdom: it is intended to take a minimum of eight years after matriculation, of which at least four are spent in employment.

It consists of a primary university degree in engineering, followed by an apprenticeship that is measured in terms of training and experience. The training programme is designed to enable apprentices to sample a variety of jobs, while exposing them as early as possible to the demands of real work. The scheme with which the author is familiar has the following main training elements: practical skills; product/service specification; design and development; documentation and data preparation; procurement, manufacture, testing and quality assurance; system engineering; installation and commissioning; operation and maintenance; marketing and sales; health and safety at work.

It is recommended that a professional engineer act as a tutor, or mentor, during the apprenticeship period. The qualification is attained by undergoing a professional test after at least two years' working experience.

This covers Stages I and II of the professional career. In Ireland and the UK, the profession recognises the attainment of Stage III by awarding the title 'Fellow'.

The FEANI qualification was designed to facilitate mobility for professional engineers throughout the European Community. It also provides both individuals and employers with a clear standard for professional development up to Stage II.

ing the motivation of 'steady staters', in a culture where promotion has been expected as the reward for consistent performance.

At present, most telcos are still at the 'proprietary' stage, with closed internal labour markets, though increasingly open for exit, via early retirements and redundancies. Drivers towards increased openness to entry can be envisaged: where new business developments require skills unfamiliar to the telco, it will be necessary to hire people at higher than the normal entry level; where project work is involved, telcos will be likely to hire temporary staff or engage consultancy firms in order to avoid the cost of developing and maintaining their own professional staff.

This section has shown professional development as a problem and an opportunity. The problem is that graduate recruits, if they concentrate on professional rather than career development, may lose ground that cannot be made up again. Therefore, to be attractive, professional development has to be consistent with general advancement.

The opportunity is that telco engineers who decide to stay and compete with each other and with incoming professionals should set high standards for self-development, and those who decide to leave should acquire qualifications which signal their value to the external labour market. On this basis, professional development is worthy of at least an initial examination.

## Professional Development: Stages, Standards and Self-Support

This examination considers the stages of professional development, the value added by formally organising the profession and the inputs which maintain a professional development system.

The simple 'stage' model of a professional career, developed by Dalton and Thompson, offers a useful starting point. Four stages are identified:

- At stage I, the intern or apprentice, under the direction of another professional, carries out small projects.
- At stage II, the professional works independently on significant projects.
- At stage III, the senior professional assumes responsibility for a group of professionals.
- At stage IV, the eminent professional speaks for the profession.

In some professions, these stages are recognised informally, by reputation only. The formal professions provide standards by defining qualifications which indicate the stage of professional development and development packages to bring candidates to the necessary level of expertise.

These standards are useful in three ways. Firstly, like any other quality standard, they facilitate the market by reducing the need for clients or employers to spend time checking the capabilities of the professional in detail. Secondly, they indicate to professionals a reliable way to reach the next stage of expertise. Finally, they standardise practices, making it easier for professionals to communicate and work together.

There are no such standards for telecommunications engineering in Europe, though FEANI has a generic package for engineers which could provide a starting point (see box). The FEANI model includes the education process, and defines requirements for professional development in the early stages of the career. There is an increasing debate about extending development standards to cover the entire career—so-called continuing professional development or 'life-long learning'.

Standards alone are not sufficient: a profession has to be passed on from one generation to the next. Professionals adopt four distinct roles in the development process, directly comparable with the four career stages:

- At stage I, the *apprentice* is expected to study and adopt the values and practices of the profession.
- At stage II, the *master* is expected to supervise the work of apprentices and demonstrate the values and practices.

- At stage III, the *mentor* is expected to control the development of apprentices and provide them with guidance.

- At stage IV, the *sponsor* is expected to provide leadership for the profession and oversee the development process.

Historically, professional development has not been of major relevance to telco engineers: they were unlikely to require mobility outside the PTTs, they did not face competition from outside, and they operated in a 'fair' rather than a competitive internal labour market. Therefore, only the vestiges of professional support systems exist in telcos at present, and even these are under threat due to the current emphasis on managerial rather than professional development.

## Summary and Study Proposal

In the telcos, the increase in internal competition, with an emphasis on selection of the most accomplished, makes the road to a professional qualification attractive as a high-quality self-development path for engineers. With an increasing likelihood of exposure to the external market, such a qualification becomes desirable as a tradeable sign of achievement.

It is therefore necessary:

- to *examine* the existing standards of the engineering profession for quality and relevance to the careers of telco engineers (If an overhaul is required, this should be done in consultation with FEANI and its member organisations.);

- to *promote* professionalism among telco engineers, with an emphasis on self-support systems; and

- to *persuade telcos* that the professional approach is a solution to the problem of maintaining a supply of competent and well-motivated engineers.

In this author's experience, it has been difficult for engineers to establish common ground with telco management on professional development because it becomes confused with career issues within the organisation. One solution is to tackle the problem on a basis broader than a single organisation. Due to the structure of the industry, this implies at least an international, probably a European, scale.

In several respects, this is timely. There is an ongoing debate within the European Community on professional standards. The Federation of Telecommunications Engineers of the European Community (FITCE) has already expressed an interest in these matters[7]. The telco industry provides a cross-section of manageable size but reasonable significance, so FITCE is in a position to make a significant contribution to the definition of pan-European standards for the engineering profession.

It has been proposed that FITCE takes a fresh look at the professional development of telco engineers, with a view to ensuring that members' requirements for each stage of professional development are met. This study should examine the FEANI qualification, determine the extent to which it is relevant to FITCE members, and, if necessary, propose ways to increase this relevance to a satisfactory level.

Benveniste[8] suggests that the solution to problems such as those discussed in this article is to 'professionalise the organisation'; that is to structure the organisation to suit the needs of the professional. Given the new commercial emphasis of the telcos, this is evidently inappropriate. But surely we can organise the professionals?

## References


1 KANTER, R. M. Careers and the wealth of nations. Handbook of Career Theory. Arthur *et al* (*eds*), Cambridge University Press, Cambridge, 1989.

2 SONNENFELD, J. A. Career system profiles and strategic staffing. Handbook of Career Theory. Arthur *et al* (*eds*), Cambridge University Press, 1989.

3 GRIFFIN, R. W. Management. Houghton Mifflin, Boston, 1987.

4 QUINN, J. B., MINTZBERG, H., and JAMES, R. M. The Strategy Process. Prentice Hall, New Jersey, 1988.

5 MAYO, A. Managing Careers: Strategies for Organisations. Institute of Personnel Management, London, 1991.

6 BARDWICK, J. M. The Plateauing Trap. Amacom, New York, 1986.

7 FITCE Study Commission 88/I: Training of Telecommunication Engineers. Report to FITCE Congress, Strasbourg, 1991.

8 BENVENISTE, G. Professionalising the Organisation. Jossey-Bass, San Francisco, 1987.


## Biography


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EurIng John Lysaght qualified with a B.E. in electrical engineering from University College Dublin (UCD) in 1974, a C.Eng. from the Institution of Electrical Engineers (IEE) in 1983, a Certified Diploma in Accounting and Finance in 1986 and an M.B.A. from UCD in 1990. In addition to his duties in Telecom Eireann's Switching Division, he is Chairman of Ireland's FITCE association (the ATE), and Secretary of Ireland's professional body for electrical engineers (IEE Irish Centre).

*Michael Raistrick*

# Outsourcing and Communications Facilities Management

*North America has seen an increasing tendency for companies to concentrate on core business; this has resulted in some devolving responsibility for their communications networks. Will European companies follow the network outsourcing trend?*

## Introduction

Outsourcing and communications facilities management (CFM) are both perceived as key activities for telecommunications companies across Europe in the 1990s. This article describes these activities and examines why they are causing so much interest.

Initially, the article defines and differentiates outsourcing and CFM. The article discusses the reasons why customers are increasingly seeking these new services, and why they are seen as an area of growth throughout the next decade. This is presented against a background of what a typical customer might demand in terms of European and global communications.

Outsourcing and CFM are also considered from the supplier's point of view: how does the supplier benefit from offering these services?

With such radical changes in the working relationships between customers and outsourcing and CFM suppliers, there are bound to be disadvantages to each party, and these are also discussed.

Finally, the history and future of the markets for these services are considered to give a well-rounded, top-level view of the outsourcing and CFM environment.

This article is based on a paper presented by the author at the 31st European Telecommunications Congress, held in Granada, Spain, 27 September–2 October 1992. The author received the award for the Most Promising Young Engineer.

Many legal and regulatory aspects are involved in outsourcing and CFM, but these are not covered here.

## Outsourcing and Facilities Management

### Some definitions

Outsourcing and facilities management can mean different things to different people. The terms as used in this article are defined below.

The terms define the degree of contracting out of a company's functions to a suitably qualified external source:

- at agreed service levels,
- to an agreed cost formula,
- over an agreed period, and
- with agreed asset ownership.

In this article, the company who wishes to delegate responsibility for providing the functions is called the *customer*. The organisation who offers the outsourcing or CFM service is called the *supplier*.

With *outsourcing*, the customer does not retain direct control of any of the resources used in providing this function.

With *facilities management*, the customer still retains overall control of some or all of the physical assets and people—the supplier manages these resources (and uses others that it controls) to provide the function.

Communications facilities management is the same as facilities management, but the functions being managed relate specifically to the provision of communications services.

(Note, these are the author's definitions.)

### An example

Consider an electrical manufacturing company with extensive in-house printing facilities. The company owns printing presses, paper, inks etc. and employs staff with sole responsibilities in this area. In order to concentrate on its core business, the company decides to divest itself of its printing functions, either through outsourcing or facilities management. The supplier who takes on this function usually has printing as its core business.

If the customer *outsources* the printing function, then it sells or scraps the hardware, and either releases or redeploys its staff in a different area. The customer now has no direct involvement in the business of printing. When the customer has a printing requirement, it goes directly to the supplier who will work to a service level agreement (SLA).

The SLA defines how the supplier provides the product or service. Often the supplier agrees to buy the hardware and employ the staff from the customer as part of the outsourcing contract.

If a *facilities management* option is chosen, the customer may retain either its staff, hardware, or both. The supplier now just manages the printing process (using its own resources where necessary), using its expertise in printing to add value to the function.

To approach the subject of the outsourcing of telecommunications functions, it is useful to look at the typical telecommunications requirements of a potential customer.

## Companies' Communications Requirements

Outsourcing and CFM are services which can be used by companies with networks ranging in size from small (a few telephone extensions) to large (with hundreds of multi-megabit links). For sake of example, this article concentrates on the larger networks.

In order to stay competitive, many companies now have truly *global* needs for communications services; these services include:

- voice telephony,
- virtual private networks,
- videoconferencing,
- mobile telecommunications,
- frame relay,
- packet switching,
- managed bandwidth services,
- high-speed data services, and
- paging.

Increasingly, customers are developing truly European organisations with a consequential European community of interest, this means that these services must be provided seamlessly and easily across the whole of the community. Many regulatory issues still stand in the way of this. To provide the customer with high-quality services, it is imperative that all barriers which limit cross-border communications are removed.

Up until recently, companies' communications needs were met by the company building its own private telecommunications networks. This involved leasing data and voice links from PTT's, buying the equipment to build network platforms using these links, and maintaining and running the networks to offer the services needed.

More recently, the larger companies have been looking to divest themselves of these large private networks either by moving towards an outsourcing or CFM environment, or by buying 'managed services', for example, Centrex, from their suppliers. The reasons why many of the companies are seeking to do this is described in the next section.

## Advantages for the Customer

As the recession of the 1990s continues to bite, companies are not only trying to offload non-core enterprises, but are trying to contract out services which the company has in place to support the core business.

To gain a competitive edge, companies are having to become more efficient and flexible in reacting to customer needs. Using state-of-the-art telecommunications systems is a way to achieve this, and this in turn can be realised cost effectively by outsourcing or CFM.

Immediate advantages and areas for saving money for the customer can be seen as:

#### *Technology/implementing new networks*

Telecommunications is heavily dependent on technology, and this technology is changing ever more rapidly. Customers are often justifiably reticent to invest in the necessary skills and prototypes to keep up with implementing this technology in new networks. The costs can be prohibitive, and broadly based as they must cover the full area of service delivery, not just network design.

With outsourcing, the technology is not the concern of the end user, only the service that it provides. The supplier bears the cost of designing, implementing, maintaining and depreciating state-of-the-art networks, and has the expertise to do this effectively.

#### *Performance/network management*

Private networks often have variable performance statistics, though these are seldom measured. A common problem is the lack of adequate service management systems to qualify performance for the end user.

*For many companies, telecommunications data is mission critical; loss of a major network for one day could lead to bankruptcy.*

This is understandable in a world where investment is limited and largely directed to providing basic network elements.

Often the volume of traffic carried by a private network does not warrant the expenditure to provide top-level features and resilience. The basic economies of scale that a supplier enjoys in network provision allows this top grade of service to be provided to the customer.

Many predefined aspects of an outsourced network's performance are monitored and produced in reports to ensure that the agreed figures in the SLA are met. With the network now being managed, the customer can easily track how well the network is running, and how much it is costing.

Some of the performance figures and statistics which can be measured include availability, grade of service, utilisation figures, traffic patterns, number of severely errored seconds, network delay, mean time between failure and mean time to repair.

### *Flexibility*

In-house networks can suffer from a lack of flexibility in changing capacity, either in expansion or contraction. Again outsourcing is seen as a way around this problem, enabling the customer to react quickly to rapidly changing markets, with the supplier balancing one customer's 'peaks' with another's 'troughs'.

### *Staff*

The company does not have to employ, train, manage and offer career progression for its telecommunications staff. As well as immediately saving money, this can offer greater opportunities to the staff in terms of career development, if they transfer to the service provider.

### *Management headaches*

With outsourcing, the responsibility for all aspects of negotiation and ongoing relationships with suppliers of hardware, software and maintenance can be delegated, with the supplier presenting the customer with a single bill (if desired) in any currency. This leaves the management free from administrative headaches and able to concentrate on running and developing the core business. Also, if an outsourcing agreement has been reached with a preferred supplier, then the need for managers to deal with competitive tendering procedures is removed.

### *Dealing with foreign PTTs*

As an increasing number of companies have truly international networks, they have to deal with many telecommunications companies. They have to be able to communicate technically in several languages, deal in a number of currencies, and work within the regulatory regime of each country. As part of an outsourcing deal, the supplier can take on all of this responsibility so that the customer has only a single point of contact.

To summarise, a company that outsources telecommunications can focus on providing its core business; expenditure is tightly controlled, the supplier should be able to offer services with increased value for money, and the services are monitored and contractually guaranteed. Managers in the company can easily understand the service contract conditions and the business benefits they bring as these are independent of the technology used by the telecommunications company.

## Disadvantages for the customer

The purpose of this section is to highlight the potential problems to a company considering outsourcing its requirements.

### *Staff*

If staff are lost from a company, considerable resistance and bad feeling can be generated in the workforce, leading to low morale. The staff can often feel that they are being lost because they are not wanted. This is one of the reasons why outsourcing deals are handled in strictest confidence at high levels of management in their early stages.

Considerable care is needed from both customer and supplier to help staff accept any changes in a positive manner, and any plans must carefully take into account the needs and feelings of staff. If this is managed well, the change should be beneficial to customer, supplier and staff.

### *Security of data*

Much of the information that a customer transmits (both voice and data) contains material which is confidential to the company. Companies are understandably nervous about allowing this information to be handled by a supplier; especially as they may use a single logically partitioned network to serve both the customer and its competitors.

Trust is important between the customer and the service provider. Where this does not exist through an existing working relationship, it can be built up by outsourcing the less sensitive networks first; for example, voice followed by data later. Use of encryption devices at customer premises can also help the customer feel more comfortable with security.

### *Critical nature of data*

A separate issue from that of the confidentiality of the data is the critical nature of the data. For many companies, telecommunications data is mission critical: the loss of a major network for one day could lead to possible bankruptcy.

A system of compensation for service failure will always be defined in the outsourcing contract between the companies. The problem is that any compensation would be inadequate if they do go bankrupt due to a service failure!

This can be a severe stumbling block for customers: they are obviously very nervous about handing over such a vital part of their survival to a supplier. Again this fear can be overcome to some extent by the customer outsourcing its

*Generally, large private networks have evolved to meet unforeseen business needs, rather than having been designed to meet today's business needs.*

networks on a 'least critical first' basis to gain confidence in the supplier.

However this problem is tackled, cases will always arise where the customer will insist on maintaining control of its most critical networks for its own peace of mind; the customer will not outsource a network for this single reason, whatever the other advantages.

## Advantages to Suppliers

So far, the arguments that a company could use for or against outsourcing have been discussed. The gains that telecommunications companies can make from providing the service are now considered.

### *Financial*

Suppliers believe that they can run networks more cheaply and more efficiently than the company they outsource; this means that they can make money by offering the service. This is achieved by:

### *Rationalisation*

Generally, large private networks have evolved to meet unforeseen business needs rather than having been designed to meet today's challenges, and so they can contain redundancy which represents under-utilised capital and current expenditure. If the networks are outsourced, then the supplier can usually rationalise the networks to realise immediate cost savings.

### *Migration to core*

Ultimately, the supplier will want to remove the need for the customer's 'private network' as a separate entity; this will be achieved by offering services from a core network, or from a standard portfolio. This erodes the value of building and maintaining customer networks, as the supplier can save money through economies of scale by serving many customers from the same network and portfolio.

### *Key in*

With outsourcing, a supplier can key a customer in to only its services for a number of years, to the exclusion of all of the suppliers rivals. This can be seen as a big comfort to a supplier with ever-increasing competition and loosening regulation.

To summarise, an incumbent supplier can derive profitable business from an outsourcing deal by careful planning and network management, but stands to loose significant amounts of revenue if a rival wins the contract.

## Disadvantages to Suppliers

Outsourcing a large network is a huge task with many potential problems, some of which are discussed below.

### *Information solicitation*

One of the reasons why companies often turn to outsourcing is because their networks are not adequately controlled. Audits are sometimes not updated and network records and diagrams can be of variable quality. The supplier must have accurate information to be able to outsource networks. So for each outsourcing bid, the supplier must spend time gathering and validating data. This information must relate to the current and planned networks, and must be ongoing as networks are always in some state of flux.

If subsequently a bid is not won, many man years of work will have been invested for no return.

### *Fishing trips*

This is a problem relating to information solicitation. Sometimes if a network is not tightly controlled, as described above, the customer can issue an Invitation To Tender for outsourcing. The suppliers which respond use their expertise to audit and unravel the customers networks, detailing in a Response To Tender document how the networks would be rationalised and made more efficient. If the customer then decides not to outsource its network, it has had many man years of expensive work done on its behalf, for no cost.

### *Contract liability*

If a company agrees to provide outsourcing, prices are determined and set in a contract for several years. It is often difficult for a supplier to forecast accurately how much it is going to cost to provide these services. If this forecast is too low, the supplier will end up losing money on the contract; potentially millions of pounds.

## History of Outsourcing and CFM

Outsourcing and facilities management of computer and data-processing functions is now a well-established market. Network outsourcing is much newer, and indeed is still an embryonic form.

## Examples

### *Eastman Kodak*

Eastman Kodak was an early customer in the late 1980s, outsourcing both its data processing and telecommunications functions. This has been followed by several large outsourcing deals, some of which are mentioned below.

### *J. P. Morgan*

BT North America and AT&T have agreed to outsource two of the bank's three international networks. BT will migrate services from the companies X.25 network onto the public X.25 service (GNS) to connect 26 cities in 14 countries. BT's $20 million contract will save the bank some $12 million in operating costs over 5 years[1].

### *Euro Disney*

France Telecom has been appointed to facilities manage Euro Disney's telecommunications with an operating budget of £15 million per year[2].

### *BP*

Syncordia has been awarded a multi-million pound contract to manage a significant part of BP's communications infrastructure and services.

### *Microsoft*

Microsoft has awarded a 5 year contract to BT to facilities manage its European data network[3].

### *IBM*

IBM has awarded a $10 million three year contract to Syncordia to provide 6% of its data network needs[4].

### *Barclays Bank*

Barclays Bank has saved a capital spend of £5 million by appointing BT to offer a virtual private network service to replace its corporate voice network[5].

### *GEC*

GEC has placed a contract with Mercury worth £50 million over the next five years to provide voice and data services to all of GEC's companies[6].

## The Future

Communications outsourcing is new; more and more companies are becoming interested after seeing the results from the deals mentioned above.

Currently, telecommunications outsourcing accounts for 10% of outsourcing deals. In 1991, the US network outsourcing market was expected to grow from $2·3 billion a year at a rate of more than 20% a year (see Figure 1).

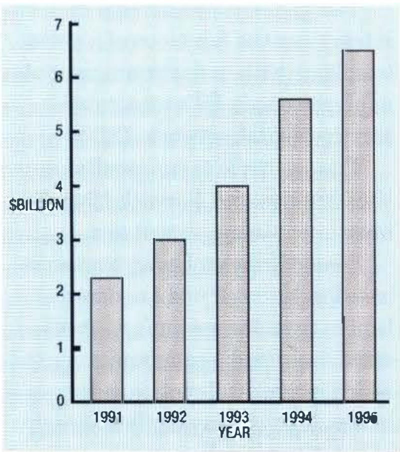


*Figure 1—Value of US network outsourcing market in $billions per year (Frost and Sullivan)*

## Conclusions

In the 1990s, outsourcing is seen as a key activity to provide seamless national, European and global telecommunications services to large customers. The market is new and expanding rapidly.

This article has given a broad top-level view of the outsourcing and CFM environment. Hopefully, this will be of value to the reader in following outsourcing deals as these services will radically affect the way that both customers and suppliers operate over the coming years.

## *References*


1 *Computerworld*, 17 Feb. 1992, p. 50.

2 *Electronics Weekly* 13 May 1992, p.4.

3 *Newsbytes News Network*, 8 May 1992.

4 *Exchange*, 1 May 1992.

5 *Computergram International*, 18 Oct 1991.

6 *Electronics Timesdate*, 7 May 1992.


## *Biography*


Mike Raistrick joined BT after graduation from the University of York, where he studied Electronic Systems Engineering. He is a network designer in a group which specialises in the migration and evolution of business networks. His work includes voice, time-division multiplex, packet switch, cell relay and LAN network design. Previous work has included modelling the effects of temperature on high-frequency devices and circuits at BT's research centre at Martlesham Heath.

### Saga Ensures Business Efficiency with BT's FeatureNet

Saga, the UK-based international travel and financial services group, has invested in BT's FeatureNet 5000 service in a telecommunications upgrade which will significantly enhance the company's business efficiency.

The callcentre installation, which went live at the beginning of March 1993, at Saga's Folkestone head office, combines a FeatureNet virtual private network with an automatic call distribution (ACD) system to enable the company to benefit from the many features and functionalities offered by the advanced network.

FeatureNet 5000 provides users at Saga with sophisticated digital switching technology which can handle all telephone calls, will accommodate all domestic dial-up calls, and most of the voice/data traffic that would normally require dedicated leased circuits.

The service gives Saga complete transparency of features and facilities across its whole organisation. In addition, the system allows Saga to increase or reduce call capacity at only two hours' notice, enabling rapid reaction to specific situations and to accommodate increased demand as a result of marketing activity.

Pete De Haan, Saga Group finance director and company secretary, explained: 'FeatureNet provides us with an opportunity to vary and considerably improve our working practices. In the past, telephone systems have been a limiting factor for the purposes of business expansion, but FeatureNet 5000 allows us to expand our services to customers while giving us substantial economies on call charges.'

As a direct-sell organisation, Saga Group relies on maintaining an efficient telemarketing operation for its core business areas. The previous telephone system meant that callers to a particular Saga service were unable to transfer to another service area without redialling. The FeatureNet ACD access lines enable calls to be diverted quickly and conveniently minimising lost marketing opportunities and improving the quality of customer service.

The ACD product gives improved queue management, the ability to give announcements to queued customers and comprehensive call-management statistics.

As a FeatureNet customer, Saga will achieve priority international traffic at beneficial call charges. FeatureNet will also give Saga the option of realising cheaper outgoing traffic into specific areas.

### BT Unveils Next Step in its Global Strategy

BT recently outlined the next stage in its plans to provide multinational customers with innovative global telecommunication services.

BT has submitted an application to the United States regulator, the Federal Communications Commission (FCC), for authority to resell international private line services and to offer switched services so that BT can provide international virtual network (IVN) services.

The new IVN services will offer all the benefits of private networks, but without the fixed costs and operational requirements associated with privately-owned international networks.

Plans include offering sophisticated and customised telecommunications features such as authorisation and account codes, customer-defined call handling and dialling plans, service and network configuration as well as customised bills and reports.

The user networks and services will be provided between the United States and other countries over international private lines to be acquired from US common carriers and their overseas correspondents.

The Yankee Group telecommunications consultancy currently estimates the market for IVN services will grow from less than $1 billion in 1993 to more than $5 billion by 1996.

If regulatory approval is given, it will allow BT to provide global customers with advanced international services on an end-to-end basis, unlike current services of this kind which are offered on a correspondent basis.

Gerald W Thames, president and chief executive officer of BT North America said: 'BT's strategy is clearly driven by our customers' need for simpler more-robust cost-effective international services from a single supplier.

'BT's aim to be a leading supplier of global telecommunications services relies on its ability to offer advanced international services to multinationals, most of which are headquartered in North America.

'Companies are looking to network suppliers to provide customised telecommunications services with private network functionality and the reliability and flexibility normally associated with shared and public networks. It is our intention to lead the industry in the delivery of such services.'

Commercial services will not be provided in the United States until such time as the FCC has granted the necessary authority to resell international private lines and switched services.

### BT Announces First ISDN Multimedia System Trialist

Norwich Union, the insurance and investment group, is to become the first commercial trialist of the jointly developed BT/Olivetti personal communications computer (PCC).

The PCC is a multimedia PC integrating the functions of a video telephone with mainstream computer applications via BT's integrated services digital network (ISDN).

The system is to be installed at two sites belonging to Norwich Union's investment management arm.

Senior Norwich Union managers based in Norwich and London will benefit from the system's sophisticated multimedia communications, which include full-motion video image, high-quality audio and high-speed data transfer.

Graeme Manson, BT Insurance Sector market specialist, is confident that the system's ease of use and array of functionality will result in the trialists achieving a significant improvement in communications between the two trial sites.

'Users at Norwich Union will benefit from the system's video-conferencing facility which will minimise the need to travel between London and Norwich. They will be able to interchange ideas on screen via a whiteboard drawing facility, exchange and share text and still videos, complete forms and perform fast file transfer', he said.

Mark Churchwood, Divisional Manager, Olivetti UK Document Management Division, adds: 'The PCC is an exciting new development of live interactive visual communication. It dispels at a stroke the distance barrier between disperse work-groups and individuals.

## BT Pioneers New Optical-Fibre TV Network Design to Boost Reliability

BT has developed an optical-fibre distribution network template for the broadcast industry after master-minding the successful switch from analogue to digital transmission at Channel 4.

The network design configuration, which is based on a diversely-routed core network, will boost reliability and allow BT to guarantee the quality and delivery of signals to transmitters around the UK.

The core network comprises two loops which originate in London and are routed east and west, respectively. Diversely-routed circuits link transmitters into the core. Signals are automatically redirected from one loop to the other if a fault develops.

John Swingewood, BT Broadcast and Satellite Services operations manager, said: 'The network architecture developed by BT is extremely resilient. The Channel 4 network has at least two diverse routings from London to every transmitter site.'

The digital network has distinct advantages over the existing analogue networks currently used by the BBC and ITV. It is highly flexible and immune to degradation over distance giving improved signal quality to remote locations.

BT's decision to base the network on optical fibre instead of microwave will cut out the noise and weather interference associated with radio signals.

This new design philosophy is combined with computer-controlled systems for proactive monitoring and diagnosis of faults for further improvements in reliability.

## BT Computerised Network Management Gives Channel 4 Improved Reliability

BT has developed a sophisticated package to proactively manage signal distribution to Channels 4's 25 transmitters in six regions.

The new network is monitored 24 hours a day through a sophisticated computer control system. BT's network management gives a continuous overview of the status of the network—allowing Channel 4 to maximise the reliability of their service to viewers.

BT's information technology enables automatic remote switching within milliseconds of a fault developing. Sensors at transmitter sites constantly feed data back to activate switches and to direct engineers within seconds to the location of faults by means of a computer screen. Fault diagnosis is also computer controlled by BT.

John Swingewood, BT Broadcast and Satellite Service operations manager, said: 'Effectively, the network is self-healing—if a fault develops, the management system activates a switch to re-route the signal before the viewer is conscious of it.

'Combining computer technology with a diversely-routed optical-fibre network architecture has allowed BT to give broadcasters cash-back guarantees on the delivery of signals to transmitters.'

Channel 4 is linked to the BT system at its Charlotte Street headquarters, allowing it to analyse performance data and to check the status of signals in all regions around the country.

## BT Compression Technology Halves Signal Distribution Costs for Broadcasters

Broadcasters switching to digital networks can halve the cost of distributing signals to transmitters by reducing transmission rates from 140 Mbit/s to 34 Mbit/s.

Chris Daubney, chief engineer at Channel 4, said: 'The use of 34 Mbit/s technology was an important factor in BT winning the contract for Channel 4's new signal distribution network. 34 Mbit/s technology was the most cost-effective option open to Channel 4. A 140 Mbit/s network would have been twice as expensive.

The introduction of the digital network has provided improved picture quality for Channel 4 areas such as the Channel Islands and Northern Scotland, making the service indistinguishable from that received by viewers in London.

The success endorses BT's commitment to video compression for TV distribution and contribution networks. BT has been testing digital transmission systems with 'live' simulations for a number of years, and has proved with the Channel 4 network that compression can be used with no significant sacrifice in picture quality.

BT has also engineered a digital solution which gives Channel 4 complete flexibility to migrate to new technologies such as PALplus.

## BT Wins Multi-Million Pound Payphones Contract with Shell

BT payphones will replace Mercury Paytelco models at 660 Shell service station forecourts across the UK. Under a new 5-year contract valued at more than £10 million, BT will also install up to 840 more payphones for the petrol company.

Other recent multi-million pound deals have been with Post Office Counters, Marks & Spencer and London Underground.

## ITU Moves Towards Global Standards

More than 450 telecommunications standards were adopted at the recent 1993 World Telecommunications Standardisation Conference (WTSC) held in Helsinki during March.

Organisers of the conference, the International Telecommunications Union (ITU), also took another step in streamlining telecommunications standardisation to increase competitiveness and meet global industry and market needs.

Delegates from 68 countries and eight international organisations, including the European Telecommunications Standards Institute (ETSI), approved the setting up of a Telecommunications Standardisation Advisory Group (TSAG) under the chairmanship of Mr B Horton from Australia to review priorities and strategies for the Telecommunications Standardisation Sector. They also agreed to review the progress of its work programme, and to recommend measures to improve cooperation and coordination between bodies with an interest in standardisation.

TSAG will advise groups on how best to prioritise and allocate work, adapt to market, industry and user needs, and recommend setting up joint coordination groups when necessary.

Other decisions taken at the two-week conference included:

- Establishing Joint Coordination Groups to facilitate standards development and to liaise with other standards bodies.

- Establishing an electronic document handling (EDH) group to review and study EDH user needs and to look at long-term convergence of EDH standardisation tools.

- Launching ITUDOC—a document exchange service which will include administrative and general information as well as a full text of all the ITU telecommunications standards approved since 1988. CD-ROM technology is to be used as part of the ITU's future publications activities.

- Reaffirmation of the Melbourne conference decision to cut standards-approval time from four years to 18 months with additional safeguards for developing countries.

Closing the conference, ITU Secretary-General Pekka Tarjanne said that the decision to set up TSAG would help maintain the Union's pre-eminent role in standardisation. 'The only way to succeed is to look forward,' he told the 459 delegates. Earlier conferences had led to major changes in the Development and Radiocommunication Sectors and that while small steps in the Telecommunications Standardisation Sector had been taken at the conferences in Melbourne, Nice, Geneva and now in Helsinki, it was not enough.

'In order to live up to these challenges, much more is needed', said Dr Tarjanne. 'I am looking forward to a lot more work and many more changes, both in Kyoto in 1994 and at the next WTSC in 1996 or 1997.'

The conference chairman, Professor Seppo Halme, pointed out that many of the 450 standards adopted at the conference belonged to the Q-series, reflecting the growing emphasis in networks and distributed intelligence. He also stressed the importance of TSAG for the future of telecommunications standardisation.

The Finnish minister of Transport and Communications, Ole Norrback, said that the conference had taken a 'long step forward in standardising new networks and applications'.

'Let us hope that we can all develop and construct the global network in peace and that people are given the freedom to exchange information and thought with their fellow humans in all countries.'

## PTT Bypass in Europe

National public telecommunications administrations are retaining overwhelming dominance of the European service markets and will suffer only modest market share erosion from an average of 95% today to 86% in 1997, according to a recent Yankee Group report. However, the report points out that the market-share figures understate the impact of bypass operators which will have a dramatic effect on the PTTs and the market in two respects.

Firstly, they will exert downward price pressure towards cost, particularly where there are several players in free competition such as satellite services or resale. Secondly, they will set new benchmarks for quality, and innovation to reduce costs or enhance services.

The Yankee Group Europe has published a pair of reports which examine the bypass market in Europe. One looks at bypass from the technological and commercial perspective, while the other reviews developments in re-regulation.

Bypass first appeared in the US over a decade ago, and some operators have become multi-billion dollar enterprises which now compete fully with the 'PTT' (AT&T) and are formidable global competitors.

There is keen demand for bypass in Europe, which, with deregulation, is being provided through alternative fixed networks, terrestrial radio, satellite and virtual bypass (for example, with calling cards).

Regulation at both the European and national level is crucial to the development of bypass. In most countries, the PTT traditionally had a statutory monopoly on most or all services, making bypass of networks illegal. The second report examines the centralised and national initiatives for change, the current regulatory status of bypass, and the outlook in each EC and EFTA nation.

The aftermath of Maastricht is resulting in a shift in the balance of power back towards the member states. This may slow the movement towards liberalisation and there are signs that the impetus for internal competition created by the Single Market programme is petering out.

## Vodafone Centres to Arrive on High Streets

Vodafone Limited has announced a major initiative to encourage the setting-up of retail outlets, known as *Vodafone Centres*, across the high streets of Britain. The company hopes to have 170 stores operating nationwide by summer 1994.

# industry news

Under the terms of its operating licence, Vodaphone is not permitted to sell direct to the public. Instead, the end-user must buy a mobile telephone from a separate service provider. Vodafone's plans are designed to help service providers or their dealers in opening retail outlets on or close to high-street locations. Vodafone will jointly fund the refurbishment and shop fitting of suitable retail units, and will provide a long-term package of advertising support, both on an individual store basis and as part of national advertising campaigns.

### Mercury on Hand

Mercury Personal Communications has announced that when its forthcoming Personal Communications Network service is launched at the middle of the year, there will be three types of handset, manufactured by Siemens, Motorola and NEC. The company says that all of these will feature integral voice messaging or answerphone, and will be available through high-street specialist and electrical outlets, as well as MPC's direct salesforce.

### Cable Vision

The UK cable television and local telephone service market is set for strong growth in 1993, with the existing 434 000 subscribers set to be joined by 300 000 new clients, according to the Cable Television Association. Broadband cable now passes more than two million British homes; penetration was 22·4% in January this year, up from around 20% last year. A total 109 133 telephone lines had been installed by January this year, up from 20 000 a year ago. Of those, 92 824 were residential and 16 309 business lines. Most investment is from North America, but this year is expected to see both UK and European institutions investing.

# next issue

Articles planned for the July 1993 issue of the *Journal* include:

- Systems Engineering in BT's Account Management
- Account Management in BT
- New Roads and Street Works Act
- Northern Ireland SDH Network
- Future Electronic Office
- Standards for ISDN Architecture
- ISDN2 Performance Analyser
- Compatible Coding of HDTV and TV
- New Cooperative Framework for European Public Network Operators

[*Editor's note*: Final contents may be subject to change.]

# book review

### Audio, Video and Data Telecommunications

*David Peterson*

Telecommunications has gone through an enormous revolution in the past few years and, as a result, texts which were regarded as standard four or five years ago now look horridly dated. In Britain, the major operator replaced its analogue trunk network by a digital network in about 18 months around 1990. Its competition never has had an analogue network. Thus the extensive references to analogue FDM networks contained in textbooks of the 1980s and earlier became of only historical interest and of little use to practising technicians. Hence, there is an opportunity for a whole new generation of textbooks at all levels to explain to modern students the realities of telecommunications apparatus and networks. Peterson's book is aimed at early undergraduates and is generally successful in giving a background to present-day telecommunications.

*Audio, Video and Data Communications* sets out to cover the principles of signals, networks, modulation theory, coding, radio, television, information theory and data communications. The author has an excellent style, and manages to make even some of the more challenging mathematics roll out quite easily. Even Shannon's law of channel capacity is derived quite painlessly in a few lines; I assume that the usual proofs covering several pages are more rigorous but are hardly needed here.

Inevitably there must be some criticism. His reference to the 'Post Office Tower' makes me feel less alone when I slip into the same old error. More serious to my mind is the trivial treatment of optical-fibre propagation. Firstly, he uses the word 'dispersion' on p. 3 to indicate the reduction of radio signal with distance as the beam spreads. However, to use 'dispersion' in the same way on p. 30 with optical fibres, where it usually has a totally different meaning, must inevitably confuse students. Also his brief consideration only covers multimode fibre. Another detail concerns microphones which consist of two plates of a capacitor; as no charge on the plates is mentioned, where would the output come from? Also modern television cameras rarely use tubes, but use charge-coupled devices instead. In view of the book's broad title, the range of CCITT standards referenced in the appendix could well be broadened. Perhaps these points can be taken for a future edition.

Notwithstanding these comments, if you want a simple, but technical, overview of telecommunications, this could well be the book for you. Its style is very readable and, making allowances for the inevitable simplifications, it is highly informative.

*Published by McGraw-Hill Book Company.*
*£17·95. xiii + 333 pp.*
*ISBN 0-07-707427-0.*

***Reviewed by John Griffiths***

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# TELECOMMUNICATIONS ENGINEERING

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**Issue 8 April 1993**

**Editor-in-Chief:** Professor Keith Ward, CENG, FIEE, MBIM
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