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Special Issue on

Network Management Systems

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The Board of Editors is grateful to John Helleur, Departmental Manager, Network Management Department (NMD), BT Development and Procurement; John McQuinn; Trevor Fitchett; Yasmin Abigail and the staff of the NMD Front Office for their contribution to the preparation of this issue of the *Journal*.

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Special Issue on Network Management Systems

BRITISH TELECOMMUNICATIONS ENGINEERING

FOREWORD by Chris Earnshaw

I am pleased to introduce this special issue of the *Journal* on Network Management Systems, which provides an effective sequel to the issue on Network Administration produced in October 1990.

BT has set as its objective the goal of being the leading global telecommunications operator, offering world-class telecommunications services. As we move through the 1990s, we will see a growing pace of change and rapidly increasing complexity. Effective support systems which provide efficient automation of service and network management are vital to achieving our goal.

The essential groundwork to steer the modernisation of BT's UK network support systems to enable them to cope with the challenges of the 1990s was laid by the Network Administration Task Force (NATF) and the Network Administration Implementation Programme (NAIP). Combined with the business process framework created by the Strategic Systems Plan (SSP), these initiatives produced the guiding principles for a major systems development and roll-out programme, supporting the evolving operational organisation.

This programme has already produced major gains from a set of integrated systems which are now automating key operations and providing a comprehensive range of network surveillance and control functions.

Similar analyses have been carried out in respect of BT's international networks and its private networking portfolio. In the case of international networks, these are converging on the operational framework and support system structure mapped out for the UK network. In parallel, the Concert™ programme encompasses integrated support systems for private network services.

The next phases of our drive to enhance our capabilities involve the creation of a comprehensive service management platform, integration of service and network management and the linking of systems on a global basis.

The combination of these programmes, using the enabling framework of the Co-operative Networking Architecture (CNA) and powerful skill bases in the Development and Procurement Division, is producing an integrated systems platform which will enable BT to meet the challenges of services on a global scale.

Much will need to be done to keep pace with the continuous evolution of new services, enabling control of those services directly by customers, and the management of a constantly changing global network.

CHRIS EARNSHAW
Managing Director,
BT Worldwide Networks

Network Management Systems: Introductory Overview

R. J. HELLEUR†, and N. R. P. MILWAY*

Significant effort has been made by BT since the mid-1980s to revise radically the company's approach to managing networks. This introductory article considers the jigsaw of network management support systems, the architectures that are used to control its evolution and the complex challenges still to be met.

INTRODUCTION

It is increasingly accepted by the leading public telecommunications operators (PTOs) that the key differentiators in their competitive business are the services offered and the efficiency with which they manage the networks supporting those services.

Significant effort has been applied in BT since the mid-1980s to revise radically the company's approach to managing networks and the systems required to automate this activity.

As a result of the Network Administration Task Force (NATF) and the Network Administration Implementation Programme (NAIP) which combined headquarters and field views of the way forward, together with the Strategic Systems Plan (SSP) analysis of the business processes required to plan and operate the network efficiently, the shape of the target vision is well understood.

The October 1990 issue of the *Journal* recorded some of the key aspects of this complex programme. One such aspect of the programme encompasses the systems which support the process of operating the network. This special issue concentrates on the network management functions and the major computing systems used to implement the vision created by the NATF.

In parallel with these public networking initiatives, the essentials of managing private networks have been analysed and embodied into the Concert™ development programme. Both public and private programmes, despite being driven with different short-term priorities, are evolving within a common technical framework, the *Co-operative Networking Architecture-Management* (CNA-M).

Developments are moving rapidly to meet these objectives, creating a jigsaw of interworking pieces which efficiently support 'flow-through' of workstrings.

However, several significant challenges remain to be met as new services are launched, and as the technology and topology of networks change.

† BT Development and Procurement
* BT Worldwide Networks

This article considers these challenges and the way in which the network management jigsaw will evolve to match these changing demands, and is intended to act as an introduction to this special issue of the *Journal*.

THE VISION

The NATF study led to a rationalised vision with the minimum number of integrated operations and computer centres, with highly skilled, flexible and mobile technicians and automated work management.

As with Concert™, all networks and network elements should be managed by a consistent, integrated set of network management systems, supporting standardised operational processes and workstrings. These highly effective systems must be optimised to provide rapid evolution to support new products and services.

FUTURE REQUIREMENTS

Clearly, BT is continuously driving to offer its customers:

- new services,
- reduced charges,
- improved quality, and
- customer control of service.

In line with other PTOs, BT is also looking to a networking future which is significantly different from the existing situation, encompassing:

- virtual private networks,
- hybrid public and private networks,
- multi-service networks,
- global networks,
- intelligent core network,
- mobile network periphery, and
- diverse technologies including synchronous digital hierarchy (SDH), asynchronous transfer mode (ATM), pair gain, fibre in the access network, and radio.

Crucial to achieving rapid and flexible service provision is the need to integrate network administration functions fully with service management, customer-facing and financial systems.

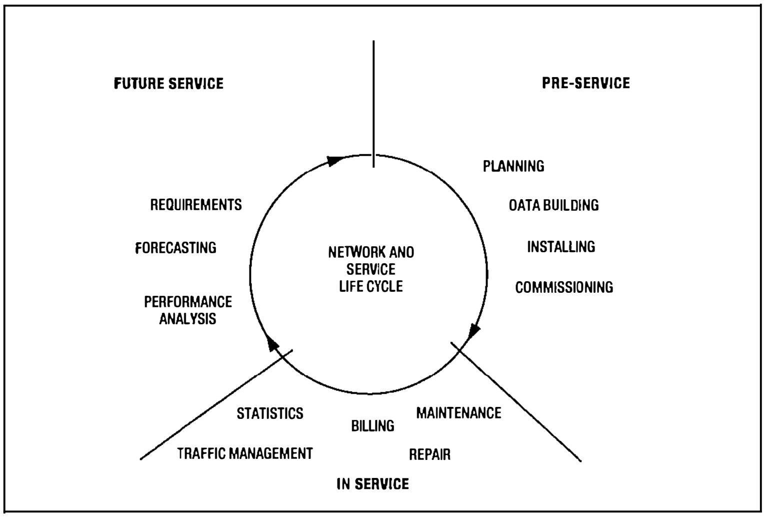


Figure 1 Communications management life cycles

The combination of these initiatives and the enormous pace of change being undertaken is going to put considerable stress upon the network management systems that are now becoming fundamental to the effective operation of the business.

RÉSUMÉ OF NETWORK MANAGEMENT FUNCTIONS

Networks and services must be managed from 'cradle-to-grave', throughout their whole life cycle (Figure 1), covering:

- forecasting,
- requirements analysis,
- detailed dimensioning and planning,
- configuration data management,
- construction,
- work management,
- inventory management,
- maintenance and repair,
- traffic management,
- capacity assignment and frame management,
- performance analysis,

and ultimately iterating to enhancement or withdrawal.

The challenge of network management is to encapsulate all of these life-cycle functions, to allow them to interwork effectively and cover all networks.

ESSENTIAL APPROACH FOR SUCCESS

An ad hoc, uncoordinated approach to meeting the above challenge will not succeed.

In BT, the fundamental need for cohesion and consistency has been recognised both in the organisation of teamworking and the technical solutions.

Organisation for Success:

- BT Worldwide Networks (WN) has established a view of the way forward by forming strong links between field end-users and headquarters coordinators through the NAIP[1, 2]. This, through a number of working groups, has been identifying and prioritising areas of improvement.
- The improvements targeted by the NAIP, and indeed all changes affecting network management systems, are channelled through the Network Control Architecture Board (NCAB). This body ensures that all system developments follow appropriate evolution paths. It is run by the Operational Policy and Systems (OPS) unit in WN, and reinforces team play by encompassing development interests from BT Development and Procurement (D&P) and field input.
- Cohesion of development is achieved by a coordinated approach within D&P, with the focus and design leadership vested in the Network Management Department.
- For private networks, the cohesion across the BT portfolio is achieved by the Concert™ programme, under the control of Managed Network Services, BT Products and Services Management.

Technical Cohesion:

- The essential shape of the processes to run the business has been identified in the Strategic Systems Plan (SSP). SSP is providing vital guidance in ensuring that the necessary system interworking is identified, and that the appropriate system functional groupings are defined, and provides a template to aid the consolidation of the existing 200+ support systems into some 40 *key* systems for the future[3, 4].
- The NCAB has created a vision which embodies:

(*a*) end-to-end network management,
(*b*) coverage of the whole network life cycle (Figure 1),
(*c*) fully integrated functionality,
(*d*) flexibility—evolution and growth,
(*e*) high levels of automation/decision support, and
(*f*) conformance to architectural objectives.

- The other enabler which allows the jigsaw of systems to be put together to meet the vision and SSP targets is the architecture—CNA-M[5]. This forms the essential framework for integrated support systems:

(*a*) the functions in each jigsaw piece,
(*b*) interfaces between pieces, covering protocols and message sets, and
(*c*) an open computing platform.

- Synergy between public and private network management portfolios is being exploited by the use of the common CNA-M architecture and the common prime contractor focus provided by Network Management Department.

ENABLING ARCHITECTURE

The application of CNA-M architecture creates a layering of the logic and a functional segmentation, shown in Figure 2.

In order to explain the impact and benefits of the architectural approach, each element of the architecture will be described and the way it contributes to the success of systems development defined.

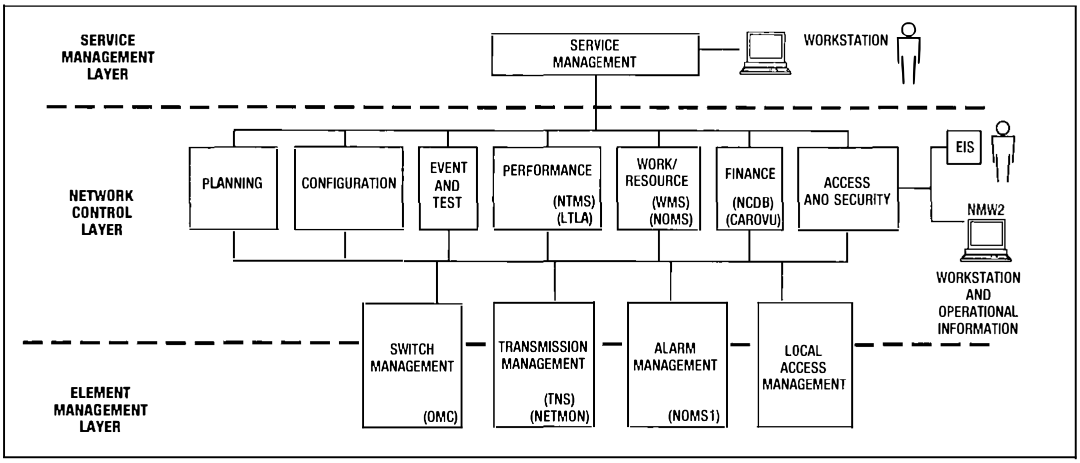


Figure 2
Systems portfolio

EIS: Electronic information system
CARDVU: Charging and routing data verification utility
LTLA: Long-term log analysis
NCDB: National charging database
NETMON: Network monitoring system
NOMS: Network operations and maintenance system
NTMS: Network test management system
NMW2: Network management workstation
OMC: Operations and maintenance centre
TNS: Transmission network surveillance
WMS: Work management system

'Business' Architecture

This 'enterprise' perspective concentrates on business process analysis, as employed by the SSP. This has defined all of the processes that are carried out in efficiently running an advanced telecommunication network organisation. By examining how these processes are grouped into logical systems and how each group of processes exchanges information with other groups, so an ideal set of systems and interfaces can be defined.

Network Management Hierarchy

In parallel with the process view of the support systems, a layered view has been defined, pragmatically grouping systems according to their role. Thus service management systems are distinguished from network control systems and element managers. The architecture and implementation of service management is a complex issue in its own right, being the focal point between BT's customers and their interaction with the company. Service management is discussed further in Reference 6, and will be covered in more detail in future issues of the *Journal.*

Physical Architecture

The NAIP has created a coherent deployment architecture which deals with the physical placement of hardware and people. This includes ten network operations units (NOUs), network field units (NFUs) and network administration computer centres (NACCs): structures, which are a vital part of the overall architecture[1].

Interface Architecture

The interface architecture provides the framework for a communications infrastructure which connects users to systems, systems to other systems for information sharing, and systems to the network elements they are managing.

Key standards for these interfaces are being defined in the CNA-M programme, which maps and intercepts agreements of the international bodies, such as the Open Systems Interconnection (OSI)/Network Management Forum and CCITT.

The interface architecture is supported by 'open' and proprietary products which enable interconnection with other architectures, such as IBM's SNA and DEC's DECNet.

Data Architecture

Data architecture offers the ability to standardise what the processes need to talk about. Defining the structure and format of the key information items provides a common currency which may be shared by the complete family of support systems.

The object-oriented style of the CNA-Management communications protocols will force the standardisation of objects as well as simple data structures. Work is progressing rapidly on creating the standards in the CNA-M programme and external standards bodies like ISO, CCITT† and the OSI Network Management Forum.

System (Computing) Architecture

The system architecture defines how a particular system is constructed, rather than the functional role it plays within the jigsaw. This deals with the following main components:

- computer hardware,
- operating system,
- database management system,
- transaction processing,
- communications drivers,
- man–machine interfacing (MMI), and
- the application programming interface (API).

† ISO—International Organisation for Standardisation
CCITT—International Telegraph and Telephone Consultative Committee

There is a drive by the computing industry to create standard open interfaces to these elements, based on UNIX/POSIX and X Open standards to produce the *open platform*.

The system developers are also driving towards reusable sub-functions and utilities.

These two initiatives are being brought together in the *Generic Systems Architecture* for BT network management systems.

Communications Architecture

In order to provide cost-effective and tailored access to systems and network elements by field personnel and NOU people, it is essential to construct universal communications networks with the flexibility to support, for example, progressive use of workstations.

A backbone X.25 packet network has been established, with use of common T-NET local area and wide area networks.

THE SYSTEMS PORTFOLIO

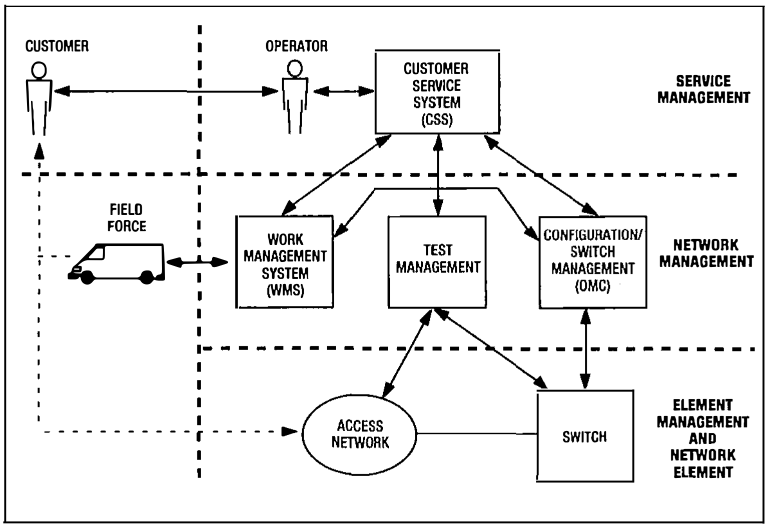
The systems portfolio is outlined in Reference 7. The following elements are covered in detail in this issue of the *Journal*, and are shown mapped onto the architecture in Figure 2.

- Switch management: operations and maintenance centre (OMC).
- Transmission management: transmission network surveillance (TNS), network monitoring (NETMON) system.
- Alarm management: network operations and maintenance system 1 (NOMS1).
- Local access management.
- Test management.
- Traffic management: network traffic management system (NTMS).
- Performance management: long-term log analysis (LTLA).
- Finance management: national charging database (NCDB), charging and routing data verification utility (CARDVU).
- Work management: work management system (WMS, NOMS2).
- Access and security: network management workstation (NMW2), electronic information system (EIS).

The remaining functions, particularly planning, configuration and event management will be covered in a future issue.

The above systems are addressed mainly with a public networking emphasis in this *Journal*. However, an outline is also included of the private network and service management objectives of the Concert™ programme.

Figure 3
Simple service provision—workstring flow-through



WORKSTRING FLOW-THROUGH

The essential feature of providing good service to customers, and achieving efficient network management, is to support the main workstrings (sequences of tasks) of the business. This requires support systems to be linked together electronically, and the workstrings to be optimised. It cannot be achieved by developing systems in isolation. This brings a new dimension of linkage and effective, automated *flow-through*, which can be illustrated by considering provision of telephony service.

In Figure 3 for example, the order for new service is taken by the operator of the Customer Service System (CSS).

The operator can:

- take details of service required;
- check the availability of resources to provide service; and
- make an appointment with the customer to carry out any work required at his/her premises.

The CSS system will:

- send a task to the work management system (WMS) to arrange for any customer premises, network, frames or exchange work to be carried out;
- send a task to the configuration manager with details of the service required; and
- set up billing details.

The WMS system will:

- identify appropriate manpower to do work at the customer's premises and put the job in the individual's worklist; and
- allocate other associated jobs to appropriate staff.

The configuration manager will:

- send transactions to configure the switch.

The test manager will:

- schedule tests on each network element involved and, at the right time, perform the tests.

Satisfactory test results will mean that the customer is provided with service, and billing will be started.

The workstring for service provision is performed by computer systems linked through task interfaces. Manual intervention is minimised, and is closely defined and scheduled.

CHALLENGES

A strong support structure with high functionality is rapidly becoming available, but many issues remain to be resolved in the short and medium term; for example:

(*a*) traffic management in a multi-service network where call priorities, durations, bandwidth and quality demands are very different from plain old telephony service (POTS);

(*b*) the design/planning implications of virtual private networking, including resilience and recovery aspects;

(*c*) the significant differences in planning and network control required by SDH;

(*d*) the opportunities to add remote surveillance and control to copper local access networks with the deployment of pair-gain systems[5];

(*e*) the easing of management of multi-vendor networks as suppliers add open management interfaces to their network elements, and add functionality to their element managers;

(*f*) the need to link customer service systems with network planning systems and network elements that are remotely configurable to provide immediate service (for example, 'warm dial tone');

(*g*) attainment of a consistent approach across local, core and international network management systems;

(*h*) management of CCITT No. 7 signalling systems in the intelligent multi-service network; and

(*i*) a quantum improvement in system delivery times and costs by making use of computer-aided software engineering (CASE) and prototyping techniques.

These issues are discussed further in Reference 8.

FUTURES AND EVOLUTION

The portfolio of systems will evolve into a set of generic functions which will be customisable for any BT network, and will eventually cover all BT network requirements[9].

These generic functions will conform to the CNA-M architecture, and will interwork via open interfaces conversing about commonly defined objects and data, and mounted on open computing platforms.

The basic functions will automate the SSP processes with interoperability providing 'flow-through'.

In addition, new advanced information processing technology[10] will allow many more aspects of network and service management to be automated.

Throughout the evolution of systems, a balance must be struck between achieving the benefits to be gained from immediate satisfaction of an urgent business need, and the secondary objectives of clean architecture. In time, as the generic reusable piece-parts become the norm, these potentially conflicting demands will converge; solutions will be produced in the quickest and most effective way by using architecturally conformant solutions.

Where ad hoc, proprietary network management systems exist or are introduced for expedient reasons, they will (normally) be replaced by conformant solutions to achieve long-term cost effectiveness from consistency.

The portfolios for public and private network management and service management will coalesce, and this will bring the following advantages to customers and the operator:

Advantages for the Customer:

- Direct control of network services.
- Controlled quality of service.
- Flexible service management.
- Rapid service provision.

Advantages for the Operator:

- Cheaper and more-effective network operation.
- Rapid deployment of new services.
- Reduced cost of change.
- Interoperation with wider business processes.

CONCLUSIONS

Four years after developing a clear vision and architecture for network administration, BT has made great progress in its realisation.

All the major components are now in place and are evolving rapidly to meet the target architecture and achieve full functionality. In parallel, the new operational centres are opening rapidly.

While there is much still to be done, BT is now very well placed to meet the ever-increasing demands on network management.

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Biography

John Helleur is Department Manager of the Network Management Department at BT Laboratories, Martlesham Heath. He joined the then British Post Office from university in 1969 with a degree in Electronic Engineering and later obtained an M.Sc. in Computer Science. From 1973–84, he was involved with the development of the System X advanced switching system, including fault tolerant computer design; software design principles; software life cycle and project management; call processing, overload, maintenance and statistics subsystem development; and software development tools and computing support network (development and operation). He was responsible for launching the embryo Network Management unit in D&P in 1984.

Nigel Milway joined BT from Brunel Unviversity in 1972 with a degree in Applied Physics. His early experience was closely associated with the development and roll-out of digital exchanges and the modernisation of the network. He has held a range of posts in BT covering various aspects of network operations and associated computer systems. In 1987, he led a task force to establish the strategy for restructuring network administration in BT, and has been closely associated with the deployment of that strategy and related systems. Nigel now manages the Operational Policy and Systems Department in BT Worldwide Networks. In that role he manages the evolution and development of core network processes and systems in support for field operations.

Cooperative Management: The Key to Managing Customer Networks

K. J. WILLETTS†

The art and science of managing some of the most complex systems on earth, the world's telecommunications systems, is changing rapidly. This article looks at some of the needs of customers in managing their networks and some of the solutions that are emerging in the marketplace worldwide.

INTRODUCTION

In many markets, particularly those of the triad of North America, Europe and the Pacific Rim, networked information systems have become fundamental to business activity. Initially, these networks were based on leased bandwidth from operators and sophisticated customer premises equipment.

With the growth of the liberalised telecommunications marketplace of the 1990s, customer networks are becoming increasingly complex. They comprise products and services from multiple suppliers, spanning many parts of the world and many time zones. The demands on these networks for reliability, capacity and new services are rising dramatically. The focus on the successful planning, implementation and operation of complex networks, in other words, management, has never been greater.

This article looks at some of the needs of customers in managing their networks and some of the solutions that are emerging in the marketplace worldwide.

CUSTOMER MANAGEMENT NEEDS

Most organisations who need advanced communications networks are not primarily interested in owning and operating that network infrastructure. Their principal businesses are in industries as diverse as banking, retailing, travel and transportation.

As markets have developed internationally, organisations have expanded from a national base, first into multinationals and then into transnationals. The latter type of organisation not only replicates its structure in other countries, but places different key functions in different parts of the world. It then becomes totally reliant for its operation on sophisticated information networks.

With such reliance on a corporate network infrastructure, with such a potential to influence company productivity, it is no wonder that these organisations should want to build and control these networks themselves. Information systems directors are now a common feature of a corporate board, reflecting the importance of the network to the company.

The needs of such an organisation are very clear. The network must serve the corporate purpose and mission. It must be tailored to the needs of that organisation in terms of quality, availability, reliability, security and cost. The organisation's management must be able to make decisions over priority if the network suffers failure or impairment. They must decide on locations served and when new services are introduced. To do otherwise would give the organisation no competitive advantage over its rivals and would put a major area of corporate infrastructure outside the managerial span of control.

MARKET TRENDS

The telecommunications operators around the world were, until recently, monopolies either publicly or privately owned. In general, their customers had little choice and, as organisations, most telecommunications providers were not particularly responsive to their customers' needs. The needs of major corporations, growing ever more reliant on networked information, went largely unnoticed by many traditional operators. This led to a huge growth in 'do-it-yourself' networking by major corporations during the 1980s. As the customer premises equipment businesses were liberalised in many countries, many corporations leased bandwidth from operators and added sophisticated customer premises equipment to develop networks often more advanced in terms of features and functions than those of many telecommunications providers.

During the late-1980s and early-1990s, the market for network services has also begun to liberalise, leading to several major trends across the world.

First, the telecommunications industry has begun to be market led. No longer will customers accept poor quality, long lead times and inflexible products and services; they simply go elsewhere.

Secondly, the marketplace is a multi-vendor

† BT Products and Services Management

one. Many new products are appearing from many new suppliers and have increasingly shorter life cycles.

Thirdly, network operators are rapidly introducing new flexible services, giving customers a choice between the 'do-it-yourself' approach and a managed service owned and operated by the telecommunication service provider.

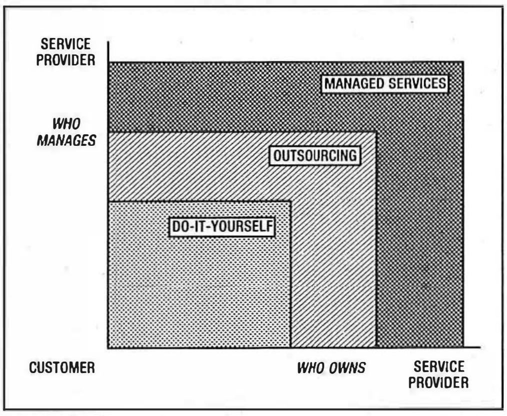
Finally, and most importantly, the cost base of networking has shifted.

The costs of both customer premises equipment and network services are falling as a result of competition and technology advances. Meanwhile, the 'hidden' costs (people, facilities, software changes etc.) which are a product largely of increasing complexity are increasing. This complexity cost is now causing whole segments of industry to re-examine their approach to network ownership and management.

Many customer organisations are seeking only to buy easily manageable products and services, with additional technology to integrate the management of diverse supplier products into a cohesive whole. For example, modem and multiplexer procurement choices are now made with an increasing emphasis on manageability and ongoing costs of ownership rather than simply price and functionality.

Other customers are turning to more radical network solutions. Many companies, especially during the current recession, are looking for a safe way out of networking altogether. Purchasing the network from a third-party facility manager is becoming increasingly popular. The use of managed services, especially on a worldwide basis, is also growing rapidly.

Figure 1
Control of the corporate network



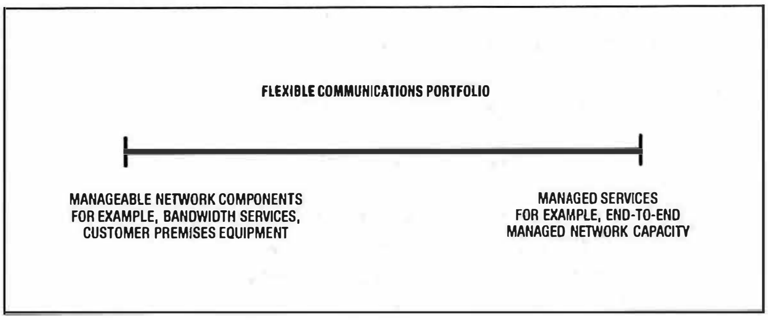


Figure 2—Products and services

LESSONS FOR THE INDUSTRY

The 1990s will see unprecedented change in the structure of telecommunications and the services provided. Information systems will continue to grow in importance to their user corporations whilst the availability of flexible and reliable networking will continue to grow dramatically. The ongoing management of the information system, maximising its value to the corporation whilst minimising its costs, will be of paramount importance.

It is also clear that management will be an increasingly cooperative activity between the user organisation, the information system provider and the network provider. For the telecommunications industry, these trends will dictate some rethinking and repositioning of their products and services. Customers need control over their vital asset—the corporate communications system. They will exercise that control in two dimensions—who owns the network asset, and who manages it (see Figure 1).

Successful network operators will be those that listen and respond to their customers' network needs. Today and into the mid-1990s, customers are demanding flexibility of ownership and manageability in tailored packages to meet their changing business needs. This demands a flexible portfolio of products and services which network operators are now beginning to promote (see Figure 2).

Those corporations who wish to continue building and operating their own networks increasingly will demand manageable network components. Others will want a smooth and safe migration to a point where a network operator is running all or part of the customer's network and taking care of extensions, upgrades, changes and so on, for a predictable fee. Some customers, for example, may want to retain operation of the data network, but use an outside source to provide the voice network, or they may want to run the North American segment of the network, but use an outside source to provide the European nodes. The split may be based on different criteria; for example, the time of day.

Finally, a customer may want to contract the entire provision and operation of the network to a managed services operator.

SERVICE LEVEL MANAGEMENT

In the case of a customer contracting all or part of the network to a network operator, the agreement will be based on agreed services for a known cost. This type of service level agreement is common and often exists as a paper contract. Increasingly, however, the customer does not want a 'fixed' and static agreement, but will want to dictate service levels for various network applications. For example, very high service levels for high-value applications, such as an on-line reservation system, may be required, and much lower (and hence lower cost) service levels for less vital functions, with the ability to switch these priorities dependent on business demand.

The customer will want to dictate the locations to be served and the capacity between those nodes, and may want to alter the price/performance mix of the network by time of day/year or geography.

This type of flexible service needs an electronic form of service level management between customer and network operator. In order to implement these requests, the operator (and customer, if continuing to operate part of the network directly) needs an integrated structure between this service view of the network and the network itself so that control can be exercised with minimal human intervention. This leads to a layered architecture for the management of customer networks and complex management information which flows between the customer and the operator (see Figure 3).

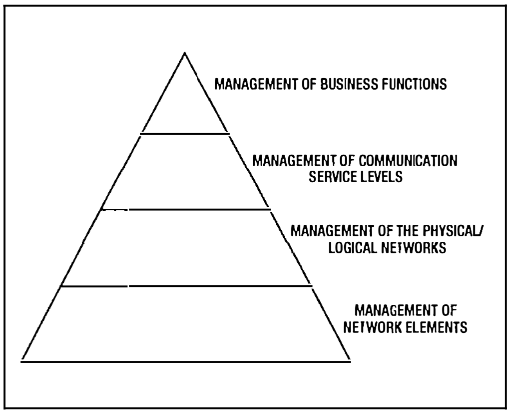


Figure 3—Integrated managed network

This architecture becomes more complex as the management of the network is split into domains. There may be several separate spheres of control in an overall information system. These must be interconnected at least at the service management level. Examples are the local area network infrastructure, the wide area network and the end computing and application infrastructure. Each of these may be further partitioned between various managers such as the customer and the operator (see Figure 4).

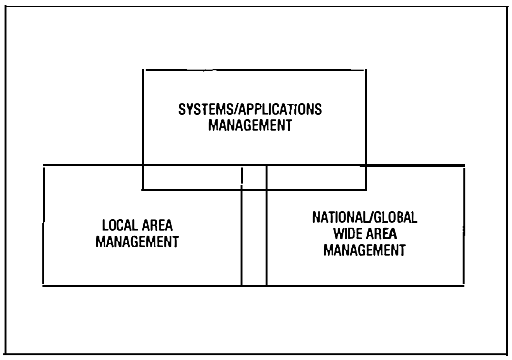


Figure 4—Management domains

END-TO-END MANAGEMENT IN PRACTICE

There is a staggering number of combinations of network type, supplier, product or service and management domain owner in a global information network. Consequently, the highly flexible systems and architecture required to meet this need are sophisticated and at the leading edge of today's technology.

There are several key points that must be taken into account. Management systems must be capable of supporting the following characteristics:

Interoperation: There will be many islands of management control and data in a system, which must be able to share information when required.

Distributed data: Data is held in many forms, in many places across an information system. This data must be capable of being viewed as one logical whole.

Flexibility of deployment: No two networks will be alike and no two customers will require the same management infrastructure. Systems must be very flexible in their design and implementation at all levels, data structure, management applications, user interfaces and physical deployment.

Portability and scalability: Networks vary tremendously in size. Different customers have different computing policies. Management systems must be very flexible in their ability to mount on a wide range and scale of computing platforms.

Cooperation between vendors of information system components is extremely important if the various domains of management are to integrate successfully and thus permit true end-to-end management.

This cooperation is not based on altruism, but sound commercial needs. No single company globally produces the range of products and services to supply an entire information system. Even if it did, most customers prefer competitive purchasing and multiple sourcing. Thus, for a product to be viable, especially internationally, it must be able to fit into an overall management scheme.

This cooperation comes about at several levels. Many companies have natural business partnerships and cooperate regularly on business issues. At the other end of the spectrum is the limited cooperation of the national and international standards organisations. A new phenomenon helping to foster industry cooperation on vital interfacing issues has been the rise of industry consortia in recent years. One such organisation, the Network Management Forum, is dedicated to promoting interoperability between different management domains. Using open systems methods where possible, this group of over 100 companies from 17 countries has made great strides in accelerating the availability of interoperable products to meet the rapidly growing needs of the marketplace.

MANAGEMENT SYSTEMS OF THE 1990s—BT'S CONCERT™ APPROACH

These trends are strongly influencing the forward direction of many major players in the networked information systems industry. As an example, BT has embarked on a comprehensive strategy to meet its customers' management needs in the 1990s. This programme, begun in 1989, has yielded a broad management platform from which to meet the widely varying and changing customer requirements.

The Concert™ programme has four key objectives to meet BT customers' needs.

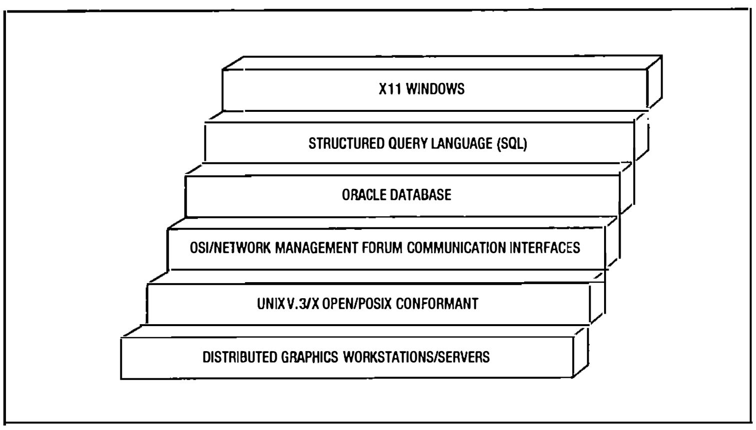
- It has built a comprehensive architecture for manageability in information networks. This architecture, forming a cornerstone of the company's Cooperative Networking Architecture, is now mature and widely recognised as one of the most advanced and comprehensive in the world. Many of its concepts and structures have been adopted into the work of the Network Management Forum, the European Telecommunications Standards Institute, CCITT and the International Standards Organisation.
- The Concert™ programme is building this architecture into a family of networking products and services that are manageable in a common way. Engineering development and field trialling are now well advanced and these products will begin to appear during late-1991.
- The Concert™ programme is delivering a comprehensive capability to integrate various domains of management into a single view of the network. This view can be partitioned in many ways allowing hybrid management between the customer and operator.
- The Concert™ programme is building a range of cooperative alliances with other suppliers.

The Concert™ 'Partner's Programme' ensures that BT networks can interconnect to, and exchange management information with, many of the customer's other suppliers.

CONCERT™ TECHNOLOGY

Concert™ is a highly flexible and modular system for the 1990s. Its technology addresses complex issues such as distributed databasing, advanced graphics and artificial intelligence. The system is based on open standards, where possible, and uses the base shown in Figure 5.

Figure 5 Applications architecture base



Hardware utilisation is flexible and the system is currently implemented on Sun Microsystems' Sparc 2 range and IBM's RS6000 series distributed workstations range for customer premises applications. Larger fault-tolerant platforms are utilised for functions supporting major networks.

Concert's internal architecture is also flexible. It is an object-oriented design consisting of four key sub-structures (see Figure 6).

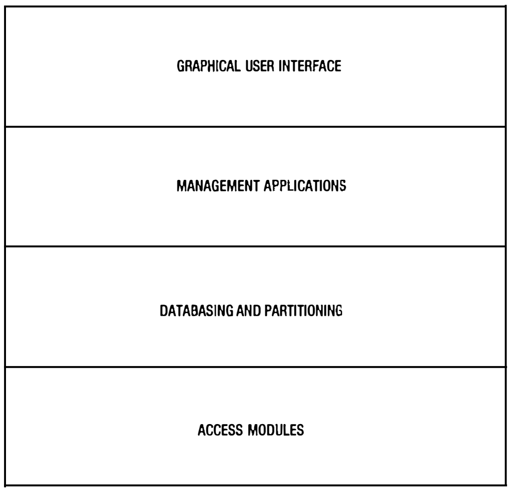


Figure 6—Concert™ internal architecture

There are several access modules to interface to external systems, ranging from a full Open Systems Interconnection (OSI) object-oriented protocol and message structures, to proprietary and *de facto* interfaces.

Databasing is via the Structured Query Language (SQL) interface to the ORACLE database. Comprehensive sieving and filtering of information is supported which enables a wide range of views of incoming or stored data to be performed. This allows Concert™ to meet the flexible implementation demands of customers.

Applications use this data to construct user information. Concert™ uses a fully-defined functional architecture based on an expanded OSI model. Functions such as event handling, resource management and configuration management are handled in initial releases.

Finally, there is a comprehensive user interface system based upon X11 (XWindows) standards. This is a highly featured graphics interface using zooming techniques to show multiple network views and information. The system can be tailored to user needs and contains a context-sensitive help system.

COOPERATIVE MANAGEMENT

The market trends overviewed earlier indicate that the traditional 'public' and 'private' split of telecommunications is rapidly changing. New

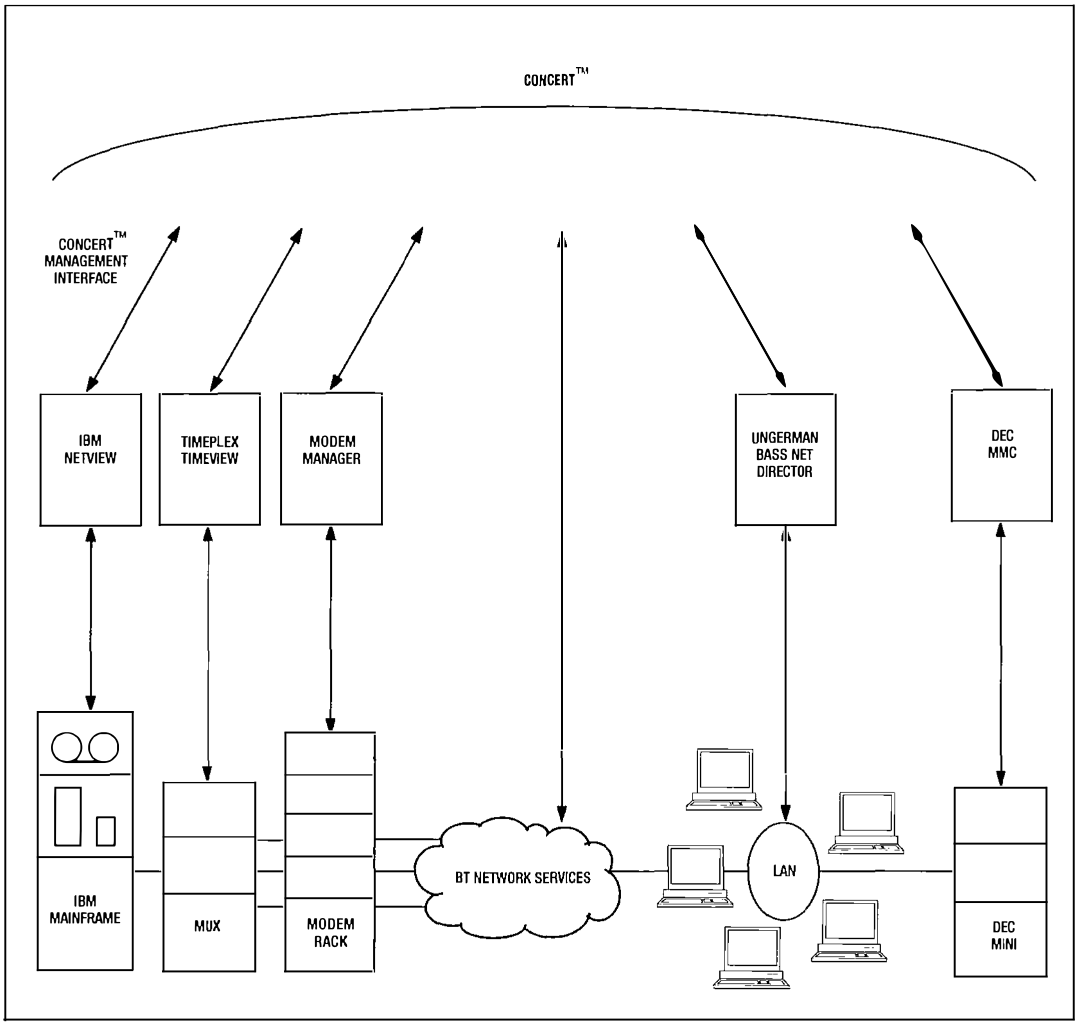


Figure 7
Span of management requirements for communications systems

virtual network services are emerging whilst many user organisations are re-evaluating their need to own and operate their private networks. This is leading to a 'utility' and 'tailored' segmentation rather like suits off the peg or from a Saville Row tailor.

However, when the communications package is designed and delivered, it is likely to be a mixture of some customer premises equipment and one or more increasingly sophisticated network services. The management of that package must span the entire system, across local, national and international boundaries and across the numerous vendors' systems that are likely to be deployed (see Figure 7).

In addition, the management of this communications package is likely to be a shared activity between network operator and the customer: in other words, a cooperative activity between the two. This sharing will need to be on a tailored basis but typically, most customers will want to concentrate on the business and service management aspects (see model shown in Figure 3), whilst the network provider handles the operational issues of managing the network on a day-to-day basis within agreed service levels (see Figure 8).

BT's Concert™ programme is designed to provide the management platform that will deliver this end-to-end view of the network, partitioned to suit the customers' needs. Compatible technology is being deployed both within BT's network and on the customers' premises. This cooperative platform provides great flexibility in how the management can be shared and, if required, BT can provide a complete managed service with minimal customer involvement in the process.

Figure 8
Focus of management activity

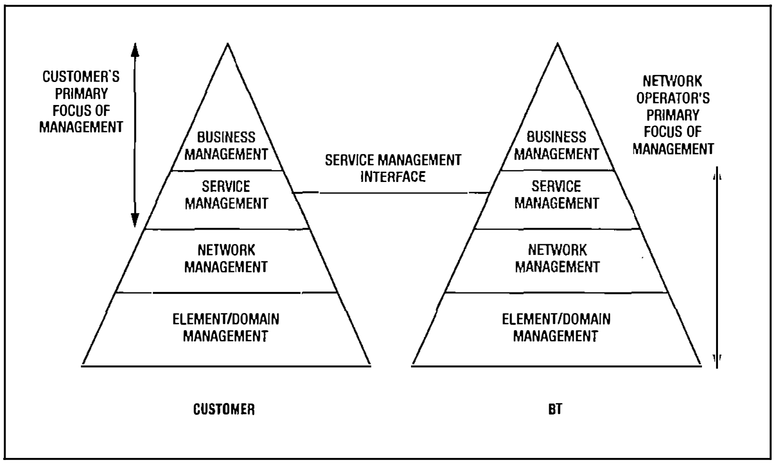
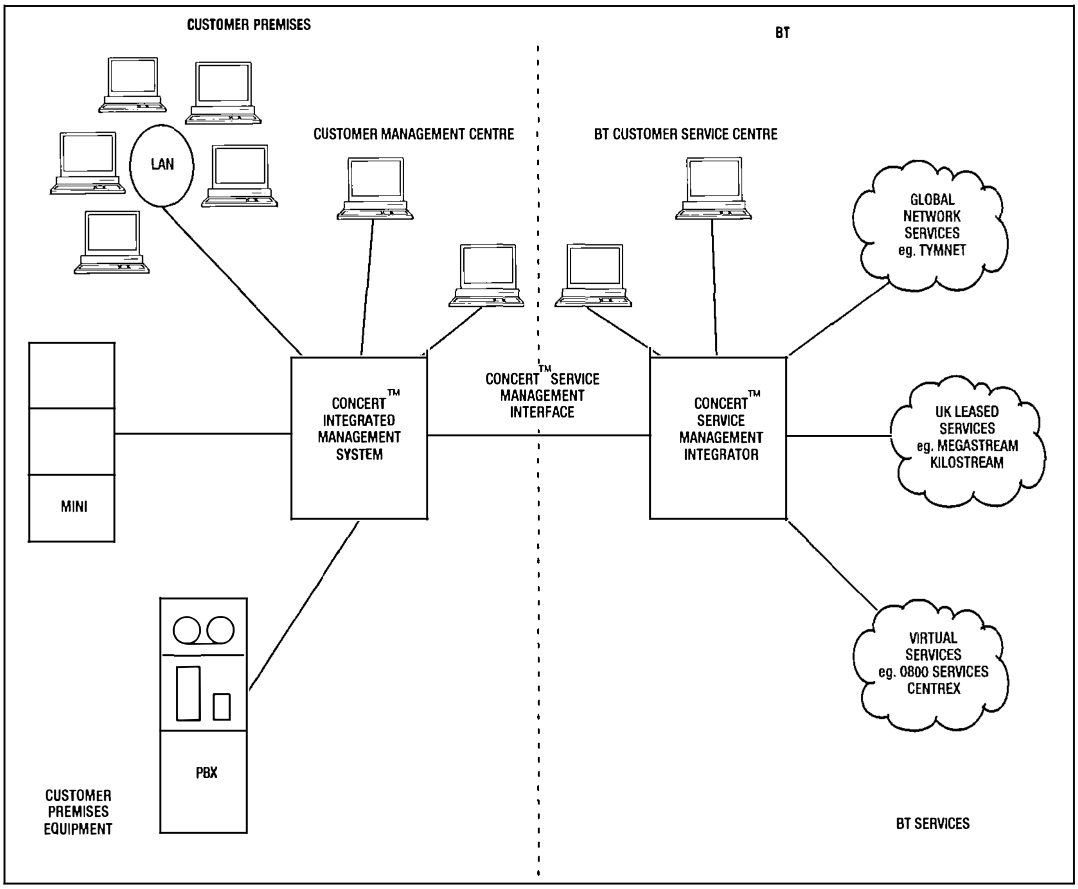


Figure 9
Concert™ service management



Alternatively, the customer can have a high degree of control over all or part of the network partitioned on a geographic, time, network domain or management layer basis (see Figure 9).

CONCLUSIONS

The art and science of managing some of the most complex systems on earth, the world's telecommunications systems, are changing rapidly. This is not change for the sake of change, but is being brought about by fundamental restructuring of the telecommunications marketplace and by the growing needs of customers to tailor these services to meet the needs of their businesses.

Communications management is both automating and becoming unlocked from its isolated islands into full end-to-end spans of control, whilst the network operator and customer are starting to share that role in a variety of ways.

Understanding customer needs and translating these into deliverable management features and functions has never been so complex and so important. BT is rising to these challenges and the Concert™ programme is well on its way to delivering its capability across the globe.

Biography

Keith Willetts has considerable experience in the telecommunications and computing fields. He has undertaken a wide range of responsibilities in operational, development, marketing and product management areas. In the last four years, his focus has been on the management aspects of complex networks. He is currently heading BT's network management systems unit and manages the company's corporate network management programme—Concert™. He has had considerable international experience and was one of the prime movers behind the establishment of the Network Management Forum based in New Jersey, USA. He became its first Vice-President and Technical Director in 1988. he was appointed president of the Forum in 1989, and in June 1990 was appointed as Chairman of the Board of Trustees. He regularly writes and gives seminars on network management. He was recently honoured in the *Communications Week* top 25 most influential people in the US communications industry.

Service Management Systems

F. N. SINNADURAI† and G. MORROW*

Customers are making increasing use of a wide range of services with a variety of customer equipment. To meet these growing customer demands, an integrated service management concept is being developed with the emphasis on providing familiar and friendly customer access. This article outlines the philosophy of integrated service management and shows, by use of examples, how different operations are handled by the service and network control layers.

INTRODUCTION

Telecommunications has moved on considerably from just providing the plain old telephone service (POTS), to an increasingly varied and sophisticated set of services which require integrated management.

Use of telecommunications facilities, and their importance to businesses, has increased to such an extent that customers need a wide variety of services provided either solely from the public network or as a hybrid with some element of their own equipment. In either event, telecommunications has reached a turning point where customers require control and choice over the services they use and seek to use. Hence the emphasis today is on integrated service management and customer control.

From the customers' point of view, this is the ability to access information on all their services and control them worldwide, whatever their entry point into BT. This is not a single geographical access point, but is a form of 'one-stop shop' in that they will receive a consistent and helpful reception irrespective of the point of origin of the request.

The concept of service management places emphasis on the customer-facing functionality of network services compared with the predominant emphasis, until recently, on the management of network equipment[1]. At the service level, control and management of the services does not require detailed knowledge of the underlying network, just the knowledge that an adequately functioning network platform is available.

This article gives an outline of the service management architecture and some of the current systems being developed, and gives some examples of the way in which service and network management layers will interwork. Emphasis is placed upon the way in which customers will be given visibility and control of services within contracted service level agreements.

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These are early days in the creation of integrated service management—future articles will explain more detail as the work unfolds.

SERVICE MANAGEMENT

The Cooperative Networking Architecture for Management (CNA-M), which is the enabling framework for successful interworking of all BT's communication management technology, has defined a number of layers of logic (for example Reference 2) to support the complex task of managing the BT communications business. (See Figure 1.)

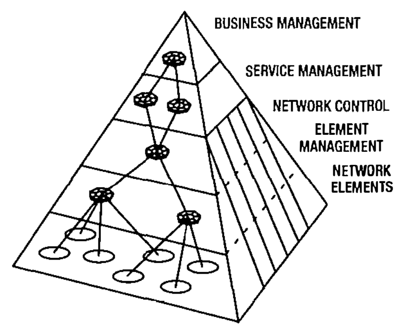


Figure 1—Cooperative Networking Architecture (Management)

The layer which primarily deals with the logic associated with the services, service level agreements, and customer access and control, is the service management layer (SML).

The SML, which is responsible for managing customer service, reports its effectiveness into the business management layer (BML). The BML has the authority and facility for managing the business, particularly administering business facets such as payroll, accommodation etc., and monitoring the meeting of key service and financial targets. The SML obtains its network services

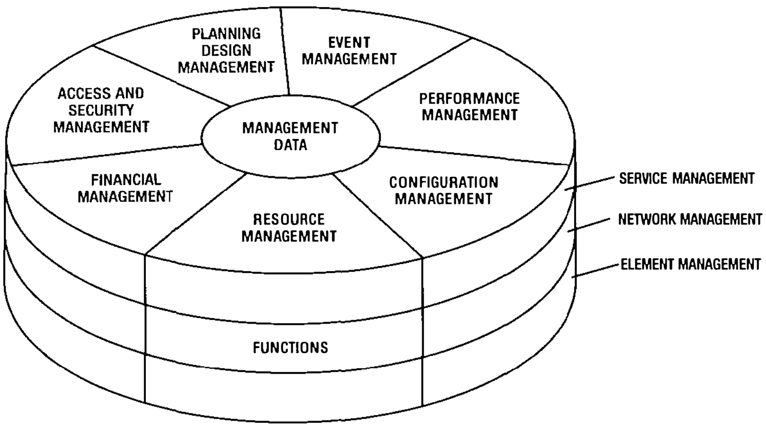


Figure 2—Functional areas

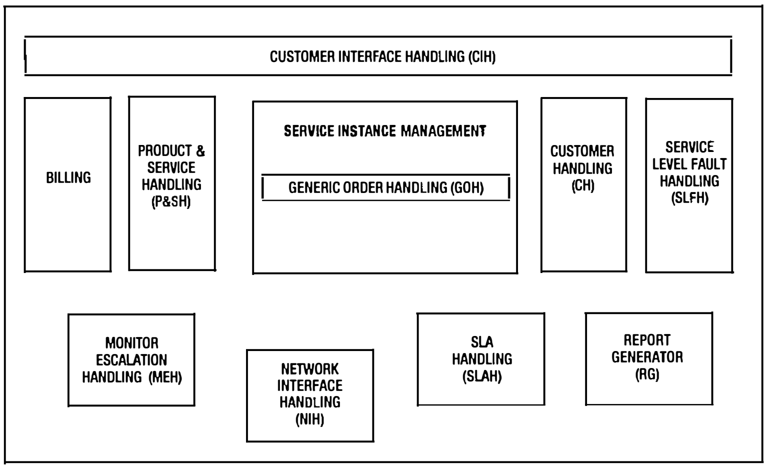


Figure 3—Service management outline design

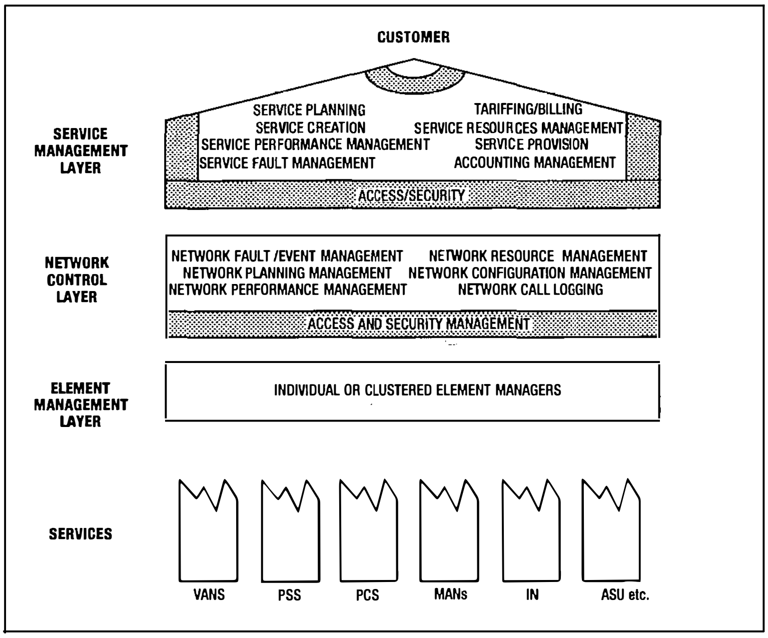


Figure 4–Common framework

from the network control layer (NCL) which is described elsewhere in this issue of the *Journal*[1].

The SML must manage a service level agreement (SLA) for each customer, covering a basket of services.

The SLA clearly covers the basic telecommunications service, or set of services, and the 'support' framework for each service, including provision times, repair times, maintenance charges, reliability and error rates etc. It also includes the basic charge for each service, volume discounts and special pricing across the basket of services. In addition, the guarantees of quality and performance, and the associated penalties have to be understood and recorded.

Therefore, the SML must offer facilities for a customer to pick, price and agree the options which form the SLA. It must then set up all the telecommunications and support services through the network control layer. From this point, the SML must monitor performance levels to ensure that a quality service is provided in accordance with the SLA.

Finally, the SML must provide controlled access by the customer to allow interrogation of billing or performance information, and to initiate service reconfiguration where this is allowed by the SLA.

Thus, service management is supportive of, and nearer to, the core of a customer's business activity. In addition, it is the first point of contact with a customer from which the telecommunications provider ensures that the service offerings are configured, manipulated and monitored either by the customer or on the customer's behalf—it ensures customer control and choice.

Architecture

BT has identified seven functional areas that are needed to serve the complete life cycle of providing telecommunications network services to its customers. (See Figure 2.) In the architectural hierarchy, these functions recur with different emphasis in the different layers, as described in subsequent sections.

The tasks within the SML can be summarised as the ability to:

- provide and create
- monitor and inform
- maintain
- account for

the services of each customer.

Analysis of the detail of these tasks has resulted in a process-based view which is encapsulated in the outline design in Figure 3.

CNA-M then gives a common framework, shown in Figure 4, in which the layers of service management and network control can operate. The functional architecture provides the consistent basis to allow interworking between the layers and reuse of components. The outline design for service management will be realised within the seven-segment view of management functions.

FUNCTIONS

The functions at the SML comprise the management functional areas, which are generic to the CNA-M, as well as service specific applications.

The generic functions are outlined below.

- Access control and security are primary requirements to ensure that customers and the network are safeguarded at each level of access (see later section on Access Control).
- Configuration management at the SML deals with handling of the customers' orders, issuing appropriate commands to the network layer for implementation and reporting to the customer. The functions can include new provisions, number changes, name changes, moves (of people or terminal locations).
- Resource management deals with the assembly of the services in a coherent way, keeps track of schedules and creates the inventory from customer requests and implementations.
- Planning and design management accesses the inventory to aid the customer in planning new services or extending existing ones.
- Performance management ensures that the service is being offered with the correct quality—response time, error rates etc.
- Event management services customer reports on faults and problems and has the responsibility to pursue the action through the NCL, and to report on progress. Faults arising in the network are reported up to the SML only if they are service affecting; an example is presented later. Events affecting billing are also reported to financial management.
- Financial management reconciles the customer's requests, inventory, schedules and usage of network services with the tariffs, charges and discounts derived from the service level agreement reached between the customer and BT.

ACCESS CONTROL

As the number and complexity of available services increases, it is essential that customers are able to continue to understand and retain familiar control of the services they require. This necessitates common access and consistency across the full portfolio of services.

The manner in which customers can have access to manage their services can be either direct or indirect. (See Figure 5.) Direct access can be from a simple terminal on the customer's premises or, if they wish to manage both their services and have integrated management across the full range of their equipment and services, they would use a Concert™ terminal. Alternatively, and for back-up, customers can contact the BT service centre to give their requirements or to seek help.

Customer access into the SML is controlled by a strict security regime to ensure only authorised access to that particular customer's agreed facilities. There is also security control between the SML and the NCL in order to safeguard the network.

SOME EXAMPLES

Consider some examples of customer-oriented activities which illustrate the operation of the SML and the NCL, and their interaction.

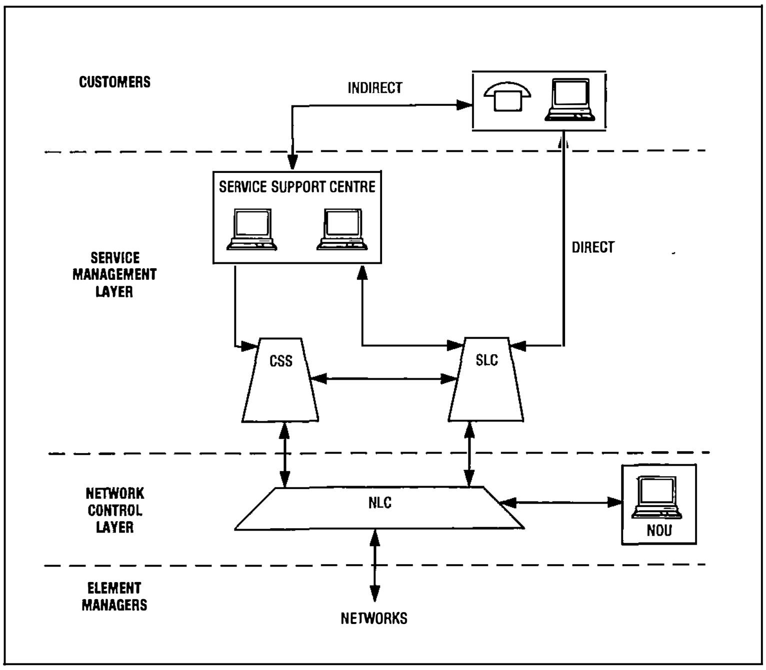
(*a*) A customer with a Centrex service requests the allocation of a directory number to a named person to be actioned at a certain time and date at a particular location.

The SML accesses the service providing the directory number related to the location, schedules the provision and sends the necessary configuration command to the NCL.

The appropriate function at the NCL identifies the switch that should provide the line, interrogates it to ensure the connection can be provided and if necessary finds alternative solutions and resolves contention. The subscriber records system database in the operations and maintenance centre (OMC2) would be addressed from the NCL to determine the circuit allocation and the main distribution frame (MDF) wiring that would be necessary. Where there is pre-provisioning of wiring pairs, then configuration would be implemented. Where local connection is found to be necessary, then an appropriate request would be sent through to the work management system (WMS).

If the required schedule can be met, then the SML and the customer will not know of any underlying operations in providing the service, the customer will simply receive a message from the SML that the request has been met. If there are any problems in providing or scheduling the service, then this will immediately be flagged to the customer indicating alternative choices and offering planned dates.

Figure 5
Customer access



CSS: Customer Service System
NOU: Network operations unit
NLC: Network level controller
SLC: Service level controller

(*b*) If a multiplexer or a bearer link fails, the network would attempt to circumvent the problem by rerouting. The fault would be deemed to be service affecting only if the service could not be rerouted within the network.

The fault having been intercepted and handled at the lowest management level, the information to the next level up (the NCL fault manager) will be to report the need to replace the faulty multiplexer or repair the link.

As the event (fault) would not have been service affecting, the SML and the customer would not be made aware of the occurrence or cure of the fault. If the fault were service affecting, then the NCL would prioritise the repair activities requested in its message to WMS, according to the requirements of the service level agreement for that service. In addition, it would open a dialogue with the SML by reporting on the likely effects on service.

(*c*) Figure 6 shows the architecture of intelligent network (IN) systems providing service management functions.

For a new customer to IN services, the SML supports the provision of initial customer profiles and enables them to be read or modified from an appropriate terminal.

Where the customer desires to create or amend access to their services, the service management system enables this through the service creation environment. By means of service creation, the network services provider may create 'if, then' management of the customer service on the customer's behalf. Calls may be rerouted according to time of day (for example, 'if' after 6pm, 'then' reroute to number *wxyz*), number of rings (after *x* rings, then divert call to *nnnn*), priority of caller, and so on. The SML can also control access to and from service providers (for example, 0898 suppliers), for instance, managing call screening for selective connection of calls to them.

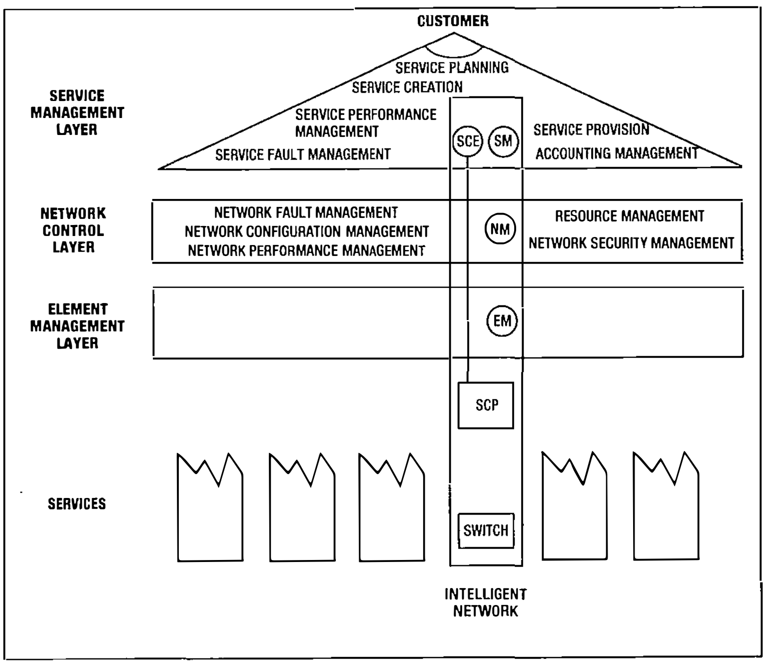


Figure 6
Intelligent network layered architecture

EM: Element mangement
NM: Network management
SCE: Service creation environment
SCP: Service control point
SM: Service management

Management is implemented through control files, and data is then downloaded to the service control point which provides specialised call processing for those calls routed to it by the service switching points. The service creation environment enables new services to be created over pre-provided connections to the customer.

CURRENT SYSTEMS

As an introduction to service management, a brief review of some existing systems is given. A later edition of this *Journal* will return to the subject of service management in more detail.

Service Management Supporting the Concert™ Programme

Concert™ provides a capability for integrating the customer's management of the services provided by individual elements of a network, be they public, private or hybrid. It is creating a cohesive set of developments using the same basic technologies and is based on international standards for network management. Thus, it is capable of interfacing with, and thereby integrating the management of, products and services from many suppliers.

Current plans include service management in managed network systems (MNS), private circuits, global network services and interfacing with virtual private networks.

The current developments in the Concert™ programme conform to the CNA-M architecture described above. Each of the network elements is interfaced into the Concert™ integrated (network) management system (IMS), enabling the full range of management functions to be applied to the various elements which may be operated in concert to provide and control a particular service.

The customer interface handling for both customer premises equipment and public network services would be managed from a common service management system. Information on service-affecting events and performance is reported to the SML which correlates the information and takes action according to the service level agreement reached with the customer. For instance, the customer may want to be notified if a circuit fails for more than five minutes, or may have an agreement with BT that there will be a reduction in charging if there is a break in service greater than an agreed length of time. These agreements are enforced by the SML.

Consistent service management features will be presented to users for both private and public network services. The service management system also includes the billing system where charges are calculated according to an agreed tariff negotiated with the particular customer. The service management system enables customers to have electronic access to their account information and inventory, and to make enquiries of ServiceDesk (a help desk support system), so providing a rich set of functions which, for example, allows the customer to review bills or have them delivered at specified intervals.

Access to the service management system and ServiceDesk allows the customer to request or cease services and to report faults on-line. Ownership of the fault report is retained by the service management system which pursues the repair request, via IMS, until the fault is remedied. The customer, therefore, has access to the status of appropriate fault handling.

The Concert™ terminal provides the customer with a full-colour graphical map of the logical network, and can use colour to show changes in status of services.

Customer Service System

For POTS services, BT has in place a very effective Customer Service System (CSS) which provides service management and interfaces into the network to ensure the POTS services are provided and monitored, and bills are issued as appropriate.

CSS enables a customer's order to be taken by telephone or at a shop and entered and processed by an operator at a terminal. At the same time, the customer's telephone book entry is created automatically. Customer records are managed with a facility to locate customers by name, address, telephone or account number. By virtue of being integrated, CSS also keeps track of customer account management and billing.

CSS also has strong functional links into the NCL:

- for service provision, it configures the network, via the OMC2, and launches the workforce, via WMS;
- in the event of a fault being reported by a customer, CSS can initiate line test action and register the fault with the NCL fault and repair management functions.

CSS is an example of a large service management system, having to cater for the vast majority of BT's customers.

Service Level Controller

The service level controller (SLC) has been developed to support both the Concert™ offerings and public network services. It provides terminal access for the customer either through a Concert™ graphics screen or through a simple user-friendly character screen. Access is security controlled according to terminal and personnal identification number (PIN) together with other safeguards at the interface to the underlying network. SLC functionality includes:

access security,
configuration,
inventory,
resource management,
event/fault handling, and
performance management.

Implementation of the functions is governed by the requirements for the services for which the SLC is used.

Currently, the SLC is being rolled out, for example, to provide status monitoring for private circuits.

COMMON TECHNOLOGY

Service management shares an architectural and technological basis with network level management systems. Some of the key aspects are introduced in this section.

At the computing level, this can be identical with the open platform used at the NCL, encompassing common

- database management,
- human–computer interfacing,
- communications drivers,
- transaction processing, and
- operating system (POSIX).

In addition, many of the components of the applications software can be common, as they have to make reference to common services, network elements, etc., called *objects*.

This 'object-oriented' approach encourages standard definitions of these objects, their attributes and the actions that can be carried out upon them. In this way, it greatly facilitates software reuse.

A top-level object at the SML would be the service level agreement. Within this there may be a number of feature agreements. Underlying this at the SML, for instance, a private circuit would be represented as the logical links from premise to premise, or the link capacity. At the network layer, the link may be represented by the physical routing. The definition of service objects is a topic that is currently being studied. As many as 600 object classes can be identified for the more complex services such as virtual private services.

The composition of the full network management hierarchy shows that the objects relating to a particular service function are mapped from one layer to the next. (See Figure 7.) This enables efficiency of design whereby an object modelled at one layer will require only marginal effort to integrate it into the next.

For instance, a generic fault manager which accumulates, correlates, filters, reports and instigates repair can undertake these functions directly at the NCL for network elements. The objects modelled at the NCL are reusable and integrated into the SML. However, the functionality and emphasis at the SML is to report and pursue only events that are service affecting, as described earlier.

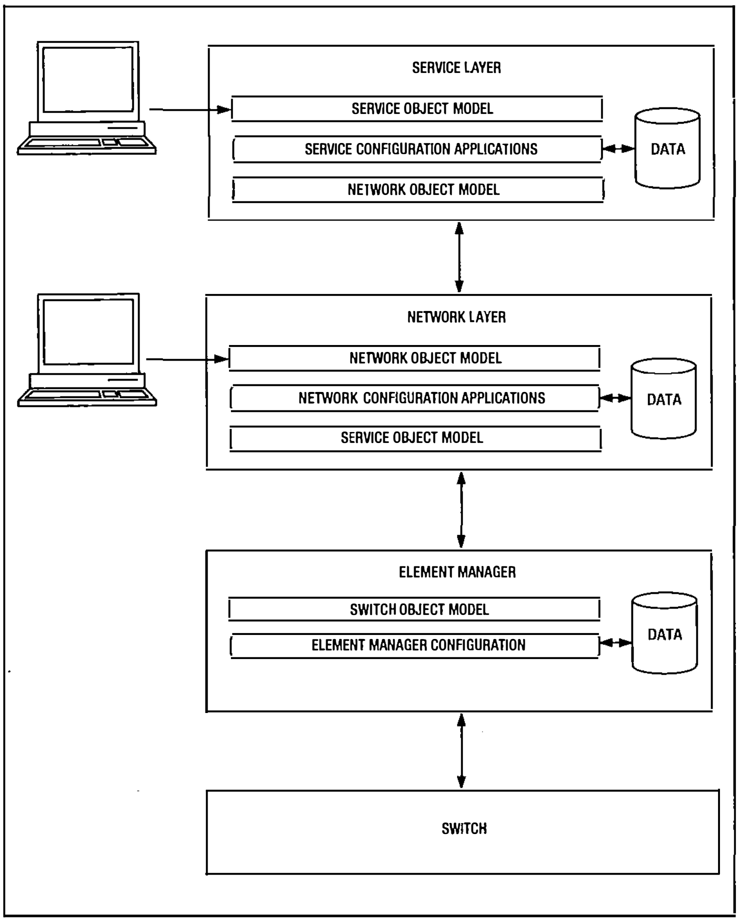


Figure 7—Configuration architecture interfaces

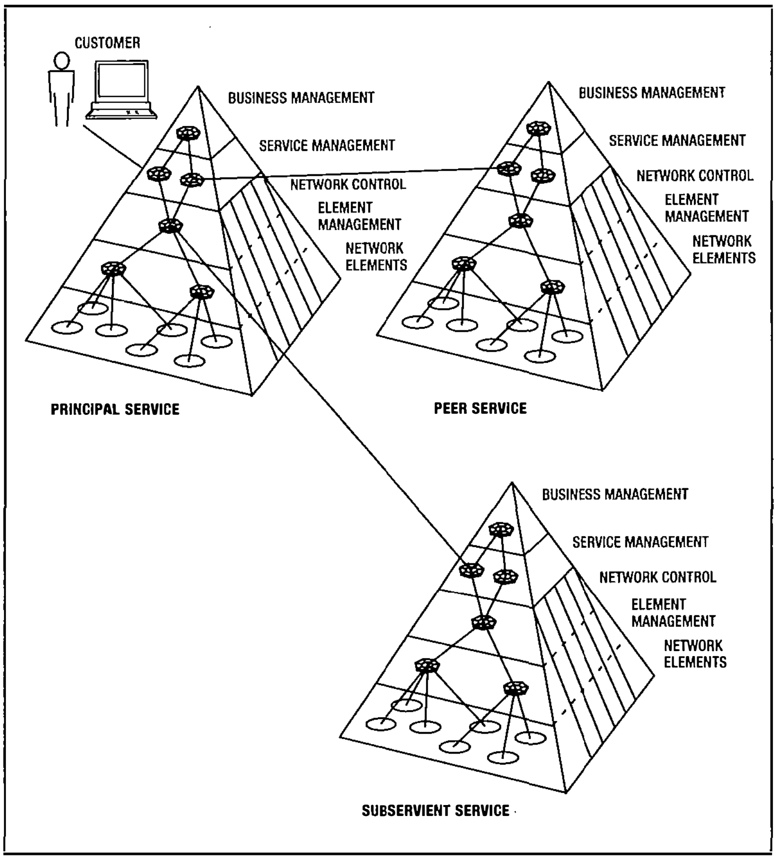


Figure 8—Service management across several operators

Common technology may be shared not only within a network management hierarchy, but may also be shared between cooperating networks provided they conform to the same architecture and standards. This has already been made clear in the discussion on architecture and is illustrated in the reuse by BT for both customer premises equipment managed by Concert™ and the public network services, both of which use SLC functionality for service management.

THE FUTURE

The evolution of service management functionality will enable a rich vein of services to be provided and managed within a single telecommunications network and even across many telecommunications network providers. This capability is facilitated by the adoption of a common architecture, CNA-M, and open interfaces across and between the management layers.

Where a service makes use of other networks and services, then the architecture provides for nesting of the network services. Thus, a principal service may comprise a number of underlying services (each having its network attributes and architecture) treated as network elements supporting the principal service. The architectural model that results is illustrated in Figure 8. The actual layers at which the dependent architectures interface will depend on the conformity of the principal and subservient architectures to open standards (where they exist). Where open common management information protocol (CMIP) interfaces are used, then peer-to-peer service management interactions can also be implemented (see Figure 8). Thus, services from many providers and across international boundaries may be integrated and managed in this way.

Service management is progressively being integrated over the range of services provided by BT, including integrated management of both private and public (that is, hybrid) networks.

In support of the Concert™ programme to integrate the management of new customer premises equipment products and services as they are acquired, a set of message interfaces is being developed. The messages are based on defined Network Management Forum standards and, where possible, the suppliers are being encouraged to develop and provide the interfaces.

Service management is being progressively rolled out, becoming increasingly seamless at the interface with the customer for all services. The diversity in management systems is also being rationalised towards a common integrated architecture and technology, as described in this article. Thus, customers will be able to manage their own equipment and interact electronically with the full range of BT services through one Concert™ IMS located on their premises; that is, 'one stop for shopping and control'.

ACKNOWLEDGEMENTS

We gratefully acknowledge the contributions of our colleagues whose invaluable technical developments have enabled the construction of this article and whose diagrams we have liberally drawn on in providing illustrations. In particular, we thank Bill Chapman, Roger Parker, Graham Turner, John Helleur and those who worked in compiling the Concert™ technical literature.

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Biographies

Nihal Sinnadurai is Manager of Advanced Services Management Section in the Service Management Division of BT Laboratories. His responsibilities are primarily in developments in service management, in configuration of network-based services, and in the interworking between the layers of network management hierarchy for BT's network products and services. Nihal worked as an international consultant for a number of years providing strategic technology advice to international companies in the USA, Japan and Europe. He returned to work for BT in 1986 to take charge of the computer-aided engineering strategy for circuit and system design. His experience includes design, reliability and testability from the component through to system level. Nihal holds a Ph.D. in reliability engineering, an M.Sc. in semiconductor physics, and a B.Sc. in physics. He is a Fellow of the Institute of Physics and a Senior Member of the IEEE.

Gerry Morrow is manager for the Service Management Programme in BT Products and Services Management. He has responsibility for working with the network service providers to provide service management. Current programmes includes Syncordia, GNS, RACE (PBX alarms) and Communications Facilities Management. He joined BT in the Liverpool Telephone area and worked on transmission systems in the Area and at BT Laboratories until 1977 when he joined the Prestel team at Martlesham. In 1983, after doing research into distributed computing, he joined Merlin, the newly formed product arm of BT. He has held a number of posts in product management, usually concerned with the introduction of new products. He holds an M.Sc. in Computer Studies, and is a Member of the IEE.

Switch Management: The Operations and Maintenance Centre

H. G. AMBLER, C. H. SCOBIE, and V. W. BALDWIN†

Modernisation of the switching and transmission networks does not, in itself, provide the full range of benefits available to the network operator or the customer. An efficient and adaptable switch management system is required to meet the ever-changing demands on the network. This article outlines the development of the operations and maintenance centre that plays a key role in the management of BT's digital switches.

INTRODUCTION

It has long been recognised that the modernisation of the switching and transmission network elements would not alone result in a quality and cost-effective network. The increasing expectations of BT's customers are not limited to the availability of new products and services, they also demand that the service provider has an operational capacity to provide and maintain the new services rapidly, with ever-increasing efficiency. The operations and maintenance centre (OMC2) plays a key role in enabling BT to meet this objective by managing all of its digital switches.

Overview

The OMC2 enables BT to centralise its digital telephone exchange maintenance and administration activities for a wide range of catchment areas, up to two million exchange connections.

The system receives alarms and fault reports from exchanges which it stores and forms into prioritised work schedules, offering facilities for tracking and recording the resolution of each problem. Maintenance personnel also have access to an inventory of all exchange equipment including available spares.

In addition, administration staff are given access to advanced databases covering customer service records and network connection records, to enable the exchange to be managed remotely.

The OMC2 offers ergonomically-designed human-computer interfaces which enable staff to operate consistently on different exchange types. It is a highly secure system and provides many audit facilities as well as access control.

The system currently supports both the System X and AXE10 exchange families, and further exchange types can be added in the future.

Importance to BT

The OMC2 development has been a vital enabling activity in BT's massive digitalisation programme. It is not possible to manage very complex modern exchanges without a sophisticated support system of this type. No digital telephone exchange (and BT Worldwide Networks (WN) is currently commissioning two local exchanges per day) opens for service unless it is parented on an OMC2.

The system has enabled WN to centralise its exchange maintenance workforce, assisting with necessary efficiency and quality improvements. This gives WN the benefits of consistent operational methods, associated with the freedom to operate a multi-vendor exchange purchasing policy.

The importance of the role of the system can best be gauged by the continuing demand for more facilities to be added since the original specification was met in 1984. These new functions are being added every six to eight months, with enhancements currently planned through to 1992.

By reusing 60% of the software engineered for the OMC2, other vital support systems such as the transmission network surveillance system[1], and the network level controller for the optical-fibre systems used by business customers (flexible access systems, FAS/NLC), have been spawned.

HISTORY

The need for support systems to administer and maintain the new digital switches was identified early in the System X development programme. The local administration centre (LAC)[2] was the first attempt at a computer-based operational system to manage the then developing digital switches. The LAC was based exclusively on System X technology and used a processor developed for the small/medium local exchange. The resulting support system was designated the *operations and maintenance centre 1* (OMC1)[3].

Early operational experience with OMC1 identified significant deficiencies, particularly in managing the local exchanges. In an attempt to meet the urgent needs of the local exchange managers, the basic OMC was developed and deployed by using the BT Factories multi-user multi-processor (MUMP). This was always considered an interim solution, and in parallel with

† BT Development and Procurement

its development, work was in hand defining OMC2 to provide an effective long-term means of managing the digital switches being deployed in the local network.

After definition and BT Main Board approval in 1983, OMC2 was the subject of competitive tendering. There followed a period of parallel development with two contractors, during which a field trial took place. Shortly afterwards, the (now) Network Management Department (NMD) of BT Development and Procurement (D&P) emerged in 1985 as the sole development contractor. During that same year, OMC2 first entered operational service at Bedford, Hull and Bristol, the latter as a result of a decision by the then National Networks to adopt a cost-reduced version of OMC2 called the *operations and maintenance unit support system* to manage its digital trunk exchanges. By 1988, some 50 systems had been installed at sites throughout the British Isles.

The development of OMC2 has been a continuing process as the range of products, services and types of duty supported has increased over the years and the operational processes refined. Today, OMC2 uses over 70 DEC VAX computers housed in the 10 network administration computer centres (NACCs), and supports 13·5 million lines on System X and AXE10 digital local exchanges and the 56 digital main switching units. It is used by over 12 000 BT staff throughout the country who have access to one or more of the 20 different duties.

The total cost of the OMC2 project was £98M to March 1991. This is within the authorised budget and includes the development costs of under £20M. To date, savings have been of the order of £500M.

SYSTEM OUTLINE

OMC2 is a network support system that provides a single point of interface with digital exchanges (see Figure 1). It enables users remotely to control and manage exchange resources, recognise and report faults, perform diagnostics, and undertake a variety of other management functions. Operational staff can perform maintenance, customer service and many other duties by manipulating resources in the exchanges and by accessing the databases in both OMC2 and the exchange.

OMC2 consists of an operations and maintenance system (OMS) and an independent alarm handling system (AHS).

Facilities

OMC2 aims to hide the complexity and diversity of the control interfaces of the digital switches from the operational staff so that customer services can be defined in a user-friendly high-level way. It automatically translates these high-level requests for service into the detailed low-level commands needed to provide these services on the switches. The performance of this type of function is critical in meeting the expectations of BT's customers, and is shown by the statistics for the provision of a five-line PBX (see Table 1). For this operation, OMC2 has delivered a major improvement over the manual provision time whilst simultaneously releasing skilled engineering personnel to perform more appropriate actions for BT's customers.

These advanced system-design principles have allowed the OMC2 to meet the evolving needs of the operational units, providing cost-effective solutions to their customers' requirements.

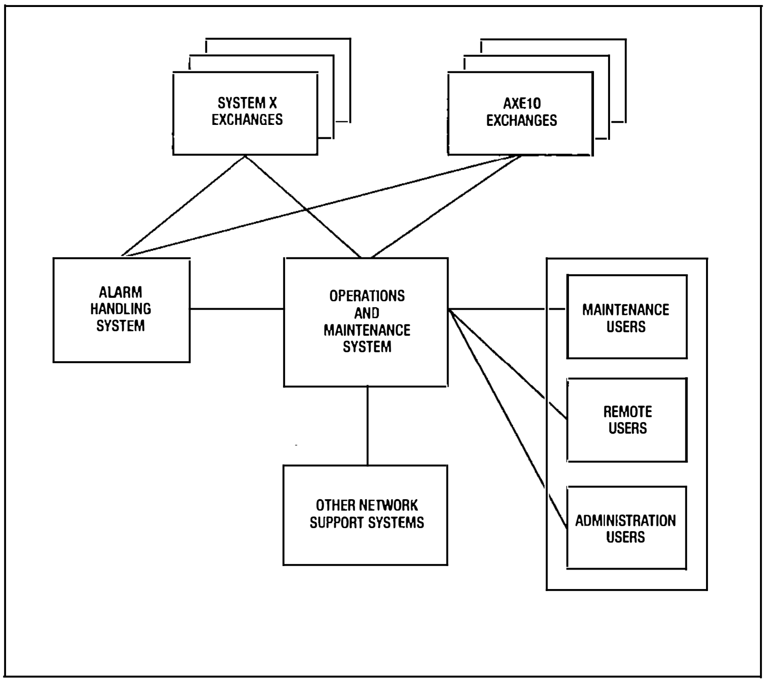


Figure 1
OMC2 overview

TABLE 1
Provision of 5-Line PBX

System	Date	Elapsed Time hh:mm:ss	Keystrokes
Manual	1985	1:30:00	350–650
OMC/D	1986	0:15:00	25–27
OMC/E2	1987	0:09:00	25–27
OMC/F2	1988	0:03:00	25–27
OMC/I1	1989	0:02:00	25–27
OMC/J1	1990	0:01:07	25–27

OMS Man–Machine Interface

The man–machine interface (MMI) is a user-friendly menu and form-based system that offers a consistent interface across a range of duties and exchange types. Transactions can be completed synchronously while the user waits, or executed in background mode leaving the user's terminal free for other work. Automatic job control and an indicator reporting progress gives the user information on the status of jobs which can be activated immediately or at some future date and time determined by the user.

OMS Access Security

The security of access to the OMS is determined by:

- a passcard to enable the terminal, and
- a valid user identity and password.

OMS Communication Links

User terminals can be linked to the OMS by a variety of methods:

- V.24 using direct connections with speeds up to 9·6 Kbaud, line drivers, statistical multiplexers or auto-answer modems;
- T-NET and Ethernet local area networks (LANs); or
- X.25 network.

Exchanges are connected to the OMS by synchronous X.25-based communication protocols.

Exchange Configuration and Data Management

Accessed via the MMI, a number of software applications allow the user to manage both AXE10 and System X exchange elements. These applications cater for the in-service configuration of exchange customer and routing data, either individually or in bulk. The MMI protects the user from the difficult man–machine languages (MMLs) used to operate the exchange systems. On-line validation of user-entered data is carried out automatically against configuration data held in application databases such as the subscriber record system. Information on the status of exchange resources (for example, directory numbers, equipment numbers etc.) is held within the database and is available for automatic allocation, resource summaries and management statistics.

Unsolicited Report Handler

The OMS obtains raw maintenance information in the form of unsolicited reports from exchanges. It has facilities to receive and recognise reports of many different types and to store them in the maintenance database. Reports that are considered serious enough to generate maintenance tasks are termed *active* and stored in an exchange work list. A maintenance officer is alerted at his terminal if an active report is associated with an alarm event in an exchange.

Alarm Handling System Outline

The AHS (see Figure 1) is an independent microprocessor-based system capable of collecting and displaying alarms from a variety of sources. It provides an immediate summary of all alarm reporting locations, and monitors the alarm collection equipment. The AHS also supports the concentration of alarm reporting for out-of-hours working.

Implementation

OMC2 is a modern system constructed on the principles of data-driven flexible design to allow evolutionary tracking of the exchange modernisation programme.

OMS Capacity

The OMS has been designed and implemented to handle a catchment area with the following parameters:

Numbers of	
Exchanges	30–50
Exchange connections	2 000 000
User codes	250
Simultaneous users	60–100

OMS Hardware

The OMS is based on DEC VAX computers, each OMS being tailored to meet the needs of individual installations by exploiting the available VAX hardware options of processor power, peripherals, cluster architecture and communication interfaces.

OMS Software

The application software is written in the C programming language and makes sophisticated use of the facilities provided by the VAX/VMS operating system. Database services are provided by the VAX utilities such as the DEC record management system and the ORACLE relational database management system.

SYSTEM DEVELOPMENT AND EVOLUTION

Drivers for OMC2 Changes

The pressures to enable OMC2 to support new builds and services have, in the past, been considerable and continue to grow. The incentives for such change include:

Customer Services Increasingly, the business wishes to capitalise on the increased flexibility of the new digital switching systems by introducing new services and product lines. In many cases, the new services are complex and can only be administered and maintained automatically. In other cases, there are strong economic advantages for doing so.

Faster Provision of Existing Services There is also the business need to provide existing services faster. The automation of provisioning activities is one way in which this can be achieved.

Network Switching Development The OMC2 must be capable of interfacing with any new exchange release. Of paramount importance is the continued compatibility with all facilities and services supported on earlier exchange builds. OMC2 must also support any additional services provided by any new exchange build.

Operational Administration and maintenance procedures are constantly being refined in the light of operational experience. Often it is appropriate that OMC2 should be enhanced to support the new procedures.

Technology Exploiting the improvements in the hardware and proprietary software used by OMC2 can generate optional changes which result in a more economic and powerful system.

Architecture Fundamental design of OMC2 was completed in the mid-1980s, and it is this architecture which often determines the rate at which OMC2 can be enhanced and the cost of doing so. Changes to the architecture have been and are being made to intercept a generic system architecture embracing the concepts of the Strategic Systems Plan (SSP) and the Cooperative Networking Architecture-Management (CNA-M).

Release History

The evolution of OMC2 has been managed by a series of carefully planned software releases. To date, there have been 14 major builds, each of which have contained a large number of development changes. The builds are listed in Table 2 together with their major facilities and the operational date.

TABLE 2
OMC2 Release History

Build	Major Facilities	Date
A	OMS field trial	85
B	System X SEP1 maintenance, administration, alarms	10/85
C	Subscriber record system	4/86
C+	Multicluster SEP1	7/86
D	AXE phase 1 maintenance administration, alarms	10/86
E1	System X SEP1 DDI and macros	3/87
E2	AXE10 phase 1 large processor	6/87
F	System X SEP2 distributed communications SEP1–SEP2 upgrade	9/87
G	System X SEP2 X.25, ISDN, improved maintenance inventory system	5/88
	AXE10 subscriber record system	
H	AXE10 phase 2 subscriber record system, X.25	2/89
	System X multiline IDA, exchange stats processing, PASTE database link to Oswestry	6/89
I1	AXE10 phase 3A, System X builds, London code change	12/89
I2	AXE10 multiline IDA, enhanced fault data for IDA customers, phase 1 OMS and OMUSS rationalisation	7/90
J1	AXE10 phase 3B, AXE10 inventory system Canary Wharf, IMUX line hunting	11/90
J1e	Exchange data management system	3/91
J2	Communication and transaction processing architecture Intelligent network support	10/91
K1	OMC2/CSS interface Tariff group charging	2/92

Project Management

The development of OMC2 over the past five years has been a process of continuous enhancement to meet changing business requirements. The need to control this process has resulted in the evolution of a specialised project management methodology which focuses on the control of change. This has enabled changes to the product to be undertaken by separate teams working in parallel, improving BT's ability to meet the tight timescales often imposed by the business requirements.

The content of any proposed OMC2 build is a compromise. The development effort necessary to implement all the requests for change in any one build far exceeds the resources available. A proportion of the requests will be essential to ensure the continued compatibility of OMC2, or to provide facilities to meet regulatory issues. The remaining requests for change included in any proposed build are determined by their relative business priorities and benefits.

OMC2 is a large development utilising the skills of over 100 engineers. The success of the project and the continued high quality of the product would not have been possible without the commitment of the engineers involved and the excellent, open and honest, working relationship that has been established between developers, project management and customer representatives.

Development Cycle

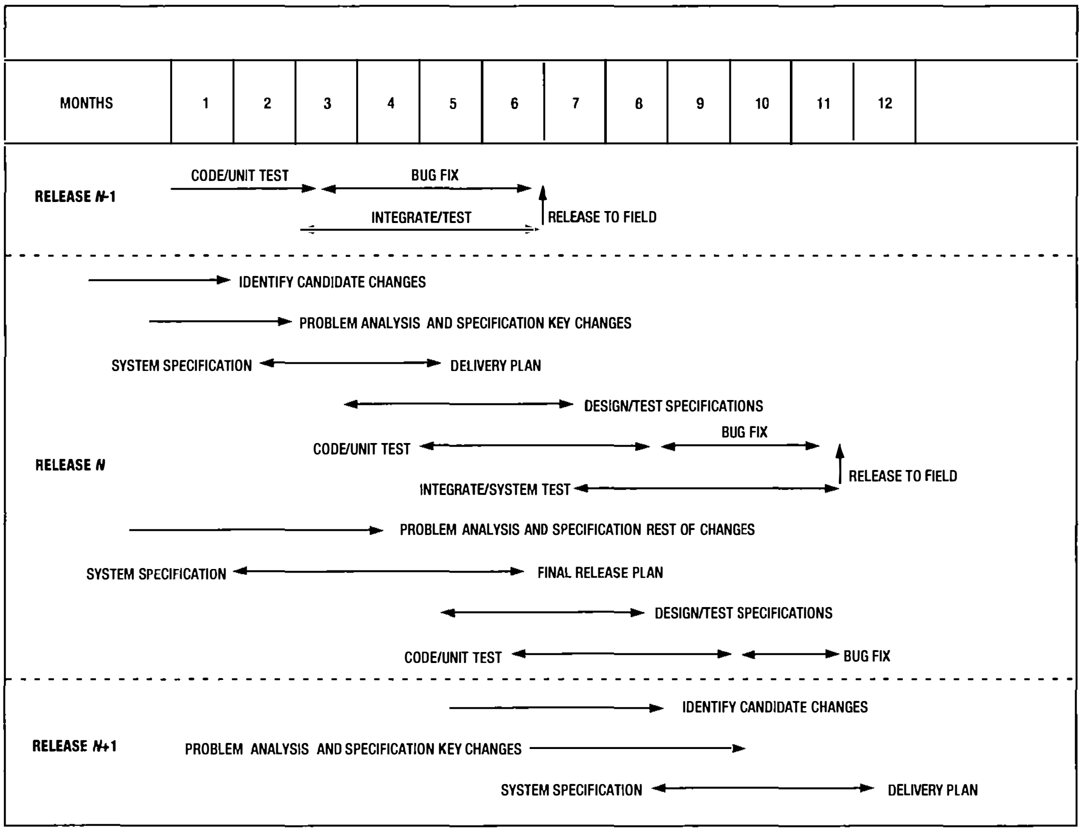
The key activities in the development of any OMC2 build are shown in Figure 2. The development cycle from specification to full release exceeds 12 months. If new releases are to be available at 6 monthly intervals there has to be a considerable overlap. At any given time, build (*N*–1) may be involved in integration and testing, build *N* may be at the coding stage, whilst the specification and early design work is in hand for build (*N*+1). Such a complex development strategy requires careful planning and management of manpower, development tools and testing environment.

Test Strategy

The test strategy currently in use for OMC2 is based on a verification, validation and testing approach. It consists of formal reviews of specification and design, informal code trials, and a series of graduated test stages. Module and subsystem tests are performed by the implementation teams, followed by integration and system test. The new release is then trialled at pilot sites under the supervision of the Product Supply Group prior to its general release.

Specification and design reviews are used (for testing purposes) to ensure testability and to check conformance to specified requirements. Code trials are used to verify that the code produced is correct, both in form and content.

Figure 2
Overlapping development cycles



Integration testing takes place only when the implementation team has demonstrated that the new or changed facility works correctly.

System testing only takes place when a final build is available, including all changes successfully integrated, for a release. The objectives of this phase of testing are to ensure that facilities added later in the integration phase have not adversely affected those added earlier, and that the new functionality has not had any unforeseen effects on the rest of the system.

NETWORK ADMINISTRATION COMPUTER CENTRES

NACC Establishment

The Network Administration Task Force (NATF) report[4] identified considerable advantages in concentrating the computer support systems needed to manage the network in a small number of large centres around the country. A subsequent and more detailed study determined that the optimum number of centres was 10 and proposed suitable sites. Board authority was successfully sought to establish the 10 NACCs and a fallback centre, and to consolidate the then operational OMC2s, of which there were over 50, into the NACCs.

The objectives set by the Board were achieved within budget and three months ahead of schedule. Detailed planning was the key to the success of the project. The many activities, which included preparation of accommodation, provision of communication systems, installation and commissioning of computer hardware, and the exporting of operational databases for reload at the newly established NACCs were carried out with the minimum of operational disturbance. Staff from the NACCs, D&P, WN Headquarters and DEC contributed to the success.

Dimensioning

Having established OMC2 at the NACCs, it was essential to monitor performance and, more importantly, estimate the future demands on the systems and establish budgets for additional hardware that would maintain an acceptable level of performance. The requirements for processing power, storage etc., are determined by many factors which are constantly changing. They include the number of digital lines to be managed, the numbers and types of user, changes to the OMC2 software, communication systems in use, etc. A dimensioning document, produced and regularly reviewed by D&P, is available for OMC2. With each NACC system manager providing details of the future operational environment, it is possible to estimate changes that are necessary to maintain operational effectiveness. A yearly cycle, involving NACC, D&P and WN Headquarters staff is now well established whereby future hardware requirements can be assessed, budgets established, orders placed and expenditure monitored.

Software Roll-out

Roll-out of enhanced OMC2 software releases now follows a well established release procedure that has been developed over the last five years.

As a new release reaches the final stages of system testing, an early release is taken by the OMC Product Support Group (PSG) to test the upgrade procedure that will ultimately be performed at all in-service operational sites. This testing is performed within a captive model environment at the switching systems test facility (SSTF) located at Martlesham Heath.

The upgrade procedure and the new software with its new or enhanced facilities, is then loaded onto a live system within an operational NACC as a pilot site trial.

Upon satisfactory completion of pilot site trials, with agreement and authority of the customer, the new build is replicated and distributed to individual NACCs by the PSG.

Support

All requests for day-to-day support are handled by the OMC PSG front office via a central contact telephone number. Details of each enquiry are recorded upon a fault database to enable fault history and progress to be monitored, and appropriate corrective action taken by support engineers. Out-of-hours support is provided on a 24-hour rota basis, 365 days of the year.

Reliability

Maximum resilience to points of failure has always been a major consideration in the system design of OMC2. Typically, systems in the field achieve total availability of between 98–99·75%. This excludes planned down time for maintenance activities.

Fallback

The total loss of an NACC would cause massive disruption to the services BT provides to its customers. Contingency plans, enabling services to be maintained with the minimum of disruption, have been established in the form of an operational resilience facility commonly known as *fallback*. If such an event were to occur, procedures have been developed such that centralised maintenance of the network/administration facilities can be provided by OMC2 systems located within the fallback centre at BT Laboratories, Martlesham Heath.

To test these procedures, live fallback practices have been accomplished without loss of service from NACCs at Glasgow and Belfast. It is planned to test fallback procedures regularly for each operational NACC site on a regular basis.

FUTURE DEVELOPMENTS

The growing complexity of telecommunications management is such that it is insufficient to continue developing support systems which tackle only part of the management task in isolation[5]. Although the benefits of a standalone OMC2 can be demonstrated, the need for efficient network management means that, in future, switch management will be provided within a coordinated architecture.

For example, links with problem manager workstation will allow a network-wide view of fault reports, and will provide advanced user-interface facilities. Work management functions currently provided on OMC2 will migrate to the work management system, WMS(N)[6], and generic piece parts for fault management, correlation etc., will be used more as OMC2 changes to become the switch domain manager in the network control layer.

As part of the continuing evolution of OMC2, the following changes are being made to the implementation architecture.

Transaction Processing

The recent development of a core applications support system based on a transaction processing (TP) model provides a base from which future applications requirements can be met cost effectively. The TP approach also facilitates the adoption of the workstrings approach to complex network management requirements described in the SSP.

In combination with the facilities offered by the current and planned communications developments, TP provides the means by which the OMC2 system can be made 'open for business', becoming an active participant in the integrated community of network management systems of the future.

Communications

The existing communications facilities restrict the hardware architecture for each OMC2 installation. The potential for major cost savings through enabling systems to share machines more flexibly has led to the provision of a new communications architecture, the Common Communications System (CCS).

CCS provides symmetrical inter-process communications, via a standard interface, between any two OMC2 applications in a NACC, and a set of integrated gateways for onward communications to exchanges. A simple name service relieves the applications from the need to be aware of the physical location of the destination, thus facilitating increased distribution of OMC2 functionality.

CCS is currently being extended to provide communications between OMC2 and other systems. These activities are strongly based around the Open Systems Interconnection aspects of BT's CNA-M, and includes both common management information service (CMIS) and file transfer, access and management (FTAM) capabilities.

Data Handling

Specialised database engines will be provided to cope with the increasing demand for data processing and storage. They will also open up the data to external systems, allowing the development of a single logical network management database.

CONCLUSION

The OMC2 project is a good example of the large software contracts undertaken within BT to provide high-quality network management. From the outset, it has been a highly visible strategic project with a sequence of very demanding milestones which have kept the team under considerable pressure throughout.

Very few competing systems offer the ability to achieve centralised maintenance and management of several types of exchange equipment. Because of the complexity and proprietary nature of current switch management interfaces, the opportunities for organisations other than switch vendors or major telecommunications operators to develop a solution is exceedingly small. No significant examples are known to cover economically a range from a few thousand to two million exchange lines, providing a full set of the necessary functions.

OMC2 remains a very competitive system which continues to provide benefits to BT in improving the quality of the network while reducing operational costs. It would be hard to conceive of the network modernisation programme without such a system.

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Biographies

Gordon Ambler has been project manager for OMC since 1989. Prior to that, he worked on System X and was involved in the development of OMC, running the OMC test and integration group. He currently heads the testing and integration section within Network Management Department.

Colin Scobie joined BT Fulcrum Communications, in 1981, working on materials requirements planning and production control systems. In 1987, he moved to Ipswich to join a project implementing network management systems for the Government telephone network. In 1990, he joined D&P and is currently working on the development of transaction processing and related systems as part of an integrated reusable network management application support environment.

Verrill Baldwin joined BT from Oxford University where he studied Natural Sciences. He started in London, in 1973, working on TXE4 exchanges. He then moved to Ipswich to work on System X, and was involved at the inception of OMC, in 1984, when he was responsible for maintenance control subsystems. He is currently Section Manager for generic software development.

Glossary

AHS	Alarm handling system
CCS	Common Communications System
CNA	Cooperative Networking Architecture
CNA-M	Cooperative Networking Architecture -Management
CMIS	Common management information service
DEC	Digital Equipment Corporation
D&P	Development and Procurement
FTAM	File transfer, access and management
LAC	Local administration centre
LAN	Local area network
MMI	Man–machine interface
MML	Man–machine language
NACC	Network administration computer centre
NATF	Network Administration Task Force
OMC	Operations and maintenance centre
OMS	Operations and maintenance system
PSG	Product Support Group
SSP	Strategic Systems Plan
SSTF	Switching system test facility
TP	Transaction processing
WMS(N)	Work management system (network)
WN	Worldwide Networks

Transmission Surveillance in BT Worldwide Networks

G. HART, R. M. GALLAGHER†, S. R. MOOR, and T. H. M. McKENZIE*

In recent years, centralised transmission network surveillance has been given a high profile within BT. This article describes the transmission network surveillance system, TNS, and also looks at NETMON, a system which emerged from a number of practical field initiatives. The history and experience of using these systems is reviewed, together with their future evolution and integration with other network management systems within BT's portfolio of systems.

INTRODUCTION

Some significant steps have been taken over the past decade to modernise and improve the technology used in the BT network, driven by the need to improve quality of service, reduce costs, and make available new products and services to customers. Significant improvements have also taken place in the way in which this network technology is operated and managed by BT, especially in the switching environment. The advent of processor-controlled switches paved the way for tools such as the operations and maintenance centre (OMC2) and alarm handling systems (AHS) which have enabled radical changes in operational procedures, compared to analogue units. Surveillance and fault diagnostics, and in some cases rectification, can now be performed remotely from centralised operation and maintenance units, and the maintenance workforce can be directed and managed in a way which benefits customer service. This has resulted in a large reduction in operational costs whilst sustaining the focus on quality of service.

In contrast, the introduction of digital transmission technologies did not enable such procedural changes to be realised at the outset. The operational facilities of transmission equipment supplied on the world market tended to mimic analogue practices which relied on manned stations, with people available to respond to and manage on-site alarm conditions with no centralised control. The scale and cost of providing centralised surveillance for transmission is higher and more difficult to justify than for switching systems, due to the larger number of equipments and sites involved, coupled with wide geographical spread. A number of initiatives developed by field staff led to a basic surveillance system known as *NETMON*, first deployed in 1985.

A consultancy study undertaken in 1986 indicated that there would be significant financial benefits from deploying a much more powerful transmission network surveillance (TNS) system on a national scale. The conclusions of the Network Administration Task Force (NATF) also highlighted the need for TNS as part of a plan to rationalise network management and control and reduce operational costs. The NATF recommendations led to the Network Administration Implementation Programme (NAIP), which has established the operational template for Worldwide Networks based on ten network operations units (NOUs). TNS is a key enabler alongside OMC2 within the NAIP programme for the consolidation of network management and control, and work management into each of nine NOUs.

In 1987, the BT Management Board authorised the capital expenditure required to retrofit centralised transmission surveillance facilities to the existing base of digital transmission technology in the network over the period 1988–92, and to enable developments to ensure that all future growth could be accommodated. Initial plans for a collaborative development with AT&T were eventually aborted in favour of an internal development programme, now being undertaken by the Network Management Department of BT Development and Procurement as part of the evolving network control layer.

The thrust of the TNS programme consists of two parallel activities: the first is a concentrated deployment of monitoring infrastructure to maximise surveillance coverage; the second is a focus on phased development of the system to provide incremental functionality changes in line with operational needs.

This article begins by tracing the history of TNS and NETMON, and pinpoints the key business benefits these systems provide to BT. It looks briefly at the way in which the systems are currently used in the field, and then describes the main functions and architecture of TNS and NETMON, together with the next development steps currently being undertaken. Finally, it gives an indication of the various factors influencing current thinking on the evolution of these systems.

† BT Worldwide Networks
* BT Development and Procurement

HISTORY AND BACKGROUND

NETMON emerged from a consolidation of a number of practical initiatives in the Manchester and Scotland Districts. Scotland's initiative was to monitor the input to chart recorders from digital radio and line equipment with low-cost home microcomputers. This idea eventually led to the displacement of chart recorders, each costing hundreds of pounds. Manchester District's proposal involved capturing muldex† frame alignment alarms. These alarms indicate loss of service to customers, but are often of such short duration that they are virtually invisible to conventional station alarm equipment. NETMON became operational in 1985 and incorporates both of these original ideas, as well as a number of other practical suggestions gleaned from direct field experience of transmission operations.

However, NETMON was not designed to cope with the demands of national network surveillance. These demands include:

- coping with large-scale deployment of transmission systems;
- the potential high cost of ownership of the communications infrastructure;
- the requirement to gather performance management information in order to facilitate a more proactive management of the transmission network; and
- the requirement to integrate network surveillance systems with other network management systems, including work management.

The TNS project was originally conceived to overcome these limitations. Its origins go back to June 1986, when the first generation of transmission monitoring systems (TMS) was developed to manage the BT outer core (junction) network. The system used about 60% of the software, and the same hardware platform as the existing switch maintenance system, OMC2. In February 1987, TMS Phase 3 was given a pilot trial in Manchester. After further development and extensive trials, the subsequent system, TMS Phase 4, received its operational beta test in London during early-1990. TMS Phase 4 was enhanced and released as an operational system in July 1990, and development was completed in November 1990, when the TMS project objectives were met.

Subsequent work is now being performed under the TNS programme, starting with the first release TNS0.1. Further releases of TNS software will incorporate key facilities and user requirements captured from direct field experience.

BENEFITS OF NETWORK SURVEILLANCE

The key business benefits of network surveillance are:

- Improved quality of service achieved by being able to eliminate consequential fault reports and rapidly pinpointing failures and deterioration as they occur. This in turn leads to a reduction in short breaks and improved circuit reliability. Analysis of data from NETMON can, for example, be used to produce a league table of the most faulty circuits, providing the opportunity either to switch customers to better circuits and/or to target investigation on troublesome circuits.
- Improved manpower efficiency due to improved prioritisation and direction of the workforce.
- The ability of staff to use network surveillance systems to correlate alarms so that the source of multiple alarms is accurately diagnosed.

† Multiplex/demultiplex equipment

THE PORTFOLIO OF NETWORK SURVEILLANCE SYSTEMS

The surveillance of a variety of transmission network elements such as digital multiplexers, line and radio systems is the responsibility of the Transmission Operations and Maintenance Unit working in the NOU. By necessity, this role includes liaising with other maintenance staff in order to bring faults to the attention of field staff, and controlling out-of-hours attendance at remote sites. These units also act as single-number fault-reporting points, so that fault reports on MegaStream and KiloStream circuits can be passed from BT customer-facing units for diagnosis and clearance.

The monitoring of these network elements is performed automatically using NETMON, TNS, and the alarm monitoring systems Gateway and network operations management system (NOMS1) which monitor simple station-based alarms. These systems generally operate independently, although there is a field initiative to develop a simple interface which will enable the passing of TNS alarms to NOMS1.

The way in which these systems are currently used within the NOU environment is shown in Figure 1.

The following sections describe the TNS and NETMON systems.

TNS SYSTEM DESCRIPTION

The TNS0.1 build provides a comprehensive system for the surveillance of transmission network elements. This requires the handling of transmission alarms, and the monitoring of transmission performance from a large number of elements. While OMC2 manages a smaller set of complex network elements (stored-program-controlled exchanges), TNS faces the challenge of collecting, collating, processing, and displaying information from a vast array of less complex, physically dispersed components.

System Architecture

Each TNS host processor serves a given catchment area defined by the NOU in which it is located. The host processor is used as a standalone system housed in a network administration computer centre (NACC), and accessed remotely by NOU personnel. The system uses a two-tier hierarchy (see Figure 2) of:

- data collection network
- operations support system (OSS).

In addition, the communication infrastructure links the OSS and the data collection network.

This architecture is based upon data collect equipment located at the equipment stations, and a central computer located at the NACC. With the current TNS0.1 build, the central computer supports up to some 200 stations, and 50 000 systems†. Later builds will support a larger number of stations and systems.

Data Collection Network

The transmission network presents a significant challenge to any data collect system. It has to cope with a very large number of alarm points and stations/locations. In addition, it has to be cost effective. These criteria were major drivers for the TNS0.1 data collect equipment. As a result, a number of key features were incorporated in the data collection network design. These include:

- low-cost interface circuits, supplied with new equipment provisions;
- retrofit capability; and
- high system capacity.

The data collection network consists of interface units, and primary collect equipment (PCE) shelves. In order to provide data collection and forwarding for the different generations of transmission systems currently in the field, interface units provide connectivity in four ways, which are, in order of preference:

(*a*) via an embedded monitoring interface within the transmission equipment as part of the supplied element;

(*b*) via a retrofitted replacement alarm card called a *network surveillance interface unit* (NSIU) provided for monitoring equipment within each shelf;

(*c*) via a digital signal monitor network element (DSMNE) used to monitor early copper line systems for 2 Mbit/s monitoring, normally employed to monitor private circuits (maximum of 16 transmission systems); and

(*d*) as a last resort, via an input/output network element (IONE) using a shelf alarm isolator. This is generally used for simple transmission equipment alarms* (maximum 32 alarm points); for example, shelf, rack or suite alarms.

The above elements are polled by a primary collect processor (PCP) every second for raw alarm and performance data. Data collection is provided by a duplicated, multi-drop HDLC bus (RC8245 - RS485 bus) which forms a daisy chain linking NSIUs, IONEs, DSMNEs and PCP on the PCE shelf. This bus is cost effective, and uses its own BT proprietary message and protocol defini-

† In the traditional sense, each system refers to a network element or an 'alarm point'.

* This interface unit has no capability for capturing performance error data.

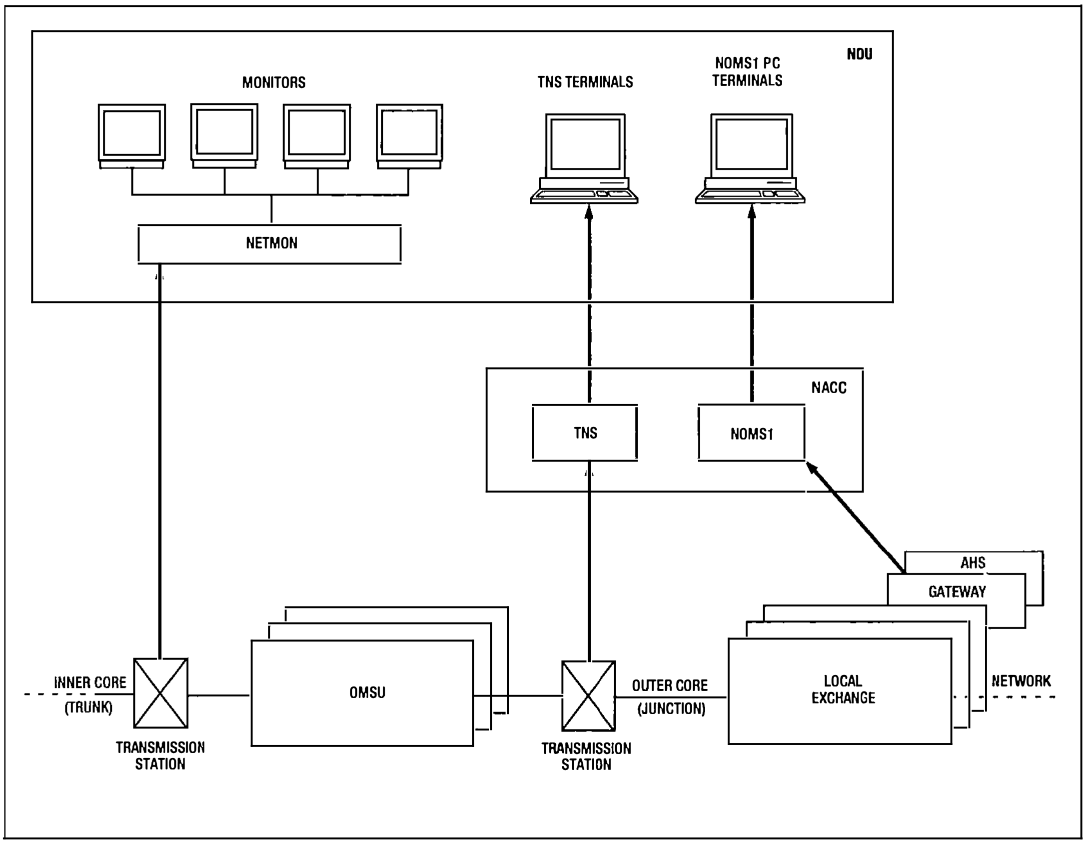


Figure 1 Transmission surveillance systems in operation

tions. Any alarm state changes or definable performance threshold exceptions are immediately preprocessed, formatted and reported unsolicited to the OSS.

Otherwise, CCITT Recommendation G.821 performance parameters (including, for example, total number of errors, number of error-free seconds, seconds of break, total breaks on a given day, number of days with one break) are processed, stored within the PCP and passed in response to interrogation by the OSS, once every 24 hours. In addition, TNS provides facilities for operators to read performance data for individual items of transmission equipment.

DSMNEs and IONEs, and PCPs are housed in a PCE shelf, which incorporates a power supply. Each transmission station can comprise one or more PCPs, depending on the station size, although most stations can be accommodated by a single PCP.

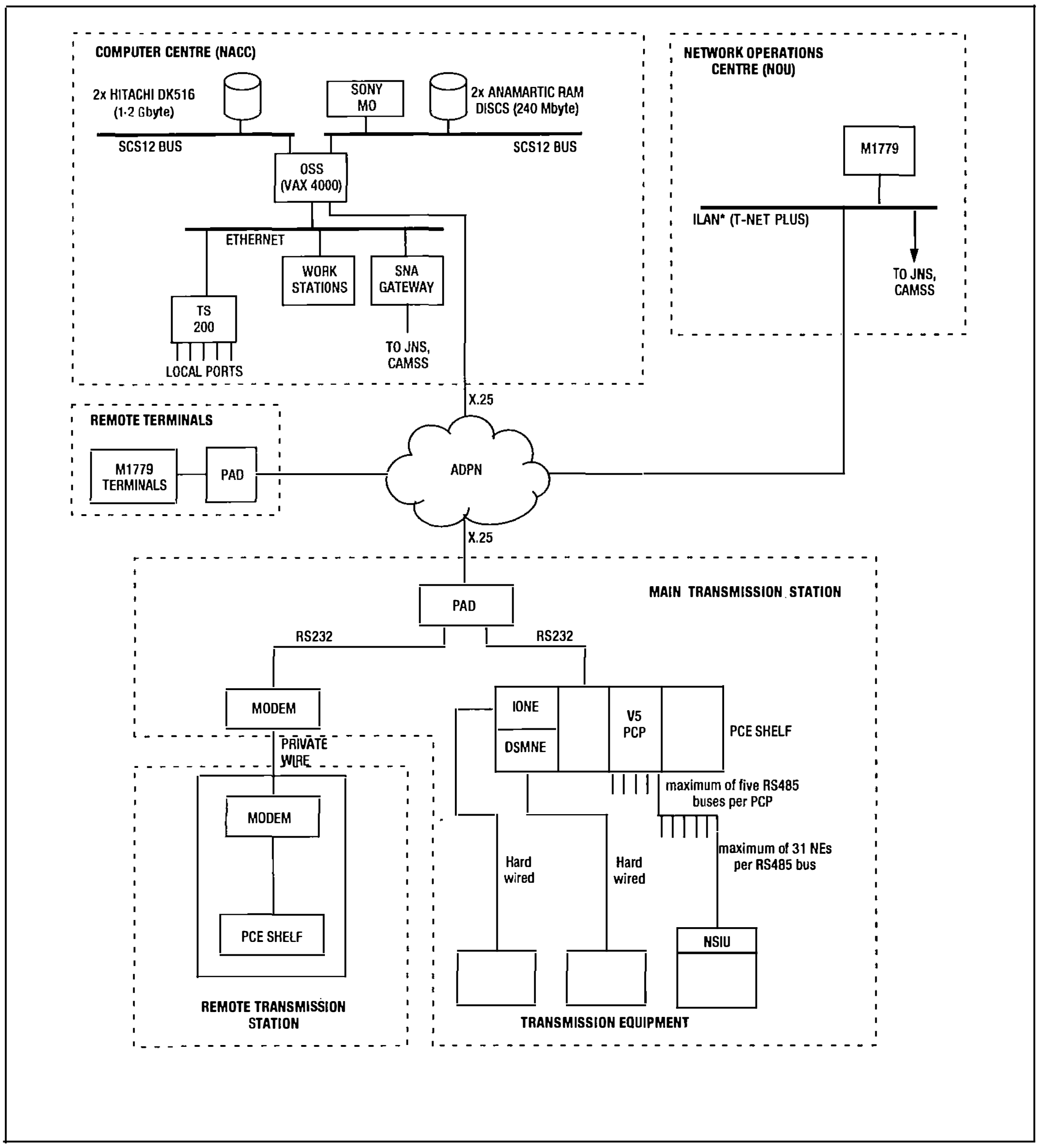
Communication Infrastructure

In the main transmission station, each PCE is connected by a serial link to a packet assembler/disassembler (PAD), which acts as a communications concentrator. The PAD converts asynchronous V.24 messages from PCEs to X.25 packet transmission, and reconverts incoming messages sent by the OSS. A number of PCEs can be connected to a single PAD via RS232 links. Local PCEs are connected directly by simple, cost-effective line drivers; remote PCEs use a modem link or statistical multiplexer.

X.25 packet transmissions are sent via the X.25 administration data packet network (ADPN). In the NACC OSS, discs and workstations are interconnected by an Ethernet local area network (LAN).

In the NOU, TNS users are linked by an ILAN (INTERNET LAN or T-NET Plus) network which links workstations, VT200 terminals, and

Figure 2
TNS 0.1 system architecture



* ILAN: INTERNET LAN

M1779 terminals. Users also require access to the transmission network configuration database held by the junction network system (JNS) and computer-aided maintenance of special services (CAMSS). This is provided by dedicated SNA gateways in the NACC, and by the ILAN.

Operations Support System

The heart of the TNS system is the OSS which performs:

- alarm handling;
- performance data monitoring; and
- data collect equipment management.

The OSS is installed on a VAX 4000 host processor in the NACC, and supported by an array of high-performance peripherals which include a pair of shadowed discs (see Figure 2). The OSS contains the PCP database, which holds detailed information about the data collection network, equipment being monitored, and alarm and performance data being collected.

OSS alarm handling includes the collection (on a secured log) and processing of alarms from subordinate PCEs. It then presents these alarms to users as maintenance tasks. The OSS also performs the important function of alarm association. This requires that alarms from the same equipment are grouped together and presented as a single task, stored by the OSS for future reference.

The OSS presents threshold exceptions and performance data which is collected and stored for viewing over a selected 24 hour period.

Finally, the OSS provides functions to manage the data collection network. This includes facilities to download and validate new, updated PCP software, and to perform data-building and system administration activities, the latter including data collection network configuration data, and details of monitored transmission equipment.

NETMON SYSTEM DESCRIPTION

NETMON has provided BT with a cost-effective solution to manage transmission elements in its inner core (trunk) network. Communication links connecting repeater/radio stations to the NOUs enable data from monitored transmission elements to be centralised at the NOU, and downloaded to the national support centre at Milton Keynes. The system provides:

- capability for rapid detection of failures and accurate matching of faults to specific equipment;
- performance monitoring to highlight problems which conventional alarm systems and protection switching are not designed to report; and
- real-time event reports.

NETMON System Architecture

The system comprises several individual components, which (as in TNS) can be categorised into data collecting network, communications infrastructure, and central processing. The central processing in NETMON is, however, distributed over a number of collocated processors (see Figure 3).

The data collecting network comprises a number of data collect components, the principal ones being station surveillance units located at remote transmission sites. Each station surveillance unit consists of three main microprocessor-controlled elements which can be treated as separate entities. These are:

(*a*) the digital radio and line scanner (DRLS);
(*b*) the alarm logging equipment (ALE); and
(*c*) the collator.

Digital Radio and Line Scanner

The DRLS monitors error rates, loss of signal, loss of alignment and so on, on digital radio and line equipment in the inner core (trunk) network.

Alarm Logging Equipment

The ALE is a general-purpose alarm interface and can transmit any alarm condition based on voltage from repeater stations or exchanges. It is also possible for a limited set of commands to be issued remotely from the NOU in order, for example, to effect resets.

Collator

This unit acts as an interface between the shared peripheral devices (printer, terminal and one or two modems), and satellite units. It is used to drive a modem link which sends data from the data collect equipment via the public switched telephone network to a remote NETMON computer at the NOU.

In addition to the station surveillance units, a number of other data collect components are used. These include:

(*a*) *Digital Multiplex Data Logger (DMDL)*

The DMDL is a microprocessor-controlled unit capable of detecting ON/OFF events of duration as small as 4 μs. It also detects and reports multiple muldex frame-alignment alarms from either 2–8, 8–34, or 34–140 Mbit/s multiplexers, and reports alarms when four consecutive incorrect frame-alignment signals are received. The DMDL can be also deployed to capture ordinary alarms, saving the cost of separate ALE/DRLS equipment.

(*b*) *ASPE† Monitoring Unit (AMU)*

The AMU is a microprocessor-controlled unit designed to interface NETMON to the ASPE units. Its main function is to give an indication of switching activities onto the service protection network, and to allow remote switching from the NOU.

(*c*) *Radio Control Unit (RCU)*

The RCU is the equivalent of the AMU for microwave radio transmission equipment. It enables microwave radio channel switched protection equipment to be controlled and monitored.

† Automatic switched protection equipment

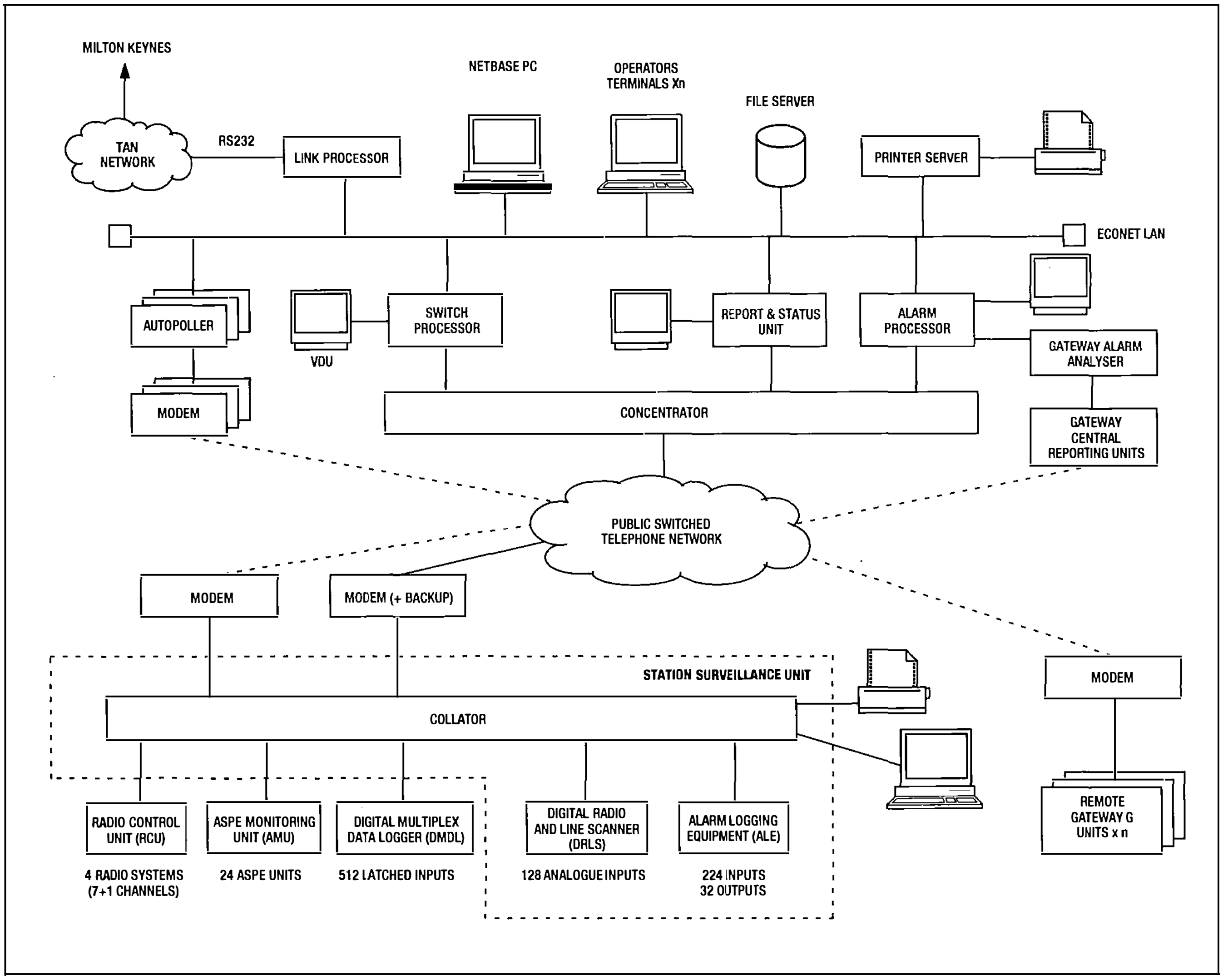


Figure 3 NETMON system architecture

(d) Gateway G

Some smaller transmission stations are fitted with Gateway G monitoring equipment. These units transmit one alarm input per system for digital line and radio systems, and one alarm input for each level of multiplexer for digital multiplexer equipment. In many transmission stations, Gateway G is used as a standalone system. Remote sites are normally linked to a central reporting unit, which in turn feeds alarm information to a Gateway alarm analyser, part of the NETMON computer equipment at the NOU.

Events from each data collect equipment are compared in severity with set thresholds. Those events below the threshold are stored until the central unit in the NOU polls the monitored site. Events exceeding these preset thresholds are sent immediately to the NETMON central unit as alarms which have to be acknowledged by NOU operators. Incoming data from each station surveillance unit is diverted to one of a series of screens, depending on their origin, and each report can be highlighted in different ways to identify the type of fault represented.

NETMON Central Processing

The main NETMON computer consists of several processors linked by an Econet LAN (see Figure 3). These processors are briefly described in turn.

File Server

This server provides disc storage facilities for all the other processors in the NETMON network.

Auto Poller

This unit interrogates all remote data collect units at predetermined intervals to download remote unit fault files, synchronise remote sites (every 24 hours), and conduct confidence checks (every two hours). After polling is complete, the autopoller combines all the polled data into an archive file on the file server. One file is kept for each date, and each file is kept for a maximum of 30 days before automatic deletion.

NETBASE PC

Once the remote data files have been gathered, a PC-based analysis package, NETBASE, processes and prints a league table of system performance over a preset number of previous days (usually 30). The league tables enable faults, failures, and trends to be analysed. This analysis, called *black-spot/gold-spot analysis,* has proven to be very useful in identifying and fixing troublesome circuits, or highlighting reliable circuits.

Link Processor

This unit provides communication between central sites (NOUs), and the National Support Site at Milton Keynes which monitors alarm and performance statistics nationally. The link processor uses a modem to communicate over the trunk administration network (TAN).

Report and Status, Switch Processor and Alarm Processor Units

In conjunction with directly attached VDUs, these units provide immediate views of performance information reported by DRLS/DMDL, AMU/RCU, and ALE/Gateway data collect equipment, respectively. Alarm information is presented to operators through various display screens on VDUs. Operators can use custom keypads to switch rapidly between a number of screens displaying alarm information in a number of pre-defined formats.

Gateway Alarm Analyser

This unit collects data from Gateway central reporting units located at remote transmission sites. It converts the alarms received into a format recognised by NETMON and presents alarm details on the alarm processor VDU, together with alarms from the ALE unit.

Operator Terminals

These are actually Acorn Master (BBC) series computers with which operators can gain access to NETMON system facilities.

IMPLEMENTATION PLANS

NETMON has already been extensively deployed throughout the inner core (trunk) network. In addition, several sites in the outer core (junction) network have a significant penetration of higher-order systems collocated with inner core (trunk) network plant. These outer core (junction) network systems are normally connected to NETMON, if there is sufficient spare capacity. Currently, NETMON monitors network elements at about 600 sites throughout the UK, out of a total of 5000. These elements comprise approximately 67 000 alarm inputs, with each NOU gathering on average, 9000 events per day.

While the deployment of NETMON is extensive and at a mature stage, TNS deployment is in contrast embryonic, with just under 50 transmission stations being monitored country-wide, at present. Full implementation of TNS requires a major investment of resources, and the coordination of activities across a wide spectrum of disciplines to install both the computer hardware with configured TNS application software, and the data collect equipment required to collect surveillance data.

Thus, in order to maximise the effectiveness of the implementation programme, TNS deployment has to be prioritised. Currently, this priority is aimed at delivering the maximum quality of service improvements for digital private circuits/Premium Services.

TNS computer hardware with configured TNS application software has now completed field and product trial stages in London. TNS hardware and TNS Release 0.1 application software are now installed in NACCs at Croydon, Manchester, Wolverhampton, Bristol and Leeds. Also, a special release of TNS, TNS0.1E, enhanced to meet the requirements of international transmission operations, has been installed at Madley.

The dates for initial TNS hardware and application software deployment to the remaining NOU catchment areas are:

Southern Home Counties	Oct. 1991
Northern Home Counties	Jan. 1992
Scotland	Apr. 1992
Northern Ireland	Jul. 1992

With regard to the TNS data collect equipment, the deployment strategy for retrofit is that:

- TNS is being used to monitor larger transmission nodes where no surveillance exists, or where existing NETMON capacity is near full utilisation;
- utilisation of spare NETMON capacity, if sufficient, is considered for deployment at co-sited transmission nodes;
- TNS, where installed, will be fully deployed at 8 Mbit/s and above. TNS deployment at 2 Mbit/s, is being focused at services such as MegaStream; and
- in small transmission nodes such as small local exchanges, existing surveillance methods including Gateway, REAMS and so on, will continue to be used, for a period of time.

This strategy aims, initially, to focus deployment of the TNS data collect equipment and network interface units on the outer core (junction) network sites. Inner core (trunk) network stations, the majority of which are already monitored by NETMON, will be delayed until the end of the initial roll-out programme in the latter half of the 1990s. This plan gives maximum surveillance coverage, and leads to a quicker realisation of the benefits envisaged from the surveillance programme.

Even so, the implementation programme is very ambitious, and while TNS station surveillance is still rather modest (see Figure 4), this will change rapidly in the next few months. For example, in London, surveillance is planned for 76 sites during 1991–92, with the ultimate capacity in London of the order of 300 sites, serving

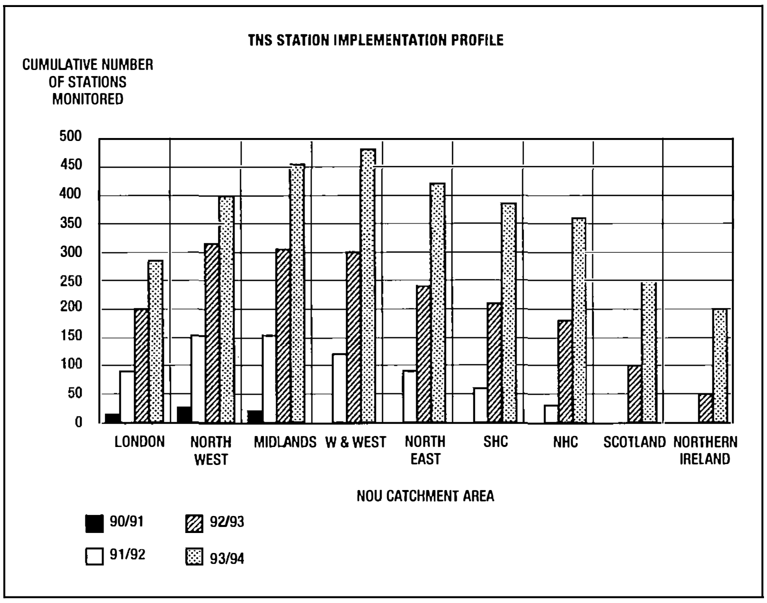


Figure 4 TNS station monitoring 4 year implementation plan

400 000 transmission systems. This capacity is an order of magnitude greater than current NETMON deployment in London.

Figure 5 shows the approximate number of national transmission sites that are planned for surveillance for the first four years of the six year programme, together with the approximate percentage of transmission station coverage that these figures represent.

THE NEXT STEPS

TNS and NETMON are converging into an integrated, consistent system which incorporates and builds upon the best features of both systems. The drive behind this integration of surveillance systems within the transmission domain is based on the need to provide tools to aid the operational processes which guide the flow-through of events from their occurrence, through reception, diagnosis and ultimate repair.

TNS priority development steps are:

- enhancement of existing TNS0.1 user interface and adoption of a network management workstation (NMW2);
- the introduction of basic correlation functions;
- real-time display of alarms;
- interface to the work management system; and
- performance management functions.

One of the key development targets due for trial in February 1992 is the enhanced user interface which is better geared to the needs of the NOU transmission operations and maintenance staff. Such an interface will be realised by the UNIX-based NMW2 platform which will cut down on the number of terminals required, giving NOU users multiple access to TNS, NETMON, and other TNS support systems from the same workstation in a consistent fashion. This interface will be based on generic fault management software with added TNS functionality. It will also use the common management information service (CMIS) Cooperative Networking Architecture-Management (CNA-M) conformant communications stack for interoperability with the main body of TNS software.

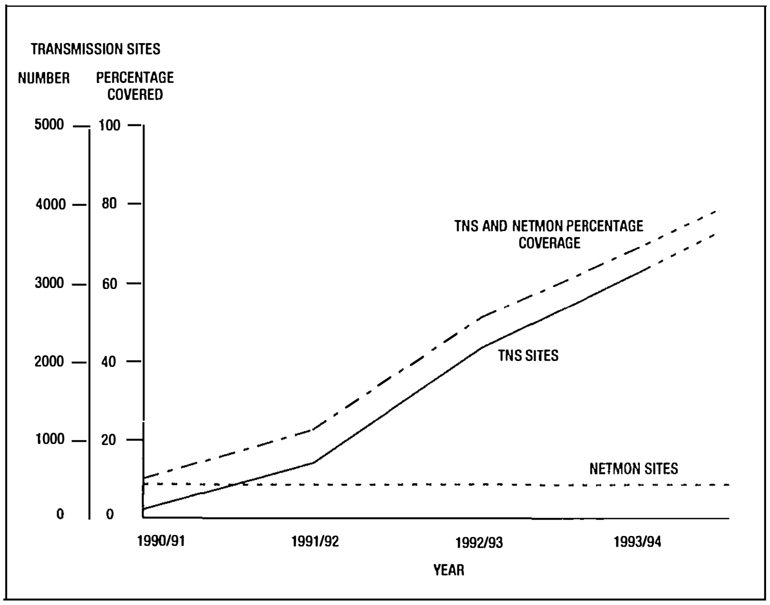
This transmission management application software will incorporate temporal correlation (that is, correlation based on the time interval between alarms) to group associated alarms received from both TNS and NETMON, enabling users to identify the underlying problems more swiftly. In this configuration, the transmission application will act as the manager node, sending commands to TNS (the agent node) to control sieves in TNS event management software. The user will therefore be able to select what type of events are to be transmitted from the main TNS system, ensuring that the user at the transmission workstation is not overwhelmed with inconsequential events.

The correlation will further help to filter much of the alarm information that would otherwise be displayed to the user at the transmission management workstation. Thus, while the initial implementation of transmission event correlation concentrates on temporal correlation in the workstation domain, it is expected that some correlation functionality will eventually have to migrate down closer to the event collection equipment.

Real-time display of alarms will be available in the next release of TNS. This feature requires a separate display and terminal, and will continually show the status of events. It is intended to give a continuous update overview of event status without the need to perform repeated terminal actions. This will enable a better integration of TNS into the NOU environment, and remove the need for the simple interface linking TNS to the NOMS1 system.

Worldwide Network's work management system is NOMS2, which will be evolved into the

Figure 5 TNS 4 year station coverage plan



WMS Module1 for networks. WMS will interface to TNS for information via a CNA-M interface such as CMIS.

Performance management functions similar to that now available on NETMON using NETBASE PC will be made available to TNS users. This will allow users to generate league tables for black-spot/gold-spot analysis.

In order to maximise the surveillance coverage across the network in the most cost-effective manner, it is necessary to incorporate the existing NETMON event collection infrastructure, and hence NETMON is also on an evolutionary path towards integration across the transmission domain. Its priority development steps are:

(*a*) porting NETMON central functionality to a UNIX platform;
(*b*) provision of an enhanced user interface using NMW2;
(*c*) CMIS interface for interworking with the transmission management workstation;
(*d*) CMIS interface for interworking with TNS; and
(*e*) interworking with the RS485 surveillance interface.

Owing to the diminishing external support for Acorn Master (BBC) series computers, it is intended to port NETMON's central functionality onto a UNIX platform. This plan is linked with the provision of the UNIX-based NMW2 environment which would achieve top-level integration with a common NETMON/TNS application. The NMW2 windowing environment will be developed along with the transmission management application to achieve a common 'look and feel' for both systems.

This UNIX implementation will be followed by the provision of a CMIS interface which will allow NETMON to inter-work with TNS.

NETMON was deployed before the definition of the RC8245-RS485 standard surveillance interface, and is currently unable to interoperate with these interfaces. Over the last few years, the rapid expansion of the transmission network and the introduction of new transmission equipment, all fitted with the standard interface, has led to an increasing number of transmission elements not being monitored. To rectify this, it is now intended to develop a cost-effective unit between the standard RS485 surveillance interface and NETMON satellite units, enabling NETMON surveillance of new transmission kit, where this is cost effective.

FUTURE

The TNS will provide the long-term architecture for transmission management, into which NETMON and other interim systems will fit. In the case of NETMON, this will be achieved by modifying the unit between the RS485 interface and NETMON satellite units to enable the latter to act as NSIUs. This will allow NETMON to share the same communications infrastructure as TNS, and utilise common OSS facilities such as the secured (high level) log. This integrated view goes hand in hand with plans to rationalise the communications infrastructure, reducing further operation and maintenance costs.

In the development of TNS, incorporation of generic software such as component fault management software will be a high priority. In addition, significant care will be taken to make maximum use of functionality already developed. This is especially true for the data collect equipment already deployed and which will remain compatible as TNS evolves.

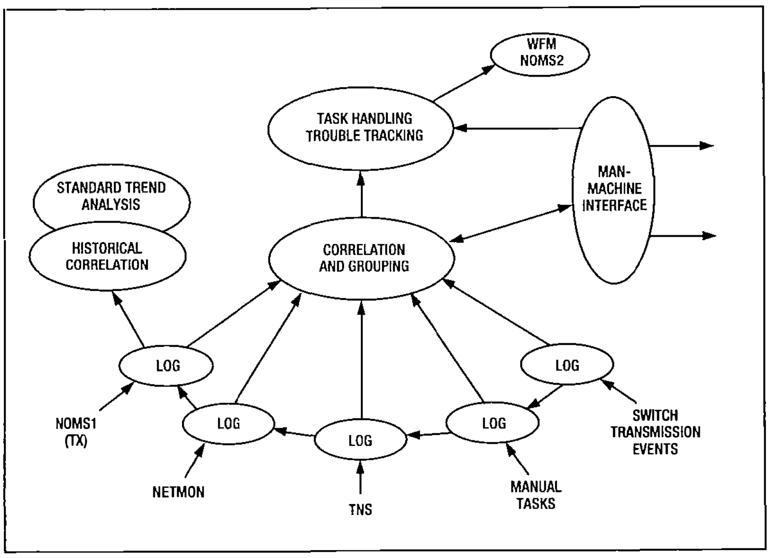
The architecture for full integration across the transmission domain is now being finalised. When completed later this year, it will provide the focus for later development releases. There will be two more major releases (TNS0.2 and TNS0.3) before the final release, TNS1.0, in the second quarter of 1993. This will complete the current development programme.

It is clear, however, that a view is required beyond the integration of TNS and NETMON encompassing the wider range of systems providing transmission information. Such a view (see Figure 6) requires the interoperability of a number of systems, with a correlation /grouping function based on that to be provided by the transmission management application.

The scope of integration is wide ranging, including issues such as:

- the introduction of the synchronous digital hierarchy, and the need for a common approach to both the synchronous digital hierarchy and plesiochronous digital hierarchy;
- driving down the cost of ownership by the use of a shared communications infrastructure between systems, for example, transmission, power and building environment alarm systems;
- fallback/disaster recovery facilities;
- test management;
- making transmission network element interfaces accessible via international standards such

Figure 6
Possible future interworking of transmission domain systems



as CMIS, SNMP and CCITT Q.2 Recommendations in the data collect equipment environment; and

● end-to-end (customer premises) management and integration with access management systems.

In the long run, it is intended to have this correlation performed virtually in 'real time'. To this end, development of other types of correlation techniques will be undertaken to supplement the original correlation methods.

CONCLUSIONS

The thrust of the TNS programme can be broken down into two parallel activities: the first is a concentrated deployment of monitoring infrastructure to maximise surveillance coverage; the second is a focus on phased development of the system to provide incremental functionality changes in line with operational needs.

The TNS and NETMON programmes are both key elements of the NAIP. The evolution plans for these two programmes converge towards a unified network surveillance capability for BT, bringing a rationalisation and reduction in operation and maintenance costs. The precise architecture to achieve full integration is close to being finalised.

The single most daunting challenge, however, is simply the sheer size and cost of the total surveillance programme. For example, over 5000 locations (consisting of up to 400 000 systems) will eventually be monitored and supported by a single OSS node. In addition, the context of TNS within the FARMS† study has been, and will be, a major consideration. The road ahead is therefore a challenging one.

Completion of the final release of the current TNS program (TNS1.0, due in the second quarter of 1993) will deliver comprehensive transmission surveillance capability across the transmission domain.

ACKNOWLEDGEMENT

The authors would like to express thanks to members of the TNS development team in Ipswich, the TNS and NETMON programme team in Milton Keynes, the Transmission and Operations Maintenance Unit staff in Manchester, and the Local Access Strategy group in London, all for their kind cooperation, time and assistance in the preparation of this article.

Biographies

Greg Hart graduated in 1971 and joined BT's Transmission Systems Engineering Department. Initially working on cable television technology, he was eventually promoted to head of microwave system engineering, responsible for all technical standards, specifications and type approval of systems, antennas and structures design. During that time he had considerable involvement in international standards work where he helped to formulate many of the current CCIR and CCITT recommendations on error performance and availability. He also chaired a CEPT subgroup accountable for determining European harmonisation standards for radio relay system design and performance. In 1988, he joined the Network Operations Support Department as head of transmission network operations responsible for the development of support tools, such as TNS, and new working methods to facilitate the National Administration Implementation Programme. Since February 1991, he has headed the unit in Worldwide Networks which is responsible for the operational processes associated with maintenance, surveillance, technical support and repair across all technologies.

Roger Gallagher is the programme manager for transmission network surveillance in Operational Policy and Systems in Worldwide Networks. He started as a Youth-In-Training in 1965 in the London Centre Area and progressed through the ranks on a variety of duties. During his career, he obtained a B.Sc. degree in Electrical and Electronic Engineering. He has been involved in a number of projects in the transmission area, including remote testing for private circuits (RATES), automatic digital cross-connect equipment for the fibre access systems, automatic switched digital service protection system (ASDSPN), and, prior to his current position, he was responsible for network protection systems, SDH management and network aspects.

Steve Moor currently heads the Transmission Surveillance and Network Development section within BT Development and Procurement's Network Management Department, Ipswich. Steve joined BT from University in 1974 as a Contract Supervising Officer. During 1976, he was involved in the 60 MHz Project Group and, in 1979, progressed to Team Leader in System X Development, producing test software for System X exchanges. During 1984, he joined the OMC/OMUSS programme and introduced a new project 'System Design'. He headed the OMC System Design and Communications Group in 1986, and left OMC development in 1989 to head the TNS programme. This position requires the management of a number of teams, concentrating on all phases of development from requirements capture through to delivery, support, and the development of special hardware.

Mike McKenzie currently works as a Network Management Consultant in the Front Office of the Network Management Department. He joined BT in 1989 after completing an MBA at Imperial College, London. Since then he has been involved in a number of business development activities within the department relating to major systems such as the OMC2, and fast track solutions such as the National Charging Information Package. Before that he worked as an offshore engineer for five years in the oil exploration industry. Mike graduated with an MSE in Mechanical Engineering from Princeton University in 1983, and a B.Sc.(Hons.) Mech. Eng. from Queen Mary College, London University in 1980.

† FARMS (fault and repair management system) is one of the strategic systems areas within the network support systems architecture, part of the NAIP

Work Management System

G. J. GARWOOD†, and A. C. ROBINSON*

As a result of a study to initiate major improvements to the work management activity, a work management system was identified as a key area of development. This article outlines the development of a real-time process control system required to provide such a work management system.

INTRODUCTION

What is Work Management

At any given time, the company will require work to be undertaken. It will also have available people who are able to perform that work. The task of work management is to match the available people to the required work in an optimal manner.

Work Management Programme

The Work Management Programme (WMP) was formed, in 1988, to initiate major improvements to work management activity. The requirement was to study the current situation, to propose a future strategy, to plan a course of action, to understand the benefits and costs, to develop any systems that may be required, together with changes in operational procedures and then implement.

The WMP had to take into account other key BT initiatives, in particular the Network Administration Implementation Programme (NAIP)[1], and the Strategic Systems Plan (SSP)[2].

In the light of the above initiatives, the WMP undertook a detailed analysis of business costs and failures, including the manpower utilisation surveys which clearly pin-pointed areas for improvement. At the same time, increasing pressure on the business in the form of competition, focused the vision on improving the quality of customer services and reducing unit operating costs.

WMP Objectives

The main objectives can be crystallised in the following form:

- to get the right person
- in the right place
- at the right time
- with the right stores
- and the right information

and provide information so that we know

- where the person is
- what he/she is doing
- when he/she will finish
- what he/she will do next.

† BT Development and Procurement
* BT Personal Communications Division

WMP Deliverables

After intensive and extensive analysis, the WMP charted a migration and implementation plan focusing on three key areas:

(*a*) what initiatives currently existed which could be coordinated and enhanced,

(*b*) what new initiatives would make the real step improvements which could only be achieved by a major change programme, and

(*c*) what facilities and functionality would give early benefits and would support a strong business case.

For (*a*), a local initiative on time recording, to use a Psion Organiser for replacing paper-based job allocation sheets and improving management information, would be rolled out together with enhancements to the Customer Service System (CSS)[3], to support the activity. These projects are now known as *Cipher* and *National Job Recording*.

For (*b*) and (*c*), a new development would be undertaken, with the working name of *WMP Module 1*, which would offer:

- electronic communication of work details and work progress between field technicians and central systems,
- significant improvements to the decision process with regard to resource allocation and control,
- facilitation of multi-skill working covering both repair and installation, and
- an available developed system which could commence pilot trial in 1991.

This article concentrates on the work management system (WMS), the central deliverable of Module 1.

OPERATIONAL REQUIREMENTS AND USE

Under the leadership of the WMP, people concerned with future operational requirements met with BT Development and Procurement in late-1989 and January 1990 to consider how the statement of user requirements could be translated into computer systems that could be realised within the challenging delivery time-scale. A key objective was to build upon existing support systems and reuse functionality wherever feasible.

The process inevitably led to some compromise between the requirements and the achievable technical solution. Some requirements were scoped out (to form part of later deliverables), while modification/enhancements to existing systems were identified together with new developments. The main criterion in making the decisions was to achieve maximum operational benefit within the required time-scales.

Operational Scope

A statement of requirements (SOR) was then produced which formed the framework within which the project has operated.

The main focus covered the allocation and control of work. Table 1 identifies the specific work areas.

After the reorganisation of BT under Project Sovereign, the above were aligned with the respective parts of Personal Communication Division (PCD), Business Communication Division (BCD) and Worldwide Networks (WN).

Technical Scope

The proposed technical solution for Module 1 takes full advantage of existing systems and the functionality they offer, combined with new developments, as illustrated in Figure 1 showing both the customer and the network aspects.

WMS will be connected, via a new interface, to the CSS which can provide details of orders and repairs, customer information, appointments or target clear response times, people information and product skill identification.

Figure 1 Technical solution for WMP Module 1

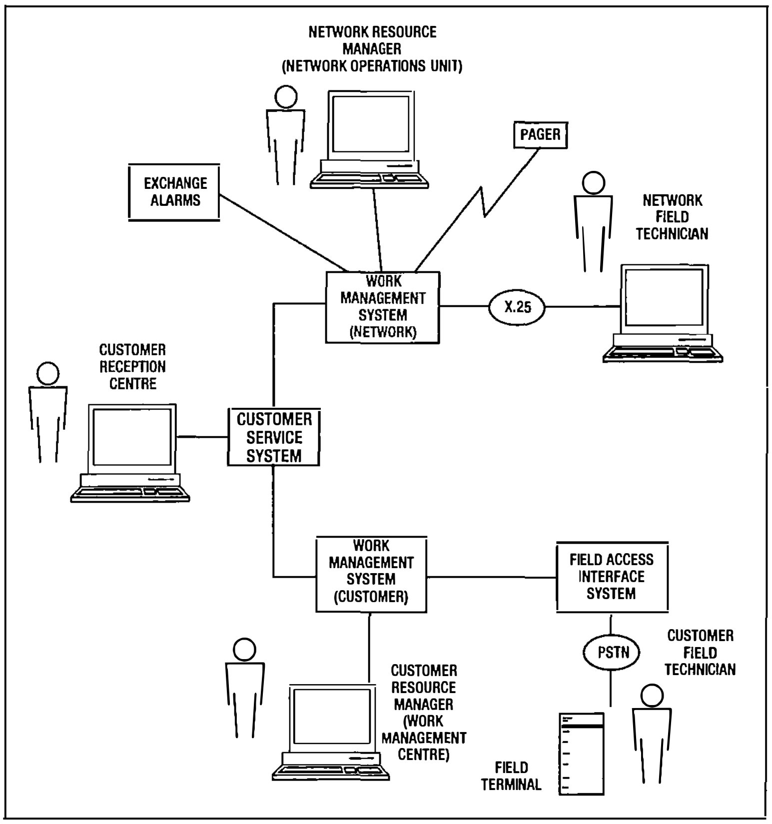


Table 1
Original SOR Scope

PSTN Repair	Customer Apparatus and Line Faultsmen / Jointers Renters and Public Payphones Job and Pay Records
PSTN Installation	Single Line Residential and Business Renters Payphone Job and Pay Records
Network Operations	Repair for TXD Repair for TXE4 Repair for Transmission Buildings and Power

The WMS will take account of contractual agreements in terms of response time, the size of the job, and the skill required with the availability and location of the field technicians who possess the requisite skills. Further, it will take account of existing work, recognising that each item of work will take different amounts of time and will be undertaken at different locations. Sophisticated algorithms will match the required work with the people available in the most efficient manner.

The WMS development, based on the existing network operations management system (NOMS2)[4], is to be made available as two variants, WMS(C) for customer-facing activities, and WMS(N) for network operations. Both will have a substantial common core element.

For the WMS(C) option, work will be despatched to field technicians via a field access interface system (FAIS) to hand-held field terminals.

Operational Benefit

The main benefit to be derived from WMS is the opportunity to improve productivity whilst maintaining service levels to the customer and reducing failures. Specific gains will be by:

- optimum allocation of a day's work over a large geographical area,
- taking full advantage of multi-skilling opportunities,
- automation of routine control and allocation processes,
- provision of a multi-stage jeopardy system enabling improved management of potential failure situations,
- more visibility of work progress,
- reduction in ineffective time and wasted time (travel time per job, waiting to contact control etc.),
- provision of full job information plus previous fault history to field technicians, and
- significant reduction in paperwork and reconciliation procedures by electronic collection of time, jobs, and activity data just once, for all operational, accounting and pay purposes.

It is expected that customers will benefit through reduction in failures, better appointment keeping and improved flexibility. Ultimately, the reduction in operational unit costs will provide BT with the opportunity to perform work often not done (for example, uplift), and to reduce service costs to the customer.

STRATEGIC REQUIREMENTS

Strategic Process

The SSP identified how the company should operate. It established 'manage people and work' as one of the five key high-level processes, which with others, in particular 'serve the customer' and 'run the network', is present in most of the end-to-end business processes or workstrings. This vital area should be standardised and wherever possible automated to allow all other processes to use the same approach.

The WMP started at the outset to map its work on to this process, thus achieving a single development and maximising its use for the company.

Strategic Technology

Major companies are now moving their computer technology towards 'open computing platforms', in order to gain commercial advantage through competitive tendering and selectively choosing appropriate technology.

The WMS product is required to be capable of being ported to a range of computer systems and thus be conformant to the 'open platform' concepts.

Strategic Business

The WMS is required to support the work management requirements of PCD, BCD and WN. Ideally it should be capable of supporting all other work management functions within the company.

A strategic requirement is that the majority of the software should be reusable. This allows WMS to be tailored to many applications through small specific enhancements to a common generic base and hence benefit from lower development costs.

WORK MANAGEMENT SYSTEM

System Overview

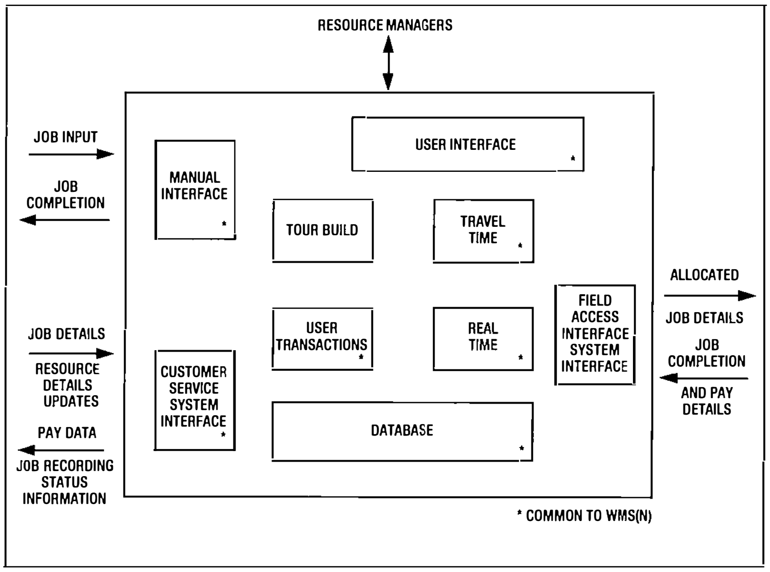
WMS is a real-time process control system which is required to automate the process of matching the required work to the available field technicians who are able to undertake that work. It has to undertake this task as a continuous process, constantly optimising its allocation as real-time events occur. It must support both customer facing and network operations for both installation and repair activities. Two variants of Module 1 have been produced from a common development programme; WMS(C) for customer-facing activities, and WMS(N) for network operations, each sharing a substantial core element. Figures 2(*a*) and 2(*b*) identify the major components for both variants and show the common elements.

WMS(C) Facilities

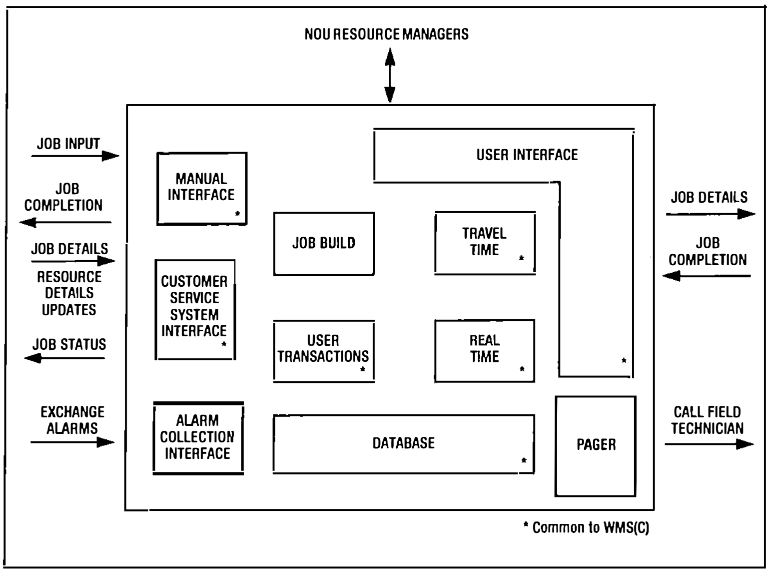
In the customer-facing domain, CSS maintains a file of jobs to be undertaken, field technician attributes such as addresses, telephone numbers and training, together with associated standards covering the equipment involved, job completion times, and skills required. WMS(C) receives this information through a CSS interface, and uses it to identify future or 'same day' work. The primary goal is to assign the right field technician who will incur the minimum cost to the business while meeting quality-of-service targets and customer commitments.

In a typical eight hour day, each WMS(C) will handle up to 10 000 jobs with up to 1200 field technicians.

Figure 2
Work management system



(*a*) Customer facing WMS(C)



(*b*) Network operations WMS(N)

Planned Work

Customer work which can be planned in advance generally consists of installation or routine work. In response to orders placed via CSS, including those with appointments, WMS(C) compiles a list of consecutive jobs, known as a *TOUR*, for a single day for each technician.

In building the TOUR, WMS(C) takes into account the following field technician attributes: locations and stores point, start and finish times, any planned absences, overtime availability, skills, and preference for type of work. These are then balanced against the job attributes: the location, estimated duration, skill required and appointment time. The primary goal is to fill completely the working day with minimum ineffective time, including travelling time. This process involves a two-stage approach.

An initial build can take place up to three days in advance of appointment date. Work is balanced between geographic areas, and jobs which may be done by the same field technician. In addition, the starting and/or stores point is identified and stores ordered.

On the night before, the final build takes place in which the jobs are allocated to the actual field technician. The build takes into account any amendments received since the initial build, preassigned jobs, any concentration of work, travelling time and any slack time.

It is also possible to plan non-CSS work, for example, uplift and rewiring, into TOURs by direct input into WMS(C).

Unplanned Work

Since faults arrive as unsolicited reports, repairs cannot be planned in advanced. Further, as each repair job will have its own priority, the preferred sequence of attending to such work will continually change.

To handle this, WMS(C) is equipped with a real-time algorithm which runs every few minutes to refresh the allocation of unassigned work. This takes into account not only those attributes given for the TOUR build work but, in addition, the priority of each job (based on customer class of service and remaining time before jeopardy), those field technicians who are likely to become available shortly, and local geography. If planned work cannot be undertaken owing to unforeseen events (for example, work taking longer than expected or field technicians suddenly being unavailable), it can be removed from the TOUR and handled by the real-time algorithm.

Despatch

Each field technician will be equipped with a hand-held field terminal, a small computer in its own right, with which they can communicate with WMS(C). The interface between these terminals and WMS(C) is via FAIS, which manages the access rights, security, line protocols and the data exchange.

To communicate with WMS(C), the field technician plugs his terminal into a standard telephone line and calls a pre-allocated telephone number. Once the link is established, via FAIS, the technician can obtain full details of the next job. Further, on completion of the work, he can communicate to WMS(C) job closure information or progress to date.

To complete the work cycle, WMS(C) provides a store-and-forward function to update the job and pay recording module via the CSS national job recording module.

WMS(N) Facilities

In the network situation, WMS(N) supports corrective and preventative maintenance. In the initial version, alarm and current information from digital and electronic exchanges and transmission systems will be transferred electronically from the alarm collection system known as the *Network Operations and Maintenance System 1* (NOMS1). Information on customer-reported network-related faults will be transferred via the CSS–WMS link.

Most other WMS(N) facilities have been derived from the design of WMS(C) together with the main features of NOMS2. Most of the time and skill standards are created automatically within WMS(N) and the facility to input work manually allows other activities to be managed by the system. WMS(N) also has the ability to schedule automatically routine maintenance activities.

Since WMS(N) is only concerned with the real-time allocation of work, the TOUR build function has not been provided. Communication to the field technicians will, at present, be via the existing fixed terminal network rather than using the portable field terminal.

Further, as network operations differ from the customer-facing requirements, a number of the user screens have been modified to meet the specific network need.

Nevertheless, even with different features, some 70% of the total software is common to WMS(C) and WMS(N) and constitutes a core element.

User Interface for both WMS(C) and WMS(N)

WMS has been equipped with a range of user tools to allow operational users to tailor WMS to their operational needs. By using an executive tool known as the *session controller*, a whole range of specialised facilities, known as *transactions*, allow people at the centre to enter information, and monitor the flow of work.

WMS offers a user-friendly interface which conforms to the CNA-M style guide, making use of drop-down menus, forms and picklists. These are typically overlaid on each other during transactions allowing continuous progression through a transaction. For experienced users, options exist to execute a series of complex tasks by entering brief instructions on a command line.

The data-build tool allows the user to create, modify and delete fundamental information in the database; for example, allocation parameters, work types, people details, domain controls and constraints, exchange areas, and travel time parameters.

Several standard tools have been provided to allow the resource managers to progress and monitor the flow of work. These provide them with visibility of jobs pending and in progress, TOUR details per technician, resources available and work/staff jeopardy situations. Jeopardy monitoring in real-time provides a continuous picture of the total work situation.

Development

The WMS system architecture and detailed design took into account the following aspects:

Development Environment

A network of workstations and computer systems was engineered such that the developed system could be ported to a range of target machines.

Technology Standards

In supporting the open approach, the implementation was undertaken using the software languages C and C^{++} (featuring object-oriented design), under the UNIX operating system V and employing the ORACLE relational database management system. These tools have a very large user base and thus provide additional benefits in terms of facilities and support.

The benefits of symmetrical multi-processing have been exploited by using a number of concurrent processes. In addition, certain processes are also configured as client/server models, with remote procedure calls being used for communications.

For inter-computer communication (WMS–CSS and WMS–FAIS), the *de-facto* standard TCP/IP protocols have been adopted. This allowed readily available interface units to be purchased, enabling a UNIX environment to communicate with an MVS environment.

Reusable Features

Using the experience of developing NOMS2, it was possible to produce a design for WMS with many reusable features. The combination of this approach with those above has resulted in a generic solution.

Software Methods and Tools

Software engineering tools (the Yourdon software methodology support by the Software through Pictures (StP tool) were successfully used to produce a singular but comprehensive design, captured in electronic form. All objects and their relationships are checked to be logically correct while missing ones are noted.

StP provides total visibility of the design, making it easier to understand and change when required.

On completion of the design, WMP people were then involved in the review process to ensure all parties achieved a mutual understanding of precisely what is required and what is to be developed. This approach is to be recommended to all developments.

System Build, Integration, Test and Release

For WMS, separate units were charged with system build and integration, testing and release phases, independent from the development stage.

System Build and Integration

This is the process of incrementally building the system until all the code units have been integrated and the complete system can be run on the target platform.

System Validation, Verification and Test

Traditionally this has been a manual task. However, for WMS, approximately 70% of the required component, system and regression testing was automated.

By using suitable test tools, a range of test scripts was developed to provide the automatic test environment, covering execution, documentation, test results, metrics and traceability analysis. A typical test suite which used to take three days to administer, and was error prone, is now undertaken in 40 minutes. Further, the tests were executed repeatedly and consistently, with or without user intervention.

Automatic testing has not only improved productivity and quality, but has made testing into an interesting and challenging activity.

Release

A separate unit provides the installation and commissioning of the system on the target machine on site, provides product familiarisation with the field users, and subsequent support of the system.

In summary, the acceptance cycle (system build to release), for builds of WMS was realised in a 7 week period. The integrated approach between the development and the system test teams, together with the use of automatic testing tools and techniques made this possible.

WMP Module 1 System Integration and Customer Acceptance Testing

Once the discrete systems, WMS, CSS, FAIS, and field terminal have been released, a process of integration, system integration testing and customer acceptance testing needs to take place. This is a complex task which needs to ensure that the systems are fully compatible with real data being sent across the interfaces.

To ensure that all systems work together and deliver the requirements, initially a period of 6 months has been allowed.

IMPLEMENTATION

Following acceptance of a detailed business case, approval was given to undertake a pilot trial to demonstrate that the benefits were achievable.

The trial allowed for both WMS(C and N) to be piloted. The location chosen is the old East Midlands District which is now part of PCD Midlands, BCD Midlands Wales and West and WN Southern.

The Module 1 deliverable is not just a computer system, but involves developing new operational processes, procedures and working practices which will have a significant impact on the company's field operations.

The most noticeable change will occur in customer-facing operational units where the focus is on the automation of the existing process to minimise the need for manual allocation of work. People will have new roles of monitoring WMS, modifying and changing information about jobs, technicians or customers and taking vital decisions on resources and handling work which may move into jeopardy.

Field technicians will have their work despatched to them automatically. This provides the opportunity to improve their efficiency and effectiveness, and increase job satisfaction by being able to do a better job, whilst the field terminal will eliminate the paper-work associated with job and pay recording activities.

Field managers will be able to spend more time with their people, providing a greater technical input as WMS takes over many resource, pay and job-related clerical activities.

Key elements in implementing these changes are:

- that all concerned understand the functionality that WMS offers and the potential benefits that can be obtained,
- a full and active involvement of local field managers,
- an understanding of the operational impact, in particular the people issues,
- the provision of the communications infrastructure, and
- the provision of a comprehensive training package.

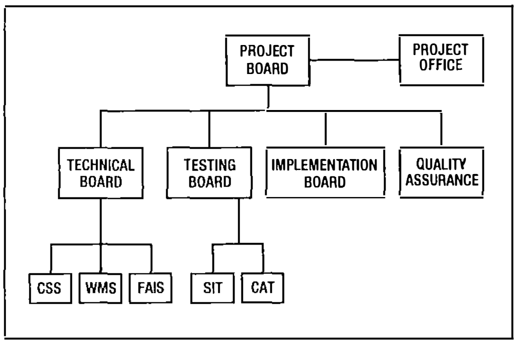
A WMP team, in close consultation with local managers, has developed an implementation plan which details all the activities necessary to support the 'go-live' operation.

On the network side, the situation is slightly different, since NOMS2 has already been used to manage work allocation and control. Here the key implementation issue is how the field migrates from NOMS2 to WMS(N). A separate implementation plan has been developed, but the principles given above still apply.

The project must provide evidence of a successful implementation in order to gain authority to proceed with national roll-out. Consequently, the WMP has developed a benefit measurement programme which identifies key measures to be tracked for a period in advance of go-live and then for a further period after go-live. These measures, which will cover the performance of various operational activities, will provide the evidence of impact that WMS has had on the business.

PROJECT MANAGEMENT

The WMP Module 1 is a large and complex project, bringing together many parts of BT with different roles and responsibilities. Key to its success is sound project management based on the structure in Figure 3.



CAT: Customer acceptance testing
CSS: Customer Service System
FAIS: Field access interface system
SIT: System integration testing
WMS: Work management system

Figure 3—Project management structure

This enabled the coordination of the lead WMP team in Manchester with the development units from Development and Procurement, located in Cardiff, London, Martlesham Heath and Ipswich.

FUTURE OPPORTUNITIES

The WMS development has made a major step in providing the company with a generic solution rather than a specific one for a specific application. The future opportunities for applying work management are now very substantial since the means to achieve cost-effective solutions are now available.

Following a successful pilot trial, the scope of WMS can be widened, in progressive modules, to incorporate other PCD, BCD and WN requirements, until all appropriate workforces within these units are covered. The scope, for example, could cover private circuits, multi-line business provision and capital network installation work.

In the near future, a generic interface could be developed to link WMS to existing support systems such as operations and maintenance centres and transmission network surveillance which would significantly improve work flow-through.

In addition, there is the scope to enhance business operations by interconnection with other support systems such as stores management, personnel and finance systems, and private network management systems. The added value is automatic work flow-through removing the need for paper transactions and human intervention.

WMS could also be applied to other parts of the company, such as Product and Services Management, Special Businesses and Group HQ.

CONCLUSION

The work management programme, through its development of WMS, has delivered a key strategic system which maps on to a key strategic process. Not only will WMP Module 1 generate significant benefits in its own right, but it will provide a generic base for a much larger application of work management across the company.

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Biographies

Gerry Garwood joined the Company in 1960 as a Youth-in-Training in the Norwich Telephone Area. He then undertook technician duties covering, test desk, linesman, and exchange and repeater station maintenance. After graduation in 1969, he spent 4 years in computer development within the Postal Mechanisation Department. He moved to Research Department in 1973 and became involved in software systems development for SPC exchanges and the associated support. After some research work on the use of expert systems to support maintenance activities, he developed a number of software systems which demonstrated that software technology could be applied to the work management domain. He was responsible for the development of the district control support system and the network operations management system which have now been deployed within the BT. He is currently the Section Manager for the Work Management System development. Gerry graduated with an Honours Degree in Electrical and Electronic Engineering from Brunel University, holds a Diploma in Management Studies, is a Chartered Engineer and a Member of the Institution of Electrical Engineers.

Andy Robinson joined the then Post Office as a graduate entrant in London South Central Area in 1971 and was involved in the management of a very wide range of Area operations spanning external planning and works, exchange planning, construction and maintenance and customer service, provision and repair. He moved to Sheffield Area in 1984 to head the Local Network Division and was Sheffield CSA Manager in the Sheffield and Lincoln District before joining the work management programme which is based in Manchester. His main role has been in the management of the requirements definition for the Module 1 project. He became the Work Management Programme Manager in April 1991. Andy graduated with honours in Electrical and Electronic Engineering from Nottingham University, is a Chartered Engineer and a member of the Institution of Electrical Engineers.

Local Access Network Management

K. J. MAYNARD, and P. J. HAWLEY†

The different technologies which are found in or planned for the local access network are considered, together with the demands they make upon management systems. The impact of more sophisticated customer expectations on the network operator is discussed briefly. Finally, current work on an architectural model for the local access network is outlined.

INTRODUCTION

The local access network can be considered as the first or final hop in the transmission network through which all network-operator-supplied services pass. Most of these services pass through the local access network twice, once for each end connection. Only recorded information and enquiry services have a single pass through this network. For the purposes of this article, the local access network is regarded as starting at the transmission terminating equipment in the serving local exchange and ending at the network termination equipment (NTE) at the customer's premises. Depending on the technology in question, the transmission terminating equipment may be the main distribution frame (MDF), digital distribution frame (DDF) or multiplexing equipment.

At present, BT's local access network consists, in the main, of twisted copper pairs. However, other media are also in use, such as optical fibre, coaxial cable and radio. A range of network topologies is also in use: star, tree and ring. If the NTE in the customer's premises is also included as part of the local access network, then the overall technology used becomes an important aspect. For instance, twisted copper pair can be used to deliver simple analogue speech or digital signals up to (and in the near future beyond) 400 kbit/s. These technologies, in turn, are used to create and deliver the many services that BT supplies to its customers.

In order to increase the bandwidth and flexibility for customer service delivery, ever more complex technology is being developed. The large investment needed to develop this is inevitably concentrating the source of such technology in a small number of very large multinational companies. This means that all network operators in future could potentially have the same range of technology with which to deliver customer services. It is therefore the efficiency with which network operators manage the technology resources available to them that will distinguish them. The technology itself will be a secondary issue in gaining profitability. Market share will be determined by an operator giving customer satisfaction and value for money.

† BT Development and Procurement

Technology variants have been evolving, and are continuing to evolve, and are providing network planners with a diversity of solutions for any one customer application. These local access network technology variants can be regarded as an expanding portfolio of piece parts. It is these piece parts that BT as a service provider and network operator must use and manage in order to meet customer requirements efficiently, flexibly and economically.

TECHNOLOGY VARIANTS

When discussing the management of the local access network, it is useful to establish what some of the technologies used are, and what management opportunities they provide. This article does not attempt to be a definitive reference of all technologies in use or proposed by BT for the local access network. It should, rather, provide an insight into some of the technological possibilities and their individual management considerations. The technologies have been chosen in order to highlight the main management issues associated with topology, media and analogue/digital systems.

A number of management considerations are common to all or many of the technologies. These include:

- configuration, capacity and geographical location of underground plant—manholes, joint boxes and duct;
- configuration, capacity, physical make-up, transmission characteristics, allocation and geographical location of cables;
- potential serving domain of distribution points (DPs);
- test access; and
- inventory and performance aspects of element types.

Single Pair of Metallic Wires

This is the most basic of all technologies and the backbone of many more complex technologies. A single pair of wires is dedicated to an individual customer circuit. It has a star topology, with the possibility of multiple flexibility or cross-connection points between the MDF and the NTE at the customer's premises. The NTE for this technology is a purely passive device. This technology can be used to deliver POTS (plain old telephone service), Telex or private circuit services. (See Figure 1.)

Specific management considerations include:

- the configuration, capacity, pair allocation and geographical location of cross-connection points (MDF, primary cross-connection points (PCPs) and DPs);
- the determination of transmission loss parameters given line length; and
- the monitoring of cable pressure alarms.

Metallic Pairs and Modems

This technology uses the metallic pairs to transport data in analogue form (Figure 2). The modem is used as the conversion unit from analogue to digital transmission. If the technology uses a single metallic pair, then it may be connected to a standard analogue line card in the local exchange to provide public switched telephone network (PSTN) access. It may also be used for low-data-rate private circuits. The use of two metallic pairs is another option for providing higher-data-rate private circuits.

Specific management considerations include:

- all those involved with single-pair metallic-wire technology;
- remote soft configuration of the modem unit;
- test access and diagnostics; and
- event handling.

Pair Gain—DACS1

The Digital Access Carrier System No. 1 (DACS1) is a two-channel technology providing analogue interfaces to the exchange and the customer, but using digital transmission between the units (Figure 3). The medium used is a standard single metallic pair. The NTE is a purely passive device. This technology can be used for access to the PSTN or for analogue private circuits.

Specific management considerations include:

- all those involved with single-pair metallic-wire technology;
- configuration of multiplexing units to the single metallic pair;
- logical/physical addressing of multiplexing units;
- planning/feasibility given transmission loss parameters;
- basic line test facilities of the metallic drop to customers, with the provision of mimic impedances for exchange line testers, to enable the correct repair staff to be dispatched; and
- monitoring of the digital transmission path.

Fibre Access Network (FAN)

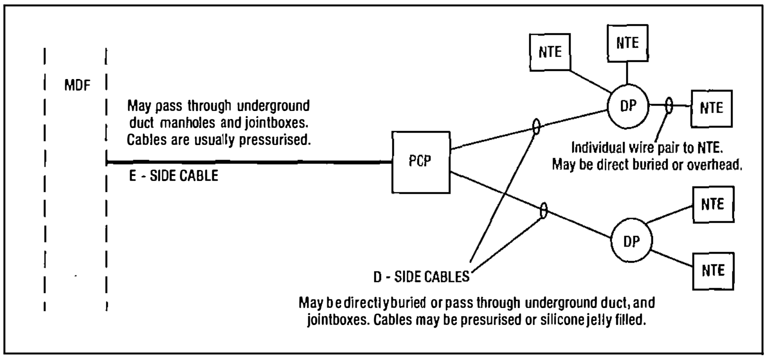
With this technology, the customer's premises are connected to the local exchange by optical fibre. This provides an access mechanism for several services (Figure 4). The connection comprises a number of fibres to allow diverse routing for reliability.

The equipment at the customer's premises comprises opto-electronics, high-order multiplexers, line transmission protection switching, and common equipment, which together comprise the network service module (NSM).

The primary multiplexers consist of a series of line cards which provide the interface to the customer (via the building distribution frame) for the services required. These 64 kbit/s inputs are then multiplexed together for forward transmission via the high-order systems to the exchange serving site.

At the serving site, the high-order systems are demultiplexed back down to 2 Mbit/s low-order systems. These are forwarded, via the bearer transmission network, to the service networks (for example, PSTN, X-Stream, or integrated services digital network (ISDN)).

Specific management considerations include:



MDF: Main distribution frame   DP: Distribution points
PCP: Primary cross-connection point   NTE: Network terminating equipment

Figure 1—Metallic pairs

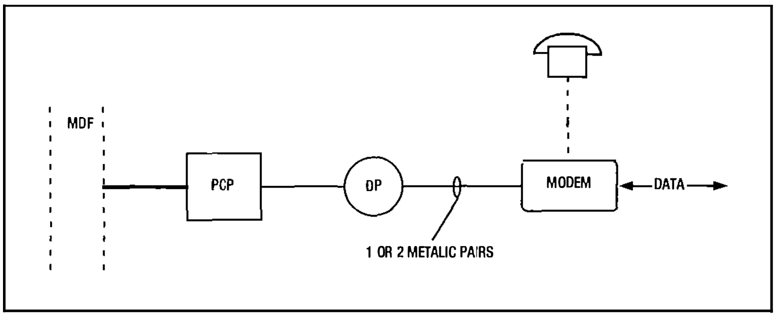


Figure 2—Metallic pairs and modems

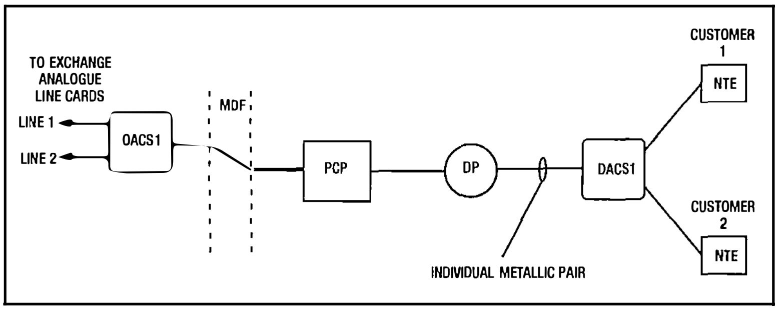
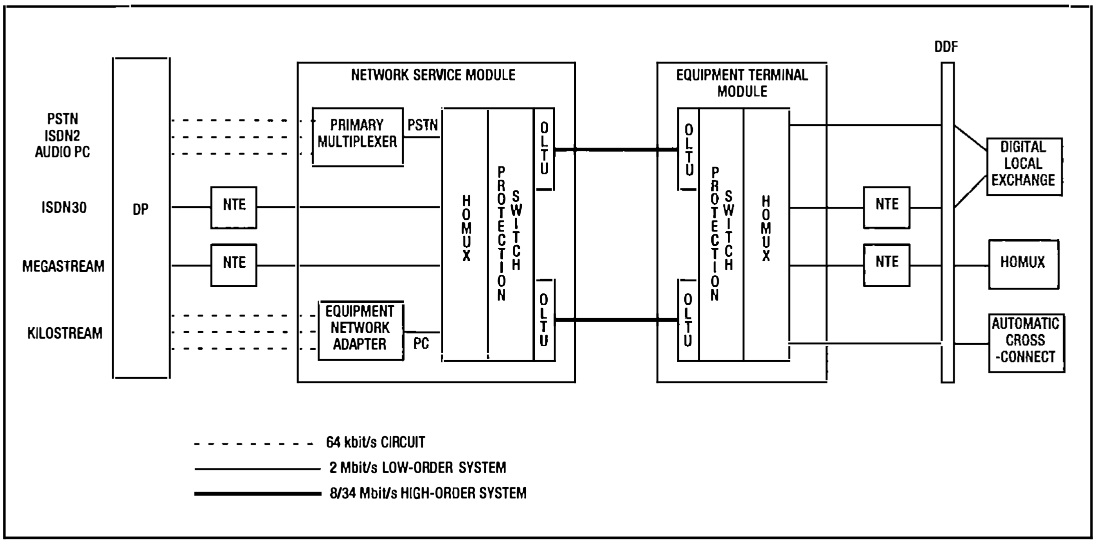


Figure 3—Pair-gain Digital Access Carrier System No.1 (DACS1)

Figure 4
Fibre access network configuration



HOMUX: High-order multiplexer OLTU: Optical line terminating unit

- configuration and allocation of elements—MUX, line card, optical end, NTE type;
- state control of elements; and
- automatic event reporting.

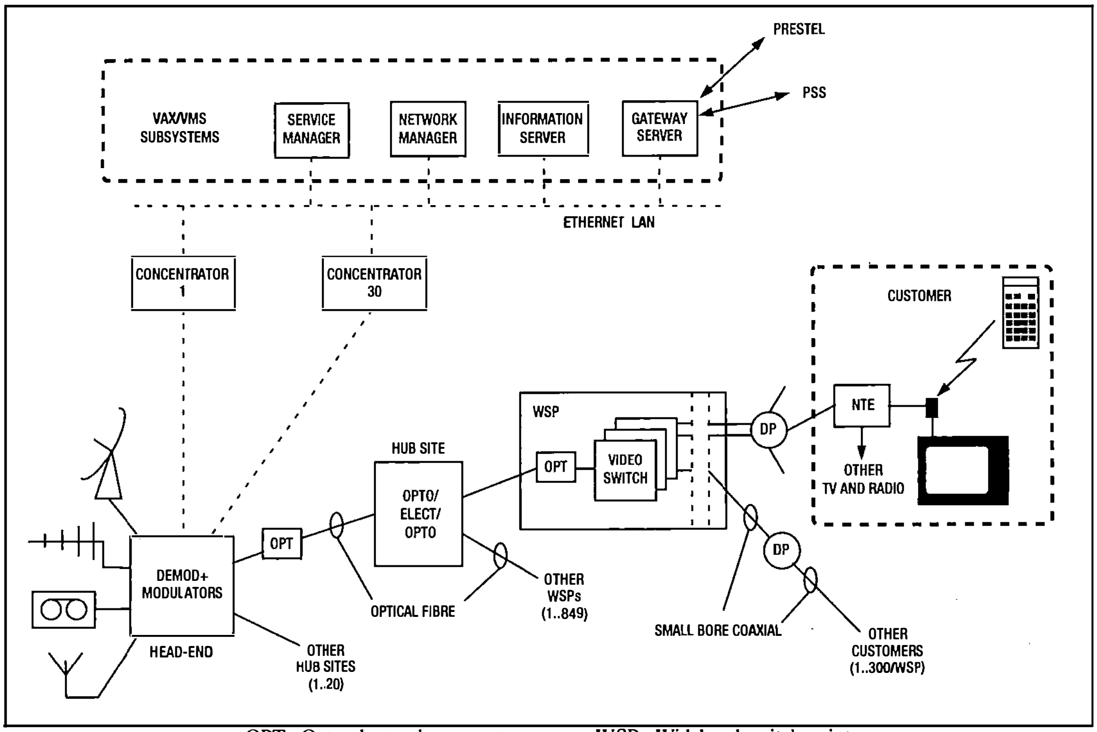
Optical Fibre, Switched Broadband

This is the technology employed in BT's switched star cable TV network (Figure 5). The only extant installation is located in the City of Westminster[1,2]. Video channels are multiplexed together and transmitted down optical fibres, four video channels per fibre. Some video channels are broadcast via the hub-site, which performs fan-out, to the wideband switch points (WSPs). Other video channels are sent via dedicated optical fibres to the WSP. The WSP converts the optical signals to electrical signals and feeds them to the inputs of the video switches. When a channel is selected by the customer, the appropriate switching is performed by the WSP to provide the required signal. The final link to the customer is via small-bore coaxial cable. Text generators in the WSP allow for customer interaction with information databases held at the head-end.

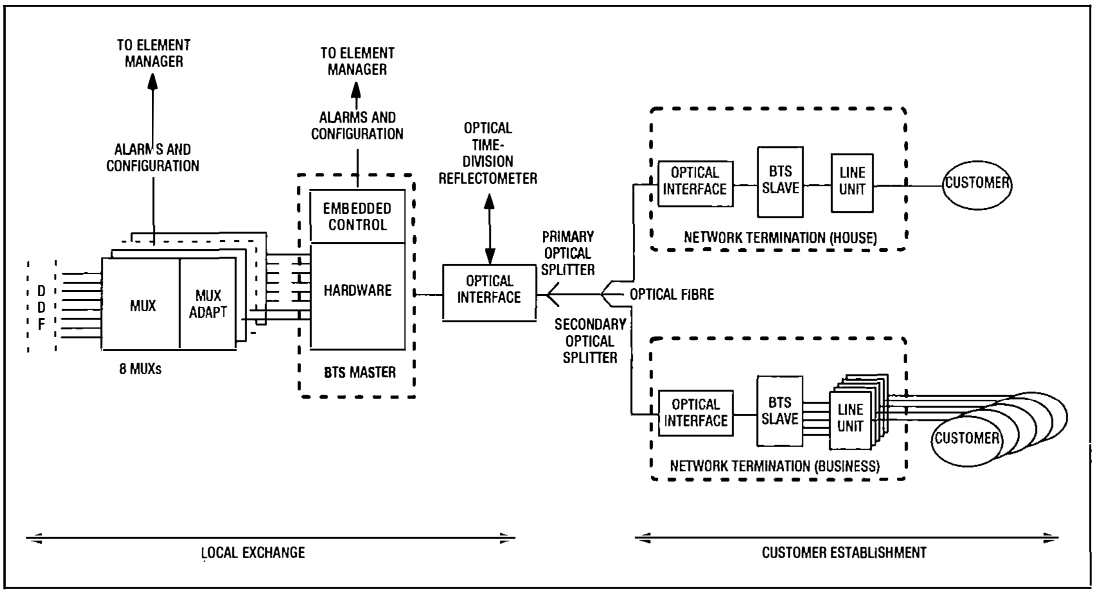
Specific management considerations include:

- configuration of subsystem control and data links;
- configuration and allocation of subsystem elements;
- serving area of WSPs and DPs;
- monitoring and control of subsystem and element states;

Figure 5
Switched-star cable TV schematic



OPT: Opto-electronic converter WSP: Wideband switch point



BTS: Bit transport system DDF: Digital distribution frame

Figure 6
TPON schematic

- automatic event reporting for subsystem elements;
- signal strengths;
- performance aspects of element types;
- remote update of the WSP database; and
- passing information to control customer access to video channels and/or data services.

TPON (House/Business)

TPON[4,5] (telephony over a passive optical network) is a digital technology which uses optical fibres in a 'tree' topology and time-division multiplex (TDM) and time-division multiple-access (TDMA) techniques (Figure 6). The opto-electronics are used to separate the multiplexers from their line cards. This allows the MUX line card to be remotely located in the customer's establishment. For residential or house TPON, the NTE contains only a single line card. However, for business applications, the NTE can contain a number of line cards, each of a different type. The services provided by this technology are dependent upon the type of line card used, and the bit capacity allocated.

Specific management considerations include:

- potential serving domain of the secondary splitter;
- configuration and allocation of elements; MUX, line card, bit capacity and position within TDMA, optical end, and NTE type;
- state control of elements;
- automatic event reporting;
- attribute set up of the bit transport system (BTS) slave; and
- test access, including optical time-domain reflectometry.

Radio, Point-to-Point

As Figure 7 shows, a multiplexer is remotely located at the customer's establishment and linked by the use of a line-of-sight radio system. It is currently used only to provide MegaStream.

Specific management considerations include:

- geographical location of radio units and multiplexer;
- planning/feasibility by determination of line of sight, avoidance of interference to or from other systems, signal strength;
- allocation of frequency;
- configuration of the multiplexer; and
- line card types, locations and allocation.

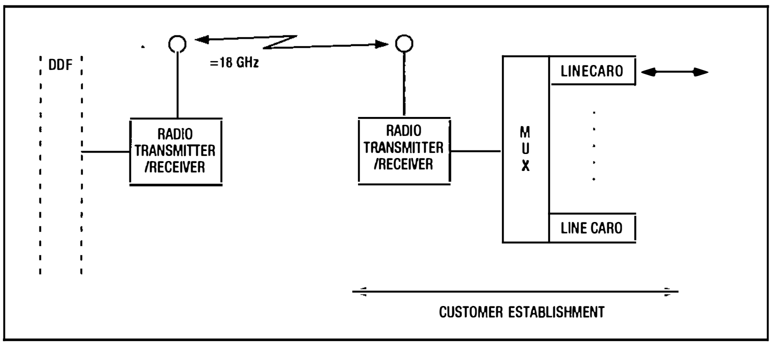
Mobile GSM

GSM (*groupe speciale mobile*) uses digital cellular radio techniques to provide connection from portable or mobile telephones into the PSTN. The specification is common across Europe and will allow suitably authorised mobile telephones to access the system at any point in its coverage area across Europe. The system will allow data calls to be made as well as voice calls and also provides a paging service.

Specific management considerations include:

- base station site planning and cell coverage area determination;
- cell frequency allocations;
- GSM network planning and PSTN access point determination;

Figure 7
Radio schematic



- mobile authorisation, both on first subscription and per call;
- call accounting, charge determination and assignment;
- system performance monitoring and refined coverage area determination; and
- system growth planning and provision.

Cordless DECT

The DECT (digital European cordless telephone) standard provides for low-power digital portable radio telephones providing connection to a base station over a short range. The base station may be located in the home, connected to a standard telephone line, or may be located in a public place; for example, a railway station or motorway service area. In this case, only outgoing calls from the portable can be made. The technology can also be used to provide a PBX service.

Specific management considerations include:

- base station site planning and coverage domain determination;
- DECT public access network planning and PSTN access point determination;
- portable authorisation on first subscription;
- call accounting, charge determination and assignment;
- system performance monitoring; and
- system growth planning and provision.

MANAGEMENT CONSIDERATIONS

The local access network is unique in at least one respect of its management requirements: the need to determine the potential network access points or points of sale with respect to a geographic identifier for the customer's address, the postal address or map reference coordinates.

It is likely that in the near future a given customer location may be served by more than one technology. Management systems must be able:

- to identify the technologies capable of providing the service required by the customer, and
- to select between the different technologies on the basis of cost, reliability, performance and availability.

In the event of insufficient capacity, the management system should also be capable of managing the provision of customer service via a relatively more expensive technology in order to satisfy an urgent requirement. This would be followed by supervising the planning and transition (at a later date) to a more cost-effective technology. For example, it may be possible to provide a customer's circuit quickly via a radio-based technology, while planning a change to a fibre-based technology. It may also be possible to upgrade a metallic-pair-based technology as a result of opportunities presented by the introduction of pair-gain systems.

The impact on the planning process of the presence of multiple alternative networks is likely to be considerable.

In addition to the management considerations of the various technologies, future network and service management systems should also consider the issues of facilities required by the network operator:

- Customers should be provided with a single point of contact for all their enquiries and calls for assistance. It should be possible once the customer has requested assistance to be able to respond rapidly to the customer, regardless of topic. Comprehensive work management facilities should be available to support field installation and maintenance activities.
- Centralised network management centres should have the ability to test circuits remotely. By employing the techniques of routining, alarm gathering and 'hot-spot' analysis, these centres should also be capable of detecting any deterioration of service, ideally before, but at least as soon as, a customer experiences difficulty. It should also be possible for faulty circuits to be taken out of service automatically and the network management centre informed. Auto-transfer of service to back-up circuits should be undertaken where the technology in use allows for diverse routing. Wherever possible, maintenance tasks should not degrade the quality of service, and field maintenance activities should be minimised.
- Strategic objectives for management systems should ensure that the system design is evolutionary and expandable for the easy addition of new operational facilities and the management of new types of technology. In order to achieve this, the system design should conform to an overall telecommunications management architecture employing international and open standards as these emerge. It will be this system design that provides a competitive edge for the network operator over its rivals.

The ability of management systems to meet these objectives will depend on the underlying network technology in use, in particular the degree of built-in intelligence for monitoring and control, and equipment redundancy for fault-recovery.

Network operators and the technology providers of new equipment or services often have different perspectives of management requirements. A technology provider would normally wish to sell equipment and an associated management system to cover all aspects of its use, from service management through to the operation of the network elements. The technology provider perceives a complete turnkey system as the best way to market his product, so he produces a *vertical slice* (Figure 8). This will contain an integrated management capability, but for this particular product only. The network operator, on the other hand, will have structured (or planned to structure) his operation in a layered fashion, in *horizontal slices* to provide a single customer-facing point of contact for *one-stop shopping*, which is considered to be the key to fostering good relationships with customers.

The different perspectives of network operators and technology providers could both be addressed in the same system package from a technology provider. This would provide interfaces at the business level, service level and network control level to facilitate integrated working to satisfy the network operator, while still providing a complete turnkey operation for those who require this.

The different technologies described above provide the network operator with many varied opportunities and challenges. With the different technologies available, and an integrated management solution with customer access, it is likely that in the future the customers themselves will be able to configure new services without the intervention of the network operator.

To reduce the provision time of customer circuits, it will be necessary to ensure that as much of the time-consuming preliminary work as possible is carried out in anticipation of a customer order. With the growth of competition to supply even basic telephony service, improved efficiency must be given more attention. In the US, operators are increasingly employing the *warm dial-tone* concept, where new buildings are pre-wired and telephone sockets connected through to the exchange. The new resident plugs in a telephone purchased from the local store and is connected directly to the network operator's customer service office. The new sale can be initiated immediately, with the required record changes, billing function, directory number allocation and service provision taking place automatically. To achieve this, a fully-integrated set of management functions must be in place.

MANAGEMENT SYSTEMS ARCHITECTURE

It is important that network management systems are developed to overall architectural standards if such systems are to interwork and to provide integrated network management and service administration across the network at all levels. Recognising that the local distribution network is an integral part of the overall telecommunications network, it is important that management of the local network evolves within such an overall architectural framework. The following outlines a general architectural model considered from a local network viewpoint.

The architecture for telecommunications network management is defined in terms of a hierarchy of five layers[6], as shown in Figure 8. Starting from the bottom layer, the network is partitioned into network elements which are treated as distinct network entities from a management viewpoint but which cooperatively provide a service to the customer.

As shown earlier, the local access network is made up of several managed element types; for example, network termination units, MUXs, cables and DPs. Each network element has an associated element manager. This may, in practice, be a separate processor linked to the element, or

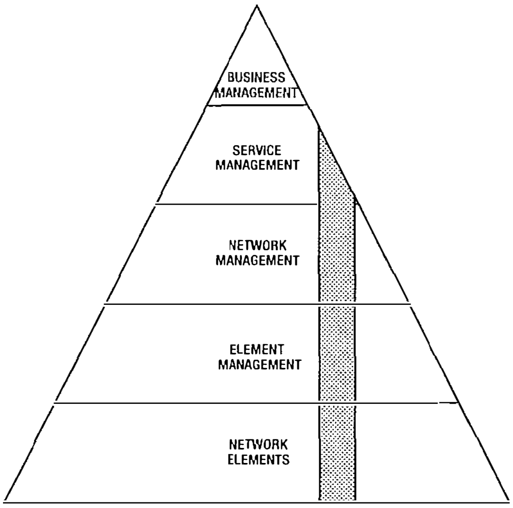


Figure 8—CNA-M architecture—outline

software embedded within the element. An element manager would normally manage multiple instances of an element.

The network management layer, in turn, supervises the various element managers. This is the first layer where the management relationships among elements are coordinated to provide overall network and technology supervision. The interface between an element manager and element may be specific to that element type. The element manager 'hides' equipment variability from the higher network management layer. For example, there may be different types of modem in the network, all providing the same basic service, but requiring different control streams to configure them. The differences would be confined to the element manager level.

This *layering*, applied to the components which form the local access part of the network, is exactly the same as that applied to the switching and transmission parts; the architecture is common.

Work management facilities would be linked to this level to ensure that maintenance and repair activities are coordinated with network management.

Thus the higher-level interface between element managers and network management is independent of particular equipment implementations. This application of the design principle of 'layering' achieves open network management whereby the network control level can develop independently of changes in underlying equipment.

The interface between network and service management levels is defined such that service management need not know about the physical details of the network and need be concerned only with administration of the services that the network supports. Service management should have sufficient interaction with the network to allow comprehensive development of single-point-of-enquiry and one-stop-shopping administration facilities. Refining this general model from a local network viewpoint, the elements making up the overall telecommunications network fall into two

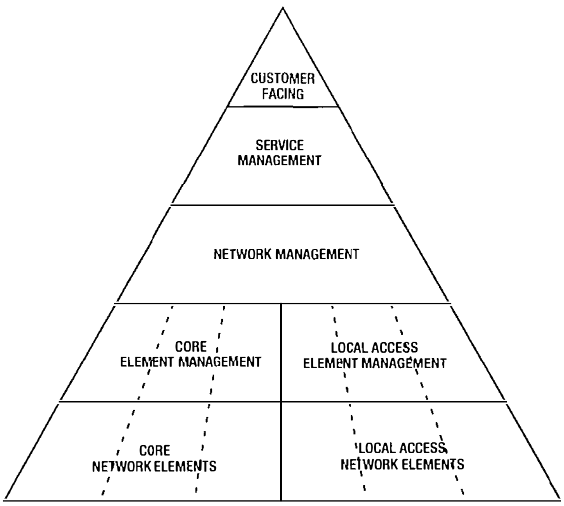


Figure 9—CNA-M architecture—local access perspective

groups: those within the core segment and those within the access or local segment of the network, with their respective element managers. Coordinated supervision is necessary across the access/core segment boundary, and would be implemented at the network management level, as represented by Figure 9.

Traditionally, different services have been carried on physically separate bearer circuits, particularly in the local network. The management of the services and of the networks that bear them have often been common. In future, multi-service networks will be the norm, and services and networks will have to be managed separately if the desirable layering structure is implemented across the network operator's business. Agreements will need to be made between the service and network management units to ensure that the overall quality-of-service requirements of the customer are fully met.

A model for technology-independent management of the local access network based on CNA-M (Cooperative Networking Architecture-Management) is currently under consideration. The model attempts to prevent diversification or duplication of effort, and the urge to re-introduce vertically segmented solutions when new technologies and services are developed.

FUTURE WORK

The model achieves technology independence through the functionality of the layers, the data contents of the layers, and the data definitions and relationships. The model defines the local access network using object-oriented techniques and the use of the Open Systems Interconnection (OSI) Network Management Forum object library. Data are passed between the functional categories and the layers by using the OSI Common Management Interface Protocol.

The model uses the standard CNA-M network control layer functional categories: configuration, event handling, performance, access and security, planning, finance and resource management to achieve conformance with the architecture and to encourage reusability.

It should be noted that changes will have to be made to the current management systems and processes if substantial benefits towards managing the local access network in a technology-independent manner are to be made.

It may well be that, in future, the business case for the introduction of new proprietary technologies will include a requirement for the product to be capable of control by using the established management model, to ensure that BT maintains a coherent product set.

ACKNOWLEDGEMENTS

The authors are indebted to all the people involved in the FAS, FAN, SSN and TPON development projects. This article contains some information from an earlier paper[3].

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Biographies

Ken Maynard joined the then British Post Office (BPO) in 1965 as a student apprentice. He graduated in 1969 with a degree in Electrical Engineering from Imperial College, London University. He then joined a team developing an early computer-controlled switching system, the Cordless Switchboard System No. 2. He completed an M.Sc. in Computer Studies at Essex University in 1974. Since then, he has worked at BT Laboratories on several development projects, including the switched-star cable TV system currently operational in Westminster. More recently, he has taken responsibility for Local Access Management Systems in Network Management Department.

Philip Hawley joined the then BPO in 1969 as a trainee technician apprentice in Sheffield. After completion of his apprenticeship, he worked on junction and private circuit provision duties. He gained BT sponsorship to study at Huddersfield Polytechnic and in 1982 was awarded a B.Sc. Honours degree in Electrical and Electronic Engineering. After graduating, he joined BT Laboratories and worked on the development of a network management system for the BT switched star cable TV network and later on the network management system for TPON and BIDS as part of the Bishops Stortford Fibre Trial. His current work includes the management and object modelling of the local access network.

Alarm Management

R. J. MCFARLANE†

This article gives an update on progress made in the area of centralised alarm management since the publication of the October 1989 Journal *article 'Centralised Exchange Management Using Gateway Products'*[1]*. The alarm management architecture for analogue and digital exchanges is given together with current and future developments of the Network Operations Management System 1 (NOMS1).*

INTRODUCTION

Centralised exchange management and line test systems have been developed from the early-1980s to the present day by a small team of network engineers based in Edinburgh. This 'Gateway' team is now part of BT's Development and Procurement Glasgow Engineering Centre. Since the 1989 *Journal* article on centralised exchange management[1], the team has been involved in enhancing and supporting alarm management systems to meet the needs of the Network Administration Implementation Programme (NAIP). In particular, the Network Operations Management System 1 (NOMS1), formerly the alarm collection facility, plays a key role in the fault and repair management area of network operations. Although NOMS1 is currently a standalone system, the potential for further improvements in alarm management and fault repair can be best realised by providing links to other systems used by engineers in network operations units (NOUs). Links from NOMS1 to NOMS2, the interim work management system, have been developed to meet current operational needs. However, the fault and repair management systems (FARMS) evolution will define the way in which NOMS1 will be linked in with other initiatives, such as the problem manager workstation (PMW), to provide a coherent set of systems.

EXCHANGE ALARM MANAGEMENT SYSTEMS

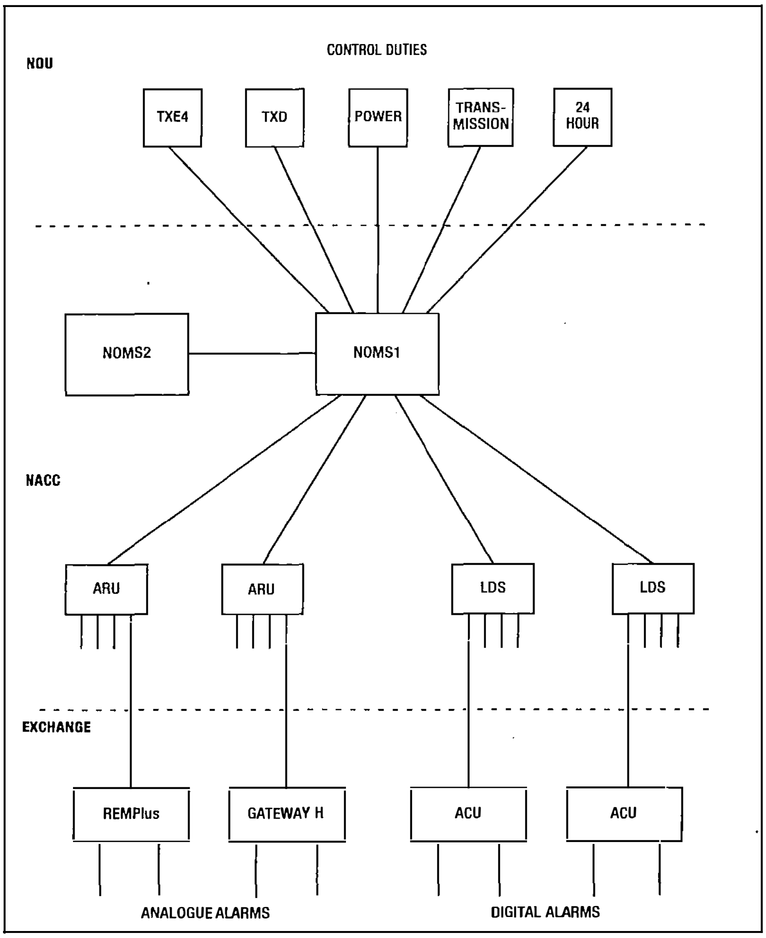
Outline Architecture

Figure 1 outlines a typical alarm management system deployed throughout the country.

Reference 1 describes this architecture in some detail. A brief overview is now given. Alarms are collected from all types of exchange; for example, digital (TXD), electronic (TXE), crossbar (TXK) and Strowger (TXS). Examples of the type of alarms collected are:

- auto,
- main control unit (MCU),
- power,
- transmission equipment,
- cable pressurisation,
- fire, and
- intruder.

All exchange types have remote units located either in the exchange or in a nearby location. For analogue exchanges, the remote units are either Gateway REMPlus or Gateway H remote. For digital exchanges, this will be the alarm collection unit (ACU). These units have the same basic function; that is, to collect and forward alarms. Concentration of alarms is carried out before forwarding to NOMS1 by the alarm reporting unit



ACU: Alarm collection unit
ARU: Alarm reporting unit
LDS: Local display shelf

Figure 1
Typical alarm management system

† BT Development and Procurement

(ARU) for analogue, and the local display shelf (LDS) for digital alarms. The alarm handling system (AHS) comprises the ACU together with the LDS. NOMS1 carries out a wide range of functions, some of which are listed below:

- It provides alarm name translation.
- It provides alarm delay.
- It distributes alarms to the relevant destination workstation; for example, TXE4, transmission, power and so on.
- It filters alarms, giving visibility of alarms with a certain priority.
- It attempts automatic alarm resets.
- It allows manual alarm resets.
- It provides automatic alarm transfer when one destination logs off.
- It provides interrelated alarms—alarms not displayed until a user-defined threshold is reached.

NOMS1 currently supports two formats of alarm messages: those from the ARU and from the AHS. The ultimate aim is to standardise the ARU message format to which new alarm management systems must conform.

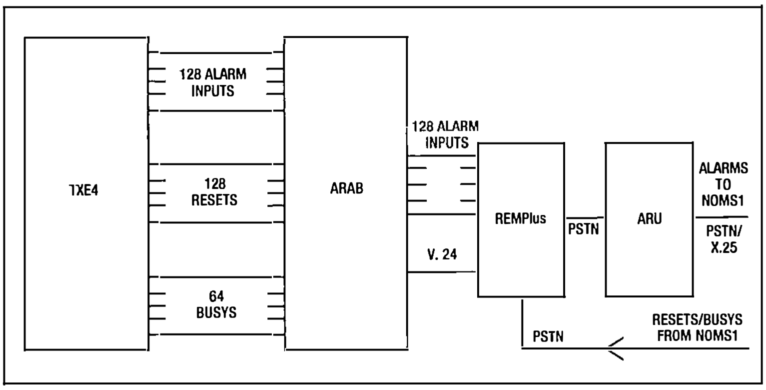
Although Figure 1 shows only ARU and LDS as alarm inputs to NOMS 1, other alarm collection systems have been deployed and perform the same function; CSX1200, SIGNALMAN, DAM5001 and REAMS, which feed alarms to a personal computer (PC) that inputs to NOMS1, are the other preferred systems. Several other systems are in use in addition to these.

Figure 1 shows a link to NOMS2, which was implemented in V3.2 of NOMS1. This link is not yet operational, and its implementation will be considered as part of the FARMS evolution in order to secure the maximum operational benefit. Introduction of an electrical link to work management will further automate the process of alarm handling.

Managing TXE4s

NOMS1 can remotely manage alarm reset and busy (ARAB) functions for TXE4 exchanges. To provide this functionality for TXE4s, a microprocessor-controlled unit has been developed to BT specifications. Figure 2 shows the ARAB connection arrangements.

Figure 2
ARAB connections



PSTN: Public switched telephone network

TXE4 alarms are fed via the ARAB unit to the associated REMPlus which forwards them to NOMS1. In addition, 128 reset and 64 busy channels are provided to allow TXE4 equipment to be reset and brought in or taken out of service (busy) under control of NOMS1 via the REMPlus unit.

ARAB Reset

ARAB configuration is carried out by the databuilder and includes macros which allow equipment resets to be actioned from NOMS1 by use of a single key stroke; for example, the BUSY - RESET - UNBUSY macro is used to reset MCU equipment in line with the TXE4 rule set.

ARAB Busy

TXE4 equipment is busied out from NOMS1 by entering the NOMS1 name for the exchange equipment and selecting the ARAB busy function.

NOMS1 Platform

NOMS1, under the name of the alarm collection facility, was initially developed on the M6000 platform by using the C programming language with the UNIX operating system. As developments in workstation technology progressed, the move to a SUN environment was taken. It should be stressed that the early decision to develop NOMS1 in the UNIX environment has greatly eased the task of moving the application to another hardware platform. The output display device has also changed from alarm display PCs to M1779 terminals. The facilities provided by the change to M1779s are:

- the ability to interrogate alarm reports for any location within the NOMS1 database,
- visibility of active alarms allocated to other terminal users,
- alarm reset functionality integrated with normal terminal usage,
- no need to update every alarm PC when a remote unit name changes or is added,
- alarm titles for remote units controlled centrally, and
- more information passed to terminal users to reduce repetitive NOMS1 database queries.

NOMS1 Roll-Out

The roll-out of NOMS1 was completed in May 1991 with 19 machines installed country-wide to meet the requirements of the 10 NOUs. Initial feedback from NOU engineers is as follows:

- reduction in number of call-outs (approximately 70% reduction),
- essential for NOMS1 to be operational 24 hours/day, 365 days/year to provide visibility of alarms throughout the country, and
- the need for standard alarm configuration for different exchange types.

Feedback is provided directly to the NOMS1 support team from the users. As roll-out has progressed, the level of support and feedback has greatly increased. Feedback provided to the support team is recorded and results in a fault report or a facility change request being generated. These are used as inputs to the user-group meeting, which agrees the content of the next release.

Operational Usage

Each NOU has several control areas assigned to manage the network within its catchment area. A typical NOU control area layout is shown in Figure 3 together with the support systems used. It can be seen that NOMS1 is the key system in providing visibility of alarms. Currently, the Customer Service System (CSS) is used as the means of allocating and actioning fault repair. TXS alarms are extended to the 24 hour control area in the NOU during out-of-office hours.

LINKS TO OTHER SYSTEMS

The need for a coordinated approach to alarm management has been recognised and is being addressed by the FARMS evolution study.

FARMS will evolve the systems involved in fault and repair management, including NOMS1, to provide comprehensive support to engineers in the NOU. Among its objectives are:

- to provide network engineers with a single 'picture' of all alarms and faults within their catchment area,
- to correlate fault reports from different systems and facilitate automatic forwarding of work tasks to a work management system (WMS), and
- to provide a standardised approach to alarm and fault management.

Figure 4 shows an early stage in FARMS evolution where the problem manager workstation (PMW) is the means of providing the overall 'picture' to network engineers. NOMS1, transmission network surveillance (TNS) and the operations and maintenance centre (OMC) are some of the systems from which the PMW will process and correlate fault reports. The PMW will forward diagnosed problems to the WMS for action[2].

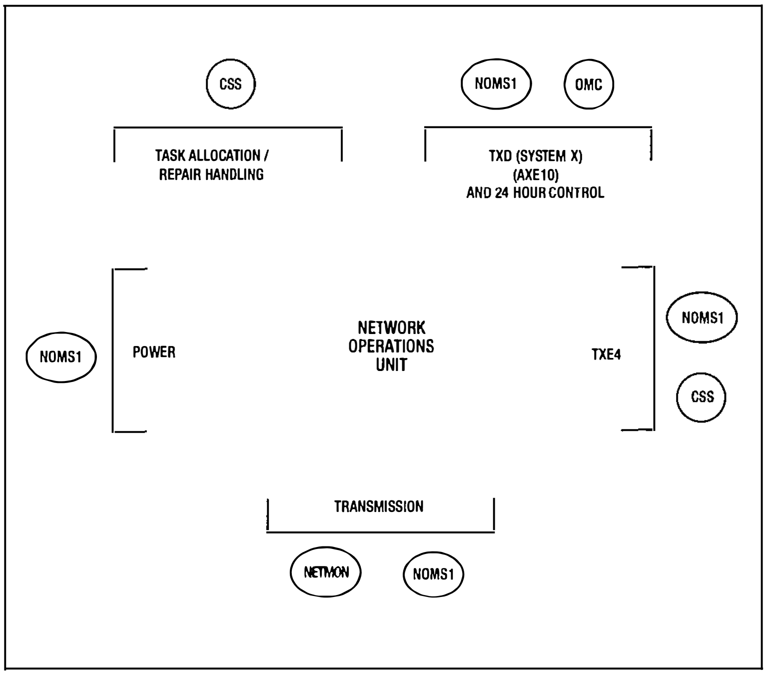
NOMS1 FUTURE EVOLUTION

NOMS1 will evolve to satisfy the requirements of the business on two levels:

(*a*) to be part of the NAIP vision of alarm management for the future (FARMS evolution), and

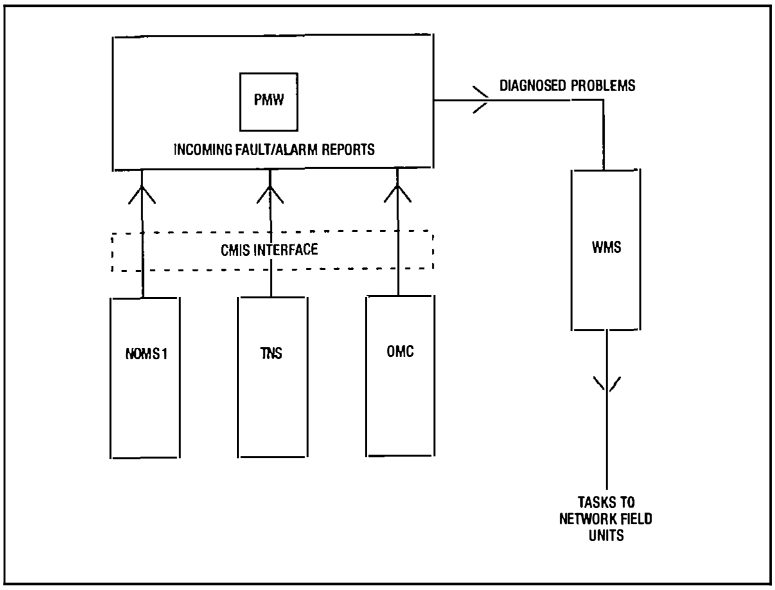
(*b*) to meet NOMS1 users' short-term operational requirements.

The process of agreeing future enhancements to NOMS1 is now well defined and controlled. The opportunity exists for operational managers to become involved in the evolution of NOMS1 by providing feedback on the suitability of proposals put forward at a strategic level. In addition, operational managers are best placed in many instances to identify opportunities for making further improvements in alarm management. This may result in enhancements to existing systems or in identifying new systems that are required to help them meet their objectives. Any new systems may have only a short lifespan until strategic systems are realised and operational. It is hoped



OMC: Operations and maintenance centre

Figure 3—Typical NOU control area layout showing control duties



PMW: Problem manager workstation
CMIS: Common management information service
NOMS1: Network operations management system 1
OMC: Operations and maintenance centre
TNS: Transmission network surveillance
WMS: Work management system

Figure 4—Problem manager workstation

that this top-down, bottom-up approach will ensure that the needs of managers and engineers at all levels are met. Some proposed enhancements to NOMS1 are given to provide an indication of future direction:

- multiple alarm displays,
- support for enhanced TXE4 remote administration, and
- provision of Cooperative Networking Architecture (CNA) conformant interfaces to other systems.

CONCLUSION

With NOMS1, alarm management has taken a large step forward in providing operational engineers with the tools they need to meet their objectives and thus providing customers with a first-class service. The scene is set to provide greater visibility of alarms from all parts of the network and to instigate action automatically for their repair.

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Biography

Dik McFarlane joined the then British Post Office in 1967 as a trainee apprentice in Glasgow and worked on trunk exchange construction until 1979. He graduated with a B.Sc. in Electronic and Electrical Engineering from Strathclyde University in 1983 and moved to Ipswich to work on technical standards for home systems. In 1986, he returned to Glasgow to work in the West of Scotland District Information Systems Unit and joined the Software Development Division in 1988 when the Glasgow centre was set up. He is currently a section manager in Glasgow and has responsibility for both NOMS1 and Gateway systems in addition to other projects related to network management.

The BT Network Traffic Management System: A Window on the Network

R. GARRISON†, A. SPECTOR, and P. C. DE GROOT*

Network traffic management involves supervising the telephone network and taking action to control the flow of traffic to maximise call success rates. The BT network traffic management system (NTMS) has been purpose-built for this role; it uses near real-time surveillance of network status and performance to enable prompt control of traffic flows as necessary. The development programme, started in 1982, has produced a world-class product, which is used for managing BT's inland network and has been sold successfully to Telefonica, the Spanish PTT, and Cellnet. This article describes the progress to date, and the functional characteristics of the NTMS, and explains why the NTMS is well placed to ensure improvement in network quality in the 1990s.

INTRODUCTION

All the world's leading telecommunications operators have come to realise that real-time surveillance and control of networks are essential for maintaining network service and providing quality to the customer.

Modern network traffic management (NTM) was first identified at a conference of regional AT&T managers held in the autumn of 1960. Hurricane Donna hit Florida during the conference, and the increased number of calls from worried customers overloaded and knocked out a local common-control trunk exchange and congestion spread, tying up main switching centres throughout the US. Although many miles from Florida, the conference delegates experienced so much trouble contacting their families and colleagues, that network management was added to their agenda mid-conference!

An article[1] in the *Journal* by Steve Heap and John Arthur in 1985 explained that digital networks, although resilient and self-regulating in some respects, are vulnerable to certain network failures and traffic conditions. Traffic overloads, such as the one initiated by the Florida hurricane, could not only cause failure of single network elements but could also lead to catastrophic rippling effects throughout the whole network. Real-time traffic management was required to monitor the BT digital network, to identify these conditions and allow network managers to apply protective or expansive controls to the network to maximise call completion rates and hence revenue.

Since 1985, BT has implemented network traffic management systems (NTMSs) for both the inland and international networks, with the operations for the whole network being combined at the Worldwide Network Management Centre at Oswestry over this period. The size of the monitored inland network has increased from 53 exchanges with 8000 traffic routes to nearly 500 exchanges with 40 000 routes. The current system requires reception and processing of over 2·5 Mbytes of data every 5 minutes. NTM control facilities have also been introduced to allow rapid deployment of restrictive or expansive control actions to exchanges to control traffic flows.

† BT Worldwide Networks

* BT Customer Systems

NTMS FUNCTION

CCITT Recommendation E.410 defines network traffic management (NTM) as the function of supervising the network and taking action when necessary to control the flow of traffic. This requires real-time monitoring and measurement of current network status and performance, and the ability to take prompt action to control the flow of traffic. The primary objective is to enable as many calls as possible to be successfully completed. This objective is met by maximising the use of all available network elements and by inhibiting and preventing the spread of congestion.

In terms of the BT Strategic Systems Plan (SSP), the processes which cover NTM operations fall within the 'Manage Network Usage and Performance' process and are: 'Collect and Evaluate Network Traffic Information' and, 'Initiate Solutions to Traffic Problems'.

NETWORK TRAFFIC MANAGEMENT CONTROLS

Network traffic management controls for System X and AXE10 exchanges have been incorporated into operations and maintenance centres (OMCs) which are located at BT's network administration computer centres (NACCs). The NACCs are linked to the Oswestry centre, thus providing network traffic managers with the ability to control the whole digital network from a central point.

There are two main types of traffic control available, expansive and protective:

Expansive Controls

Expansive controls, for example, temporary alternative routing, are generally used to re-route calls that would normally succeed around a problem area, such as loss of a route. Temporary alternative routing involves insertion of additional routing choices into routing schedules so that calls can be redirected from congested routes to other, not normally available, routes which have idle capacity at the time.

Protective Controls

Protective controls, for example, call volume controls, are used to stop calls that are unlikely to be successful, to preserve network capacity for use by other revenue-earning calls which can succeed. Examples of calls that would be restricted are those to phone-in radio and television programmes, where the number of calls made far exceeds the call-handling capability of the recipients. Call volume controls inhibit calls to a particular digit string (destination volume control), to a specific route (route volume control) or on an exchange-wide basis (exchange volume control).

Although the CCITT Recommendations suggest that call volume controls be available on a percentage or call-rate basis, System X exchanges support only the call-rate control, commonly known as *call gapping*. Call gapping works by setting an upper limit on the number of call attempts allowed to a destination or route in a particular period of time *T*. The time *T* can be varied by the network manager to match the call handling rate of a called customer or service provider.

A particular NTMS function which assists the use of call gapping is call analysis on destination or on routes, which can provide data on most commonly called destinations. Once this information is known, the network traffic manager can target the problem destination code(s) with the correct call-gapping rate.

USING THE NTMS

The essence of the NTMS is that network events are represented as clear, visual signals to the network traffic manager. Once an event is visually acknowledged, the network traffic manager uses the workstation facilities to investigate the problem in further detail.

The graphics display (Figure 1) is the primary display component, which is used to highlight those routes and exchanges that have a problem. The gravity of the problem is expressed in colours, red being the most serious and blue the least important. The graphics display also employs a split screen technique to display different schematic views of the monitored network at the same time. The left-hand view is the global display which shows a top-level schematic map of the monitored network and the right-hand view is used for user-selected displays; for example, a particular exchange catchment area.

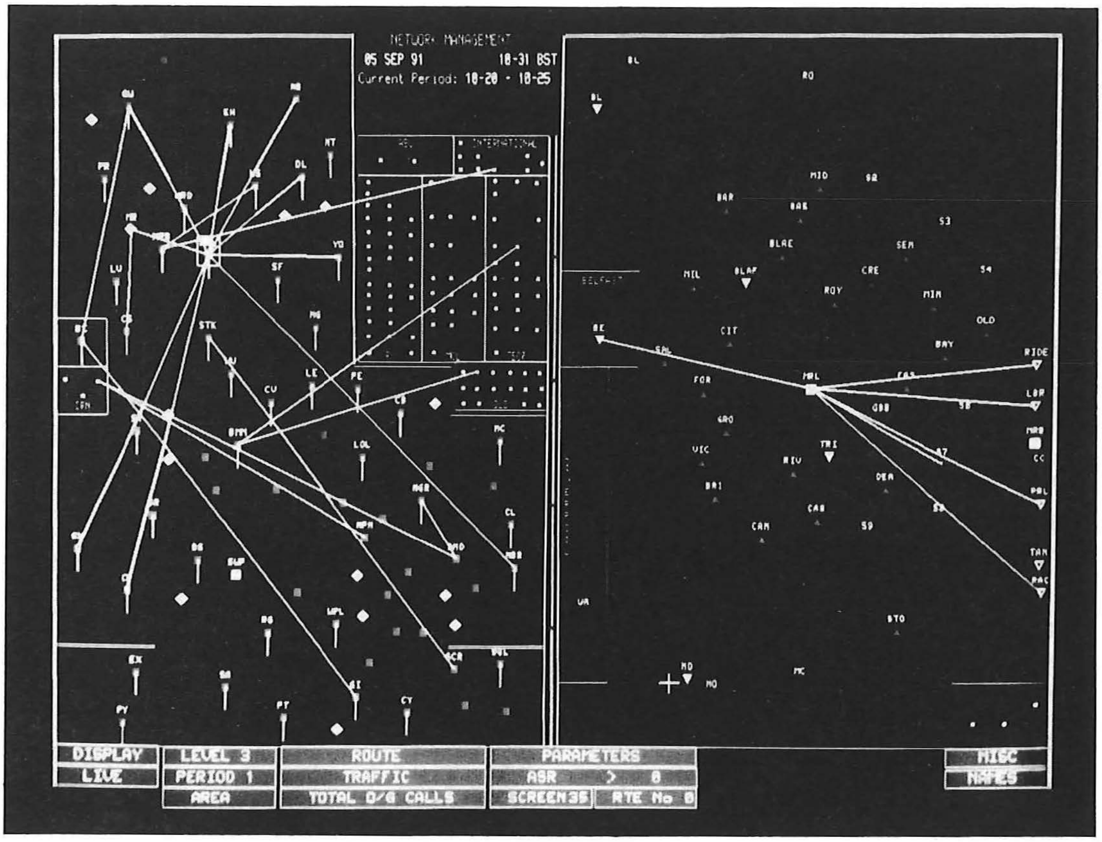


Figure 1
Graphics display, showing split-screen operation

The VDU (see Figure 2) is used to display alphanumeric data on screens which correspond to the selection on the graphics display. These comprise tabular reports of exceptions, parameters and measurements which can be selected for the current and three previous periods.

Using the system, the network traffic managers are in a position to identify particular service difficulties that will not in themselves raise exchange alarms, such as data inconsistencies or sudden changes in traffic patterns, and this window on the network gives them the global view to enable decision making and fast control response.

An increasing problem in telephone networks is the surge of traffic to a single destination or service provider as a result of a civil disaster or unexpected TV/radio phone-in. The result is a rapid increase of call attempts, most of which will fail, and a real risk that 'focus' exchanges will go into overload.

In the case of the Heysel Stadium riot between Liverpool and Juventas football supporters in 1985, the emergency number shown during the TV transmission represented a line connected to a single telephone in Brussels. The huge number of calls that followed caused disruption of national and international communications from Liverpool and the failure of local exchanges in Liverpool itself.

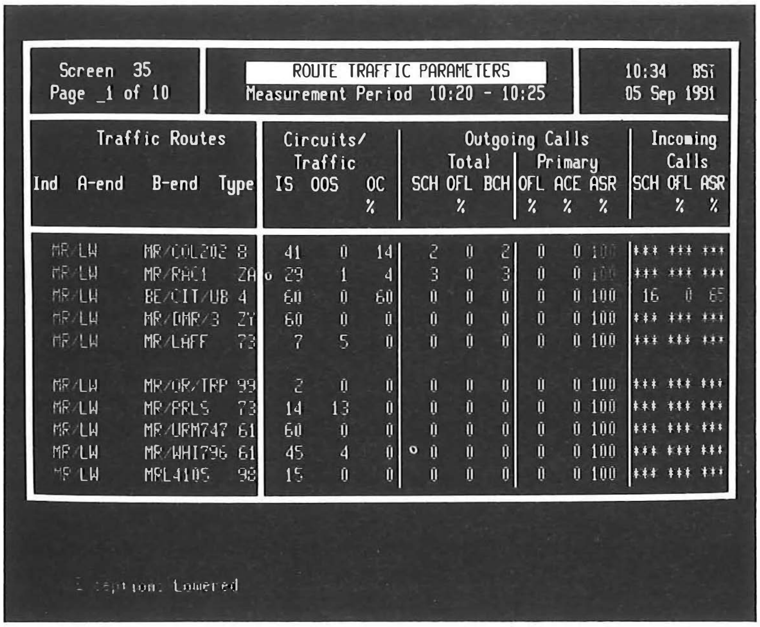
As the number of ineffective call attempts to a particular destination rises above certain thresholds, the NTMS displays the corresponding route exceptions as lines on the graphics display, which will focus on the exchange hosting that 'rogue' destination. The network traffic managers then have to act quickly to identify and restrict the calls to that destination to protect both the network and normal revenue-earning calls.

As experience of network traffic management has grown, the importance of pre-planning has been realised for known phone-in events; for example, Children in Need, Comic Relief and 'peaky' customers such as travel agents and information lines such as Channel 4 Raceline. Uncontrolled, these events would cause sustained overload of the network, leading to unacceptable levels of congestion and failure of switching nodes. By careful planning and knowledge of previous similar events, it has proved possible to anticipate problems and apply controls to the network before the start of events.

SERVING THE CUSTOMER AND BUSINESS

The driving force of network traffic management is to enable as many calls as possible to be completed in any situation. By maximising the success of these calls, NTMS is impacting on how customers view BT and how they use BT services.

When the network traffic managers apply protective controls to the network to stop overloads, it seems that they are stopping customers from getting the service they expect. In fact, quite the opposite is true. By restricting calls that would normally have failed, they are assisting the successful flow of other calls. For those calls that are restricted, facilities are available to route them to recorded announcements which provide information on reasons why the calls were blocked or the best time to re-try those calls.


Screen 35
Page _1 of 10
ROUTE TRAFFIC PARAMETERS
Measurement Period 10:20 - 10:25
10:34 BST
05 Sep 1991

Traffic Routes				Circuits/ Traffic			Outgoing Calls Total			Primary			Incoming Calls		
Ind	A-end	B-end	Type	IS	OOS	OC %	SCH	OFL %	BCH	OFL %	ACE %	ASR %	SCH	OFL %	ASR %
	MR/LW	MR/COL202	8	41	0	14	2	0	2	0	0	100	***	***	***
	MR/LW	MR/RAC1	ZA	29	1	4	3	0	3	0	0	100	***	***	***
	MR/LW	BE/CIT/UB	4	60	0	60	0	0	0	0	0	100	16	0	65
	MR/LW	MR/DMR/3	ZY	60	0	0	0	0	0	0	0	100	***	***	***
	MR/LW	MR/LAFF	73	7	5	0	0	0	0	0	0	100	***	***	***
	MR/LW	MR/OR/TRP	99	2	0	0	0	0	0	0	0	100	***	***	***
	MR/LW	MR/PRLS	73	14	13	0	0	0	0	0	0	100	***	***	***
	MR/LW	MR/URM747	61	60	0	0	0	0	0	0	0	100	***	***	***
	MR/LW	MR/WHI796	61	45	4	0	0	0	0	0	0	100	***	***	***
	MR/LW	MRL4105	98	15	0	0	0	0	0	0	0	100	***	***	***

Figure 2
VDU showing example of tabular reports

By maximising successful calls, and maintaining or improving customer perception of BT, business needs will also be served. Maximising the number of successful calls means maximising revenue and ensuring that capital investment in the network is being properly rewarded. At the same time, data being passed to capacity managers enables more accurate projection of future needs and direction of future capital investment.

NTMS DESIGN

The NTMS is connected to digital exchanges via the administration data packet network. Network traffic measurement data is transmitted to the NTMS every 5 minutes and the data passes through a number of processing stages before it is displayed to the network traffic manager.

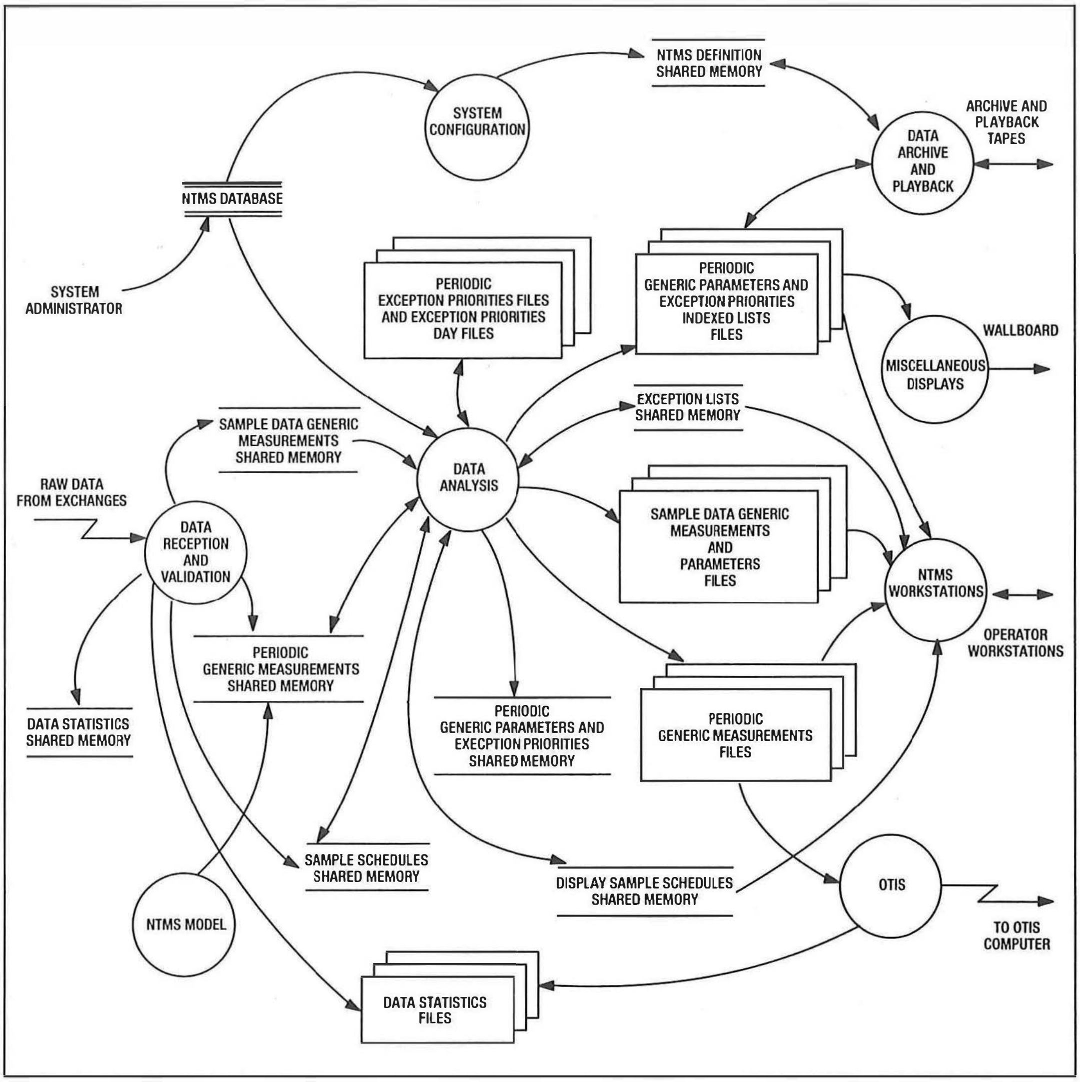
Software Structure

The live NTMS software structure consists of seven main modules which enable the reception, processing and display of data from digital exchanges. Data is transferred between modules using messages, common data areas and disc files. The monitored network and system configuration details are stored in a proprietary Reliance database.

The main software modules and related data flows are shown in Figure 3 and are described below:

- The *system configuration* module enables different NTMS and monitored network configurations to be defined and maintained.

Figure 3
NTMS software modules



Note: The following have been omitted for clarity:
Data flow lines from NTMS definition shared memory to all modules.
Controls module.

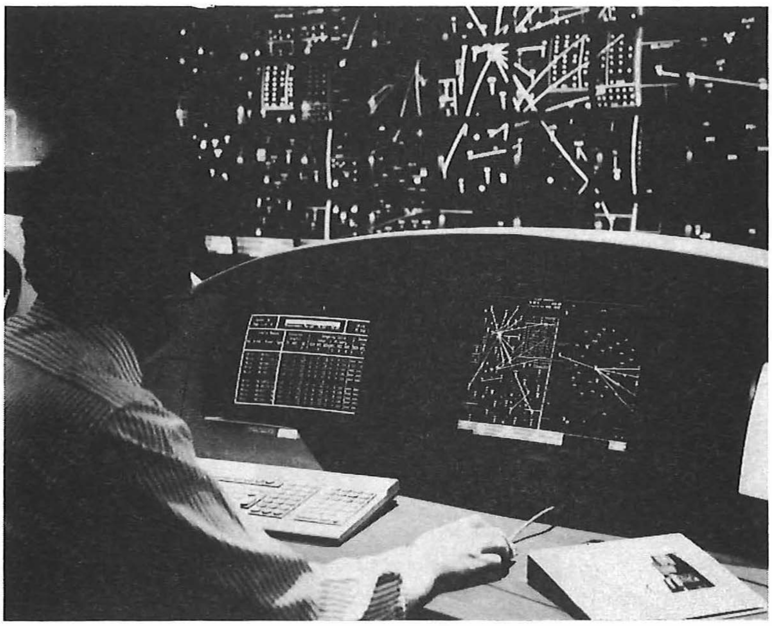


Figure 4—Typical NTMS workstation

- The *data reception and validation* module checks the values and formats of measurement data and stores validated measurements in an exchange-independent format known as *generic measurements.*
- The *data analysis* module uses the generic measurement data to derive generic parameters which are based on CCITT standards for traffic management; for example, answer seizure ratio. Selected parameters are compared against predetermined thresholds and if the threshold limits are broken, an exception report is generated. Parameter and exchange/route exception priorities are calculated for all monitored exchanges and routes, and are placed in lists ordered in terms of severity.
- The *NTMS workstation* module displays the generic measurements, generic parameters and exceptions in graphical and tabular form on the workstations, which comprise a colour graphics display with a mouse and a VDU with keyboard. (See Figure 4.)
- The *miscellaneous displays* module controls a number of top problem and exchange status dis-

plays on the wallboard display system. The wallboard display system allows inland NTM data to be displayed with international and derived services network (DSN) NTM data together with service protection network (SPN) information on a large (5 × 30) back-projection TV wall display.

- The *data archive and playback* module stores parameter and exception data on magnetic tape to record network conditions which can be replayed later. The archive and playback operations can be run concurrently with the live traffic management operations.
- The *OTIS* (on-line traffic information system) module collects and transmits network configuration and generic measurement data to the OTIS. The OTIS computer collates the data into daily and weekly summaries which can then be used for longer-term capacity management and for network planning.

Two other modules, the *network simulation* module and the *controls* module are used to simulate the behaviour and control of a switched communications network in real time for training or study purposes.

Hardware Configuration

The NTMS software runs on Concurrent Computers 3200 series 32-bit mini computers, which can be in either a single machine or a multi-machine configuration. The multi-machine configuration, which is used for the live NTMS, consists of a number of machines operating as *front-ends*, handling data reception and processing, and one machine, known as the *back-end*, which controls the displays, operator requests and database access.

In this configuration, a multi-port RAM disc is used for bulk data transfers between the machines, the non-bulk data being transferred by using an Ethernet local area network provided by Concurrent Computer Corporation's RTnet. RTnet also provides an interface to external communications; that is, X.25 across wide area networks. Each workstation consists of a Tektronix 4225 graphics display with mouse and a Tandberg TDV2200S series VDU with keyboard.

Operating System

The operating system used is Concurrent Computer Corporation's OS/32, which provides a real-time, event-driven environment for the NTMS modules, which are run as one or more OS/32 tasks.

NTMS IMPLEMENTATION

The NTMS in the BT network has been implemented as a single centralised system, with operations being based at the Central Operations Unit at Oswestry (see Figure 5). This approach has the following advantages over distributed operations:

- It enables a 'global view' of network performance which permits faster and more accurate problem identification and the development of more effective control strategies.
- It is more effective in dealing with complex, interrelated problems in the stored program control (SPC) and common-channel signalling environment. A centralised approach simplifies the problem of coordination of activities in these cases.

Figure 5
The Worldwide Network Management Centre at Oswestry showing the operations room with wallboard display system

● It provides a single point of contact for network traffic management, both internally and with other operators and administrations.

PROGRESS TO DATE

The success story of the BT network traffic management system is one of vision, energy and commitment of designers, developers and project managers to ensure quality of design and implementation. As an example, the original specification called for handling data from GPT System X exchanges, but the flexible design has also enabled other types (Ericsson AXE10 and AT&T 5ESS exchanges) to be connected.

The major milestones in the NTMS project to date have been as follows:

1982 The BT Board decided to sponsor the development of a prototype. The experience gained from this early test-bed system was incorporated into the development of a full-scale NTMS.

1985 A live NTMS entered service, monitoring the UK digital trunk network.

1986 Facilities were introduced on SEP2 System X exchanges which enabled dedicated network management measurements to be output in binary form by using X.25 communication links.

1988 An interface was provided to AT&T 5ESS Phase 2 (5E3) exchanges. The administration data packet network was launched, which enabled large numbers of exchanges to be connected to the NTMS via a common interface.

1989 Provision of traffic control facilities applied via OMCs.

1990 The Worldwide Network Management Centre opened at Oswestry, which brought together both inland and international network management operations. The NTMS4.2.3 release enabled the whole inland digital network to be monitored every 5 minutes.

The most recent release, in June this year, provided facilities for monitoring AXE10 exchanges and for accurate destination analysis to identify 'problem' numbers.

FUTURE DEVELOPMENTS AND VISION

The development plan in place will enable the NTMS to evolve to continue monitoring an expanding digital network, with the addition of an interface to the next build of AT&T's 5ESS exchanges by March 1992. A major development due at the end of 1992 will provide generic control facilities for all exchange types, together with updated workstations to access ancillary support systems. The development will also enable protective controls to be broadcast to selected parts or all of the network near-simultaneously for control of unexpected focused overloads.

The proposed system will incorporate other network management support systems, to reduce duplication of data and system function. The first stage will be to combine the functions of the NTMS and OTIS onto a common platform. This will allow the NTMS direct access to historical data to aid human, or later machine-based, decision making, which is currently under investigation by BT. The proposed system will also form the platform for amalgamation of the inland and international NTMSs.

MIGRATION STRATEGY

As with any system that has been operational for a number of years, careful thought must be given to the evolution of the underlying technology. Over the lifetime of the NTMS, the major change in technology in the market-place has been the shift away from proprietary architectures towards Open Architectures. This has happened at both the software level, where Unix has been adopted as the standard operating system, and at the hardware level, where manufacturers are making increasing use of commodity chips.

At the same time, BT has formulated Co-operative Networking Architecture (CNA) standards, based on 'open' systems, which is being used as the basis for all further support systems development.

The overall benefits to the business of migration to open systems are significant. It enables standard software packages (such as BT CNA generic software) to be used in place of customised developments. It enables much better integration with other support systems and it also opens up a wider choice of suppliers. The cost savings of commodity hardware over proprietary hardware are substantial.

As far as the base technologies of the NTMS (hardware and operating system) are concerned, the major strategic direction proposed is to move away from the Concurrent proprietary architecture, towards an open architecture, based on Unix. The migration will be based on planned and future operational enhancements to the NTMS, requiring the NTMS to move through a period where both architectures exist in a hybrid configuration.

The future NTMS application software will be based on object-oriented design (OOD); that is, software will be constructed from a number of pre-built components, rather than designing and building the system down from a unique set of requirements. There are a number of advantages to this approach, the main ones being reusability (from release to release and from system to system), flexibility and robustness.

OOD advocates the combination of data and procedural elements into objects which may be derived from the applications or design domains. Examples of application domain objects are entities such as exchange, route, network and concepts such as performance parameter and exception. Objects are combined into classes, which represent the common behaviours of the objects. An information model is constructed which defines the behaviour of each class and the relationships between various classes.

During object-oriented component design, each class is designed internally, and coded and tested. During object-oriented system design, objects are combined into physical entities such as tasks, subsystems and so on. This is the bottom-up part of OOD, and is a relatively small part of the overall analysis and design process.

Some OOD work has already been undertaken in the form of a pilot project, which has resulted in a number of reusable components, some of which are already planned for reuse in future releases.

The migration of the base technology will also enable a migration to a proposed software architecture which will provide significant operational improvements. These will include the ability to view a network in a number of different ways, the ability to monitor a number of networks or network models simultaneously, and full flexibility on the types of analysis that could be performed concurrently on a selected basis. For example, two additional types of analysis could be retrospective busy-hour or trend analysis, and rule or knowledge-based identification of network problems.

The proposed software architecture, shown in Figure 6, is split into three major parts, performance, configuration and planning. Performance is concerned with collection and analysis of performance data from network elements. Configuration is concerned with application of controls to network elements. Planning and design is concerned with the modelling and simulation of networks.

In the longer term, one aim is for the exchange-specific parts of the system to be replaced by a telecommunications management network (TMN). The TMN will provide an organised network structure, incorporating a standard set of messages and interfaces, which will enable the interconnection of network support systems and network elements.

CONCLUSIONS

BT has the capability to manage its UK and international networks using NTM systems, which will become increasingly combined and conformant with open architecture standards. The next few years should see the consolidation of these trends as the NTMS is developed further with additional functionality and with new exchange interfaces as required (for example, Northern Telecom DMS100 to be used for the advanced services unit). Investigations are also underway to determine the requirement for managing the CCITT No. 7 signalling network, as

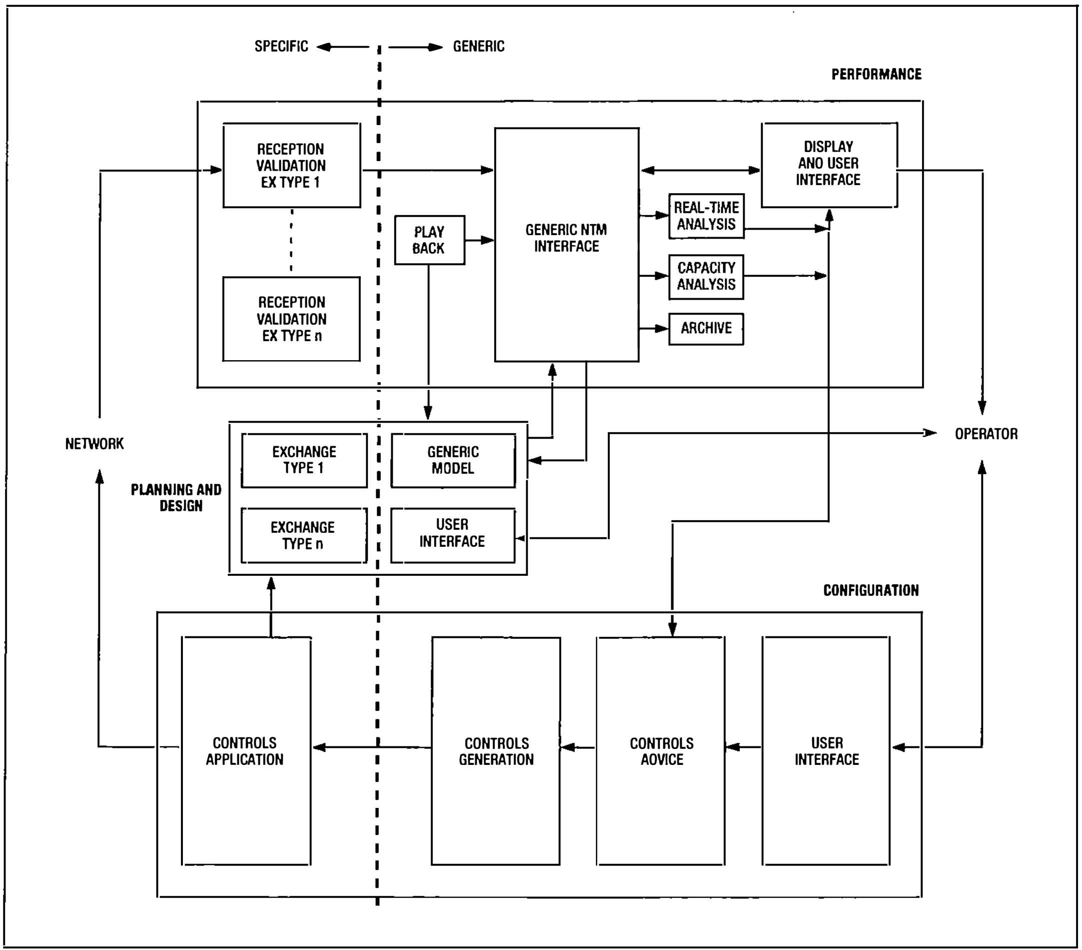


Figure 6
Future NTMS software architecture

new services are becoming more and more signalling based.

The global 'window on the network' provided by the NTMS enables rapid detection and analysis of adverse traffic conditions to aid application of 'healing' actions to maintain or improve network service.

The ability to control networks in this way will become increasingly important with deregulation and introduction of more competitors. Customers will be won or lost on the ability to maintain a top-quality and resilient network.

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2 CCITT Recommendations E.410–E.414, IXth Plenary Assembly, Melbourne 1988. Issued Geneva 1989.

Biographies

Roger Garrison joined BT in 1979 as a Telecommunications Traffic Superintendent in London Region. He worked in the traffic planning office on the design and management of the implementation of the London Digital Network before moving to the Traffic Management team in 1987. There, he has been responsible for project managing off-line statistics processing systems and, more recently, releases of the NTMS. He has a B.Sc. in Environmental Sciences and a M.Sc. in Industrial Sociology.

Adam Spector joined BT in 1985 as a senior designer in Tallis Systems. He spent 18 months leading a software development team working on the National NTMS before moving on to another project. In 1989 he returned to the National NTMS project, initially running the support team, and now leading the development teams for two enhancement projects. He graduated in Computer Science with Mathematics from Bristol University in 1978.

Peter de Groot joined BT in 1985 as a senior designer after five years of systems development in a variety of engineering environments. Since 1987 he has managed two major NTM development projects, and he is currently responsible for managing the development of the UNIX-based 5EE4 server and for second-line support of the NTMS. He has a B.Sc. in Electrical Engineering, and an M.Sc. in Computer Science, and is a voting member of the ACM.

Data and Configuration Management

R. M. BATY†

Data management of stored program control telephone exchanges is a vital aspect of operation of a telecommunications network. The services provided to customers both now and increasingly in the future are dependent on having an effective data management organisation. This article describes how BT manages the data on its System X and AXE10 switches in its digital trunk and local network.

INTRODUCTION

The service features that are offered to customers by a telecommunications operator are largely determined by intelligence built into the network's stored program control (SPC) telephone exchanges. The specific features offered to customers are tailored by means of the configuration data built into the exchange processor or, in the case of modern intelligent networks, into attached processors. This article describes how the data for BT System X and AXE10 digital exchanges is built and managed.

Discussion often centres on the functionality of systems, but the problems associated with data building and management must not be underestimated.

DATA TO BE MANAGED

A modern SPC telephone exchange is made up from three elements:

(*a*) hardware (including firmware),
(*b*) software, and
(*c*) data.

The data defines how the above exchange elements are configured as follows:

Customer Data This defines the facilities provided to the customer; for example, call itemisation, night busying, PBX line hunting, signalling type, integrated services digital network (ISDN), preference category, subscribers private meter etc.

This data is specific to each exchange and group of customers; it will tend to be of a simple, repetitive nature for residential customers, but can be complex for business customers.

Network Data This defines the network and its facilities connected to the exchange; for example, routes, circuits, signalling systems, host and remote concentrator topology, dialled digit to hardware route translations, alternative routing facilities, charging and tariff definitions, traffic and performance statistic production etc.

This data is essentially exchange specific, but there tends to be significant commonality between exchanges of a similar type.

System Data This defines the internal architecture of the exchange and its processor in a similar way to a computer operating system; for example, input-output (IO) channels and devices, alarm outputs, application software subsystem dimensioning etc. This has a high degree of commonality across exchanges of a similar type.

For all of the above three, the data must link hardware and associated software to provide specific implementations of customer, network and system facilities. For a typical 60 000 line telephone exchange, the data volumes are as follows:

Customer data	9 Mbyte
Network data	0·5 Mbyte
System data	0·1 Mbyte.

Clearly, with the quantities of data described above, this is a significant task.

DATA LIFE CYCLE

The life cycle of exchange data is split into two distinct phases:

(*a*) *Data Build* This is the phase prior to an exchange being brought into service; it largely consists of a data collection and cleansing cycle followed by loading this data on to the exchange processor and ensuring that the data-build rules of the exchange are adhered to. This process is known as *data fill* in North America.

(*b*) *Data Management* This is the phase after an exchange has been brought into service; it consists largely of managing the data to reflect churn and growth in customers and the network together with the provision of new and enhanced facilities. It also includes ensuring that the data is kept in a systematic and coherent format.

The data-build process may be carried out by the equipment supplier under a turnkey contract or, as in the case of BT, by the network operator. After the exchange has gone into service, it is normal for the network operator to manage the data.

SYSTEM X AND AXE10 DATA INTERFACES

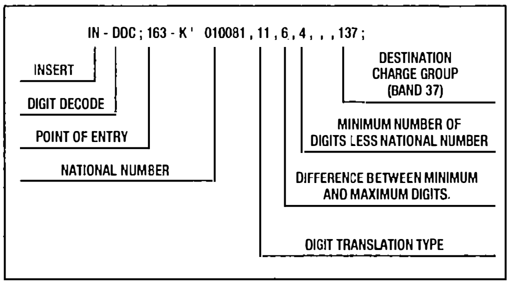
Both System X and AXE10 have man–machine interfaces (MMIs) which conform to CCITT

† BT Worldwide Networks

recommendations and give data (IO) interfaces in ASCII format. They both also have IO interfaces to their processor memories which enable system archives and reloads to be made in a binary format via magnetic media. The AXE10 MMI is a high-speed one and is the sole interface for data inputs. System X also has an off-line facility, the *data compiler-decompiler* (DCD) which enables operations to be carried out on the data elements of the system archive. The data interfaces for System X and AXE10 are shown in Figures 1(*a*) and 1(*b*) and are described in further detail below.

SYSTEM X DATA MANAGEMENT

A typical System X man–machine language (MML) input is shown in Figure 2. This input may be from either a terminal connected to an IO



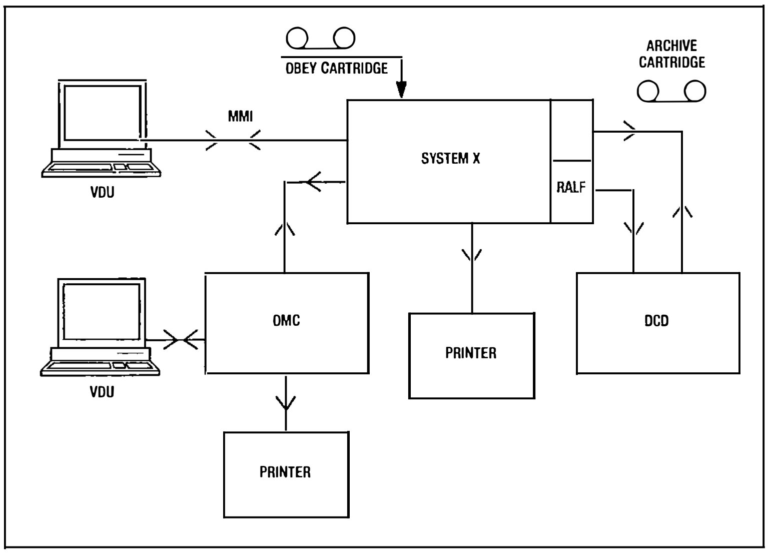
This command inserts a new entry into the digit decode (dialled digit to route translation). The example shown is the addition of ISDN access to Japan where the national code is 010081, the total maximum allowable digits is 16 and the minimum number 10. The charge group (band) for the dialled digits is 37. The dialled digits will access the spinal digit decode tree at point of entry 163.

Figure 2—Typical System X MML command

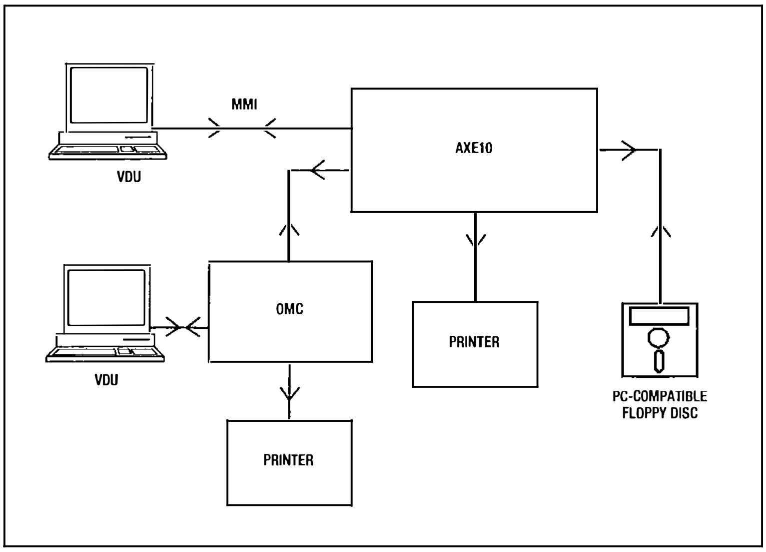
port via the operations and maintenance centre (OMC), a file applied from the OMC or an obey cartridge connected directly to an IO port. The obey cartridge interface is more secure than the direct terminal interface particularly for bulk inputs of hundreds of lines of MML as it uses handshake techniques to ensure commands are entered correctly before the next one is accepted. Both the OMC and System X itself have had macro commands developed which provide single functions derived from a series of interdependent MML commands. This technique minimises the probability of errors occurring when data is updated and is used on the OMC subscribers record system for both simple single-line transactions and complex PBX management.

The DCD operates in a similar fashion to a software programming language compiler-decompiler. It runs off-line from the exchange on a Digital Equipment Corporation VAX mainframe computer system and enables bulk data inputs to be compiled into exchange processor executable format and vice versa. The man–machine DCD inputs and outputs are in a computer-punched card flat file format known as *BA card format*. As the interface between DCD and the exchange is via the processor IO, this enables a high-speed data IO to be established for System X. This interface between the exchange and DCD can be either via a magnetic cartridge or via an electronic interface known as the *remote archive and load facility* (RALF). As the DCD runs on an off-line mainframe, it is possible to perform powerful data manipulation on the system data such as is required when reparenting a concentrator from one processor to another. When the data has been manipulated off-line, it can be reapplied to the exchange processor using the data transfer process. The DCD also checks for data consistency and is used to ensure that any data that has been applied via the MMI has not got into an inconsistent state. Outputs derived via the decompiler are also used to audit the exchange data to ensure that it is correct.

Figure 1
System X and AXE10 data interfaces

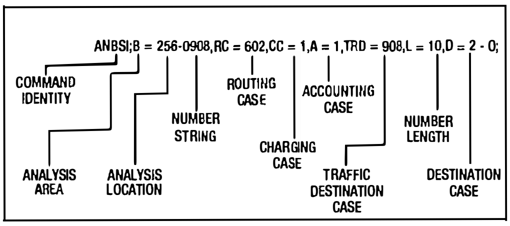


(*a*) System X data interface



(*b*) AXE10 data interface

DCD: Data compiler-decompiler
RALF: Remote archive and load facility
MMI: Man–machine interface
VDU: Visual display unit
OMC: Operations and maintenance centre



This command is a dialled digit analysis command known as *B-number analysis.* The example shown defines the call routing, charging and number length for dialled digits 0908 (Milton Keynes). Also included are parameters defining network management, call barring and network operator revenue apportionment facilities.

Figure 3—Typical AXE10 dialled digit analysis command

AXE10 DATA MANAGEMENT

A typical AXE10 MML input is shown in Figure 3. This input is either from a terminal connected to an IO port via the OMC, a file applied from the OMC or a personal computer (PC) compatible floppy disc connected to an IO port. AXE10 has powerful facilities for manipulating the data on the exchange processor. The data can be set up and tested in a non-operating area before it is brought into operation. If it is required to manipulate the data off-line, such as for an extension or for audit purposes, the data is taken off the exchange as a print file in ASCII format on to a floppy disc. AXE10 uses a support environment, running on an IBM mainframe computer, that enables a set of standard data-build files to be maintained which are used to assemble bulk data inputs for its MMI. This support environment includes TRAFDATA, a system supplied by Ericsson used for syntax checking of MML prior to it being loaded on the exchange.

DATA-BUILD PROCESS

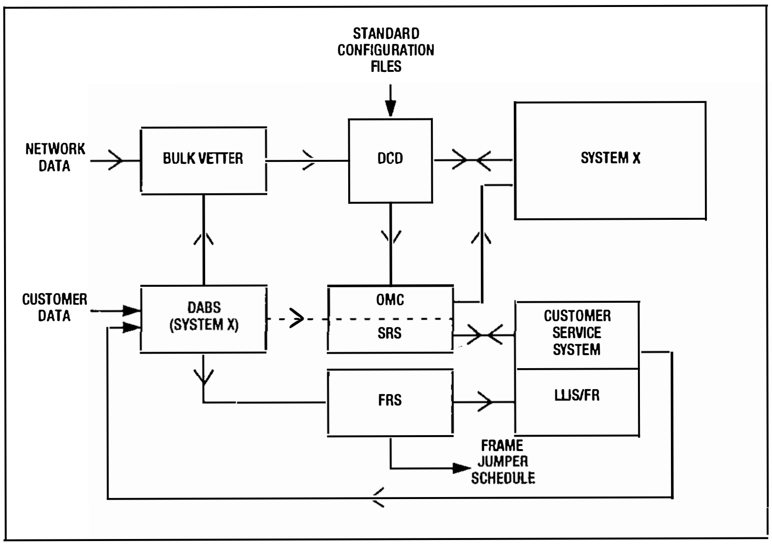
At the planning stage of the conversion of an existing analogue exchange to a digital exchange, a definition is made of the customers and network that is to be replaced, including any allowances for growth. This definition is a major input to the exchange design. The design of the replacement exchange in terms of configuration and topology may be quite different to the exchange to be replaced. Typically, a digital exchange uses high-capacity digital circuits, and this enables the total number of circuits, in particular direct links, to be reduced. The exchange design is then passed to the equipment supplier who produces a hardware design. The hardware design is a major input to the data-build process. At the same time, there is a process of collecting and cleansing the customer and network data. The requirement to have 100% correct data prior to bringing an exchange into service necessitates a thorough exercise to ensure that the new exchange data aligns with the analogue exchange that it is replacing. The new unit that is being installed may either be:

(*a*) a complete new processor with associated concentrators,
(*b*) a processor extension and additional concentrators,
(*c*) an additional new concentrator, or
(*d*) the extension of an existing concentrator.

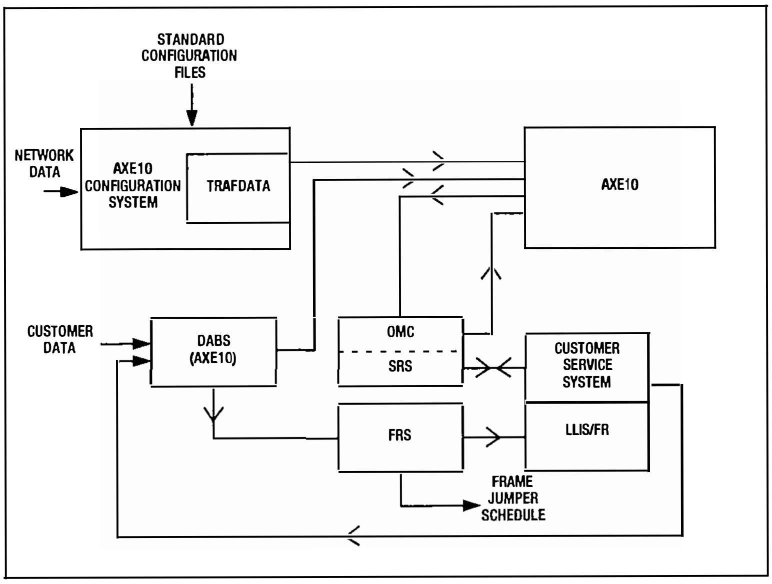
The process is assisted by a series of computer tools that have been developed within BT for both System X and AXE10. Schematics of the data flows through these systems are shown in Figures 4(*a*) and 4(*b*).

For both System X and AXE10, a PC-based tool, the data allocation and build system (DABS), is used to collect and cleanse the customer data and to allocate the customers to particular concentrator hardware. A PC-based

Figure 4
Data-build process



(*a*) System X



(*b*) AXE10

DCD: Data compiler-decompiler
OMC: Operations and maintenance centre
DABS: Data allocation and build system
SRS: Subscriber records system
FRS: Frame record system
LLIS/FR: Local lines information system/frame records

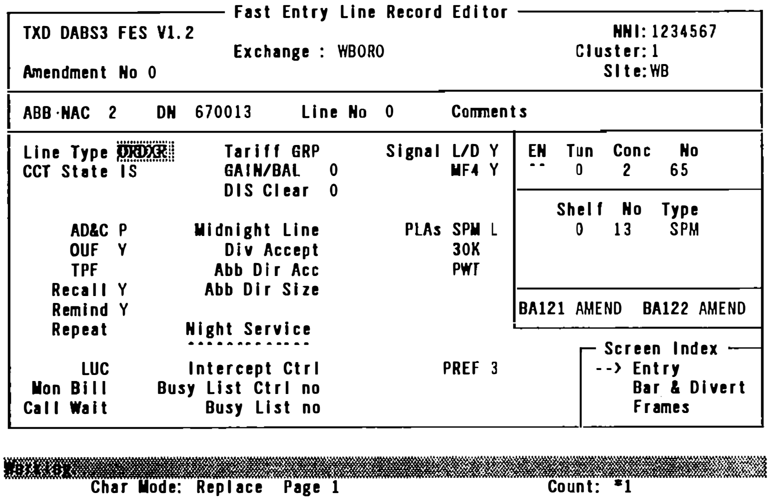


Figure 5
Typical DABS input screen

system is ideal for this type of application as this stage of the process tends to be a standalone one carried out by one person. The DABS has a series of input screens for different types of customers, a typical input screen is shown in Figure 5.

The DABS has algorithms built in to give optimum allocation of customers across the exchange so as to take into account load balancing and security considerations; for example, where possible, a large PBX is shared across more than one concentrator for security, and PBXs that normally produce high traffic are allocated so that the load is balanced across concentrators. Also at this stage, customer facilities such as subscribers private meters (SPMs) are allocated as required.

The output from DABS is used in conjunction with another PC-based system, the frame record system (FRS), to produce a jumper allocation schedule for the main distribution frame. Depending upon the size and type of the new unit, this process can typically take between 6 and 12 months.

At the same time, the network and system data are collected and built to reflect the exchange design. In the early days of the digital exchange modernisation programme, a tool similar to DABS, called *REDS*, was used to collect the network data for System X via a series of input screens. The experience gained by field data-build staff showed that this process could be speeded up by simply copying an existing exchange data build and modifying with a text editor such as WordStar. Such a text editor has powerful block copying and deletion facilities and exchanges of significant variation of size and design can be built up from standard modules. This technique ensures that the core architecture of processors, alarms, circuit allocations etc. are kept to standard designs. In the case of System X, a PC-based tool, called the *bulk vetter*, is used to check that the inputs are syntactically correct before being compiled for application to the exchange.

The hardware data for System X is provided as *exchange name documents*, and for AXE10 as *route allocation charts*.

DATA MANAGEMENT PROCESS

After an exchange has been brought into service or extended, it must be kept up to date with churn in both customers and the network. In addition, there is a continuous process of providing new and enhanced facilities including revised tariff structures.

A city centre exchange can have customer churn of up to 25% or more per annum; this is equivalent to a complete change of customers over a four year period. Routine customer data management is carried out via the OMC subscriber record system (SRS), which provides a user-friendly interface to both System X and AXE10, and requires only limited skill levels to operate. A very small percentage of specialist customer facilities, such as complex PBXs, require direct MML to implement them. Should such facilities become common then the cost of developing the necessary SRS macros will be justified.

The modernisation of BT's public switched telephone network (PSTN) has seen a transition from an analogue to a digital network. This changeover in the network has necessitated careful data management to ensure that the quality of service is maintained. A significant part of this work has included data management operations such as:

- growing the trunk network of digital transmission circuits between digital main switching units (DMSUs) as the analogue trunk network is taken out of service;
- re-parenting transmission circuits between digital local exchanges and analogue group switching centres (GSCs) to DMSUs;
- bringing new circuits into service to meet traffic growth requirements;
- developing a network that includes automatic alternative routing choices for traffic under high-load conditions;
- providing call blocking facilities to restrict traffic to specific destinations and so prevent focussed overloads on switching nodes; and
- scheduling traffic recording data to ensure a balanced loading of the network.

All of the above requires careful control to ensure coordinated implementation and an audit trail which confirms implementation back to the originator. The necessary control for such network-wide changes is provided from the central operations unit (COU) at Oswestry. Network changes are controlled by means of a network change request (NCR) database which provides details of the change to be implemented and sign-off facilities for the necessary audit trail. In particular, it is essential that any changes associated with tariffs and charging are 100% accurate and that there is a signed-off audit trail to verify this. As an additional safeguard, tariff and routing data are audited on a monthly basis to ensure compliance with the central definitive source of such data, the national charging database.

DATA DESIGN

The services that are the feature of modern networks, for example, integrated services PBXs, intelligent networks and premium services, are built by tailoring the exchange application processes by means of data designs produced by central design teams.

CAPACITY MANAGEMENT

An important part of the data management process is to ensure that the exchange processor and its associated hardware are loaded correctly. This is done by processing data extracts taken from the exchange and monitoring the usage of hardware and software resources across the exchange elements. BT tends to load its processors up to the capacity limit specified by suppliers; for example, 60 000 lines per processor. Many other administrations do not load so heavily; some administrations rarely go above 20 000 lines. This calls for careful monitoring and balancing of the exchange elements. In order to maintain this balance, it may be necessary to re-parent switch concentrators and circuits from one processor to another, or in the case of System X from one processor cluster to another.

VISION

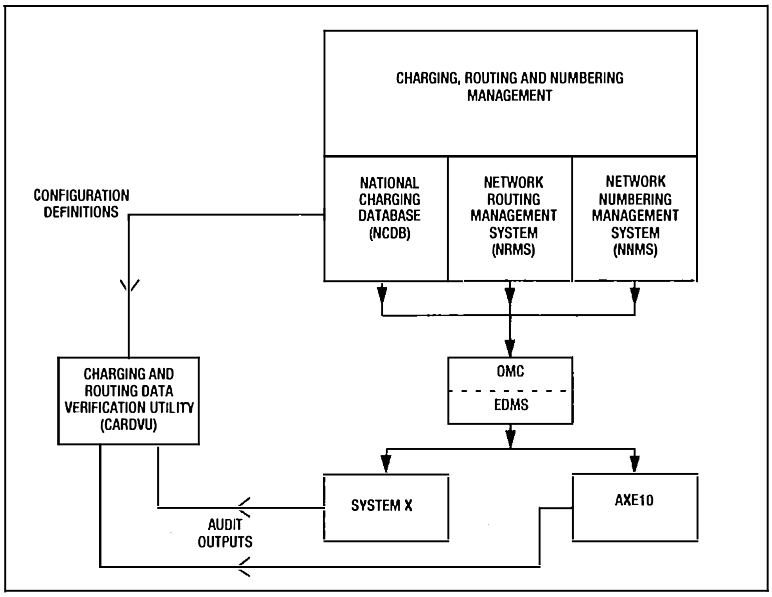
The long-term vision for data operations in the BT network is to have maximum automation to enable rapid error-free implementation of data changes at minimum cost. To this end, several operational support systems are being developed within BT as follows (see Figure 6):

National Charging Database (NCDB) This system holds all the data necessary to define the charging in the UK PSTN network including that required for international calls. It is the single definitive source of this data. It includes interfaces to enable automatic download of tariff tables for modern exchanges.

Charging and Routing Data Verification Utility (CARDVU) This system audits the charging and routing data held on modern exchanges against that defined by the NCDB. It includes electronic data interfaces to both exchanges and the NCBD to enable comparisons to be carried out.

Network Routing Management System (NRMS) This is a routing model of the BT PSTN which includes physical routing data. It is capable of setting up routing schemes for the PSTN, including 'what if' models.

Network Numbering Management System (NNMS) This provides a management system for numbering in the BT network.



OMC: Operations and maintenance centre
EDMS: Exchange data management system

Figure 6
Charging, routing and numbering management and verification

Remote Data Loading Facilities

Facilities are being provided, hosted on the OMC, which enable centrally prepared and audited files produced by off-line systems, such as those listed above, to be loaded on to System X and AXE10 exchanges from central locations such as the network operations units. This enables data management to be carried out from a minimum number of centres.

CONCLUSIONS

The data management of SPC exchanges in BT will continue to evolve as it has over the last eight years towards an increasingly automated environment. This will enable a feature-rich network to be built which can be manipulated rapidly and accurately to provide customers with the increasingly sophisticated and flexible services they demand.

Biography

Bob Baty started as a student apprentice with BICC Power Cables, and gained a degree in Electrical Engineering. After graduating, he worked on the design of cable-making machines, computer systems and peripherals before joining BT in 1972. Since then, he has worked on component standards, and on the System X local exchange proving team. As Head of Group, he worked on maintenance support of digital trunk exchanges and on customer data management. In 1989, he became head of the digital exchange data management section and is now manager of the Worldwide Networks unit responsible for data management and security.

Performance Assessment Tools

R. L. HAWTIN, and E. JACKSON†

Performance assessment is the key to success in a competitive environment. This article outlines the functions involved and explains how processes required to support these functions are being developed within a strategic framework. Some processes need to be automated and supported by computer systems. One such system, the evolving long-term log analysis product, is described in this article.

INTRODUCTION

To continue to develop and grow within the competitive UK telecommunications environment, BT must market services which are seen by customers to be significantly better than the alternatives. But, how does BT meet its objectives of delivering the best competitive services of the correct quality all the time?

One key aspect is to measure the quality and performance of services delivered—the essential feedback loop. In classic total quality management (TQM) terms, if you cannot measure it, you cannot improve it.

Business processes and support systems are required to enable and automate these feedback loops; a common technical framework[1] is required to allow the systems to form part of a consistent, but flexible, world-class solution. This article describes the *performance assessment tools* which are being developed to support this function.

Objectives

Some of the areas where performance monitoring and performance assessment tools can be applied are described below:

- to monitor the quality of service(s) to a customer;
- to provide a health check on the network and provide data to the network operation and planning process;
- to review equipment trends and provide data to purchasing and network design decisions;
- to review supplier performance and provide data to supplier management;
- to monitor the man–machine language (MML) operations performed on the network and check that only authorised changes have been applied; and
- to measure the cost and duration of key processes and workstrings.

† BT Development and Procurement

System Framework

What is the vision as far as performance assessment is concerned? How can useful information be created for managers from a vast quantity of raw data produced from tens of thousands of sources?

The idealised performance monitoring system needs to:

- monitor:
  - —service quality,
  - —cost of quality,
  - —equipment/element,
  - —circuit/link,
  - —people,
  - —processes and timings, and
  - —suppliers;
- assemble and manage large quantities of raw data and process different sets of data into the minimum required useful information;
- combine data of different types from different sources to provide optimum input to decision making;
- enable information to be customised and displayed for different users;
- allow problem areas/issues to be investigated by focusing monitoring onto the suspect target and increasing the power of the 'lens'.

The essence of such a system is that it supports the users in making decisions. Comprehensive data collection and automated, flexible processing will mean that the users have access to the information they need to make the decision. Their time is spent thinking about the options, not in collecting the base data.

A representation of such a system is shown in Figure 1. The data sources (for example, exchanges) provide a stream of information which is 'picked off' by different users (for example, a regional maintenance manager or national purchasing manager). Data streams are combined and processed to provide the information they need for their particular job. One of the key aspects of such a system will be a flexible user interface which enables different views and options to be explored.

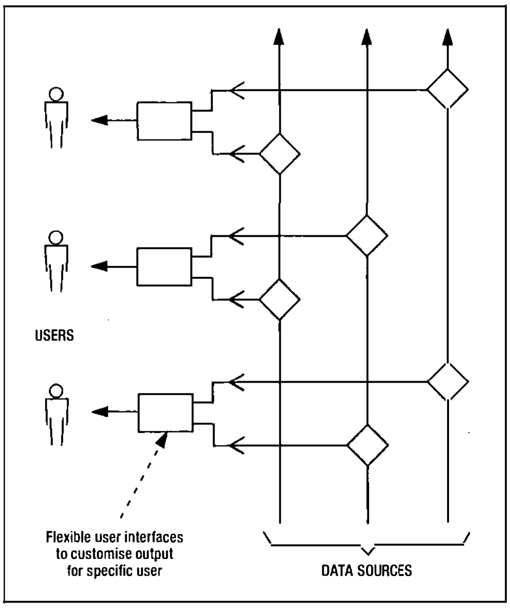


Figure 1—Flexible data collection and processing system

NETWORK SUPPORT SYSTEMS

The major business initiative influencing the evolution of network support systems is the Strategic Systems Plan (SSP).

A previous article[2] identified performance assessment systems (PAS) as one of the strategic system areas (SSAs) within the network support system architecture. The monitor, audit and analysis elements described previously lie within the SSP third-level process 'Manage Network Usage and Performance'. It is supported by tools within the PAS SSA. The repair elements are supported by tools contained within the Fault and Repair Management Systems SSA (FARMS SSA). Currently, in excess of 20 systems perform functions in the PAS area, but they have been developed to a significant extent in isolation from one another and with a lack of overall structure.

How do we get from the current position to the vision of the system framework described earlier?

The Network Control Architecture Board (NCAB) has launched a PAS evolution study (PASES) team, similar to that for testing described elsewhere in this issue[3], to provide a coherent strategy and architecture for the key support systems within the PAS SSA.

The study team will produce the following deliverables:

(*a*) a fully defined information engineering facility business model (containing SSP processes down to level 6 or 7);

(*b*) a PAS logical architecture document outlining the target logical functional blocks and data stores of the SSA;

(*c*) a PAS physical architecture document outlining the target physical realisation of the logical architecture; and

(*d*) evolution-path documents detailing the evolution path for each key support system and manual process within the PAS business area.

This study will result in a reduced number of performance systems which will support the business areas identified by the SSP and conform to an approved architecture.

Some of the areas which need to be monitored, as identified in the performance assessment vision, are addressed by current systems and these will now be described.

LONG-TERM LOG ANALYSIS SYSTEM

Reference 2 outlines a system that is already providing key functionality for the PAS SSA and is also a key data source for the FARMS SSA. This is *long-term log analysis* (LTLA), deployed on the digital exchange support system (DESS), and known as *DESS LTLA*.

LTLA is already used to monitor MML transactions which change sensitive exchange configuration data.

The LTLA performance assessment tool is described in more detail here.

LTLA DATA CAPTURE

Modern digital exchanges generate large volumes of administration data relating to call charging, traffic handling, fault management and configuration control. This data is polled by computer-based data collectors, stored, and forwarded to the relevant data processing system.

LTLA receives and processes the data subset relating to internal exchange fault management and the MML used to change aspects of the exchange configuration (see Figure 2). This is known as the *exchange log*.

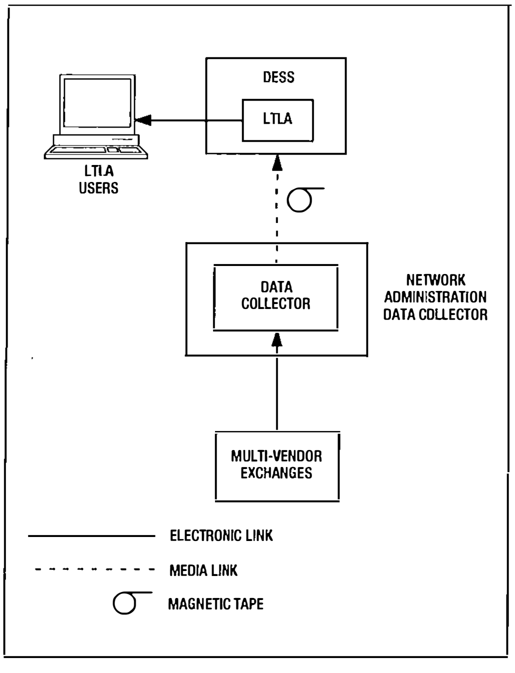


Figure 2—LTLA in the network

Data volumes are relatively high—in excess of 350 Mbyte/day is currently processed—and at present the forecast maximum is 570 Mbyte/day.

This data is loaded into a suite of databases for subsequent processing. From this historical record, occurrences of events can be pinpointed in detail both within a specific exchange, and to a specific time.

SECURITY AUDIT

All MML input is inspected automatically on receipt, and selected details associated with certain specific events are logged immediately for subsequent investigation.

The results of this analysis may indicate deficiencies in the operations and maintenance manuals supplied with the exchanges, that additional training is required, or that the exchange data is being modified without the appropriate authority.

PERFORMANCE ANALYSIS

Within the core of the exchange, hardware is replicated and the exchange endeavours to reconfigure automatically around a fault. The faulty equipment still has to be identified and repaired, as the exchange is then vulnerable to subsequent faults of a similar nature.

On the exchange periphery, hardware is not replicated. A fault on a line card may deny several customers access to the complete network. This represents a fatal degradation in the quality of service being provided to those customers.

It is clearly necessary to detect and restore such service outages quickly. This day-to-day management is the role of the operations and maintenance system[4] which works in real time. However, it is also necessary to check if there is a pattern to such failures; for example, is there a suspiciously high failure rate among the entire population of a certain type/version/supplier of this line card? This requires national data analysis of a large amount of historical data. Such off-line processing represents a load that is best provided by a specialist host environment.

LTLA analyses a wide range of fault reports to identify those having the most significant impact on the network performance. The analysis is performed on a national, zonal, and, if required, per-exchange basis. The results are made available to the exchange product support groups, and performance-monitoring duties. Such analysis can often identify failure patterns which can be used to predict and avoid similar major failures.

PERFORMANCE INDICES

A number of measurements are defined as performance indices. For example, the time taken to clear hardware faults is analysed. This is the time taken to return manually the faulty equipment to service. Software too may not act as intended and, if the level of software errors becomes excessive, the exchange may automatically initiate recovery action.

If the exchange processor is performing recovery activity, it is not providing service by setting up new calls; DESS LTLA measures this element of lost processor time.

DEVELOPMENT AND SUPPORT STRATEGY

The developers have adopted a policy of incremental builds, with several releases per year in order to combine worthwhile levels of enhancement with early availability of new functions requested. The software is run on large DEC/VAX computers at the Ipswich computer centre (DESS Central) and product support is provided by a separate team at BT Laboratories, Martlesham Heath.

LTLA ENHANCEMENTS AND EVOLUTION

While LTLA is not a real-time system, this does not mean that the business can afford to wait for the results of the analysis. The faster a generic problem is detected, the quicker it can be dealt with. Development work is in hand to provide on-line access to the database suite and to increase further the speed with which data can be captured.

LTLA could be extended to process data from additional sources; for example, TXE4(E), international exchanges and the advanced switching units.

FAST-TRACK TOOL DEVELOPMENT

There are times when the business cannot wait for a detailed requirements definition and subsequent specification and design stages covering all foreseeable eventualities. Functionality may well be required earlier. This can be particularly true for performance assessment, where it is not until some data has been analysed that it is possible to tell if there is a problem.

The solution is to restrict the initial product functionality to the minimum required, and restrict data capture to a small catchment area. Products can then be realised on a small, readily deployed computer (PC) by using 'encapsulated' software. This consists of well-proven and documented modules which can be assembled to provide the limited functionality initially needed. Subsequent 'bespoke' developments can then provide the finer detail, and in turn generate more 'encapsulated' software for future reuse.

Software originally developed for an exchange maintenance data processor that acted as an intelligent data logger for System X has subsequently been reused to develop analysis facilities for AXE10 traffic statistics (ASP).

FUTURE OPPORTUNITIES

The PASES study will identify the key systems required by BT in the PAS SSA and lay down the evolution plan to reach an integrated set of systems.

The new tools to support usage and performance management processes are now being realised using open computing platforms with powerful graphical interfaces. This gives flexibility to provide information to the users in the best way to assist their tasks.

The need to capture and analyse data is not just restricted to managing the BT core network. The performance of any service being offered in a competitive environment must be measured to ensure continuing customer satisfaction.

All parts of BT are working together to achieve the company's mission of providing world-class telecommunications services. To underpin this, the various units are setting up service level agreements (SLAs) to document the standards expected of their interfaces with one another. The performance against these SLAs will have to be measured, analysed and managed to ensure that BT can carry out its mission.

The importance of performance assessment systems in the future should not be under-estimated.

CONCLUSION

There are two quotes relating to this field that are well worth bearing in mind: 'What you measure gets done'—Iain Vallance, Chairman of BT; and from Dr W Edwards Deming, one of the TQM gurus 'You do not have to do this—survival is not compulsory.'

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Biographies

Bob Hawtin is a Technical Group Leader responsible for the development of usage and performance products within the Network Management Department of BT Development and Procurement. He has a B.Sc. (Hons.) degree in Cybernetics and Instrument Physics and joined the then Post Office in 1971 as an Assistant Executive Engineer. He has worked on Strowger design as well as trunk and local signalling systems before passing the 1979 Limited Board and being seconded to Plessey as part of the System X Development team. After his work on the maintenance control subsystem, he was responsible for modelling System X performance, before being promoted to Group Leader and moving to Ipswich in 1986.

Eddie Jackson, joined the then BPO in 1973 as a trainee technician apprentice in the Manchester Central Telephone Area. He took a minor award which resulted in an honours degree in Electronic Communications from Salford University in 1979. After graduation he worked on System X call processing development. During 1984, he gained promotion to Executive Engineer and worked on the development of ISDN PABXs. In 1990, he joined Network Management Department to concentrate on the development of the LTLA product. He is a Chartered Engineer and a member of the IEE.

Network Test Management Systems

C. F. REED†

In September 1990, the Network Control Architecture Board commissioned three evolution studies into discrete areas of computer application concerned with network administration. This article describes one of those studies, namely the Test Access and Management Systems Evolution Study (TAMSES) and the architecture for test access and management systems produced by it.

INTRODUCTION

As described in a previous article[1], the Network Control Architecture Board (NCAB) is responsible for the evolution of network support systems within Worldwide Networks. The NCAB has adopted the Network Support Systems Architecture (NSSA), which details the main areas of computer support for the network control level and their interrelationships. Those areas, termed *strategic systems areas* (SSAs), are groups of computer systems which have been identified by an NSSA top-level design team as having close affinity in the processes performed and in the data used. Figure 1 is reproduced from that previous article.

The basis for the NSSA was the top-down analysis of BTUK performed by the Strategic Systems Plan (SSP) team, now known as the Business Process Unit (BPU). The BPU has now identified 17 *business areas* within the BT business model, of which four fall within the management area of network operations:

- test management,
- network configuration, fault and repair,
- traffic and performance management, and
- network capacity assignment.

The Test Access and Management Systems Evolution Study (TAMSES) is one of three initial studies into the following SSAs:

- test access and management systems (TAMS),
- fault and repair management systems (FARMS), and
- network configuration and data management systems (NCDMS).

Studies of all 14 SSAs and the associated network data will be progressed in due course.

In the case of TAMS, there is no difference between the test network business area and the test access and management systems SSA.

The objectives of the TAMSES study were:

- to confirm the functional architecture/interfaces recommended by the NSSA top-level design team;
- to identify and document the present network testing capability;
- to identify shortcomings in that ability and rationalise the business needs;
- to produce a target architecture for the implementation of 'Test the Network' processes within Worldwide Networks, consistent with the rest of the business and with the BT business model as defined by SSP; and
- to recommend a migration strategy for the development of test management systems.

TAMSES addressed the computer support for testing which is currently used primarily for remote test control of line and circuit testing. However, TAMSES also addressed all other network testing including transmission, switching (but not internal self-testing by switches) and service testing.

THE CHALLENGE

BT's current test management capability has evolved in an ad hoc fashion as test technology has emerged in specific areas. It is therefore fragmented, confined within artificial geographical and technological boundaries, and expensive to run.

There is functional duplication between some test systems, although geographically discrete. The support costs can be reduced.

The field maintenance units require accurate test information; accurate in the sense that faults are localised by the tests applied so that the workforce can be correctly despatched first time every time. Currently this is not achieved.

The current test capability is concentrated on testing network elements for maintenance purposes, typically reactive maintenance after the customer has complained (too late!). There is little routine testing targeted at identifying degradation.

The major challenge is to introduce an advanced diagnostic capability and nightly routine testing of all local lines.

This is to be accomplished as an integrated part of the NSSA solution where tests are automatically invoked, the test results are automatically correlated with cable routing information by

† BT Development and Procurement

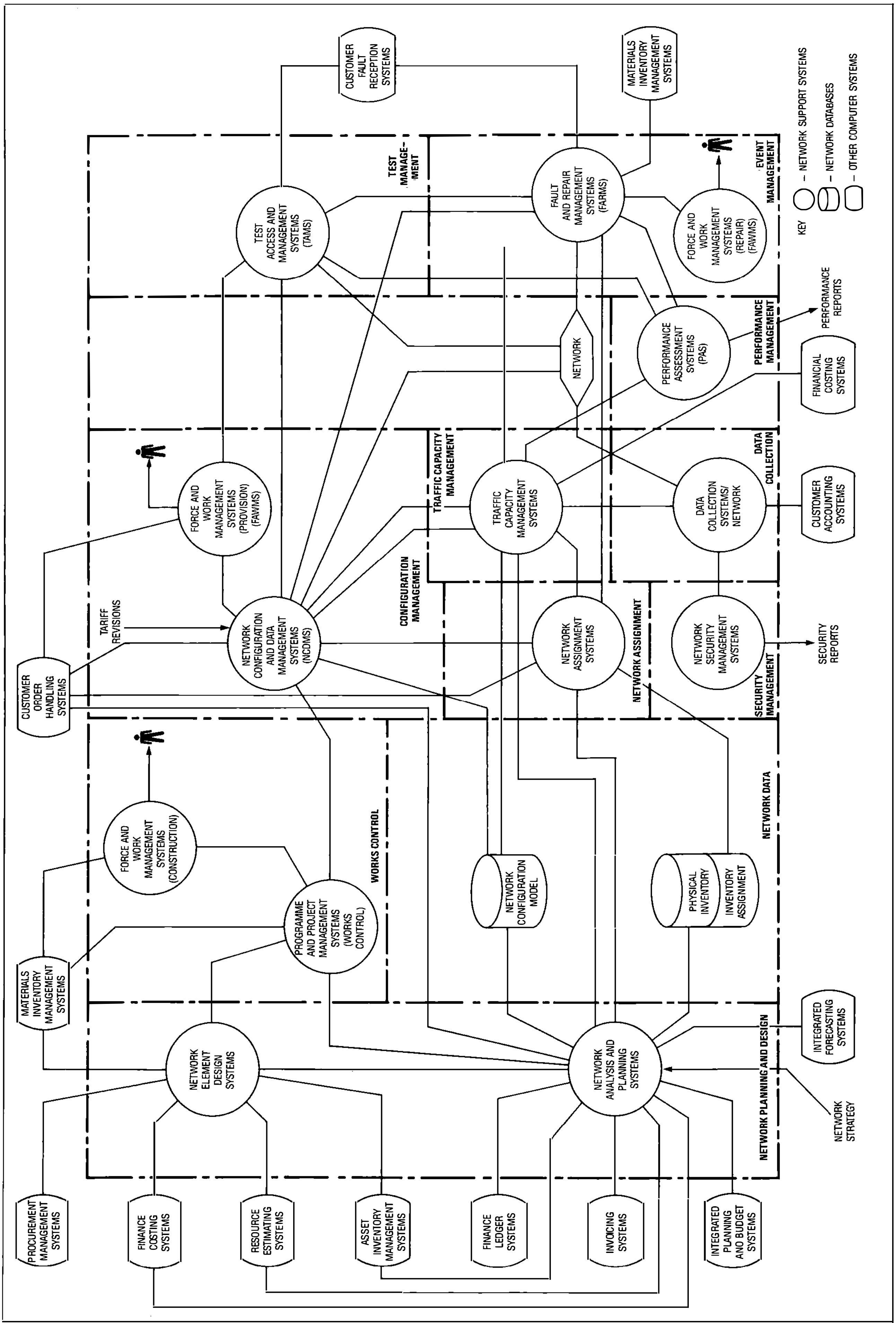


Figure 1—Network Support Systems Architecture

FARMS, followed by efficient workforce despatch by force and work management systems (FAWMS).

A significant challenge is to introduce testing of all aspects of a service which affect the customer's perception of that service.

There is also a need to improve customer assurance; that is, the ability to assure individual customers of the quality of the service actually given.

Most of the testing performed is parametric testing on the local copper network. The core network (transmission and switching) is hardly tested at all under remote test control, except for circuits during provisioning (although it is continuously monitored).

The testing that is performed is ultimately restricted by the test access of the network and the capabilities of the measurement devices. Additional test access is extremely costly (owing to the number of points of attachment to the network that is required) and was outside the scope of this study.

There is no ability for synchronised test events to occur; the capability of end-to-end testing is therefore low.

CURRENT ARCHITECTURE

The current architecture is summarised in Figure 2. The main systems are described below in respect of their test capabilities only.

Remote Access and Test Equipment System (RATES)

RATES[2] provides the primary testing capability for analogue private circuits. It consists of two types of equipment, namely the RATES management system (RMS) and the test access equipment (TAE). TAEs provide the means of access to analogue private circuits and the test capability itself. The RMSs perform the control and user interface functions and are linked via Packet SwitchStream (PSS) to enable coordinated testing of each stage of a given private circuit.

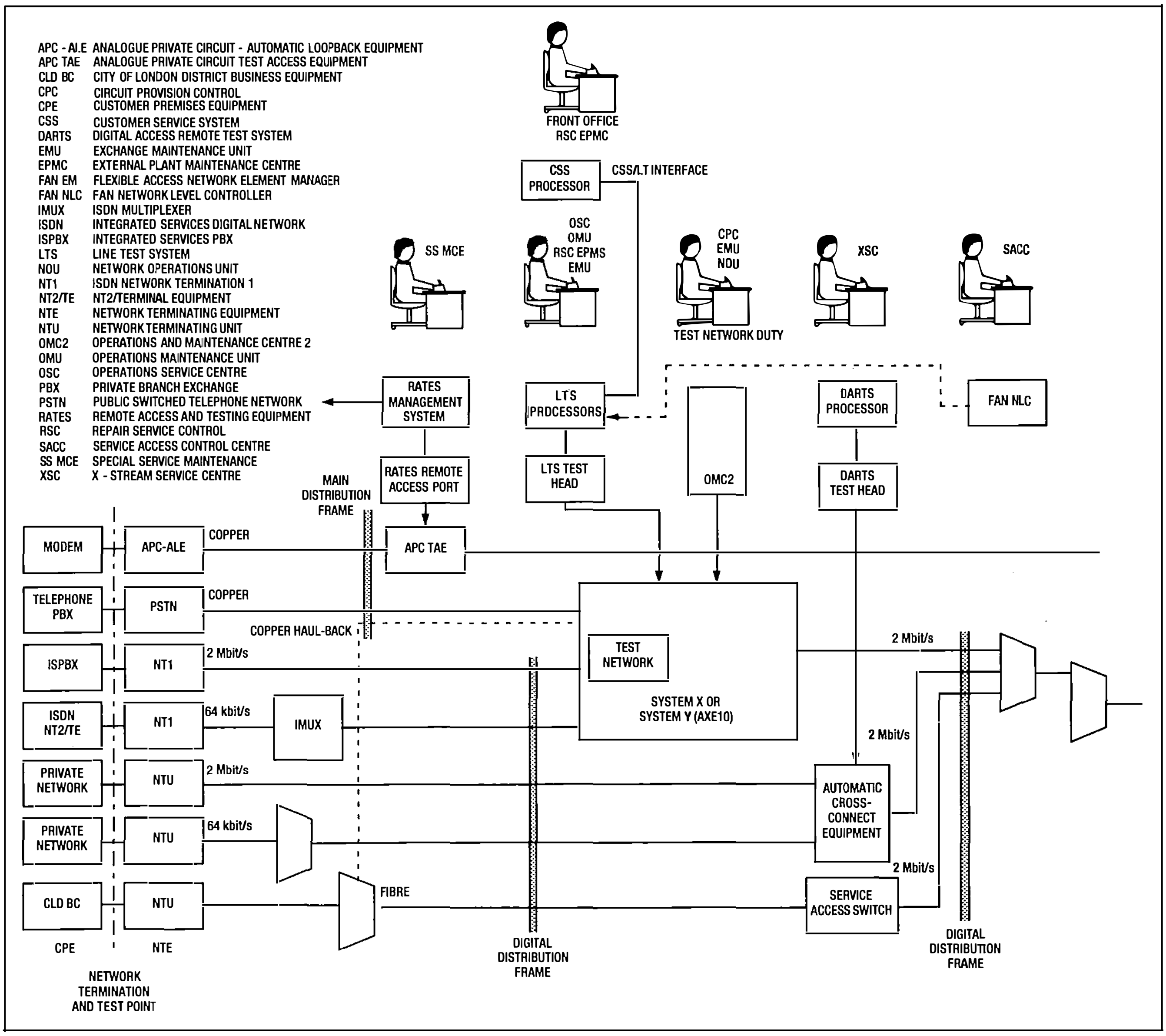


Figure 2
Overview of the current (1991) physical architecture

Digital Access Remote Test System (DARTS)

DARTS provides the primary diagnosis and fault clearance confirmation test capability for KiloStream private circuits in the UK that are routed via automatic cross-connect equipment.

Line Test Systems (LTS)

Four line test systems are used: Gateway, Vanderhoff, Teradyne and Northern Telecom. Each works in a similar fashion utilising metallic test access to customers' 2-wire lines. Each system has obtained one quarter of the total number of exchange connections. Each system performs parametric testing of analogue public switched telephone network (PSTN) lines, but there is not a common test specification or standard. Each drives the System X local exchange sub-system test network via V.24 ports. Each has a proprietary user interface typically used in repair service centres and each has an interface to Customer Service System (CSS) repair handling.

Operations and Maintenance Centre 2 (OMC2)

The OMC2 provides a control interface into the System X test network via the administration data packet network. It is used for customer access testing, including pair-gain systems and ISDN IMUXs via Digital Access Signalling System No. 2 (DASS2), and trunk and junction circuit testing used by circuit provision control duties.

Customer Service System (CSS)

CSS is designed to support field staff in the customer-facing activities concerned with the provision of PSTN service. It includes the repair-handling system, which allows front offices to invoke line tests using the LTSs. Depending on the results, the report is given a despatch code as appropriate. If there is no need for further customer contact, the report is sent to the back office, where a second iteration of diagnostic testing is initiated prior to despatch.

THE VISION

The vision is of a TAMS infrastructure offering an optimised portfolio of tests and capable of verifying that instances of BT's network elements and services conform to the specified design and operational requirements at minimum cost.

It will enable definitive statements regarding BT's ability to meet contractual obligations to individual customers or their representatives regarding quality of service and network performance.

Detection of faults and service degradation prior to customer dissatisfaction will be achieved through flexible, targeted, efficient and standard control of a total network test capability to perform continuous network surveillance of all local lines by scheduled testing. Optimum use will be made of test equipment and network resources.

The test capability will be available on demand at all times and to all authorised users from any part of the BT network with minimised manual intervention. The test capability will be unified across all types of switching systems and access technologies.

Fault localisation by on-demand testing will facilitate 100% despatch accuracy. The set-up and post-processing delays of all testing will be minimised. All on-demand tests initiated by customer-facing users will be accomplished in no longer than 10 seconds.

Open interfaces will allow international co-operative testing and competitive procurement, and will aid the integration of new tests, new network elements and services into the TAMS infrastructure.

TARGET LOGICAL ARCHITECTURE

Information engineering (IE) is a methodology which enables business requirements capture and, subsequently, all manual and/or automated activities to be streamlined. The first phase of the IE methodology, information strategic planning, was adopted in the production of the SSP. The second phase, business area analysis, was used in the evolution studies under the NCAB to enable the integration of computer applications and to avoid the duplication of data.

Business area analysis involves the identification of a data model, a process model, and their relationship by interaction analysis. More information is available in Reference 3.

A computer-aided software engineering (CASE) tool—information engineering facility (IEF)—was chosen for the evolution studies. IEF was used as a structured repository for the information collected, to maintain consistency checking of the information and to perform matrix analysis of the assembled information.

Process Model

The first task for the study was to produce a process decomposition of the three component processes assigned to 'Test the Network' by SSP[4], namely:

- Schedule Test,
- Control Test Sequences, and
- Maintain Testing Information.

It was decided that a further two levels of decomposition would confirm the validity of the parent processes and add sufficient detail.

The decomposition produced initially by using the developing team's knowledge and intuition was subsequently modified to take account of information assimilated from a wide range of interviews conducted with field personnel.

The process decomposition is given in Figure 3. This defines the distinct processes that may be performed in the course of progressing a test request. Not all may be relevant to every test, but similarly any one may be needed a number of times

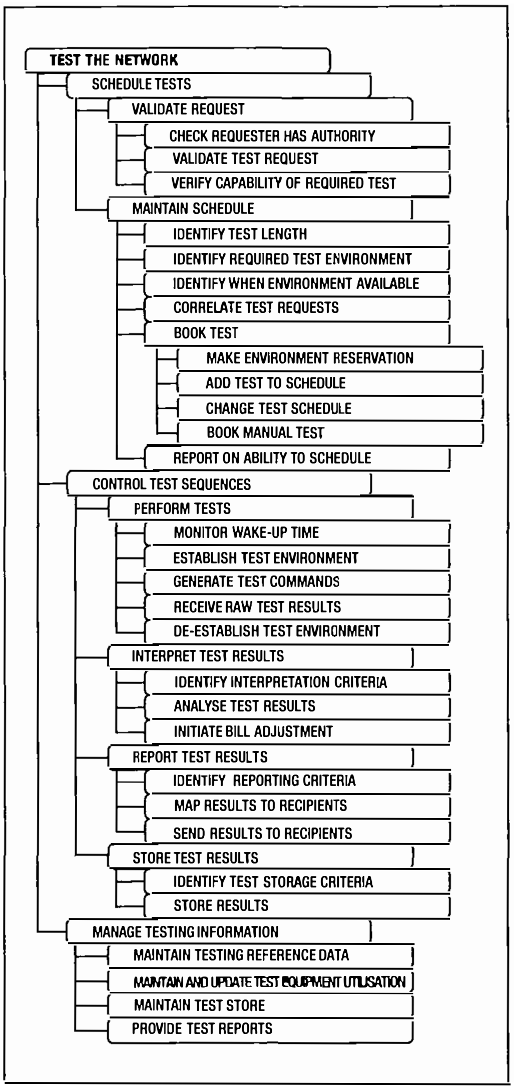


Figure 3
Process decomposition diagram

during a test. Each component process is logically unique but may need to be replicated in a physical implementation to achieve throughput. The layout of Figure 3, although apparently in time sequence, does not imply this order of processing.

Data Model

The data model, summarised in Figure 4, was created in parallel with the process model. The data entities identified represent the types of data that will be required by the TAMS systems. The figure also shows the relationships between the entity types. The notations on the relationship line further describe the relationship. Vertical bars and crow's feet convey cardinality: whether the relationship is one-to-one, one-to-many or many-to-many. The letter O on the line indicates that a relationship is optional.

In general, when a test request is received, it is vetted against test initiator data and scheduled according to the availability and capability of test equipment, which has to be configured according to the accessibility link. The request will be for a test of a specified test class to be performed on a specified test object. Each test performed will create an instance of test data which is modified as the test is progressed through the various test states in its life cycle.

Test class data includes the scripted procedures for each type of test which may contain conditional statements.

Test classes are either *simple* or *compound*; simple tests are the most elementary tests that can be invoked. Compound tests use two or more simple or compound tests to fulfil a more complex test requirement.

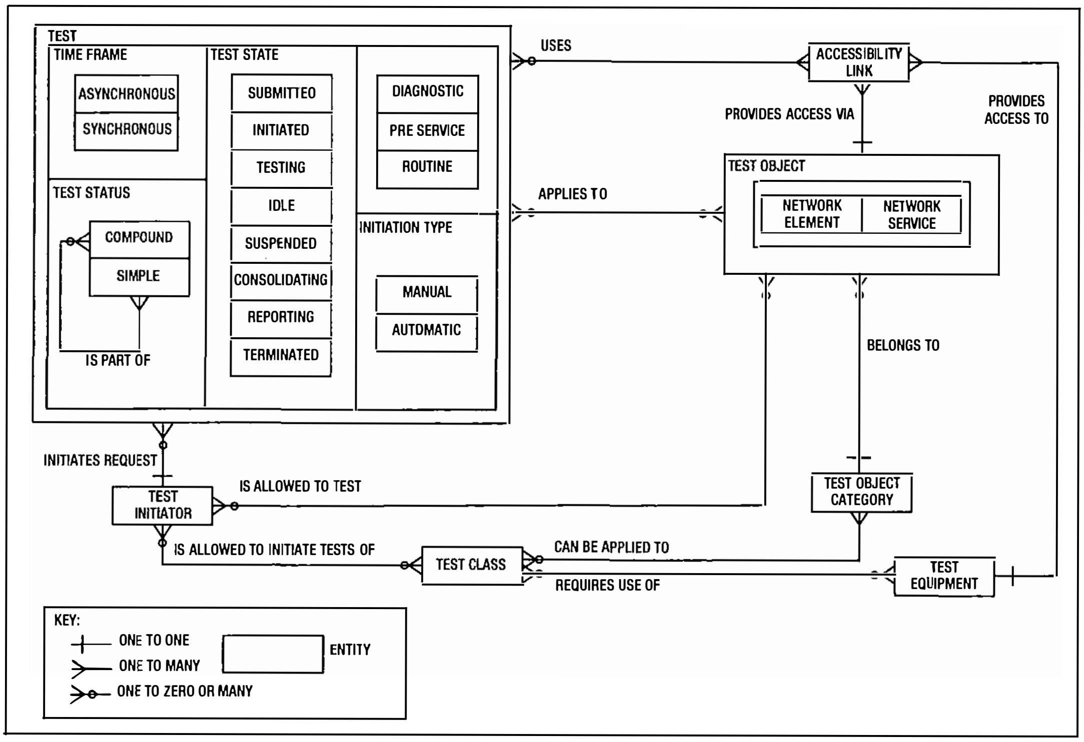


Figure 4
Entity relationship diagram

Business Processes

These identify the flow of processing which occurs within, and supports the functions required of, TAMS. This includes the progression of tests from request reception through to test deletion. It consists of strings of processes and the information which is required to pass between those processes (data flows). Figure 5 shows the level 4 business process of 'Test the Network'. Others were created at level 5 and at level 6.

Interaction Analysis

Having agreed the component processes and data entities, the next step was to decide on the interaction between them; that is, the effect that component processes have on the data entities in terms of creating, reading, updating and deleting them. The CASE tool produced information on the logical association of processes due to the affinity between processes in the use of the data.

Target Logical Architecture Design

Identifying opportunities to optimise the clustering of processes also due to their interaction with the network gives Figure 6, a diagrammatic representation of the processes and data combined which is consistent with the flow of information identified by the business processes. It is not part of the IE methodology but a view which is consistent with the contents of the process and data models.

TARGET PHYSICAL ARCHITECTURE

Generic Test Controller

The target logical architecture could be implemented in many ways. It was realised that, in this case, it would be realised not by breaking up the target logical architecture, but rather by replicating it in a network of generic test controllers (GTCs), each GTC being the physical implementation of the target logical architecture.

This approach:

- allows the provision of a common level and presentation of the testing service,
- allows the provision of an end-to-end testing capability, and
- facilitates compound tests built up from simple tests following test scripts.

Open Interfaces

Adopting an open interface between GTCs, and between GTCs and test equipment, allows:

- migration away from proprietary interfaces where beneficial,
- a clear separation between reusable test control systems and dedicated test equipment, and
- development and procurement of network elements and/or test equipment independent from the test control.

In August 1991, the OSI/NM Forum Test Management Function Specification[5] was approved as an agreed specification for implementation by Forum members in preference to any intercept of the International Standards Organisation (ISO) Test Management Function Standard which will only become an international standard by mid-1992 at the earliest. The GTC interface will be aligned with the OSI/NM Forum Test Management Function Specification as BT is working to Forum specifications where no stable standards exist.

The OSI/NM Forum Test Management Function Specification will be a stable specification which should be close to that of the final ISO test management international standard because each of these specifications have influenced the other. The Forum will provide a controlled migration from the Forum specification to the ISO standard when it becomes available.

The Forum and ISO specifications are both interface standards and as such do not define the internal representation of the test management data. The data held and transferred within the GTC needs to be of a consistent format. However, it is advantageous if the internal data format is the same as that used across the external interface to eliminate the need for translating the data formats for external communications.

This study has confirmed the technical feasibility of the use of the emerging standard *test request* and *test response* messages as candidates for becoming the primary inputs and outputs to GTC (and TAMS in general).

Description of Simple-Test Execution by a Single GTC

The scheduling engine receives and validates the test request, checking:

- the requester's authority to invoke that specific test, and
- whether that test is in the current test portfolio.

By reading the test class data, it identifies that the test is a simple test and assesses the current capability to perform that test by reading from the test equipment and accessibility link data.

Following the test script of that particular test class, it then ascertains and books required network and test equipment resources prior to scheduling the requested test at a time which will make efficient use of those resources while still satisfying any user specified time constraints.

Finally, it must report the success or otherwise of scheduling the requested test. It creates the specific test instance by using the test class as a template and modifying default settings as required.

The execution engine monitors the scheduled start time of each test and begins execution of tests at the scheduled wake-up times. This execution starts with the establishment of the pre-booked resources and continues with the generation of test commands to test equipment.

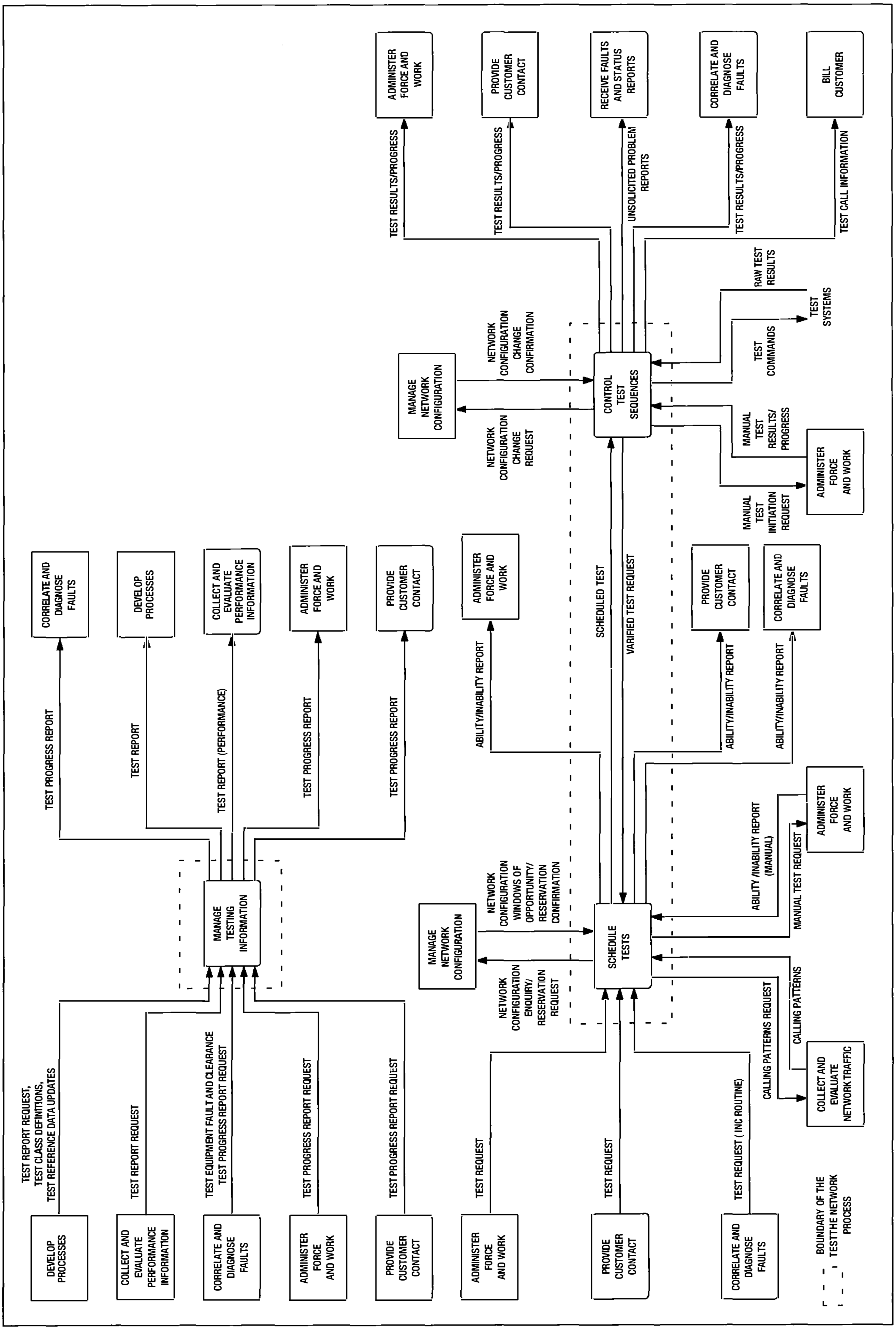
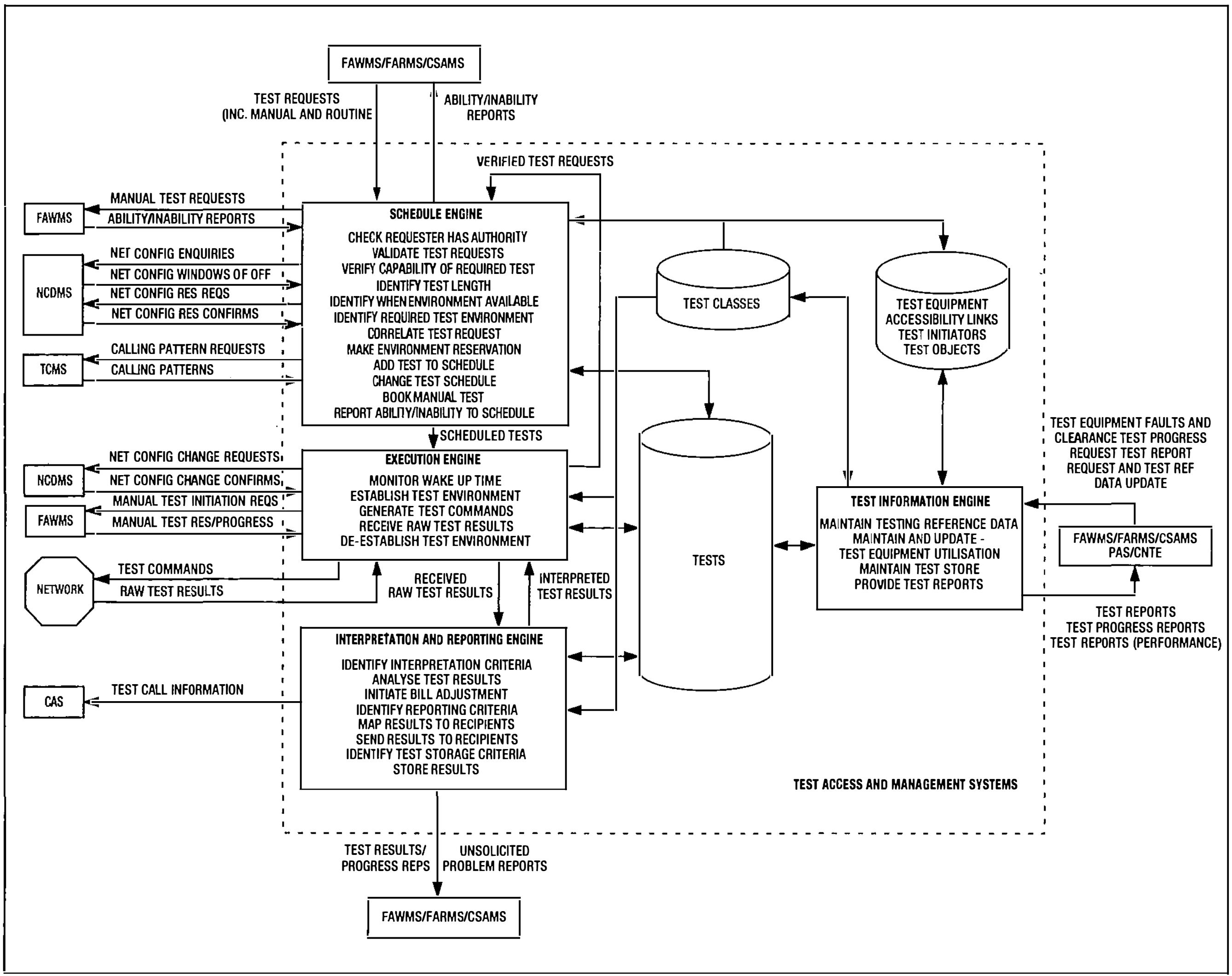


Figure 5—Top-level workstring



CAS: Customer accounting systems
CNTE: Corporate network test executive
FAWMS: Force and work management systems
PAS: Performance assessment systems
FARMS: Fault and repair management systems
CSAMS: Customer service access management system
NCDMS: Network configuration and data management systems
TCMS: Traffic capacity management systems

Figure 6
Target logical architecture

For a simple test class, these test commands do not involve any conditional decisions.

Raw test results are then received/retrieved from the test equipment. After the active testing phase of the simple test, this engine releases the remaining test equipment and network resources.

The interpretation and reporting engine uses the predefined interpretation criteria from the test instance to analyse the raw test results. It also must initiate the procedure to adjust customer bills where appropriate.

After interpretation, the required results must be reported to all identified recipients and then stored with the predefined storage time identification.

The test information engine provides data management for the target logical architecture (TLA). It allows for updating of any of the test reference data (that is, test equipment, test class, accessibility link, test object and test initiator) as test equipment/test classes are added, subtracted or modified. It continually updates the data regarding availability and utilisation of test equipment. Finally it monitors the storage times of test instances, deleting them when they are no longer required.

This engine gives both internal and external users the facility to request a wide range of test reports on almost any aspect of TLA-held data. In particular, it can provide a list of the tests available. This enables systems external to TAMS to offer their users menus and forms at the man–machine interface.

Description of Compound-Test Execution by Multiple GTCs

Figure 7 illustrates the interaction between two GTCs.

The sequence is similar in concept. From the test class, the requested test is identified as a compound test and the test script retrieved gives the instruction to request the distant GTC to perform a simple test within a time window.

The distant GTC receives the request for the simple test and goes through the sequence identified above. Once scheduled it reports the ability to perform the test at a specific time-slot within the requested window.

The near-end GTC then schedules the remaining procedures of the compound test. The near-end GTC has created a test instance for a compound test and the distant-end GTC has created a test instance for a simple test.

The window of active testing at the near end is within the active testing window of the far end. A report of the ability to perform the compound test is returned to the requester.

At their wake-up times, both ends initiate the establishment of their respective test environments and proceed with their test commands.

Once the active testing phase at each end is completed, the environments are de-established.

The near end interprets the result of the compound test taking account of the (raw) test results provided by the distant GTC. The distant GTC stores the test result of the simple test, as required; the near-end GTC reports and stores the compound test result as required.

It should be noted that the request made of the distant GTC need not be confined to a simple test, nor need the testing be confined to two GTCs.

Description of Interactive Test Execution

Some testing is not fully contained within the confines of TAMS and will require interactive testing; for example,

- speech monitor paths,
- transmission event monitoring, and
- interaction with call control.

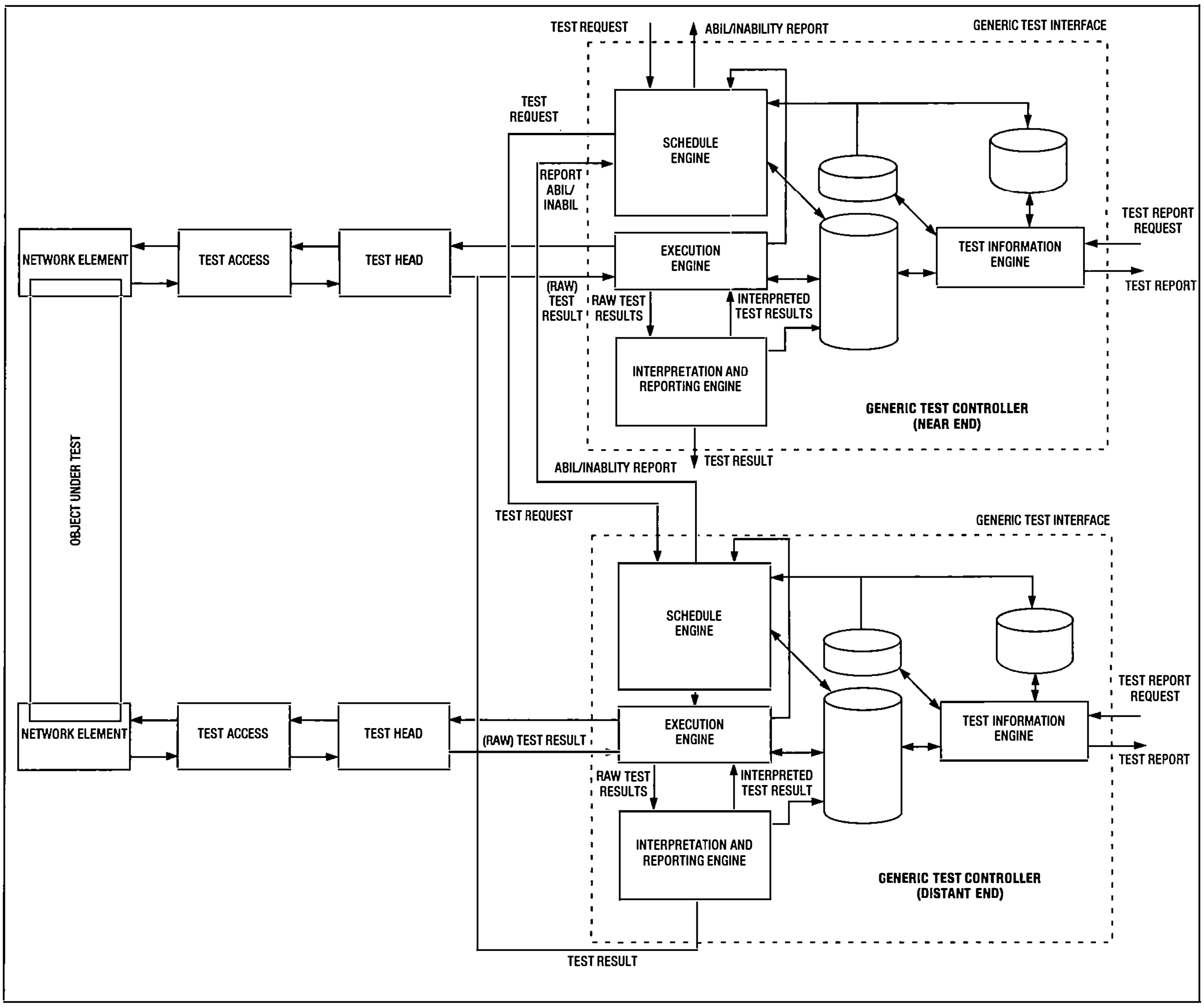
Essentially, in each case the GTC testing procedure will be as described above to apply the correct stimulus, but the test requester will be required to observe the response to the stimulus.

THE FUTURE

At the time of writing, the business model as produced down to level 6 is at the stage of draft for approval by NCAB and the Business Process Unit. Once approved, it will be incorporated in the BT business model, and then becomes subject to the BPU's change control.

TAMSES has produced a migration strategy for existing test systems and proposals to improve

Figure 7
Example interconnection between generic test controllers



coordination of the testing process across the network.

The concept of tests run according to scripted procedures means that the test control of new tests and new equipment can be enhanced and increased in due course by creating the required test scripts. The following paragraphs describe some developments already under way (the requirements for which have been confirmed by the TAMSES) which can be exploited using generic test control.

Transmission and Connectivity Tester (TACT)

TACT is a transmission and connectivity testing specification planned to be offered for competitive tender in late-1991/early-1992. It will primarily test the quality of both national and international PSTN dial-up connections for both statistics gathering and maintenance purposes.

TACT employs two types of test head unit; namely, transponders and responders. Although initially attached to dedicated test numbers, these units will have the capability to use test access to each customer's 2-wire line at the interface to the main distribution frame (that is, the same test access as the LTS).

Transponders initiate and manage all test calls to responders via a proprietary protocol and are themselves managed by a controller over a fixed or dial-up control connection. Controllers too are to be coordinated to ensure maximum access to responders.

Test heads provide the normal connectivity measurements as a consequence of the dial-up process prior to the connection phase of the test call. Once connection is made, a subset of the available parameters will be measured. The subset will be variable according to the purpose and constraints of the required test.

The measurable parameters are as follows:

- transmission loss versus frequency and level,
- idle-channel noise,
- impulsive noise,
- total distortion including quantisation distortion,
- group delay versus frequency,
- round trip propagation delay,
- echo, and
- clipping.

By specifying limits for the test results obtained for each parameter, simple pass/fail type statistics can be provided.

These might be more useful for customer-facing staff, raw data being retained by the controllers for use by personnel involved in trend analysis of fault finding/repair.

By adding a level of generic test control above the TACT controller level it would be possible to control transmission and connectivity testing between any two customers (though the allocation of the connection will not be controlled).

Event and Test Management System (ETMS)

BT Business Communications requires a combined test control and alarm handling system to unify access to all private circuits using RATES and DARTS. Agreement has already been reached, in principle, that the ETMS will include the GTC in its architecture.

Integrated Test Facility

GPT Limited is developing an upgrade of the System X test network subsystem. This promises an improvement in the speed and availability of some tests.

Expert Diagnosis

Independent studies have been taking place on expert systems capable of diagnosing faults by applying complex algorithms to the results of line tests. Similarly, algorithms can be applied to learn from the experience of previous test results.

The algorithms may in the near future be written into the test scripts and applied by the interpretation engines of GTCs.

Applied in cooperation with spacial, temporal and logical correlation of network events by fault and repair management systems (FARMS) and efficient despatch of field personnel by force and work management systems (FAWMS) repair times will be decreased.

Distributed Environment for Testing Communications Technology (DETECT)

It is sometimes necessary to construct automated test environments capable of testing the communications service provided between geographically separate points. An approach called *DETECT* has been developed within BT Development and Procurement to meet this need. DETECT technology is being exploited and enhanced to provide test services independent of the network under test. Some DETECT techniques will be exploited in the GTC work described earlier, to provide built-in network test facilities.

Concert™

By using GTCs, it may be possible to offer network test service to customers. This includes:

- customer initiated testing of BT's network and services, and
- siting GTCs on customer premises to facilitate testing at the critical boundary between customer premises equipment and licensed operator responsibility.

Test Control in New Hardware Technology

Test protocols for integrated circuits are being developed. Each chip on a slide-in-card conforms to the protocol (IEEE 1149.1) and has pins connecting it to a common bus. An associated protocol links the card on the back-plane to give remote test access into chip level functionality.

It may be possible in future, providing the future holds a significant penetration of equipment supporting these protocols (and if the requirement to remotely test within a replaceable item is established), for the GTC to provide full exploitation of that capability.

Portable Testers

BT currently uses a multiplicity of portable tester types (about 100). Given the right test access, GTC could be used to offer those tests remotely. If just a small percentage of the use of these testers could be automated, significant savings should be possible.

CONCLUSION

TAMSES has identified a target architecture for network test management systems based on a distributed network of GTCs.

Development of individual SSAs in isolation will accomplish limited advantage. Applied in cooperation with developments in fault and repair management systems, force and work management systems (FAWMS), and other systems in the Network Support Systems Architecture, significant improvements in the business processes using testing will be achieved.

ACKNOWLEDGEMENTS

The author would like to acknowledge the dedication and hard work of all members of the TAMSES team, the field personnel from the East Anglia and South Downs Districts, Manchester NOU and Liverpool front office who participated in TAMSES interviews, and the many colleagues who have assisted TAMSES from their own areas of expertise.

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Biography

Colin Reed joined Post Office Telecommunications in 1974 as an apprentice in the Brighton Telephone Area. After graduating from Brighton Polytechnic with a degree in Electronic Engineering, he joined the Research and Technology Standards Evolution and Systems Division. There he helped develop international standards for the ISDN user network interface. In 1990 he moved to the R&T Network Management Department's Architecture and Portfolio Evolution Section where he was invited to lead the TAMSES team.

National Charging Database

S. SMYTON, and U. McMAHON†

The accuracy and integrity of the call charging data used by BT's exchanges are of paramount importance. This article outlines the history and development of the national charging database and describes the new tools now becoming available to audit the system.

INTRODUCTION

The national charging database (NCDB) has been developed to maintain one set of charging data which can be utilised by all BT exchanges and systems that need to price calls. It ensures that accurate call pricing information is available for charging telephone calls originating within the BT UK network.

CARDVU (charging and routing data verification utility) is an automatic auditing tool, designed to give a network-wide summary of charging errors.

Using the data available within NCDB, CARDVU reinforces BT's ability to demonstrate adherence to the OFTEL (Office of Telecommunications) requirement that all possible measures are being taken to ensure that customers are charged accurately.

Prior to the introduction of NCDB in 1989, all tariff revisions were carried out manually. Approval for the project was granted in 1988. The first version went live in February 1989, and the London code change release went live in October 1989.

The objectives of NCDB are to:

- hold all charging and tariff data for BT Worldwide Networks call pricing systems,
- provide, wherever possible, an electronic transfer of data to the systems which price customer calls,
- provide data to enable monthly audit of pricing systems,
- update directly, pricing data on all call pricing systems,
- hold full national numbering data, and
- cope with rapidly changing network and business requirements.

Call Pricing

Before a call can be priced the following information is required:

- type of calling customer
- location of calling customer
- the digits dialled
- the time of day
- the day of the week
- the duration of the call.

† BT Development and Procurement

The NCDB holds this information in the following form:

(*a*) *Charge Group* Each customer belongs to a single charge group. A charge group covers an area of the UK and is normally made up of several exchanges. There are currently 634 charge groups in the UK.

(*b*) *Charge Band* This is determined by the origin and the destination of the call. Normally this is related to the distance between them, but the charge band can be the same over the whole country, regardless of distance; for example, CallStream Service.

(*c*) *Tariff Group* Each customer is allocated to a tariff group. Although the NCDB does not maintain individual customer groupings, it has sufficient data to price a call.

(*d*) *Tariff Data* This is used to determine the time allowed for an individual call. Tariff data includes the charge rate (peak, standard or cheap), and the day type (weekday, weekend or concessionary) for each tariff group.

The NCDB, therefore, holds charge-band information for each charge group to each destination, as well as all-number strings to identify uniquely the charge group in which every range of numbers, and thus each customer, is located.

By using the digits dialled by the customer (the charging number string), the NCDB calculates precisely the cost of a call made by any BT customer.

The ability within NCDB to update, insert and delete charge bands, charge groups, tariff rates, exchanges, etc., allows any alterations that are made to the telecommunications system to be incorporated easily into NCDB.

Structure

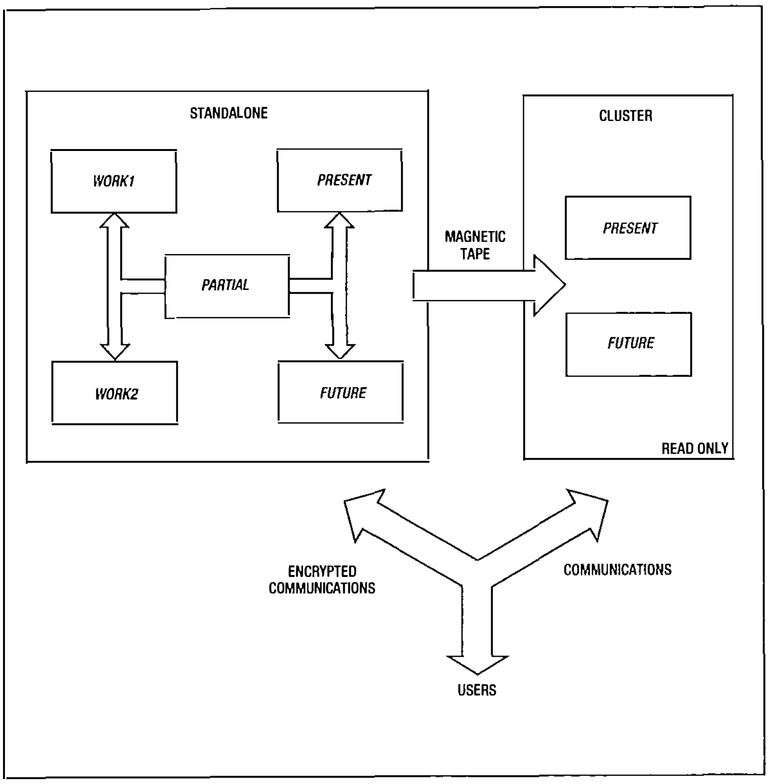
The NCDB system consists of five completely separate databases:

(*a*) *Present*
(*b*) *Partial*
(*c*) *Future*
(*d*) *Work1*
(*e*) *Work2*

Each of these databases has an identical set of tables, although the actual data stored within the same table across the databases may differ.

The system has been developed to run on a standalone computer and also as a product within the digital exchange support system (DESS) cluster. The standalone system runs all five NCDB databases, while the DESS cluster runs only the *Present* and *Future* databases, which are held as read-only files, thus preventing uncontrolled changes to those databases. These provide access to the current charging data and to data that will introduce the next tariff change, see Figure 1.

Figure 1 System configuration



The standalone computer is located within a secure environment and only encrypted links are available for access by Network Pricing and NCDB Data Collection Input (NDCI) users. The two *work* databases are held on the standalone computer and these are used for modelling and manipulation of the charging/tariff data. The *Work1* database is used mainly for the production of tariff revisions and the *Work2* database for studies of pricing structures.

CHARGING AND ROUTING DATA VERIFICATION UTILITY (CARDVU)

The method of carrying out data auditing at the moment is for NCDB to produce reports known as *M11* files. Each file represents one of the 634 charge groups within the BT network, and contains details of the charge number strings that are available to customers in that charge area, together with their associated charge band.

NCDB also produces a monthly set of standard files containing charging data which apply across all exchanges in the network; that is, duration per unit fee depending on day and time, etc. These files are provided to the district data managers as input for the AUDAX and TXE4ECAT audit tools.

Each month, the data on every digital exchange is archived and this data is used, with the appropriate audit tool, to compare the exchange charging data with the M11 and standard files, provided by NCDB. Reports, which contain errors and warnings, are produced for district data managers.

This error-checking process has some problems, not least of which is the data being up to a month out of date. Some of the enhancements planned for NCDB are aimed at keeping these files in step with the NCDB database.

When CARDVU Version 1.1 is operational in early-1992, charging data for each TXE4E exchange will be manually transferred each month (by district data managers using a file transfer utility) to the DESS environment.

CARDVU will then automatically audit that data against data supplied by NCDB (see Figure 2 for overview).

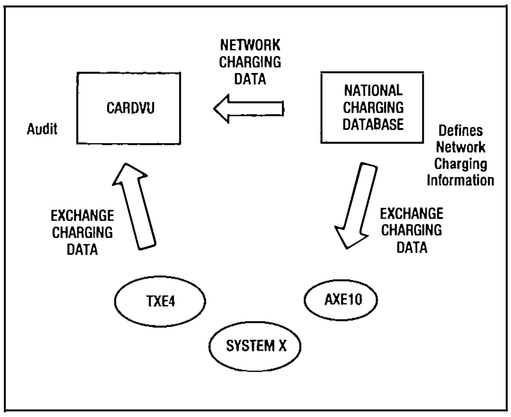


Figure 2—Overview of NCDB and CARDVU

The outline plan is to have similar facilities available for System X and AXE10 during 1992. System X data will then be transferred to DESS.

The AXE10 charging data will be automatically retrieved by CARDVU following an electronic request to the relevant district data collector (DDC). The DDC will retrieve the data from the exchange and transmit it to CARDVU by using the file transfer access and management (FTAM) protocol.

In the longer term, System X exchange data may also be retrieved automatically, though this may depend on the provision of new remote archive load facility (RALF) units at all System X processors. RALF would provide an electronic link between DESS and the System X exchanges, and CARDVU could then automatically request the data it requires. Alternatively, data collection may be possible via the DDC.

The following functions will be available to CARDVU users:

(*a*) *Scheduling*

- Schedule audits for all exchanges on the network. An audit must be scheduled (for a specific date and time) for every exchange at least once per month. Additional audits may be scheduled; for example, to check the effect of changes made to the exchange data, due to a tariff revision.
- Change any audit schedule date.

(*b*) *Auditing*

- If an AXE10 exchange is being audited, then CARDVU will launch a job on the relevant DDC and then wait for it to return the required data. CARDVU will expect System X and TXE4E data to have been transferred to DESS before the scheduled audit time.
- CARDVU will compare the exchange data against the NCDB data, log all errors/warnings in a database and inform district staff (by electronic mail) that there are errors to be dealt with.
- CARDVU will maintain a file of the status of all audits, and the result, for example, pending, executing, completed or failed, so that it can report on them.
- CARDVU will automatically clear errors found in a previous audit if they do not recur.

(*c*) *Commenting*

- CARDVU will allow users to comment on errors logged against an exchange.
- Comments can be added by more than one user.
- Errors can be noted as CLEARED.

(*d*) *Reporting*

- CARDVU will generate exchange specific, network operations unit (NOU)-wide or network-wide audit reports.
- Reports can be produced on the status of exchange audits for the current month; for example, number of exchanges audited, not audited, etc.

(*e*) *Escalating*

- If errors logged by a CARDVU audit are not commented on within a defined time period, CARDVU will escalate them to district security officers and will continue to do so until they are acknowledged. This escalation will be handled by electronic mail or by Radiopaging.

Once BT network management teams have access to the full CARDVU system, they should start to see the following benefits:

- Available resource will have more time to perform higher level functions with the elimination of most of the manual activity.
- More reliable information will be available to higher management on the accuracy of customer charging nationwide.
- Trends will be identified which should lead to improved network operation.

There will remain some manual tasks, that is, copying exchange data to DESS, but these may also be overcome in the longer term, thus increasing the above benefits.

Figure 3 shows the links between NCDB and CARDVU, and other systems.

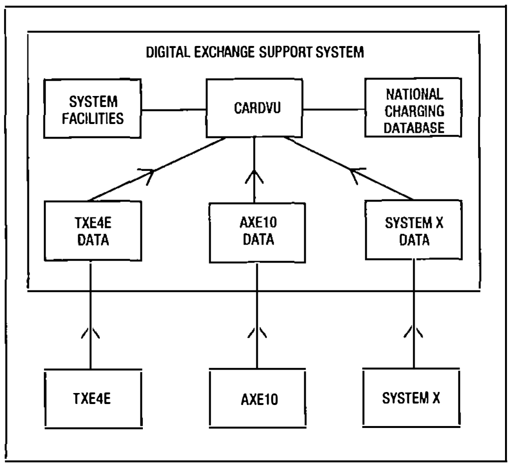


Figure 3
Links between NCDB, CARDVU and other systems

Implementation

NCDB is a fourth-generation software product developed using the ORACLE relational database management system.

CARDVU has been developed also by using the ORACLE relational database management system.

The first release of CARDVU is planned for early-1992 and will provide facilities for the automatic auditing of TXE4E exchange data. Future releases will provide similar facilities for System X and AXE10 exchanges.

Until CARDVU goes on-line, the following systems will continue to be used to audit exchange data. For System X exchanges, there is the CATMAC (Charging Accuracy Team MACro) product. This was originally a personal computer based tool that has subsequently been ported to the DESS VAX cluster.

AXE10 exchanges are audited by using AUDAX (AUDit AXe10), which is also a personal computer-based product.

For TXE4E exchanges, there is the TXE4CAT product which provides an audit facility for TXE4E exchange charging data.

There are a number of problems associated with the existing auditing tools, CATMAC, AUDAX, TXE4ECAT. In summary, they include:

(*a*) lack of control over their use; for example, there are no facilities to ensure that:

- audits are carried out on a regular monthly basis,
- any errors identified in the audit are corrected, and
- there was no manual intervention and that data was not modified before an audit took place;

(*b*) lack of a network-wide picture of the accuracy of exchange charging data;

(*c*) the manual creation of control files, and transfer of data to a personal computer; and

(*d*) generation of spurious errors due to report (M11) files being out of date.

CARDVU will resolve the above problems and will provide some facilities/features, which currently do not exist.

Responsibility for operation of the NCDB is shared between the Network Pricing Division and the NDCI group. The NDCI is responsible for incorporating number changes, provided by districts, into NCDB. The Pricing Division is responsible for all other data held in the databases. Supervision of the NCDB is the responsibility of the network pricing database administrator.

Future

During the next year, new releases of CARDVU will provide the following functionality:

- automatic access of TXE4E data via the DDC,
- assessment of financial loss/gain associated with all reported errors,
- audit of System X data,
- audit of AXE10 data, and
- audit of Operator Service System (OSS) data.

In the longer term, enhancements may be required to:

- audit new types of charging data,
- audit new types of non-charging data, and
- provide for automatic access to System X data.

Most of the above CARDVU enhancements will require enhancements to NCDB to enable it to provide the required reference data.

CONCLUSION

The NCDB is the single reference source of network charging and tariff data for use within BT.

The integration of BT's network support systems is a prime aim of the Network Administration Implementation Programme. This integration should be achieved by using Open Systems Interconnection standards; such as Co-operative Network Architecture-Management. An example of this is the FTAM link between DESS and the DDCs, which CARDVU uses to extract AXE10 and TXE4E charging data.

The role of NCDB and CARDVU is vital as the base for accurate call charging. As flexible pricing becomes a feature of the services offered by the network, call charging databases and the verification of call charging will be an important aspect of ensuring customer satisfaction.

Biographies

Shaun Smyton joined BT direct from school as a Trainee Technician Apprentice in 1971 and was part of the first intake of apprentices at Martlesham Heath. In 1974, he worked as a Technician on semiconductor reliability. In 1976, he became a minor award holder and obtained an honours degree in Computer and Communications Engineering at Essex University. In 1979, Shaun was appointed Level 2 manager in System X Development writing software development standards. From 1981, he was seconded to Plessey Liverpool to work on System X data-build tools, returning to BT three years later to continue this work. In 1984, he was involved with the Xi generic study to look at the five-year vision for supporting the digital exchange environment. In 1986, he became Head of the DESS Group, whose responsibilities included development of trunk databases, NCDB and DESS system utilities. In 1989, he was appointed Head of Section covering all DESS developments within BT Research and Technology.

Una McMahon graduated from Queens University Belfast, in 1981, with a degree in Computer Science. She then joined BT's newly-formed Belfast Systems Software Engineering Centre where she has been involved in several software engineering projects ranging from System X test tools, cable TV systems and Phonepoint to her current work in the field of network support systems. She currently leads the CARDVU system development team.

Network Management Workstation

A. D. VICKERS and V. TRAYNOR†

Computer access in BT is undergoing a transformation. The traditional image of one user, one system, one terminal is changing to one where users are increasingly being required to access a number of disparate computer systems to perform a complex range of tasks. The network management workstation (NMW2) is playing a major role in the realisation of this scenario. This article explains how the NMW2 achieves terminal and system integration, its requirements and functionality are described and some future aspects are discussed.

INTRODUCTION

The network management workstation (NMW2) offers end-users a secure and controlled windowing workstation environment from which they can access a number of host systems simultaneously. It has been developed by the Network Management Department to facilitate front-end integration of disparate key systems and to provide a platform for a more sophisticated human–computer interface.

HUMAN–COMPUTER INTERACTION

The following section discusses conventional system access in BT. It is followed by an examination of how the NMW2 overcomes the two major problems of computer access, namely, the integration of terminals and systems.

Conventional System Access

Up to the late-1980s, computerisation of network administration concentrated on improving and automating single tasks in an uncoordinated fashion using systems developed by specific manufacturers, each with its own user interface and terminal type. The rationalisation of network administration being undertaken by the Network Administration Implementation Programme (NAIP) has resulted in network operators requiring access to a number of systems to undertake their work. As a result, more and more personnel are required to operate disparate computer systems, negotiate their unique documentation, and learn entirely new user interfaces. The problem is illustrated in Figure 1.

This situation is becoming more prevalent as the network and its management are being modernised and where users perform fewer system-specific duties such as surveillance of the trunk transmission network, but instead work in functional areas (such as fault management), or support a business process (such as technical front office functions or end-to-end circuit provision).

Each individual host system is only concerned about its own security so that users must log on to each terminal with their username, password and swipe card, if required. This process is laborious when accessing more than one system such that users may be tempted to duplicate or document their numerous passwords which violates security procedures and jeopardises system security.

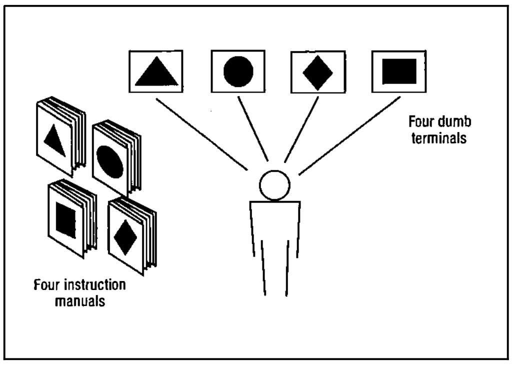


Figure 1 Conventional system access

There is neither terminal nor system integration in the above scenario, operators essentially running each system's terminal in parallel, with the inter-system communications only performed through manual keyboard re-entry. Here the user is the integrator.

The NMW2 is a means of overcoming these shortcomings by facilitating terminal and system integration. As these solutions vary quite considerably in complexity, the NMW2 provides a smooth migration pathway from one to the other.

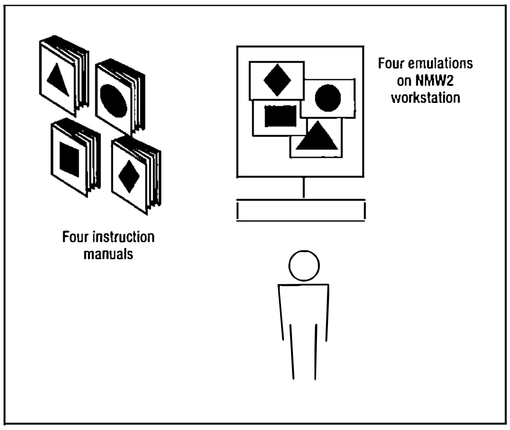
Multiple Terminal Integration

The first phase, which has proven successful at operational sites, is to provide terminal integration. Here the NMW2 has the facility to access a number of specific hosts, as individual windows, through a single workstation as if the system-specific terminals were hidden behind the workstation screen. This is illustrated in Figure 2.

NMW2 will be used to access all BT's major host systems. It is currently being validated for IBM, Digital and ICL sessions over the INTERNET network and some non-INTERNET hosts such as MS-DOS systems. Access to Hewlett Packard systems over INTERNET will be validated shortly.

† BT Development and Procurement

Figure 2
Terminal integration

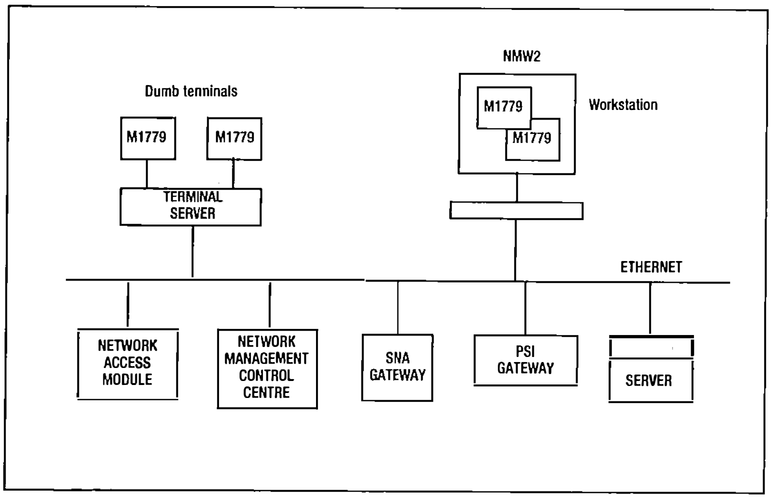


Thus, for example, operators can now access the operations and maintenance centre (OMC), and Customer Service System (CSS) simultaneously through one terminal. The system interaction is still by manual keyboard re-entry but, because it now takes place on a single screen with a modern user-friendly environment instead of a single text-based terminal, a number of benefits arise. Users learn how to operate graphical workstations quicker than a number of disparate computers, they experience reduced frustration and fatigue and, as a result, the quality of their work improves. Specifically, users complete more tasks with less errors than they would otherwise perform.

The NMW2 incorporates a mechanism which provides one of the highest levels of access security currently in use within BT. The intelligent smart card provides the facility for users to log on to all of their systems via a single secure point of access. They need only enter a single username, password and a 'onetime passnumber' which can uniquely identify users and their smart cards to the NMW2. After successful log-in, the NMW2 is tailored with each user's profile detailing the hosts to which they are permitted access. No further log-on is therefore required, users entering required hosts as necessary.

Although it is now proven to be technically possible for a secure NMW2 automatically to log users on to host systems, BT's current security policy requires that they still log on to each host system individually. Investigations are underway to amend this approach.

Figure 3
INTERNET LAN



The network management workstation has a number of facilities allowing controlled *copy and paste* between secure applications. The first permits the straight transfer of data to and from host systems. Facilities via the M1779 terminal emulation selection manager can identify predetermined strings of data and interpret and enter them on host system screens. For example, 'Control A' would be entered as '^A'. A selective copy and paste is also planned which will only copy certain fields. Text can be stored temporarily in a clipboard for frequent use.

The copy and paste facilities described above will improve the accuracy of users' transactions and will save time.

There are two variants of NMW2 terminal integration depending on the type of the local area network (LAN) on site:

- INTERNET system access, and
- non-INTERNET system access.

These are described below.

INTERNET System Access

INTERNET is BT's internal networking strategy to provide authorised access to various applications running on a variety of vendors' hosts. It employs the T-NET Plus LAN which is presently accessed by means of a dumb text-based terminal, the M1779. This was developed for BT in 1986 to gain multiple concurrent system access and to look and behave like a native terminal. The M1779 is essentially a Digital VT220-like terminal with extra features to support IBM, Hewlett Packard and certain other terminal types, and therefore reduces the number of terminals required at INTERNET sites.

The M1779 performs well in most scenarios, but for applications where simultaneous access to multiple systems is required, it is deficient. It can support multiple host links, only one of which can be active at any one time. Furthermore, neither data nor files can be transferred between sessions and, because it has no local processing power, it cannot display modern graphical user interfaces. These weaknesses are addressed by the NMW2.

To appreciate how the NMW2 operates in the INTERNET environment, it is necessary to understand how the M1779 terminals work. This is because, to conform with INTERNET procedures, the INTERNET NMW2 must behave like a number of M1779 terminals. As will be seen, the INTERNET architecture is not rigid and will be migrating towards open standards. The following sections explain how the NMW2 will operate in these scenarios.

Current INTERNET Architecture

Figure 3 illustrates an INTERNET NMW2 and two M1779 terminals co-residing on the current T-NET Plus LAN.

M1779 terminals are physically connected using Digital terminal servers to the T-NET Plus Ethernet. When powered up, both terminals and terminal servers connect to which ever network access module (NAM) is least loaded. The software on that NAM validates the user access and presents the user with a menu of hosts to which the user is permitted access. Once a host is chosen, the NAM provides emulations and gateways, if required, forges the M1779-to-host link and implements system security. The allocation of resources is managed by the network management control centre, (NMCC).

The NMW2 gains access to the INTERNET by emulating, in software, M1779 terminals and their multi-port terminal server. It runs the multiple emulations through the NAM with the NMCC carrying out its role as normal. Each time users request access to host systems, the NMW2 fires up another M1779 emulation and simultaneous system access is attained. Emulations are provided by means of an M1779 terminal emulator which has recently been validated and approved as part of the INTERNET portfolio for connection to T-NET Plus.

Figure 4 illustrates the M1779 emulation accessing two CSS sessions.

Future INTERNET Architecture

As the NMW2 is the INTERNET portfolio UNIX workstation, it will continue to be compatible with future INTERNET architectures. It is initially planned to migrate the largely proprietary NAM architecture towards an open architecture. It is likely that the M1779 terminals, NAM and NMCC will be replaced by a workstation, (providing full, direct terminal emulations) and additional equipment to replace the NAM and NMCC.

The advantages of the open architecture include: cost reductions (NAMs will not be needed, their replacements will be fewer in numbers and will be purchased in the competitive open market); improved performance (since the workstation will be directly connected to the network); reduced network traffic, and the ability for local processing.

Non-INTERNET System Access

The non-INTERNET system access is illustrated in Figure 5. Here the NMW2 sits on the Ethernet LAN and accesses host systems using the necessary terminal emulators and gateways. Non-INTERNET installations are a combination of procured emulators (for example, IBM) and internal BT emulators such as the M1779.

This type of NMW2 configuration has been successfully installed at BT's Madley Communications Centre, Hereford.

The previous sections explain how the NMW2 is being employed to integrate terminals in both INTERNET and non-INTERNET environments.

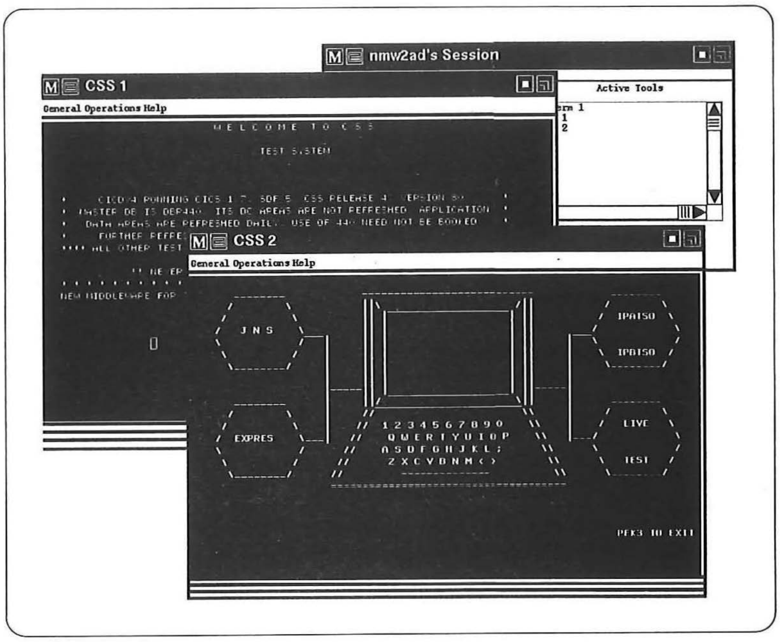


Figure 4
NMW2's M1779 emulation

It is a 'super terminal' for use by personnel who are regularly required to gain simultaneous access to, and transfer data between, a number of systems. It will, therefore, not be replacing all of BT's dumb terminals. M1779s, personal computers, Digital VT100s and such like will remain in operation for users who do not need its sophisticated interface or in areas which will not be migrating towards a distributed processing environment.

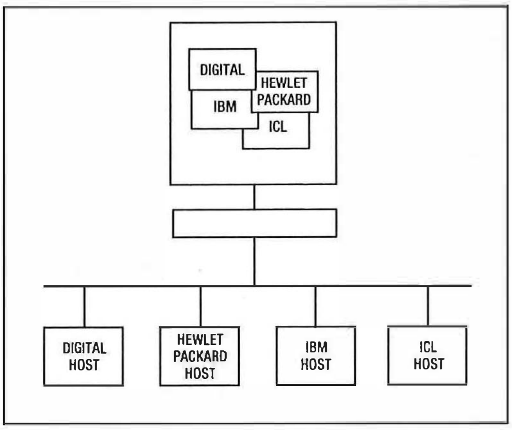


Figure 5
Non-INTERNET system access

System Integration

The preceding sections have dealt with the integration of terminals onto a single NMW2 workstation. This will greatly enhance the human–computer interface in that it will reduce the numbers of terminals and improve productivity through copy and paste facilities and such like. However, it still requires users to understand each host system, their interfaces and documentation.

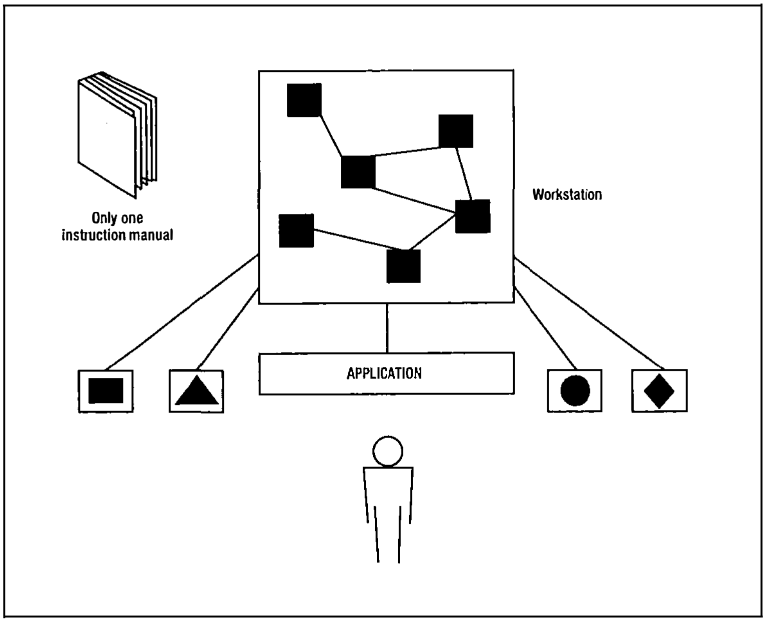


Figure 6
System integration

It is possible to integrate host systems to communicate at a process-to-process level with users having a more applicable, single-user interface based on the NMW2. This is illustrated in Figure 6.

In this instance, systems will request, receive and send data to each other over Open Systems Interconnection (OSI) networks without the need for user intervention. This communication will still be under the control of the user and, because the NMW2 supports complex graphical displays, it can be represented by using screens which are custom designed for that specific duty. These can contain higher densities of information in a format which is easier to assimilate than multiple screens of text.

Applications are being developed, using the Cooperative Networking Architecture (CNA) compliant BTXT toolkit, to carry out this process-to-process communication. Examples include the problem manager workstation, which will provide a generic fault management facility, and the customer network complaints analysis system. Both of these illustrate how large applications can be integrated with the common NMW2 infrastructure.

The NMW2 can provide a migration path from the above terminal integration to this system integration because it has been built on an open platform and it can provide the necessary distributed processing.

KEY REQUIREMENTS

The key requirements for the network management workstation arose out of analysis by the Network Control Architecture Board (NCAB), NAIP, the INTERNET Workstation Committee Requirements Capture Exercise and other network administration projects.

These requirements are described below.

Improve and Rationalise BT System Access

The improvement to system access has been described in the previous sections.

BT aims to evolve over 200 current systems to around 40 fully-integrated high-functionality *key* systems. User access to these systems must be rationalised so that users experience a consistent user interface, products for internal and external use have a common style and, most importantly, no duplication of graphical user interface development occurs.

Now that the NMW2 is the INTERNET Committee's recommended Unix workstation and the NCAB standard graphical user interface, it is intended that this will assist in its rationalisation.

Standards Conformance

To ensure BT has a truly portable graphical workstation and to exploit the price competitiveness of that open market, the NMW2 has been developed using the following standards:

- Operating System: UNIX (POSIX 1003.1)
- Protocol: X Window System ANSI X3H3.6
- Graphical Toolkit: BTXT (BT's CNA User Interface compliant toolkit)
- X Window System Applications conformant to the Inter Client Communications Conventions Manual (ICCCM)

The NMW2 and BTXT were developed in conjunction with the authors of BT's Cooperative Networking Architecture User Interface Style Guide and therefore conformance to that guide is eased.

Protect Current Investments

It is important that new technology does not render existing hardware and software worthless, but instead protects that investment where possible. Thus, for example, the development of NMW2's M1779 emulator, although obviating the need for some M1779 terminals, still makes full use of the NAM and NMCC. The latter will eventually be replaced with cheaper, open systems equipment.

Generic NMW2 Development

The NMW2 provides a software environment onto which new value-added services can be added via a smooth migration. Its open platform is modular, flexible and extensible, permitting each new installation to be essentially custom built with the core NMW2 software and the necessary 'bolt-on' components, such as specific terminal emulators or network management applications.

It will also be possible to retrofit new software modules (such as the electronic documentation retrieval system (EDRS)) to existing configurations.

The generic nature of the NMW2 raises a number of opportunities which, surprisingly, have more bearing on product coordination and build control than technological capability.

Ergonomic and Graphical User Interface

The NMW2 has been developed principally to provide terminal and system integration for end-users. It has the further role of providing a graphical user interface subsystem environment onto which BT and external applications may be developed. It poses no unfair restrictions on them except that they must be 'well-behaved' and do not compromise any other applications running on the NMW2.

BT's X Toolkit (BTXT) provides the key between the interworking of NMW2 and other applications. It is based on a widely used toolkit, InterViews, which has been in existence for many years as part of the standard X release. It is complemented with proprietary higher functionality. It consists of a library of graphical and user interface tools which application developers may employ to construct the user interface. In addition to improving the efficiency of user interface development (because such tools construct the interface much quicker than starting from basics), the toolkit provides for a consistent 'look and feel' to all user interface products. Furthermore, it encapsulates BT's new corporate identity.

BT may move to industry's eventual choice of standard graphical user interface, for example, Motif or OpenLook. It will, however, retain the option to remain with BTXT if this proves advantageous.

NMW2 FUNCTIONALITY

The NMW2 utilises a friendly WIMP (windows, icons, mouse and pointer) user interface comprising a set of standard X Windows manager clients (the session manager, window manager, display manager and colour manager) and a range of office automation application clients. It is illustrated in Figure 7. Users interact with the system by a combination of moving the mouse pointer around the display, clicking mouse buttons and typing characters on the keyboard. General and context-sensitive help is available at all times.

Once log-in is successful, users are presented with a session manager window which lists those tools to which the user has been given access and those which have been invoked. Providing the necessary communication links are intact, invoked tools appear on the workstation screen as a window. Hosts will run simultaneously on the NMW2: users may move from one window to another as necessary.

The NMW2 provides users with an environment shielded from the complexities of system invocation and where they are prohibited from accessing the UNIX operating system. Each installation has a system administrator with a variety of NMW2 administration tools to assist in its management.

The NMW2 functionality is summarised below.

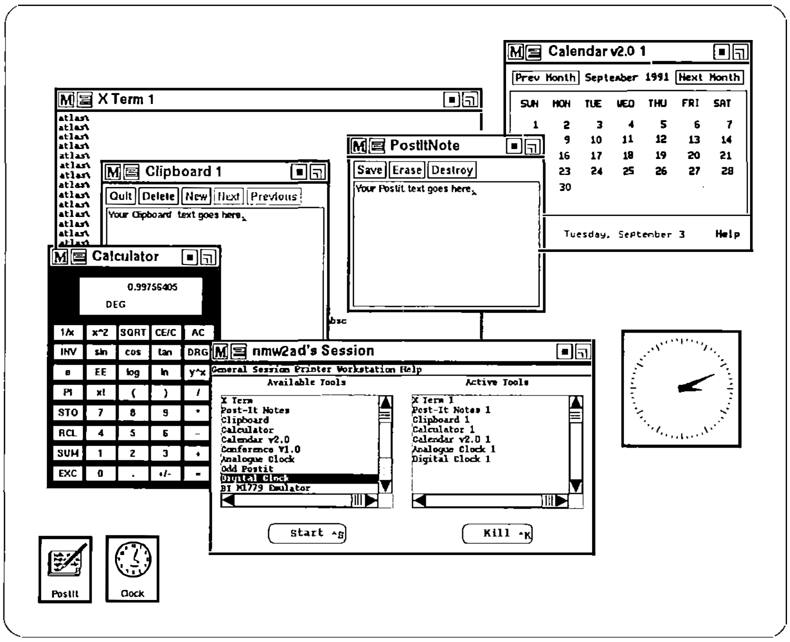


Figure 7
NMW2 user interface

BT Display Manager

The BT display manager (BTDM) is the application which validates the user for access to the system and starts the session manager. It makes use of the smart card security system.

BTDM is a modified version of the X11 Release 4 application XDM.

BT Session Manager

The BT session manager (BTSM) controls user access to all NMW2 applications. Its functions include the following:

- display session window using the user's profile to tailor the available tools menu
- start and stop applications
- log significant events and failures
- configuration of workstation characteristics and printer configurations.

The session manager is shown in Figure 8.

BT Window Manager

The BT window manager (BTWM) manages the NMW2 display. It processes and mediates requests from the user and software to manipulate windows and the NMW2 display. This includes: re-sizing, iconifying and printing the window.

It is based on the X11 Release 4 standard window manager (TWM), configured to be CNA User Interface Style Guide compliant†.

NMW2 System Administration

The NMW2 system administration facility has been developed for users with relatively little

† Cooperative Networking Architecture User Interface Style Guide, Look and Feel. RD00024.

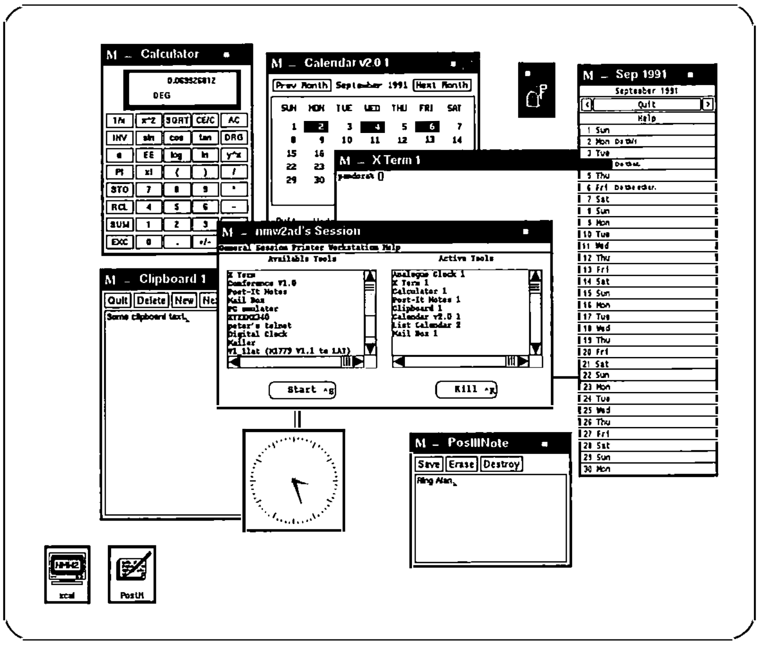


Figure 8
NMW2 session manager

UNIX system management experience. It provides the following functions: user configuration (for example, to add a new user to the system); tool control (for example, to load applications from magnetic tape); network control (for example, to maintain the network hardware); and an audit interrogator (for analysing major events).

Desktop Tools

Typical desktop tools provided with the NMW2 include: analogue and digital clocks, hexadecimal calculator, calendar, conference (broadcast) facility, mail and post-it notes.

These are taken from the standard X.11 Release 4 configured to integrate with the NMW2 environment.

NMW2 CONFIGURATIONS

The workstation-based NMW2 architecture supports a variety of configurations. It may simply be a standalone system linking into a number of hosts via dedicated lines or over an Ethernet LAN. Installations requiring more workstations may choose to utilise a server to offload processing from the workstations and improve performance. The NMW2 supports resilience and performance techniques such as disc stand-by and dual LAN configurations.

NMW2 FUTURES

Developments are currently underway to improve the mechanism of multiple terminal integration. As has been described, this will aim to provide full intelligent copy and paste facilities together with the integration of all key host systems. System integration will be provided through projects including PMW and CNCAS.

Furthermore, applications are being developed to ease the automation of repetitive tasks which users are required to perform.

The NMW2 will have a significant roll-out into BT's operational sites for those users who require a sophisticated integrating terminal: it will not be replacing all of BT's terminals.

Although developed for network management applications, the NMW2 could also be used to access a variety of non-network management scenarios which need multiple, simultaneous system access.

CONCLUSIONS

Efficient computer access in BT requires the integration of host terminals followed by the interconnection of host systems in an open environment. The NMW2 provides a platform to facilitate this migration. It is a powerful windowing workstation giving simultaneous system access together with a platform for more sophisticated human–computer interaction.

Biographies

Alan Vickers joined BT in 1982, having graduated from the University of Liverpool with a B.Eng. in Electronic Engineering, and has worked on various software engineering projects. On joining NMD in 1985, he tested a call accounting package (Switchman) for the then CSD. He has worked as an industrial affiliate at AIAI and conceived and developed the NMW1 for FAS. He took on the NMW2 project in late-1989 and for the last nine months has been leading the Concert User Interface development.

Vincent Traynor joined BT in 1989 having graduated from UMIST with a B.Sc. in Electronics and an M.Sc. in Management Science. He is involved in the commercial and project coordination aspects of the NMW2 project. His work principally entails acting as a contact point for NMW2 business development activities and has included the Madley NMW2 installation.

Electronic Document Retrieval System

B. A. CLAYDON†

A feasibility study is being carried out into providing an electronic document retrieval system for operations and maintenance staff to replace the numerous forms of paper documents currently used. This article examines the problems caused by the present documentation system, describes the technologies that could be used and outlines how the new system might be provided.

INTRODUCTION

A feasibility study into providing BT's network management staff with an electronic document delivery, storage and retrieval system, called the *electronic document retrieval system* (EDRS), is currently being undertaken. It will look into providing the enabling technology to ensure that information is produced reliably, and delivered to the right place, to the right person, at the right time and in the right format.

A list of the potential benefits that the proposed system is expected to deliver is given below:

Direct

- Reduced storage requirements.
- Up-to-date information always available.
- Reduced search time.
- Reduced filing time.
- Reduced travelling time.
- Reduced transportation and postage costs.
- Full availability of information to all staff who are permitted access.
- Reduced furniture requirements allowing more staff to be accommodated in existing floor space.
- Reduced paper and photocopying costs.
- Reduced operational costs.

Indirect

- Reduced errors due to the availability of up-to-date information.
- Improved working integrity.
- Improved image to BT.
- Reduced network down time.
- Fast global updates.
- Confidence in latest information.
- Less clutter on desks.
- Faster restoration of service/facilities to customers.
- 'Green' image!

THE PROBLEM

The project is addressing the problem of managing the technical documentation used by BT's network operations and maintenance staff. This technical documentation includes, for example, the operations and maintenance (O&M) manuals associated with telephone exchanges, and other related documents produced within the company. These documents are delivered from many sources. Furthermore, documents are published by several internal sources to modify the usage of, or correct the information in, the original documents.

Consequently, many forms of documentation are currently being delivered on paper, in many formats, to the end-user. This and the subsequent upgrades present numerous delivery, storage, configuration management and release control problems, which every organisation needs to master.

Operations and maintenance staff are being retrained from single-skilled on-site operations to multi-skilled remote and on-site operations. Product life cycles are reducing as a result of the pace of change. These factors are causing an ever-increasing flow of new documentation. Centralisation of operations requires staff to have a general understanding of equipment and procedures and to refer to documentation for detail. Staff are therefore exposed to more, rather than less, documentation.

Supply

Document suppliers use word-processing packages to prepare each document, and then print it on paper to deliver it. Some external companies provide manuals on optical disc; this reduces the problems associated with the paper system, but still leaves a distribution and up-date problem. Even when documents are electronically delivered, these may not be in the required format and normally necessitate specialised equipment, which does not provide a common delivery and retrieval system.

There is no standardisation of document formats, delivery mechanisms, or release and configuration control across documents. The system is paper based, which limits the control and monitoring of distribution, and the collection of user feedback.

Additional Paperwork

Most documents are updated after they have been distributed by attaching errata and addenda to the

† BT Development and Procurement

originals. Staff raise additional notes and procedures related to a document. These need to be attached to the original, as margin or foot notes, or linked information.

Distribution

Multiple distribution points are used, some of which are in external companies, others in the various internal divisions of the company. A manual distribution method ships large volumes of paper about the company to the remote sites. Updating the document usually means inserting update sheets into the originals, which may be located at thousands of sites. There is no guarantee that the updates are inserted and therefore used.

Access

Arrangements for access to the paper documents are currently very varied. Some staff have access to local centrally-managed libraries, whereas others carry their own version of the document set with them; for example, in their work van.

To meet ISO9001 quality standards, staff need access to accurate and up-to-date documents. It has proven to be possible to keep only local centrally-managed libraries in an accurate and up-to-date state, although the mobile and office-based staff also have to meet this quality standard.

The issue of ergonomics of access also needs to be addressed. Many staff complete their activities by using a terminal remotely connected to the exchange equipment, or a mobile hand-held terminal, but they still have to follow paper-based standard procedures. They are less likely to use a document if they do not have ready access to it.

LESSONS LEARNT TO DATE

Prototypes

During this project's research phase, a number of approaches to elements of the problem have been tried:

- Optical character readers (OCRs) for non-electronic document input. A paper document is scanned with an OCR machine and converted into electronic form.
- Generation of mark-up† from raw source files. A computer program is used to parse the document for its structure. A user can then use that structure to access the document.
- Interconnecting an information system with another application. This demonstrates how an O&M system user could be provided with context sensitive access to System X documentation.
- Iconic representation of a document's structure. This provides user access to the documentation via the graphical representation.
- Hypertext. Various items in a document are interlinked so that a user can move directly to the page referred to in items like 'see page 47', 'refer to diagram', 'complete procedure 29A/1 in volume 7'.

These ideas have been demonstrated on computer prototypes, in brief trials, which have used a range of technologies: personal computers, UNIX workstations, WIMPS interfaces, specialised and general-purpose databases, standalone and integrated systems connected to operational systems.

Conclusions

- All the concepts are technically feasible.
- Some of the concepts are expensive to implement.
- There are several solutions and component parts to an electronic document system. Technically simple systems can yield business benefits and allow migration and change rather than revolution.
- It is now time to deliver a basic system that supplies the essential 80% of the benefits, for 20% of the costs of development and deployment (Pareto's 20/80 rule).

THE WAY FORWARD

Managing Change

The proposed system will support the operational staff in managing the change from a paper system to an electronic one. It will support a logical incremental solution that delivers operational improvements and business benefits in a controlled way.

It will also assist the operational staff to manage the information flowing to them.

Infrastructure

To achieve the desired business benefits, an electronic document distribution system will be set up, as shown in Figure 1. It will consist of a central library that provides the interface between the document suppliers and the system. Branch libraries will provide end-users with access to the appropriate documents.

This infrastructure will assist BT in establishing standards related to document interchange and mark-up, and then in monitoring them. It will also provide more visibility and control of the process, thus making the problem more manageable.

The network administration computer centres (NACCs), accessible over local and wide area networks (INTERNET), will provide the technology backbone on which the system will be delivered.

Staff will need retraining to work in the new libraries or to use the new system. However, if the new system appropriately models the existing

† *Mark-up* provides 'value added' service for documents. In its simplest form, it is identifying that a heading should be underlined. More complex forms provide facilities for defining the complete structure of a document prior to it being written. This document template can then be used to 'drive' a word processor so that the author has to comply with the structure.

paper system then the retraining should be minimal.

Controlled Supply

Establishing standards, and getting them written into supply contracts, will be a high priority. Release control and audit trails will be implemented, to ensure document integrity.

Documents will be validated against the standard when received. A document's usage and quality information will be fed back to the supplier, to ensure that documents are produced to an appropriate level of quality.

Adding Value

As mentioned earlier, many notes, procedures and links to other documents are produced to add value to an original document. A configuration-control problem therefore arises. Library management facilities will be provided 'to tie the paper-work together' into a coherent set.

Better monitoring and tuning of the business processes will be an additional spin-off from this coherent document set because the information can be logically linked together by using hypertext concepts. Management staff can then thread standard practices and procedures through these documents, so that this mark-up directs the technicians in their usage of the documents. Standard methods of working will then be easier to implement, both nationally and locally, and can then be monitored and fine tuned.

Access to Documents

Documents will be accessed via a terminal or workstation, connected to the computer system, which holds the branch library. Access to the documents will be restricted by the normal security mechanisms and by providing 'views' of the total library.

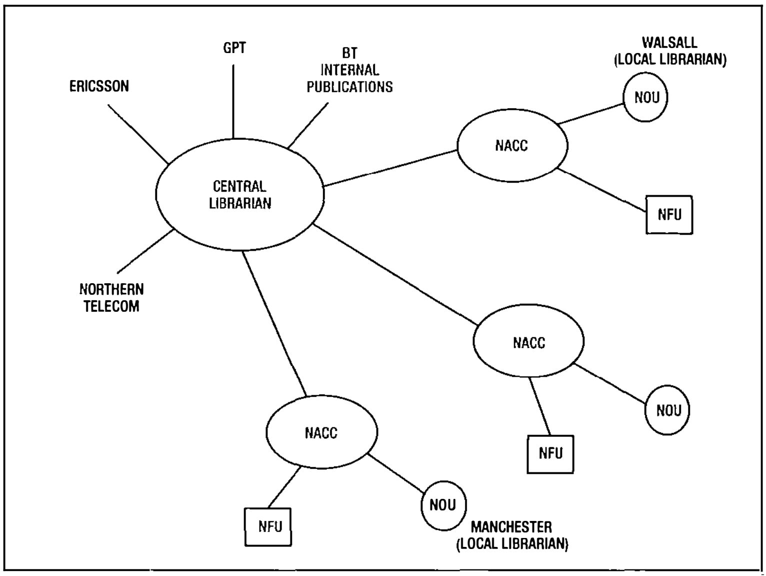
Documents will be retrieved via a simple enquiry mechanism by using the contents or index page models used in standard books, or complex enquiry mechanisms using keyword searching or hypertext models. Other network management support systems will give application-specific context-sensitive access to the documents.

System Implementation

This system is being implemented by using BT's approved technology: UNIX computer systems, C/C^{++} programs, ORACLE RDBMS, text terminals (M1779), workstations (Network Management Workstation 2 (NMW2)), local and wide area networks (INTERNET).

A client-server model is being used to allow for future client applications to use the library server services, as shown in Figure 1. Applications such as the operations and maintenance system (OMS) used to manage the exchanges, and the work management system (WMS), will have client accounts with the system, to provide their users with context-sensitive access to the documents.

This means that staff using these systems will have direct access to the documentation store, without having to leave their main application. The appropriate manual will open automatically at the page relevant to the current screen context.



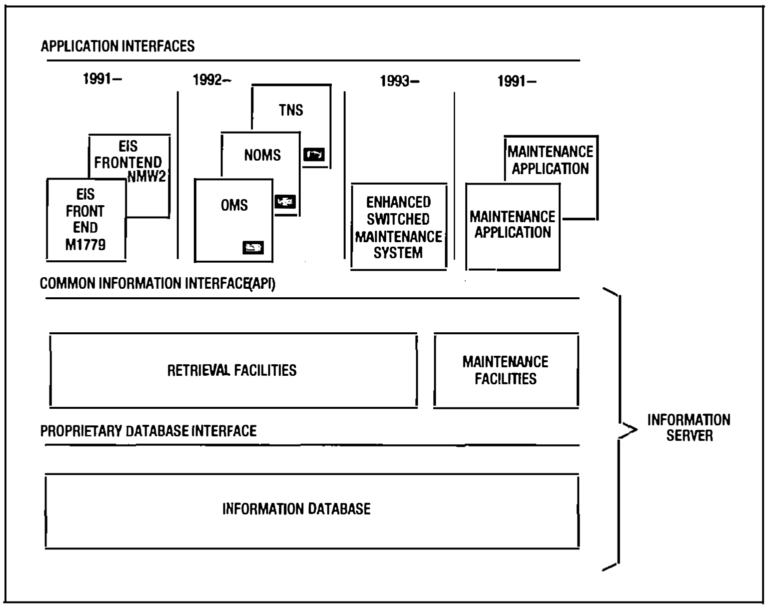
NACC: Network administration computer centre
NFU: Network field unit
NOU: Network operations unit

Figure 1 Electronic information system—document delivery

Feasibility Field Trials

Feedback from network operations unit (NOU) and mobile staff will be used to add value to the statement of requirements, so that the requested features can be built into the system at an appropriate point in time. (See Figure 2.)

Figure 2 Electronic information systems



EIS: Electronic information system
NMW2: Network management workstation
NOMS: Network operations and maintenance system
OMS: Operations and maintenance system
TNS: Transmission network surveillance

CONCLUSIONS

Facilities that deliver high-priority business benefits, for the minimum cost, will be the first target of this project. Assisting the operational staff in managing the change from the current paper system to the electronic one will be a high priority. Better management of resources will be achieved by providing an incremental approach, based on cost-benefit evaluation.

Although all the concepts are technically feasible, some will be implemented at a later date, when it is identified that they meet the business needs.

The current feasibility study, sponsored by BT Worldwide Networks, is due to be completed by the end of the year. If the feasibility report is approved, a pilot system will be developed and deployed in 1992.

ACKNOWLEDGEMENTS

The author would like to acknowledge the contributions given to this article by Ron Franklin, project board chairman; Gerry Garwood, the project manager in BT Development and Procurement; and Bob Turner, the development team leader.

Biography

Barry Claydon joined BT in 1986, after twelve years in teaching. Since joining the company, he has worked in the Network Management Department, BT Development and Procurement, on various software development-related activities. He currently works in the department's business development unit.

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Network Management for RACE

R. SMITH, and G. I. WILLIAMSON†

This article introduces the work of a number of projects active in those parts of the European Community RACE (Research and Development for Advanced Communications in Europe) programme which address network management issues. The RACE programme is focused on pan-European integrated broadband communications (IBC) and aims to support the development of technology for the commercial introduction of broadband services by 1995. IBC will integrate voice, data and video services over a single network. The article outlines three main themes: network management requirements of the integrated broadband communications network (IBCN); network management system specifications, architectures and reference configurations; and technology for network management systems, including applications and systems technology.

INTRODUCTION

At this point in time, the RACE (Research and Development for Advanced Communications in Europe) programme[1] comprises 80 or more projects that address a broad spectrum of the issues which need to be resolved before cost-effective integrated broadband communications (IBC) services will be possible. These issues include:

- definition of common functional specifications and standards;
- use of advanced technology for cost-effective implementation of IBC hardware and software; and
- application pilot schemes where the validity of IBC service assumptions may be tested by service providers, network operators and end-users.

Management of the IBC was recognised from the outset as an important issue for study in RACE and several projects were established to specify and develop the technology required. The integrated network management systems for IBC are referred to as the *telecommunications management network* (TMN).

NETWORK MANAGEMENT IN RACE

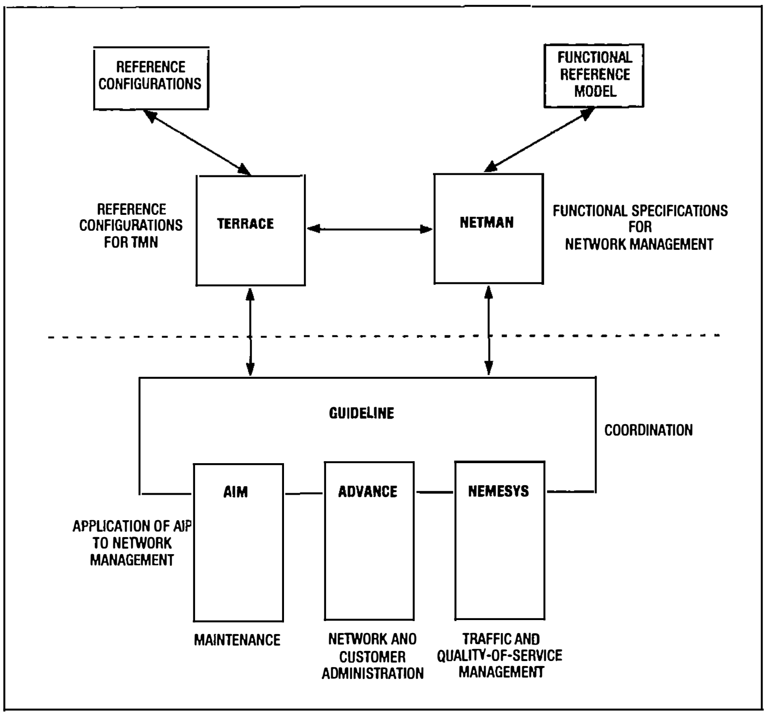
Six projects are currently active in the definition of network management for RACE. See Figure 1. Two of them are concerned with the specification of management aspects of the integrated broadband communications network (IBCN):

- the *NETMAN* project, which is concerned with producing the implementation-independent functional specification of network management for the IBCN; and
- the *TERRACE* project, which is concerned with the definition of reference configurations and evolution scenarios for the introduction of IBCN management systems in Europe that are time and country dependent.

The remaining four projects, collectively known as the *TMN technology projects*, are charged with the task of developing and evaluating the enabling technology for implementation of network management systems for the IBCN. These are:

- the *AIM* project, which is developing applications of advanced information processing (AIP) techniques, mainly knowledge-based systems (KBS), for the maintenance of the IBCN;
- the *ADVANCE* project, which is developing applications of AIP techniques, with an emphasis on advanced database and distribution techniques, for the network and customer administration systems for the IBCN;
- the *NEMESYS* project, which is developing applications of AIP techniques, for traffic and quality-of-service (QOS) management of the

Figure 1
The TMN projects in RACE



† BT Development and Procurement
This article is based on a paper presented at the IEE Broadband Conference.

asynchronous transfer mode (ATM) switches in the IBCN; and

● the *GUIDELINE* project, which provides a coordination framework for the RACE TMN work area in fields such as TMN architectures, standards, and technology assessment.

The projects are staffed by workers from a wide range of organisations in Europe including public telecommunications operators (PTOs), equipment manufacturers, software houses and universities. BT has been involved in four of the projects since their inception in 1988.

BT AND RACE TMN

BT's motivations for participation in RACE TMN are many. RACE is essentially a pre-competitive and pre-normative research and development programme.

In general, the collaboration enables internal pragmatic and architectural developments and concepts to be extended by considering: broadband; multi-service; many operators; and cross-country boundaries.

This, combined with influence on international standards creation and the understanding of telecommunications cultures across Europe, are important facets in enabling BT to achieve its goals. The pre-normative aspects of RACE allow BT engineers to work with their counterparts in other PTOs and equipment manufacturers to validate architectural ideas important in the formulation of effective international standards.

The pre-competitive technology assessments which RACE TMN is undertaking allow BT engineers to work with technology specialists from universities and software houses to understand the applicability of advanced information processing techniques to network management problems. Studies focused on the management of the IBCN are providing useful insights into such requirements of future networks.

Some of the technology results of RACE TMN are already being used in BT product developments, and this will increase over the next year. BT people on the projects have worked closely with BT's internal architectural activities (CNA-M) and a number of contributions to international standards have been adopted.

MANAGEMENT REQUIREMENTS OF BROADBAND MULTI-SERVICE NETWORKS

In this article, a very broad interpretation is taken of the term *network management*. Network management activities are interpreted as being necessary to support all activities associated with the management of a telecommunications network. Such activities are being progressively automated, either to improve the efficiency of the network operators, or to allow the networks to provide new services. For this reason, network management systems cannot be divorced from the organisations which use them. Indeed, network management concerns the people within the organisation using tools to carry out procedures to manage telecommunication networks. The management activities, whether automatic or manual, are intended to maintain the network at some operational optimum while minimising the resources required.

Coherent classification schemes for ordering the network management activities help to structure requirements. An approach to classification of requirements based on the life cycle of the network, as shown in Figure 2, gives an indication of the scope of the requirements:

● pre-service activities, which include planning, data building, installing and commissioning;

● in-service activities, which include maintenance, statistics, traffic management and billing; and

● future service activities, which include performance analysis, forecasting and requirements identification.

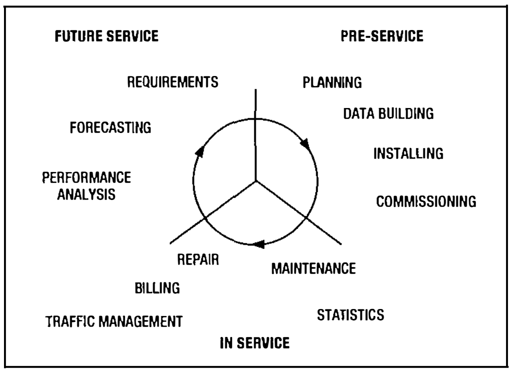


Figure 2—The life cycle model of network management activities

It is clear that this is not the only means by which network management activities may be ordered. Another important issue is the time criticality of response required. For example, many activities such as forecasting and modelling of service demands are essentially off-line, whereas traffic management and maintenance require a real-time or near real-time response. Many other activities such as administration require some intermediate response time to support their interaction with network elements.

For the IBC multi-service networks, special attention has to be given to the management of the many services they will support. This will increase vastly the degree of complexity of the service management requirement over that for basic telephony services. The management systems must support the management of both the services and the network. The multi-media (voice, data and video) services offered by the IBC may also require more sophisticated bandwidth and QOS management capabilities than are required by existing networks.

Network management systems are required increasingly to support end-to-end connections, which may cross networks and network elements owned by different organisations. In the IBCN case, this would be across Europe. The end-to-end connections will, in the future, have mobile or movable terminations, implying the possibility of handover protocols between these organisations.

Network management systems must also support an increasing number of types of user. For example, a telecommunications administration may require support for front-office staff dealing with customers as well as exchange or transmission equipment technicians and their managers. In addition, the network management systems will be required to support users from other organisations, such as value-added service providers or business and domestic subscribers. The functions of the network management system will need to be tailored to meet these users' requirements at the locations they request. Additional security requirements will need to be addressed.

Network management systems have to be constructed so as to support degrees of distribution of processing to reflect the distribution of the users and the elements of the telecommunications network. On the other hand, the network management systems reflect a degree of centralised control. Non-functional requirements are also extremely important in shaping the detailed physical locations of processing. These include: performance issues, data volumes, throughput, and response time; cost; and security.

These requirements are, in general, extensions and extrapolations of the requirements of existing networks, and therefore serve well to illustrate the trends for future telecommunications systems.

NETWORK MANAGEMENT SYSTEM SPECIFICATION, ARCHITECTURES AND REFERENCE CONFIGURATIONS

Responsibility for the specification of the pan-European TMN rests essentially with two projects, although these are assisted in detail by the technology projects. Project NETMAN defines the functions and performance of the final integrated communications management system for IBCN. Project TERRACE is responsible for defining the evolutionary path from today's situation of islands of isolated management systems to the fully integrated and interconnected system of the future.

Present communications management systems have evolved over many years to serve the particular needs of their operators. The world standards bodies have not until recent times addressed the special needs of TMN. The result has been that each administration has developed its own approach to managing its telecommunications networks. This means that NETMAN has to take account of the output from a number of standardisation bodies who are addressing the issue from their own standpoint. Since RACE requires the European solution to be in accord with world standards, NETMAN's task has to be to monitor, intercept and combine.

The approach has been to operate on three broad fronts. The first is concerned with tracking the output of the world standardisation bodies; the second has been to develop methods and models[2] to assist with representing the complexity of TMN functions; and finally the views of major players have been sought via case studies of current communications management practice. The ultimate aim of NETMAN is to provide a rigorous definition of TMN and to assist in the production of a functional reference model to guide the implementation of future TMN systems. One of the important models adopted by NETMAN to capture its requirements is the so-called *NETMAN cube model*, which supports organisation of its specifications in three quasi-orthogonal axes, as shown in Figure 3.

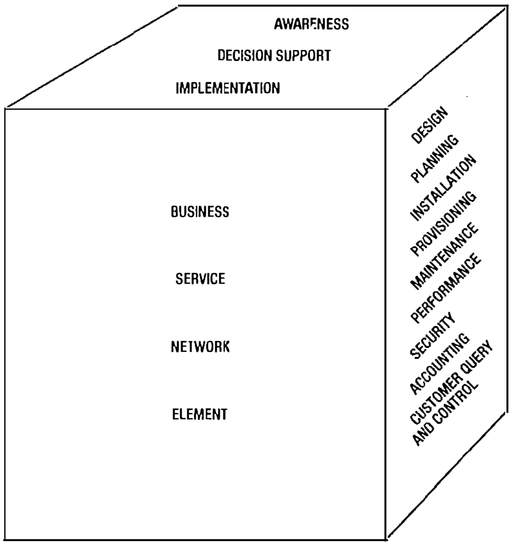


Figure 3
NETMAN cube model

The three axes of the cube are as follows:

- The four CNA-M layers of business, service, network and element management.
- Three phases of network management tasks: awareness creation, decision making and support, and decision implementation. These help to ensure that management requirements are complete.
- Nine functional areas which cover the full network life cycle: design, planning, installation, provisioning, maintenance, performance, security, accounting, and customer query and control.

Project TERRACE will take the evolving functional specifications produced by NETMAN and develop scenarios for the introduction of TMN across Europe. In building on the work of NETMAN, these scenarios will use function allocation strategies which have regard for the non-functional aspects of TMN, such as size, cost, and any special national requirements. In addition, regional issues connected with the size of the IBCN, expected traffic flow and so on, will be taken into account. The output from this project will be a set of reference configurations[3] which will show how the integrated TMN is expected to evolve.

A survey[4] of the state of the art in European network management has been undertaken to provide a current practice perspective for the work of the TERRACE project.

Management of telecommunications networks is being automated but largely on a piecemeal basis. Many companies are developing proprietary architectures to allow such automation to be provided in a more systematic and integrated fashion by a process of evolution. In the RACE programme, network management architectures are also the subject of considerable work. Their definition has been undertaken by a number of projects but principally by project GUIDELINE[5]. An eclectic approach has been pursued, with the RACE architectures being basically augmentations of architectures being developed in standards organisations elsewhere. Essentially, the additions are to cope with particular requirements of IBC or the technology to be used in network management system development. These augmentations to the TMN architecture are in turn being submitted to the European Telecommunications Standards Institute (ETSI) and CCITT for inclusion in new versions of the TMN standards.

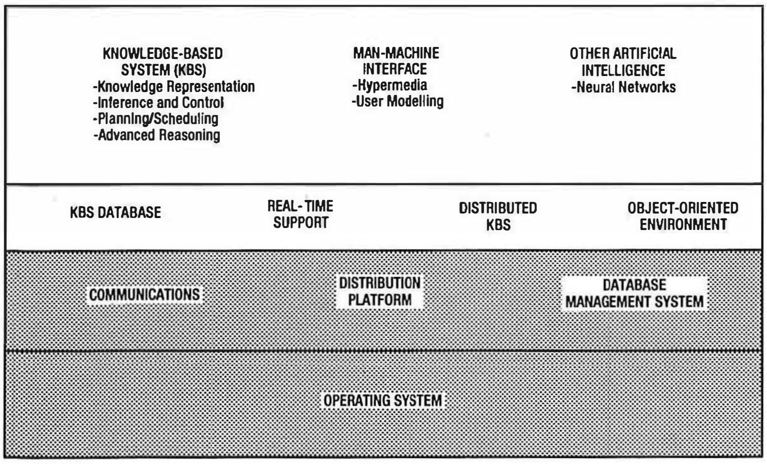
One of the key standards in the area is the CCITT concept of the TMN[6]. The purpose of the TMN as defined in CCITT M.30 is to support telecommunications administrations and recognised private operating agencies in the management of their telecommunications networks. The TMN can vary in size from a simple connection between an operations system (OS) and a single piece of telecommunications equipment to a significant network containing many different types of OS and telecommunications equipment.

The concept is intended to be sufficiently general to accommodate this breadth of range. Clearly, the range of organisations using the TMN concept could be very large. None of them are constrained to using this approach but interchange of management information will be much easier if they do. The concept of the *management information base* (MIB) in network management has been widely accepted by the standards-making and similar bodies; namely, the International Standards Organisation (ISO) in the Open Systems Interconnection (OSI)[7], the American National Standards Institute (ANSI) in T1M1.5[8], the OSI Network Management Forum[9] and ETSI in NA4[10]. Information modelling concepts are also being considered by CCITT for inclusion in the TMN recommendations. The MIB is a conceptual repository of all the data held in the TMN about the network and the TMN itself. The information base is required to store information on network and system configuration, customers and services, current and historic performance and trouble logs, security parameters and accounting information.

To date, the augmentations to the TMN standards have included:

- Layering M.30's OSs following CNA-M[11] to support element, network, service and business management systems. The approach allows a logical structuring which is natural in the context of multi-service networks such as the IBCN.
- Definition of aspects of OS internals, by introducing common functions. The common functions are of two kinds: infrastructure functions to support capabilities, such as database access, user interfaces and communications; and user generic functions related to network management, such as configuration management, statistics and event management.
- The concept of the management information base, a conceptual repository of all information required to manage the network, has been elaborated in the context of the M.30 models. This has been done by decomposing the operations system and by defining a specification language for the MIB via definition of *managed objects* which may support definition of protocol data units or the global conceptual schema of a distributed database.
- Views of the TMN as a *partially distributed processing system* have been developed. These may support aspects of distribution transparency, for example, transparency of access, location, replication and possibly migration.

Figure 4
A possible AIP implementation architecture



TECHNOLOGY FOR NETWORK MANAGEMENT SYSTEMS

The RACE TMN technology projects AIM, ADVANCE and NEMESYS are charged with the task of assessing the applicability of state-of-the-art advanced information processing (AIP)[12] techniques to various aspects of the TMN problem area. In doing so they identify suitable target applications for testing the applicability of AIP. These applications are then used to form the basis for prototype and demonstrator systems. Full-scale applications are not possible in this context. These demonstrators and prototypes are constructed within a common conceptual framework provided by the GUIDELINE project in the form of an implementation architecture for RACE TMN.

The projects address the applicability of AIP in computing platforms and infrastructure as well as TMN applications areas. Figure 4 gives an indication of the breadth of coverage.

Coordination of the three technology projects and the provision of a common interface to the TMN specification projects is provided by project GUIDELINE. This project is staffed by the prime contractors of the technology projects, and the leaders of the specification projects are associate members.

Project GUIDELINE: RACE TMN Coordination

The best way to describe the activities conducted by GUIDELINE is to give a brief account of the work conducted by its Technical Coordination Groups during the first three years of the programme:

Advanced Information Processing (AIP) The aim of this coordination activity is to monitor the AIP research and experimentation being conducted in the technology projects in order to reduce overlap of work to an appropriate minimum. Regular seminars are held to assist with the dissemination of results among the TMN AIP community. The AIP focus over the last period has included object-oriented modelling, human–computer interaction, advanced databases and distributed processing.

A sister programme to RACE (ESPRIT) is conducting research into many AIP issues that are important to the success of RACE TMN. This group provides a focus for the exchange of information between the two European Community (EC) funded programmes.

TMN Architecture Group This activity is working on an architecture[5] for use by the technology projects during the RACE programme.

Specification Assessment Group This group provides a focus for the assessment of the specifications being prepared by NETMAN from a technological (AIP) standpoint.

Interface Specification Group The detailed specifications of the interfaces to the TMN and interfaces of major subsystems within the TMN will be prepared by this group.

TMN Standards Group This group provides the TMN work area with an up-to-date account of the work being conducted by world standardisation bodies in the TMN and related areas.

Project AIM: AIP Applied to Maintenance

Project AIM defines a set of maintenance recommendations for the IBCN. In order to provide a firm foundation, the project is undertaking experimental studies into the application of AIP techniques in two problem areas: the diagnostic and repair functions necessary for modern digital telephone exchanges (GPT's System X), and the diagnosis of faults on broadband networks (SEL's BERKOM B-ISDN network in Berlin).

The diagnostic technology for these two applications is common and is based on second-generation model-based KBS. This modern approach to fault diagnosis is considered to be most appropriate to telecommunications networks since the KBS models can easily mimic the highly-structured organisation of network elements and complete networks. The *generic maintenance system*[11] being developed by AIM arrives at diagnostic conclusions by propagating known symptoms (fault reports) through the model and, by managed searching, for example, correlates these symptoms with possible fault scenarios. These fault scenarios are further refined by comparing the diagnostic conclusions with a list of mean-time-between-failure data to identify the fault.

Project ADVANCE: AIP Applied to Network and Customer Administration Systems

This project is concerned with administering customer services and managing the network, in which IBCN offers a wide spectrum of challenges.

The technology focus for ADVANCE has been on object-oriented modelling, distributed and heterogeneous databases, KBS and database interaction within a coherent implementation architectural framework[13].

One such challenge of the IBCN is that of customer control of the network. For instance, in a movable (as compared to a mobile) service, the customer is able to connect terminal equipment electrically to any appropriate IBCN port irrespective of its geographical location. When so connected, the customer will wish to use the services enjoyed at the home location. The aim is to conduct this service negotiation fully automatically from the IBCN TMN.

Such automation raises many issues concerned with availability of specific services, guaranteed performance, contracted availability and cross-network charging. Experimental work conducted by project ADVANCE has demonstrated that AIP techniques can help to provide such service level automation.

Project NEMESYS: AIP Applied to Traffic Management

Traffic management and quality of service are the two areas of communications management being addressed by project NEMESYS. In the area of traffic management, the task is particularly difficult because no network exists which exhibits the characteristics expected from the IBCN. In addition, managing traffic flows on large telecommunications networks is difficult because of the wide range of traffic levels that can be experienced.

It is likely that the IBCN will use asynchronous transfer mode (ATM) for bulk transport of data. This packet-like transmission method brings its own special problems concerned with source-rate policing.

Project NEMESYS has approached these special problems by the development of an ATM network simulator and by close cooperation with those members of the RACE community concerned with ATM. This has allowed the project to establish an experimental traffic management system which interworks with the ATM network simulator. Results to date confirm that AIP techniques offer valid solutions to the control of traffic flows in ATM networks. The technology focus for NEMESYS has been real-time KBS supported by object-oriented distributed processing platforms[14].

Project NEMESYS is responsible for preparing detailed recommendations and specifications for traffic management strategies and QOS issues in the IBCN.

FUTURE PLANS

During the final two years of the RACE main phase, the TMN projects will be concerned with extending the technology investigations and consolidating the common functional specifications (CFS).

As noted earlier, project NETMAN has the responsibility to produce the TMN specifications, but the opportunity will be taken to validate these ideas against the AIP experimental implementations being conducted by the technology projects. Additionally, the specifications will be subject to a consensus-forming activity which brings together the collective expertise of the RACE community. Aspects of the CFS will be submitted to ETSI for consideration in world standards groups. This multi-layered definition process should result in the first comprehensive definition of the complete life cycle of modern network management systems. This will be a major achievement for the RACE programme.

In addition to supporting the CFS production, the technology projects will be refining their experimental implementations to support two main phases.

The first will be to gain a deep understanding of how AIP technology can be utilised to enable the cost-effective realisation of pan-European TMN systems. These investigations will look at both the special techniques required (KBS, distributed databases, and so on) and the important issue of scaling the technology to the large system that will be required.

The second main phase will address the area of integration. During the first three years, the technology projects shared the results at a technological level: the integration of their experimental system to produce an embryo TMN was not attempted. A cross-project task has now been established to realise the goal. The investigations will assist the validation of the technical architecture for the TMN, which has been one of the significant results of the research.

Work is now beginning on the planning of the RACE II programme. This will build on the results obtained to date and focus the technology onto specific network management applications.

In parallel with discharging its obligations to RACE, the BT team members have been seeking actively opportunities for the use of the technology in BT's product lines. The network diagnosis technology (project AIM) is now being used in the Concert™ programme and the service management ideas developed in project ADVANCE will have an impact on future intelligent nctwork offerings for BT. The TMN architectural studies being conducted by GUIDELINE are having an influence on the company-wide CNA-M activities.

CONCLUSIONS

This article has introduced the work being conducted by the six projects charged with developing definitions and technology to support the introduction of a comprehensive system to manage modern telecommunications across Europe. During the first three years, excellent results have been obtained and these are having an influence on both company thinking and emerging product lines.

To a large extent, these results have validated the collaborative approach to such extensive projects. Multi-company, multi-national projects are not without special problems concerned with different goals, separate cultures and not least language and distance issues. But given a well-defined goal in a pre-competitive and pre-normative sphere, excellent results can be achieved. The benefits include lower risk, shared costs, new approaches and the potential of achieving effective standardisation.

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Biographies

Robin Smith began his career with BT during 1959, in London, as a technician. After a period working on the installation and maintenance of local area telecommunications equipment, he worked for a number of years on the development of data transmission equipment (modems) where he formed strong links with BT's Research Department. A change in career gave him the responsibility for managing the design of System X, where he headed the central system design team. Seven years ago, he formed the advanced information processing section in Network Management Department, which he currently manages. He is a Chartered Engineer and a Member of the IEE.

George Williamson took a first degree in physics at Edinburgh University and a Ph.D. in plasma physics at the University of Manchester. He joined BT in 1980 to work on various aspects of the development of the System X local exchange. After this, he moved to lead a small team researching the use of KBS in the maintenance of telecommunications systems as part of the EC ESPRIT project. He now heads a research group defining network management aspects of broadband communications networks as part of the EC RACE programme. A particular focus of this work has been the application of advanced information processing techniques to diverse network management problem areas.

Future Challenges for Network Management

T. A. FITCHETT, and M. H. REEVE†

New network technologies will be introduced over the coming decades to offer new services and to enable operating cost reductions. These will produce significant challenges for network and service management systems. This article considers these changes and their impact on network management systems.

INTRODUCTION

Over the next decade, telecommunications customers will require an increasing range of new services, packaged in various ways, available globally and able to interwork across networks provided by more than one telecommunications operator. In addition, customers will need to be able to control key aspects of their service (including turning it on and off) themselves.

These new services will require a range of new technologies and systems to be present in the network (for example, broadband systems for interconnecting local area networks (LANs)). In addition, BT and other network operators will be introducing new technologies purely to reduce operating costs. Examples here might be pair-gain systems in the copper local loop and managed transmission networks based on the synchronous digital hierarchy (SDH) in the core network.

Each of the statements just made about the way customers will use services, new services themselves and the new technologies to support them will each provide significant new challenges for network and service management systems.

On top of a continuing drive to integrate and automate management systems and to provide them on an end-to-end basis, these changes promise an exciting decade for management system development as BT pursues its aim to become the top global telecommunications operator.

This article considers some of the above drivers and changes, assesses their impact on network management systems and describes some of the ways that technology can be harnessed to meet the challenge.

DRIVERS FOR CHANGE

New Services

New services provided on the network will typically involve new network elements, connected in new topologies and requiring new or enhanced descriptions of the items to be managed. This alone will provide a challenge to the network management systems. However, it is perhaps more fundamental that these new services tend to break the easy one-to-one relationship between the physical element and the service seen in the present telephony network.

Consideration of two broad classes of new service will serve to illustrate this.

First, new services requiring some aspect of *network intelligence* can be considered. The delivery of diverse telephony-based services in a flexible way by separating switching and call processing is termed an *intelligent network*[1]. With such intelligence in the network, the almost static relationship between the physical network and the network service is removed. The service logic embedded in attached processors can alter the operation of the basic telephone call to provide an enhanced 'service'.

For example, in the case of an intelligent network providing a network-based call distribution feature routing calls to a number of sites based on time of day and call load, how does the network provider test the service in the event of reported faults? Is the base network at fault (logically or physically), the service logic routing the calls or the network database? Indeed, a knowledge of previous call load is necessary to determine the correct routing of any particular call. The points of failure are no longer fixed nor are they easy to test in the operational network.

This simple example serves to show that such services will not only require management of new physical network elements (the attached processors) but will also require that service logic and databases are considered within the 'network' to be managed.

Such network intelligence typically uses the CCITT No. 7 (C7) signalling system for control information. Such non-circuit-related signalling will place an increased load and emphasis on the C7 network. Hitherto it has not been necessary to manage this network; reliance has been placed on switch management to cope. It is inevitable that the emerging intelligent services will require that this network is also managed.

The second broad class of new service that might be considered is that requiring some broadband or multi-service aspect. Such networks might use frame relaying[2] or asynchronous transfer mode[3] (ATM) techniques to interconnect LANs, provide mainframe computer interconnect or to provide mixed voice, video and data services over the same network.

† BT Development and Procurement

Here again there are new network elements, in this case frame relay or ATM switches and multiplexers. However, the additional challenge comes from the need and ability to 'nest' services and/or to combine services down a single transmission pipe. As an example, a customer's Ethernet LAN might be connected to a BT-provided frame relay service, combined with video and computer interconnect data to run over an ATM service, and the ATM cells carried over an SDH transmission link[4]. The frame relay service must be managed end-to-end while actually nested within the ATM service, which has also to be managed end to end. Since each is carried over the same fixed throughput transmission link, sudden demands from the computer interconnect might adversely affect the frame relay or video service, resulting in a need for the network management system to include priority or policing schemes.

Packaging of Services

New services will not only be provided individually; it is likely that services will increasingly be combined in 'packages'. Charge card access to a corporate virtual private network might be an example. This will present a new challenge to the management systems, which will need the flexibility to manage services in a number of combinations and still provide compatible operations such as fault reporting and correlation.

Customer Control

Within the constraints of security and network integrity, visibility and control of the network will be demanded by many larger business customers. BT will deliver this type of capability to customers under the Concert™ programme, and compatibility with the Concert™ programme is a requirement for all customer-facing systems. The major customer service systems, used by network operators, such as BT's Customer Service System (CSS), will need enhancement to operate with this type of customer control.

Customers will demand management information to improve their decision-making processes for their communications service. They will also expect the ability to control their service usage as their business needs dictate. As an example, the installed network for such customers must be able to support the move of bandwidth from video conferencing to incoming 0800 lines to outgoing public switched telephone network (PSTN) lines. Besides such basic networking ability, the network administration systems must be able to track and control such changes.

Cost Reduction and Quality Improvement

Two of the major costs for a telecommunications company are capital depreciation and the cost of administering the network. Network administration has a significant labour cost and as such is a target for cost reduction. There will be limits to how much administration systems alone can improve the efficiency of existing operations. Combining new network technologies with advanced administration will provide the best route to continual cost reduction. To maintain and improve the level of service quality while reducing costs will require increased levels of automation throughout the network administration functions. The introduction of managed transmission networks based on SDH equipment into the core network is an example of new technology enabling cost reduction and improved network administration.

These new networking technologies will challenge the current view of a network element. For example, in the transmission realm, the element is an individual multiplexer or line system. Its position within the network hierarchy and impact upon the rest of the network is a network control level function. As multiplexers become more intelligent and understand their interconnections, there will be a blurring of these management levels. The elements that the network control level manages may become sub-networks of multiplexers which provide paths that are built together into end-to-end networks.

The new network technology will increasingly enable the construction of networks that do not affect service when they break. For example, if a PSTN exchange detects a link failure on one of its ports, it will route all new calls over an alternative route. The only customers to experience failure would be those engaged on a call over the link when it failed, who have to clear down and dial again; most customers would see no failure in the network. Resilient transport networks that can heal themselves in service protection times, and switching technologies that route individual frames, can deliver a network service where the customer does not normally see any individual failures.

New network technologies will bring their own opportunities for new operational practices. If the network technology provides for remote configuration, then the provisioning process can be automated—all the way to the customer's desk, under the customer's control if appropriate.

Each new network technology will challenge some of the ways existing administration activities are performed. Planning, data building, performance measurement and analysis are examples of activities that will change as new technologies are deployed in the network.

User Organisation

Since privatisation, BT has undergone several organisational changes. To continue to meet the demands that customers will place on a modern communications service, BT will aim to improve continually the way business processes are carried out. The total quality management (TQM) philosophy of continual improvement will be a constant force for change over the next decade. These changes to the organisation and to the skills and responsibilities of the network management systems users will require the network management systems to be flexible in order not to present barriers to the change.

Competitive Environment and Globalisation

The telecommunications environment in the UK has moved from a monopoly to one of regulated competition, a change now being followed in some other parts of the globe. Customers will use multiple network operators for their communications needs, as they already do in the USA, and the *international call model*, whereby BT is only responsible for half of the call, will become more common within the UK. Interworking and collaboration with other network operators will have to be established. For example, the traffic management problems from focused overloads, such as telethons, will not be completely under BT's control.

The challenges this brings will be similar to those posed by the move to personal mobility services. The ability of a customer to move between the fixed, cellular and GSM (*groupe spéciale mobile*) networks as true personal mobility becomes a reality will mean that the operational issues of such networking must be addressed. Not only must the networks physically interwork, the operational support systems of such networks must be able to interwork seamlessly, so that service provision, maintenance and billing appear unified for the customer, even though the networks themselves may be owned by different operators.

As an example in fault reporting, will it be acceptable for a BT customer to telephone BT and complain that he/she cannot get through to a client, whose service is provided by Mercury, and for BT to answer 'our network is OK, you need to complain to Mercury'? End-to-end network management across multiple networks will be required, meaning that operational support issues such as testing standards will need agreement between operators, and ultimately some 'view' or electronic interface between different operators' support systems will be established.

Besides the collaboration with competitors that liberalisation brings, there will also be the need to be as aggressive as regulation allows in the development and deployment of new services. Volume-related call pricing, charge cards and other such services all require changes to the network administration systems.

Many of these issues are seen in the move from a national service provider to a truly global operation, where networks from several operators may be involved in providing the end-to-end service.

CURRENT OPERATIONAL ENVIRONMENT

In considering how to respond to the drivers for change, it must be recognised that network operators are building on a current situation that is still evolving and that has a number of known deficiencies. Some of these are as follows:

Service-Dependent Systems

The present services offered to customers are not all delivered from a uniform network platform. Services such as private circuits use a separate switching network to that of the PSTN (even though they share common core transmission facilities). These separate networks often have their own specific support systems and organisations. The replication that this can entail can make the deployment of new services costly and inefficient.

Quality-of-Service Measurement

The performance of the service delivered to customers is measured in a fragmented way. The networks and support systems currently in use were not designed with the ability to measure in detail an individual customer's quality of service. Information is predominantly available on the network and its elements, not on the total service or the service provided to individual customers.

Network Elements

The intelligence in the equipment currently deployed within the network concentrates primarily on its basic function of processing calls or simple point-to-point transmission. The present plesiochronous digital hierarchy offers little in the way of management facilities for the network operator. With no internationally agreed management capability, each manufacturer offers its own; this makes it impossible for equipment to be mixed at will.

In the local access network, copper is the predominant, labour intensive, means of delivery for voice services, with specialised services using their own separate access networks. Unified access methods are still in the early stages of deployment (see the special issue of the *Journal* on local access (April 1991)).

Islands of Automation

Current network support systems have compensated for the lack of management functions within the network elements and have focused on specific operational functions. These systems have mechanised network operations in a fragmented way. This approach has led to the current systems. The challenge of the immediate future is to enable these to interwork to produce an integrated, automatic approach.

Labour Intensive

If network operators continue to use a multitude of diverse support systems and network elements, a great variety of operational units and control centres will be required, and the lack of integration and consistency in these systems demands the use of considerable effort, representing one of the major costs of network operations.

NEXT-GENERATION SYSTEMS

A number of drivers can be identified that will impact on the next generation of systems. In general, technology trends will provide enablers to improved management systems, particularly when combined with improved administrative methods.

Technology Trends

Generic Systems

The next generation of administration systems will be developed within an architectural framework (CNA-M) which provides the basis for interworking. A small number (40) of key systems will be used and this will reduce the development and running costs of the systems themselves. Each system will undertake the tasks for a functional area and be linked to associated systems, for sharing data and for passing work as it flows through the systems.

New software technologies, such as automated software production and significant reuse of major components, will be used in these systems to ensure that their development costs are constrained and that they are able to adapt to the types of changes identified earlier.

Computing Technology

The same technological advances that enable the new network technologies are continuing rapidly to improve the computer world. The computing power that once cost millions of pounds is now available for thousands (the IBM PC was not available 10 years ago). The real cost of computing power is falling in the order of 25% per year.

As well as this rapid price reduction, the computing industry is moving from proprietary architectures to systems based on 'open' interfaces. No one vendor ever provided all the computing needs of a telephone company, and problems are encountered when proprietary systems have to be integrated together. The availability of open systems across a range of computing platforms makes the development of integrated support systems a simpler task.

Savings are also being made in the operational costs of computing systems. Increasing computer power and advanced computer systems management tools enable the consolidation of computer centres, fewer software licences and other operational savings to be made.

Advanced Information Processing

Progress is also being made in advanced information processing (AIP)[5] to make software systems that are more adaptable and intelligent. The problems posed by the real-time nature of network operations are not trivial, but the progress to date is such that technology can be expected to improve the type of software used in most operational support systems over the next five years.

Network Administration

The successful development of network administration is crucial to the future of network operators such as BT. It will enable cost reduction, improvement in quality, and faster and more flexible response to customer demands. Failure to meet the challenge will result in higher costs and slow response. It must be recognised that the functionality of the next generation of network management systems will be governed by the type of network being operated and the way the company wants to operate it. Certain major features will be evident:

Flow-Through

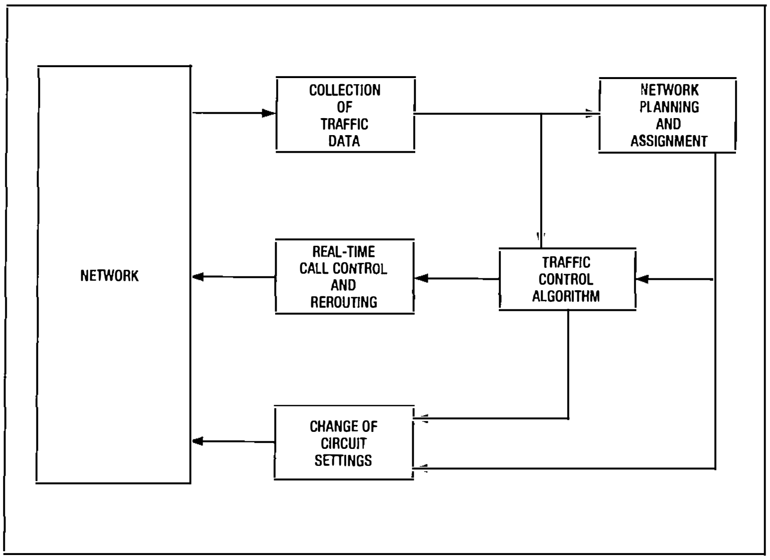
The consolidation of network administration into centralised operational units still requires extensive manual effort using systems that are not integrated. Future systems will be characterised by automatic *flow-through* whereby an event, be it a customer order or fault in the network, triggers off a set of actions in an integrated set of computer systems. These then automatically perform the relevant *workstring* to respond to that event. The processing of the *workstring* is such that the response has the minimal amount of human intervention necessary.

Figure 1 illustrates the flow-through between systems for the example of automated traffic management. A further example, covering provision of service, is given in Reference 7.

Rapid Deployment

Fast feature introduction will be demanded by the product managers of network services. Waiting years for a switch software release or change to an operational system will not be acceptable. Future operational support systems will be more flexible and be able to accept new functions in relatively short time-scales.

Figure 1—Example of flow-through for capacity management



Customer Control

Direct customer control of the network, either as individual services or combined as a whole in a virtual private network service, can reduce BT manpower. The means of control will vary from simple MF4 tones and voice response, up to a Concert™ workstation in the customer's premises. The means of delivery of customer control will vary depending upon the customer and the service being controlled.

Improved Customer Service

Quality of service to customers will be improved by future generations of network administration systems in two major ways:

● *Support of Self-Healing Networks* New networking technology can operate as semi-autonomous units. The need for all of the network management and support functions to reside in systems external to the network elements will be reduced as the network elements gain substantial intelligence. The ability of the network elements to adapt to changes without human intervention will improve the level of service. The new network elements, while adapting to changes, will also report the causes, so that longer-term corrective action can be taken.

● *Proactive Maintenance* Continuous surveillance of the network coupled with automatic testing directed by an expert system will become the norm ensuring that service-affecting faults are minimised.

FUTURE MANAGEMENT EXAMPLE

To show how some of these forces will drive network management in the future, consider the following hypothetical example (Figure 2):

The service is an international virtual private network service supplying the total network needs of multinational companies from basic voice services to 0800 services and data services.

The network is made up of a core transmission network onto which switching nodes have been added. The inter-node links and customer-node links are either owned by the operator or leased from other operators. In country A, no links are owned, in country B some are owned and some are provided by alternative operators.

The scenario: The customer's network manager (located at site 4) needs to change the automatic call distribution function. A marketing campaign in country B is so successful that there are not enough operator positions at site 2 to meet

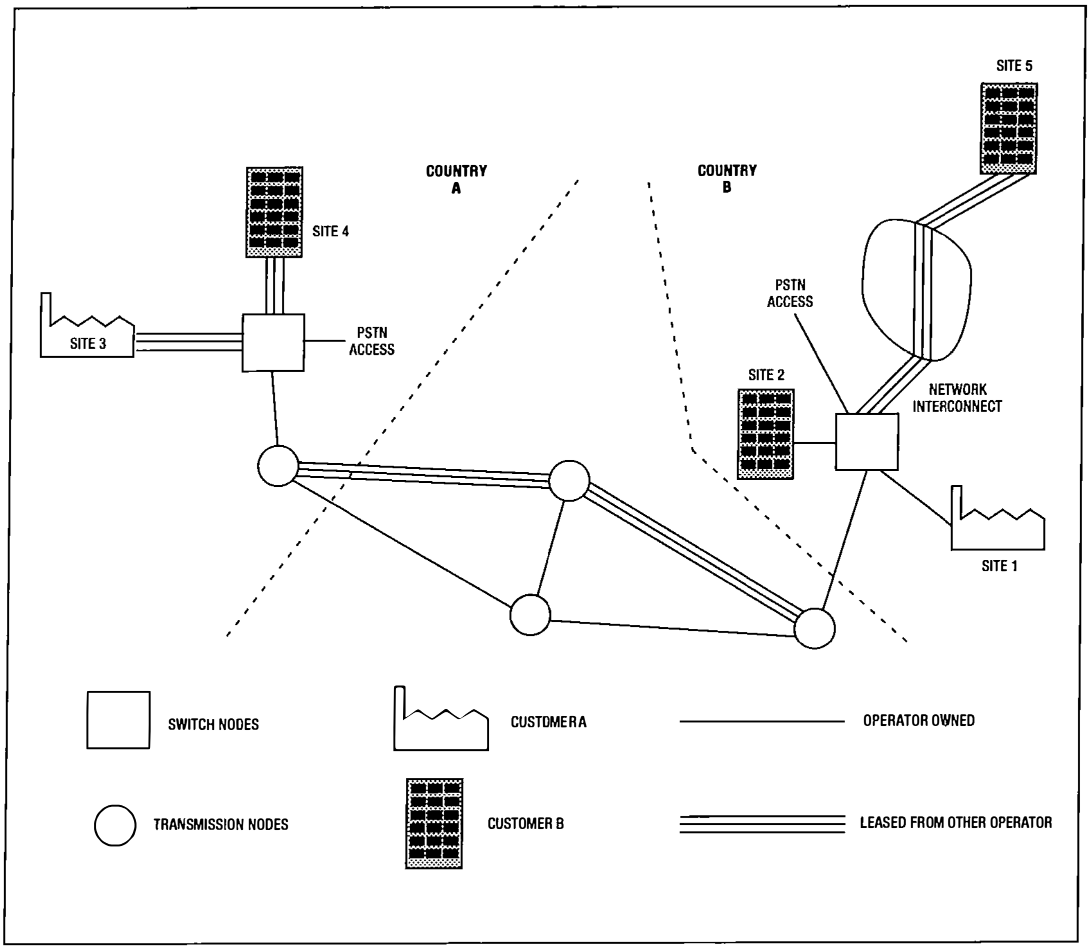


Figure 2
Future management scenario

the need, the overflow is to be directed to the evening shift at site 4 in country A.

The management (Figure 3):

(A) Via a management terminal, the customer alters 'his' network's automatic call distribution service.

(B) The service management system validates and records the change, updates the billing system (calls that were once purely handled in-country may now be going to country A), and updates the service records used by customer-facing staff.

(C) The service management system requests network change from the network control systems.

(D) The network control system 'evaluates' the change, works out any new network assignments, and updates, among others, planning systems, network records, and traffic management.

(E) The network control system instructs the network element's management systems to reconfigure the network (in this case an intelligent network service control point).

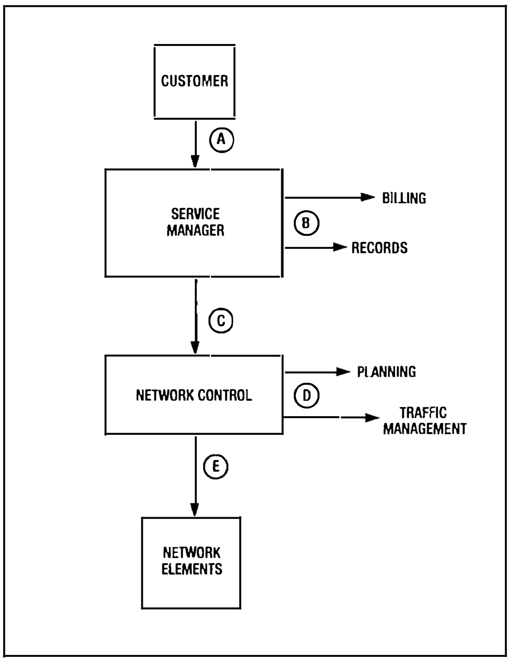


Figure 3 Management operations

The whole sequence demonstrates the flow-through required to operate the service efficiently. Only the minimal amount of intervention is required by the network operator between the customer and the customer's network service.

We can consider this network example from other viewpoints. How can the response to customer requests be automated? It could be the testing of the private circuit between site 5 and site 4, which runs over links not owned by the network operator (multiple network testing).

Or it could be a request for the doubling of the capacity at site 1 for the video conferencing service for a month while a special conference is being held (local access network capacity assignment).

From the highest level of the international virtual private service customer support system to the local access capacity assignment system, the network administration systems must be interlinked with the right functionality to ensure that the service offered is truly world class.

GETTING THERE

Earlier articles have explained how the key systems for future operations have been identified[7] and how the requirements of strategic systems areas have been analysed and the future architecture defined[8].

Achieving this future vision will be by a combination of evolution of current systems and the creation of new systems.

In some areas of operation, accelerated network modernisation will deploy new network elements at such a rate that the best option will be to deploy new operational support systems based on the target architecture, and remove the existing systems along with the old network elements. Such aggressive modernisation should produce a significant uplift in capabilities and bring major operational benefits.

In other operational areas, existing systems will be enhanced, adapted to meet the target architecture and interlinked with other systems. The benefit this brings will be one of continual improvement rather than drastic and expensive change.

The approach adopted will depend upon the existing investment in the network and support systems and how well they meet the operational needs of BT over the next decade.

CONCLUSION

The next decade will see continuing demands on network administration systems to help BT meet its customers' needs by reducing operating costs, achieving quality objectives and enabling customers to view their facilities and services.

Coupled with the modernisation of the network elements themselves, network management will be crucial to the success of the company. By building on the successes to date, and the wholehearted adoption of new technologies within a consistent architectural framework, BT can be confident of having the systems it needs in the final decade of the 20th century and into the 21st century.

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Biographies

Trevor Fitchett is currently responsible for the Network Management Department's front office group. He joined BT in 1981 working on System X call processing software after four years of development experience in the motor industry. Subsequent to working on System X, he worked on several integrated voice-data terminals for business systems. In 1988, he joined BT Datacomms working on the marketing of network management systems. He has a B.Sc. in Electronic Engineering from Hull University.

Mick Reeve graduated from the University of Durham in 1973 with a degree in Applied Physics, after a sponsorship course from the the Post Office. In his career at BT Laboratories, he has worked on several aspects of both transmission and switching research and development. These include many aspects of optical-fibre systems such as fibre specification, fibre strength, optical cabling and fibre-to-the-home systems. In 1989, he was awarded the Martlesham Medal for his work on a new method of optical cabling, the blown-fibre cable. Since 1989, he has been head of the Switched Networks Division at BT Laboratories. This covers research and development on all aspects of switching, including intelligent networks, broadband and multi-service networks, private switching (PBXs etc.) as well as managed transmission networks (SDH topologies and cross-connects etc.) The division covers a range of work from long-term architectures through to on-line support of switches in the field.

30th European Telecommunications Congress

M. SAUNDERS†, and K. MORGAN*

INTRODUCTION

The 1991 annual congress of the Federation of the Telecommunications Engineers of the European Community (FITCE) was hosted by the French Association des Ingénieurs des Télécommunications (AIT) in Strasbourg in September 1991. With the theme for this year's congress as 'Pan-European Networks and Services', Strasbourg, which is the home of the European Parliament, was aptly chosen for its cultural and innovative history in communications. It was here that Gutenberg printed the first book, which was the Holy Bible, and where the French national anthem, Les Marseillaise, was first performed for the public.

The location of the 30th FITCE congress was the Palais des Congrès et de la Musique, situated on the outskirts of the city and provided a modern, spacious, well equipped venue, which catered well for the technical seminars and a number of social functions held during the week.

OPENING CEREMONY

The congress was opened on the morning of 2 September and attracted a number of distinguished speakers. M. Irlinger, Director of France Télécom for the Alsace Region, welcomed everyone and commented on the pertinence of the conference theme in establishing the types of networks that customers wanted. Colin Shurrock of BT, President of FITCE, spoke of the rapid developments in both the commercial and technological aspects of telecommunications and talked of the twin concepts of competition and cooperation. He emphasised the role of FITCE in promoting understanding and the exchange of ideas.

M. Roulet, Président of France Télécom, pursued a similar line of thought and spoke of the roles of the various different players in the telecommunications arenas. M. Rohmer, representing the Mayor of Strasbourg, commented on the appropriateness of Strasbourg as the conference venue on this occasion.

The presence of Herr Gorts, the German State Secretary of the Ministry for PTT, gave an additional international dimension to the opening ceremony. He outlined the significance of the unfolding developments in communications throughout Europe. M. Rausch, the French Minister of Telecommunications, reflected on the effect of new telecommunications services on the way companies conduct business in Europe, and of the importance of the communications infrastructure on their ability to compete effectively on the world scene. An interesting highlight of the opening ceremony was the first public performance by a string quartet of an overture entitled 'An Invitation to European Dialogues', which was composed specially for FITCE by a young composer, Stuart Thompson, a student at the Royal Academy of Music in London.

TECHNICAL PAPERS

The Pan-European Networks and Services theme of the congress provided a good range of technical papers covering topics such as new services, mobile communications systems, European standardisation, integrated broadband communications networks, private networks and European cooperation.

The standard of presentations was generally good although occasional failures in the continuity of the visual projections and translations detracted from what were otherwise very competent performances.

A brief summary of the papers from BT authors is given below:

'Specification of Network Performance: Role of Customers Requirements on National and Pan-European Services' by A. P. Oodan.

The paper described the methodology used for specifying end-to-end performance specifications using functional models of the network, methods of obtaining customers' requirements and gap analysis techniques.

'Today's ISDN, an Overview for Potential Users of ISDN CPE' by R. Haslam.

The paper examined the current situation and future scenarios for ISDN customer premise equipment (CPE) with particular focus upon ISDN implementation problems and the emerging standards as a solution to users needs.

'Supporting the Customer Interface' by A. Houghton, D. Pollard, and N. Millard.

The paper described the work being carried out to develop expert systems as a means of improving customer service through interactive dialogue between customer-facing staff and their computer support systems.

'A Strategy for Providing an On Demand Service in a Copper Environment and Considering Future Technologies' by A. Hill, and R. Wardleworth.

† BT Worldwide Networks
* BT Business Communications

Left to right: R. Trieflinger (Germany), J. de Moitié (Belgium), H. Witberg (Netherlands), Andy Valdar (UK), and Miet Loix (Belgium)

Andy Valdar, BT, (second from right) chairing the Pan-European Radiocommunications Using Mobile Radio Session

The paper described work carried out in East Anglia to ensure that the correct copper capacity is planned and provided in the right place, at the right time, ensuring customer provision needs are met whilst maximising the return on investment in line plant.

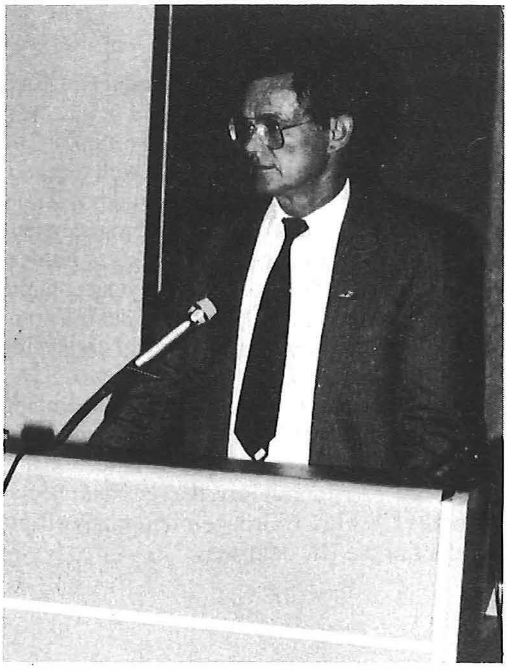
'Guidance in the Development of Integrated Multimedia Telecommunications Services' by N. Watkinson and K. Dickerson.

The paper described work carried out under the RACE programme to provide designers with tools enabling them to develop usable integrated multi-media telecommunications services.

'A New Approach to Network Structure using SDH' by C. Smith.

The paper described the development of the synchronous digital hierarchy (SDH) network by BT and the programme of phased implementation in the UK, focusing initially on the private circuit sector, but evolving to eventually replace the existing plesiochronous systems.

Ron Haslam, BT—Award for Best Presentation Material



CONGRESS AWARDS

Three awards were presented at this year's FITCE congress. The Paper Selection Committee, chaired by Gilbert Ferrieu and including Andy Valdar of the UK, awarded the Best Technical Paper Award to Madame Martine LaPierre (Alcatel France) for her paper 'Introduction of Broadband Services'.

The congress gave awards for Best Presentation Material to Ron Haslam (BT), and for Best Young Engineer of the congress to Jan Vandedrinck (RTT Belgium) for his 'Bound for a Pan-European Network' presentation.

STUDY COMMISSIONS REPORT BACK

A key area of interest during this congress was the report back from the two FITCE study commissions currently investigating the local loop and telecommunications engineering training. The commissions were set up to study specific problem areas in these fields and comprised a small team of FITCE members from different European countries. The objective of these commissions was to examine the problem areas from different viewpoints, to investigate new ideas brought about by shared research and to communicate developments and findings to the members of FITCE. They provide an active component in the work of FITCE by encouraging members of different nationalities to participate in raising information standards among the membership.

The Local Loop Commission, whose membership included Mike Parry and Peter Smith of BT, focused on quality-of-service improvements and cost reduction in local network operations. The commission was established to study the local network infrastructures in the member countries and to develop a series of common performance metrics that would enable cross-comparison of quality of service between European states. The conclusions of the study group recognised that, while other elements of the network infrastructure appeared to be well defined—for example, switch, transmission etc—strategies for the local loop were patchy and unclear in most countries, resulting in high costs and quality-of-service problems. It was obvious that more work needed to be carried out in this area but the findings of the commission would provide a good starting point for further research.

The work of the Training Commission focused on the training needs of telecommunications engineers from 1992 onwards, and the UK played a prominent role through the efforts of Dave Corrie from the BT Management College. Their research had found that changes in the markets through liberalisation and technological developments had resulted in organisations becoming more 'organic' and required engineers and engineering managers to have a broader range of skills than had been necessary in the past. For example, engineering managers of the future would require knowledge of finance, marketing, products and services, competition and regulation, and be computer literate as well as having a formal engineering education. The commission concluded that there were a number of options available to deliver such training, but the problem was the choice of the most suitable training solution from the mass of material currently on offer. Several recommendations were proposed, the key ones being the involvement of all FITCE member countries in the study group work and establishing contact with a European organisation for the development of a standard for telecommunications engineering training and development.

The work of both commissions was well received by the congress and prompted a request from the FITCE President for proposals of other possible problem areas that would warrant future study group activity.

TECHNICAL VISITS

An important part of the congress has become the technical visits, where delegates have the opportunity to see telecommunications examples in the host country through visits to sponsoring organisations. This year, visits were to Clemmesy (electronics), Telmat (software), Alcatel (PABX and videotext), Bosch ANT (microwave and fibre optics) and France Télécom (operations management).

ROUND-TABLE DISCUSSION

The final technical session of the congress was concluded by a round-table discussion on pan-European telecommunications and its importance to a united Europe. The discussion group consisted of M. Garric (European Commission (EC), Brussels), Bruno Lasserre (French Ministry of PTT), Yves Gouiffes (France Télécom), Ruth Cox (PTT-Telecom, Netherlands), Michel Huet (Cogecom), Michel Lucus (Bank Credit Mutuel Alsace) and Philippe Bette, a journalist. The discussion centred on the efforts of the EC to promote competition through liberalisation, the encouragement of technical harmonisation by the development of technical standards and the benefits that would be accrued to the customer from a pan-European perspective.

The discussion concluded that, although telecommunications would be fundamental to the success of a free European market, currently not enough concern was being shown by the EC politicians to ensure that a controlled pan-European approach is established. Rather, it is being left to national bodies to pursue a degree of technical standardisation while operating within a loose EC regulatory framework.

SOCIAL AND CULTURAL EVENTS

The FITCE congress gives the opportunity for delegates to meet in more informal surroundings and sample the cultural delights of the host country. A number of events were laid on by the sponsoring organisations with the highlights being the 'Sons et Lumieres', a light and music performance in the 14th century cathedral of Strasbourg, and a visit to the Postal Museum at the small town of Riquewihr situated in the Alsace region of France.

FITCE GENERAL ASSEMBLY

The congress was rounded off with the FITCE annual general meeting on the morning of 7 September. Two key proposals were passed by the meeting warranting further research and action.

The 'opening up' of Eastern Europe to the West has implications for a wider European Community membership. A proposal to re-draft FITCE membership to include these geographic regions was agreed.

A proposal to set up another study commission was also agreed by the congress. The study commission, proposed by the UK and chaired by Tony Mullee, BT Worldwide Networks, was to carry out research on the specification of network performance, focusing specifically on customers' requirements. A decision was also made to extend the study commission on the local loop.

1992 CONGRESS VENUE AND THEME

The 31st FITCE congress will be hosted by Asociacion Española de Ingenieros de Telecomunicacion, the Spanish national association of telecommunication engineers, and will take place in Granada and Seville from 27 September–2 October 1992. The theme for the congress will be 'Telecommunications and the Single European Market', concentrating on the impact of telecommunications in European economic development and the need for strengthening telecommunications in the pan-European industrial and service sectors.

CONCLUSIONS

The 31th FITCE congress was an educating and enjoyable event, with a good mixture of technical and social events set in a culturally stimulating location. The technical papers were well received and the feedback from the study commissions brought an enthusiastic response from delegates. There is always a danger that congress holders may try to outdo efforts of previous years, but the French Association des Ingénieurs de Télécommunications must be congratulated on organising a very stimulating and entertaining event.

Thanks must also go to France Télécom and the many sponsoring organisations that made the congress a success, the Comitté de Direction and last but not least Tapash Ray, the Assistant Secretary of the UK FITCE Group, for his many efforts on behalf of the UK delegates.

THE INSTITUTION OF BRITISH TELECOMMUNICATIONS ENGINEERS

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

General Secretary: Jon Inchley, Post Point 102, 203 High Holborn, London WC1V 7BU; Telephone: 071–728 9798. Membership and other queries should be addressed to the appropriate Local-Centre contact point as listed on p. 284 of this issue of the *Journal*.

Aberdeen Centre

All meetings unless otherwise stated will be held in Lecture Theatre No. 1, City Communications Centre, 9 Bridge Street, Aberdeen, commencing at 14.00 hours.

5 December 1991: *Operation Sovereign One Year On* by Paul Duffin, General Manager Customer Services, Scotland.

14 January 1992: *Satellite Communications—A Personal Vision of the Future* by Martin Bath, VSAT Project Implementation Manager.

4 February 1992: *Communications in Chaos* by Dr. David Leakey, Group Technical Advisor.

12 March 1992: *BT—European Leaders* by Mike Bett, Vice-Chairman, BT. To be held in the Concert Hall, Strathclyde Suite, Glasgow, commencing at 15.00 hours.

East Anglia Centre

15 January 1992: *Major Customers' Needs: A Customers' View-point* by P. Smith, Manager Communications Services, Sun Alliance Insurance Company. To be held at 3rd Floor Conference Room, St. Peter's House, Colchester, from 14.00–16.00 hours.

12 February 1992: *BT Marine* by R. Struzyna, General Manager Technology, BT Marine. To be held at the Pierce Room, Assembly House, Theatre Street, Norwich.

February/March 1992: Visit to BT Marine at Western Docks, Southampton. Members will be notified of details nearer the time.

18 March 1992: *Telecommunications in Chaos?* by Dr. David Leakey, Group Technical Advisor, BT. To be held at the 3rd Floor Conference Room, St. Peter's House, Colchester, from 14.00–16.00 hours.

East Midlands Centre

All meetings will commence at 14.00 hours except where stated otherwise.

20 November 1991: *Network Management in the 1990s* by Steve Heap, Manager, Network Management Control Centre. To be held at Leicester University, commencing at 17.00 hours.

22 January 1992: *Local Access Network Forum.* Local presentations and discussion. Midlands Personal Communications and Worldwide Networks. To be held at the Ex-Servicemen's Club, Peterborough.

19 February 1992: *Understanding BT Finance* by Tom Leitch, Financial Analysis Manager, PC Midlands. To be held at Nottingham University.

18 March 1992: *Telecommunications—A Worldwide Opportunity* by Bruce Bond, Director, BT Products and Services. To be held at Leicester University.

15 April 1992: *Sovereign Plus One.* Joint presentation by Midlands senior managers from Personal Communications, Business Communications and Worldwide Networks. To be held at Leicester University.

East of Scotland Centre

All meetings are from 12.00–14.00 hours unless otherwise stated.

20 November 1991: *Networks—Its A Gas!* by Ian Harkness, British Gas. To be held in the Conference Rooms, Telephone House, Ward Street, Dundee.

11 December 1991: *A Customer's View of BT* by Douglas Manson, Information Systems Operations Manager, Standard Life. To be held in Room E2/3, Caledonian House, Canning Street, Edinburgh.

22 January 1992: *At Your Service* by Sandy Laing, Operator Services Manager. To be held in Room 340, Telephone House, Edinburgh.

12 February 1992: *BT: Money Talks* by Robert Millington, Barclays de Zoete Wedd. To be held in Room 340, Telephone House, Edinburgh.

12 March 1992: *BT—European Leaders* by Mike Bett, Vice-Chairman, BT. To be held in the Concert Hall, Strathclyde Suite, Glasgow, commencing at 15.00 hours.

15 April 1992: *Mobile Communications: The Next Moves* by Peter Skinner, Director, Mobile Communications. To be held in Room 340, Telephone House, Edinburgh.

Lancs and Cumbria Centre

All lectures will be held in the Harris Conference Centre, Garstang Road, Preston, commencing at 14.00 hours, coffee from 13.30.

3 December 1991: *Tunnel Vision* by Paul Falkner and Gerry Lyne, project manager and engineer for BT Cordiale, the joint venture between BT and France Telecom which has successfully tendered for the contract to supply all communication links for the Channel Tunnel. The lecture will include a short video presentation.

7 January 1992: *Development in Fibre Optic* by Dr. Peter Cochrane.

4 February 1992: *A Supplier's View of Telecom* by a leading manager from GEC Plessey Telecommunications Limited.

3 March 1992: *The Local Network: More than Poles and Holes* by Mike Frost, local network manager for Personal Communications.

Liverpool Centre

15 or 22 January 1992: (Date to be confirmed.) *Health and Safety at Work* by Harry Baker, Health and Safety Inspector. To be held at Bradford Hotel, Tithebarn Street, Liverpool, commencing at 12.45 hours, buffet from 12.00.

February 1992: Prestige lecture with Manchester Centre. To be announced later.

March 1992: *PCN 2000*. To be announced later.

9 April 1992: *The World of Private Services* by Sue Davidson, General Manager, Private Services, Business Communications. To be held at Bradford Hotel, Tithebarn Street, Liverpool.

London Centre

7 December 1991: Family Christmas Lecture—*The Secret Life of Machines* by Television Presenter Tim Hunkin. To be held at The Institution of Electrical Engineers, Savoy Place, London WC2R 0BL, at 11.00 hours and 14.30 hours. Refreshments available 30 minutes before each session. Admission strictly by ticket. Free tickets can be obtained by writing to: 1991 Christmas Lecture Office, Post Point T125, Telephone House, Shoot up Hill, London NW2 3BA enclosing a self-addressed envelope to your office address.

Manchester Centre

22 January 1992: *The Future of BT's Local Access Network* by Peter Lisle. To be held at UMIST Staff House, Room 41, commencing at 13.30 hours.

February 1992: Prestige lecture at Liverpool. To be announced later.

25 March 1991: *A Personal View of the BT Engineering Academy Programme* by Adrian Attwood, Dave Mand and John Oliver. To be held at UMIST Renold RBD7, commencing at 13.30 hours.

Martlesham Heath Centre

All lectures will be held in the John Bray Lecture Theatre, BT Laboratories, Martlesham Heath, commencing at 16.00 hours.

21 November 1991: *Technologies to make the Future Renewable* by Michael Harper, Friends of the Earth.

10 December 1991: *The Evolving World of Data Communications* by John Atkins, BT Laboratories.

14 January 1992: *The Potent Mix: Communication—Information—Regulation* by Dr David Leakey, Group Technical Advisor, BT.

North Downs Centre

All meetings will be from 13.30–15.30 hours. A buffet lunch will be provided from 12.30 hours.

26 November 1991: *Payphones—Yesterday, Today and Tomorrow* by Patricia Vaz, General Manager, Customer Service, BT Payphones. To be held at The Royal Oak Hotel, Sevenoaks.

11 December 1991: Two-part lecture. (*a*) *Switch Tactical Planning* by Stewart Penfound, Switch Tactical Planning, Home Counties South. (*b*) *Pole Erection* by Martin Sadler, External Network Construction, Brighton. To be held at The Boxley House Hotel, Maidstone.

26 February 1992: *The Business Customer* by Humphrey Penney, Major Customer Service Manager, Business Communications Home Counties. To be held at The Boxley House Hotel, Maidstone.

25 March 1992: *A Customer's Perception of BT* by Stuart Ravenscroft, National Provident Institution. To be held at The Boxley House Hotel, Maidstone.

22 April 1992: *The Network Operations Unit* by Liam Kelly, Network Operations Manager, Home Counties South. To be held at the Boxley House Hotel, Maidstone.

North East Centre

All meetings will commence at 14.00 hours.

3 December 1992: *Safety Management* by Ken Clark, BT Chief Safety Officer. To be held at Neville Hall, Newcastle.

3 February 1992: *Tomorrow's Access Network* by John Peacock, BT Laboratories. To be held at Neville Hall, Newcastle.

3 March 1992: *Malicious Calls Unit* by Jessica Newhouse, BT Malicious Calls Unit, Canterbury. To be held at Neville Hall, Newcastle.

7 April 1992: *Access Network—Alternatives to Copper* by Paul Rodgerson and Keith Vinning, Fulcrum. To be held at Cleveland Scientific Institute, Middlesbrough.

12 May 1992: Speaker from BT National Advertising Unit. To be held at Neville Hall, Newcastle.

North Wales and the Marches Centre

11 December 1991: Presentation by Colin Mulcahy, Marketing Manager. To be held at Post House Hotel, Chester.

29 January 1992: Presentation by Tim LeGood, General Manager, Customer Service, Personal Communications Division Wales and West. To be held at Beauchamp Hotel, Shrewsbury.

19 February 1992: Presentation by Bob Lamb, Operations Manager, Wales and West. To be held at Whittington House, Oswestry.

10 March 1992: Presentation by John Buttle, Planning Manager, Wales and West. Venue to be announced.

Northern Ireland Centre

All meetings will be held in the Business Centre, Dial House, Belfast, commencing at 12.00 hours.

11 December 1991: *The Competitive Challenge within Northern Ireland* by Bertie Campbell, BTNI.

8 January 1992: *Finance for BT Engineers* by Kieran McPolin and Paddy Turnbull, BTNI.

12 February 1992: *Marketing to Personal Customers*, by Ian Ash, Director of Marketing, PC.

11 March 1992: *Front Office Changes and the Customer Reception Point* by Moore Kennedy, BTNI.

8 April 1992: *The Junction Network System* by Simon Kimpton.

Severnside Centre

8 January 1992: *The Future of Copper in the Access Network* by Peter Lisle. To be held in the Conference Room, 6th Floor, Mercury House, commencing at 14.15 hours.

5 February 1992: *A Glimpse of the Future* by Dr. T. Rowbotham, Director, Network Technology. To be held in Conference Rooms A and B, Ground Floor, Mercury House, commencing at 14.15 hours.

23 April 1992: *Telecommunications* by Bruce Bond, Director, Group Products and Services. To be held in the Watershed Conference Centre, commencing at 14.15 hours.

South Downs Centre

All meetings will be held at the Worthing Central Library Lecture Theatre, Richmond Road, Worthing, preceded with a buffet lunch at 12.00 hours and commencing at 12.45 hours.

3 December 1992: *What a Customer Needs from BT* by Martin Green, Worldwide Communications Manager of American Express.

14 January 1992: *Flight Simulators* by David Parkinson, Singer Link Miles Flight Simulators.

11 February 1992: *The NOU/NFU Partnership* by Steve Ellett, Operations and Surveillance Manager, and Bernard Walker, Network Maintenance Manager Sothern Home Counties West.

10 March 1992: *The Marketing of BT* by Ian Ash, Marketing Director, BT Personal Communications.

South Midlands Centre

15 January 1992: *0+2 Carrier* by James Alexander. To be held at the Auditorium, Aylesbury Conference Centre, from 13.30–15.30 hours.

12 February 1992: *B.O.A.T.*. The introduction of office automation within BT by Tom Wyman and his team, from Martlesham Heath. To be held at the Conference Room, Phoenix House, Milton Keynes, from 12.30–14.00 hours, with a buffet at noon.

April 1992: Bruce Bond will address a combined meeting with East Anglia on a topical subject.

South West Centre

A buffet lunch will be provided at Exbridge and Telecom House lectures. Visitors are required to produce identification on arrival.

15 January 1992: *Health and Safety Executive*. Presenter to be announced. To be held at Exbridge House, Exeter, from 12.00–14.30 hours.

12 February 1992: Visit to Goonhilly.

18 March 1992: Title and presenter to be announced. Meeting will be held at Telecom House, Plymouth, from 12.00–14.30 hours.

Staffordshire Centre

Except where stated, all meetings will be held at the BT Technical College, Stone, commencing at 13.45 hours.

9 December 1991: *Solar Energy and its Applications* by Professor D. Hill, President, UK Solar Energy Society. Joint IEE/IBTE meeting commencing at 18.15 hours with a buffet tea at 17.30 hours.

13 January 1992: *Distance Learning—The State of the Art* by Margaret Bell, Manager Distance Learning.

4 February 1992: *Training and Enterprise Council—Roles and Relationships* by Mr. Ward, Chief Executive and Managing Director, Staffordshire TEC.

2 March 1992: *Technology Management—The Hidden Competitive Edge* by John R Fawn, jrf and associates.

Thames Valley Centre

Members will be notified of details.

19 November 1991: *1992, The Euro Telecomms Manager.*

14 January 1992: *Fibre Optics Trials.*

18 February 1992: *Team Working.*

17 March 1992: *A Customer's View.*

14 April 1992: *Integrated Services Digital Network.*

West Midlands Centre

13 November 1991: *A Glimpse of the Future* by Dr. Peter Cochrane, BT Laboratories.

January 1992: Work Management.

February 1992: Network Forum—Finance.

March 1992: IBTE/FITCE. Telecommunications on the World Scene. Congress report back.

West of Scotland Centre

11 December 1991: Visit to the network operations unit at Woodcroft, Edinburgh, commencing at 14.00 hours. Speaker: Charlie Allison.

22 January 1992: *Operation Sovereign 1 Year On* by Paul Duffin. To be held at the Glasgow Royal Concert Hall, commencing at 14.00 hours.

19 February 1992: *Strategy for the Future of the BT Access Network* by Colin Shurrock. To be held at the Strathclyde Institute, commencing at 12.15 hours.

12 March 1992: *BT—European Leaders* by Mike Bett, Vice-Chairman, BT. To be held at the Glasgow Royal Concert Hall, Strathclyde Suite, commencing at 15.00 hours.

1 April 1992: *The Evolving Network* by Alfie Kane. To be held at the Strathclyde Institute, commencing at 14.00 hours.

Notes and Comments

NEW SUBSCRIPTION RATES—EXTERNAL CUSTOMERS

New subscription rates for the *Journal* for external customers (that is, not employees of BT) will take effect from January 1992. The new rates are as follows:

Price per copy (companies, universities, libraries and other bodies):

£5·00 (£5·75 including postage and packaging UK)
(£7·00 including postage and packaging overseas)

Price per copy for private individuals (to be paid for by personal cheque):

£3·50 (£4·25 including postage and packaging UK)
(£5·50 including postage and packaging overseas)

One year's subscription (companies etc.):

£23·00 UK
£28·00 Overseas

One year's subscription for private individuals (to be paid for by personal cheque):

£17·00 UK
£22·00 Overseas

Overseas customers can pay by sterling drafts drawn on London. Because of high bank charges, payments in US dollars cannot be accepted.

IBTE LOCAL-CENTRE CONTACTS

The following is a list of Local-Centre contacts to whom enquiries about the Institution may be directed. Where no Membership Secretary details are shown, membership enquiries should be directed to the Local Secretary.

Centre	*Local Secretary*	*Membership Secretary*
Aberdeen	Jim Martin (0224 752688)	George Cameron (0224 752857)
Bletchley/South Midlands	Jim Coley (0234 274840)	Keith Sanford (0234 274043)
East Anglia	Terry Birdseye (0702 373347)	Keith Phillips (0206 717244)
East Midlands	Dave Bostrom (0533 534212)	Ian Bethell (0602 478587)
Lancs & Cumbria	Trevor Hughes (0706 40840)	
Liverpool	David Bowe (051–229 3723)	Clive Maude (051–229 4074)
London	Anthony Oodan (071–239 1673)	Peter Martin (081–456 6007)
Manchester	John Halton (061–200 9216)	
Martlesham Heath	Mike Shaw (0473 645594)	Ian Gilbert (0473 645500)
North Downs	Nick Smith (0227 474823)	
North East	Pete Barrett (091–222 2304)	Phil Marley (091–222 2887)
North Wales & Marches	Peter Clay (0743 274205)	
Northern Ireland	David Elliott (0232 240353)	
Scotland East	Graham Neilson (031–345 4392)	Alan Dickson (031–226 2000)
Severnside	Ian Davis (0272 206701)	Dean Shephard (0272 206457)
South Downs	Graham Lindsay (0273 222234)	Roger Henderson (0903 30286)
South Wales	Peter Coleman (0222 691622)	
Staffordshire	Ray Piper (0785 813483)	Paul Field (0785 762419)
Thames Valley	Bob Hooker (0734 562614)	Dave Prout (0734 501244)
West Midlands	Gary Chattaway (0203 228396)	Paul Jervis (021–233 8162)
West Scotland	Graham Wellby (041–220 5049)	Jill Maxwell (041–220 5837)
Westward	Rob Rand (0392 212681)	Chris Gould (0392 212663)
Yorks & Lincs	Steve Wood (0532 378316)	Paul Horncastle (0274 375988)

ASSOCIATE SECTION INTER–DISTRICT COMMITTEE CONTACTS

The following is a list of Associate Section Inter–District Committee contact points to whom enquiries about the Associate Section should be directed.

Inter–District Committee	*Contact*	*Telephone No.*
London	John Tythe	081–804 2400 Ext 460
Midland	John Sansom	0604 35999
North East	Keith Whalley	0642 310937
Northern Home Counties	Andy Edmonds	0473 646414
Northern Ireland	Roy Gamble	0232 621421
North West	Phil Holt	061–600 8111
Scotland	Kevin McMonagle	041–220 2561
South East	Martyn Harvey	0424 436494
South West	David Sanders	0272 260626
Wales	Ferg Brown	0952 49886

31st European Telecommunications Congress

27 September–2 October 1992, Granada, Spain

CALL FOR PAPERS

The Federation of the Telecommunications Engineers of the European Community (FITCE) is inviting papers for the 31st FITCE Congress on the following theme:

'Telecommunications and the Single European Market'

The theme will embrace:

- The role of telecommunications in economic development and its importance in regional development.
- The need for strengthening telecommunications in the pan-European industrial and service sector.

It is anticipated that each author will be expected to submit an abstract of the proposed paper by the end of February 1992. The abstract, of no more than one page, should give a clear indication of the theme and coverage of the proposed paper.

The FITCE Papers Selection Committee is expected to advise authors during early-April 1992, after the final programme has been determined.

The full text of a selected paper should be about 2000 words to allow for a 20 minute presentation and 10 minutes for questions and debate. The FITCE Congress Office, at the address to be advised later, would expect to receive the full text from the selected authors in early-June 1992.

Prospective authors should contact: **Paul Nichols**, IBTE Office and Publications Manager, Post Point G012, 2–12 Gresham Street, London EC2V 7AG; Tel: 071–356 8022; Fax: 071–356 7942.

FITCE MEMBERSHIP

FITCE is an organisation of national associations with similar objectives to IBTE and draws its members from the public telecommunications administrations of Belgium, Denmark, Eire, France, Greece, Italy, Luxemburg, the Netherlands, Portugal, Spain, the United Kingdom and Germany. FITCE sponsors multi-national study groups (Commissions) to enquire into and report on problems of general interest, and each year one of the member countries hosts a General Assembly/Congress at which a given technical theme is discussed. FITCE also publishes a journal—*FITCE Revue*—which is distributed to Members.

Membership of FITCE is available to Members and Affiliated Members of IBTE who hold a University Science Degree and/or are Corporate Members of the Chartered Engineering Institutions and/or are Chartered Engineers.

Further details about FITCE Membership and FITCE Membership Application Forms can be obtained from **Tapash Ray**, UK FITCE Group, Post Point 213, The Angel Centre, 403 St John Street, London EC1V 4PL. Telephone: 071–239 0429.

FITCE

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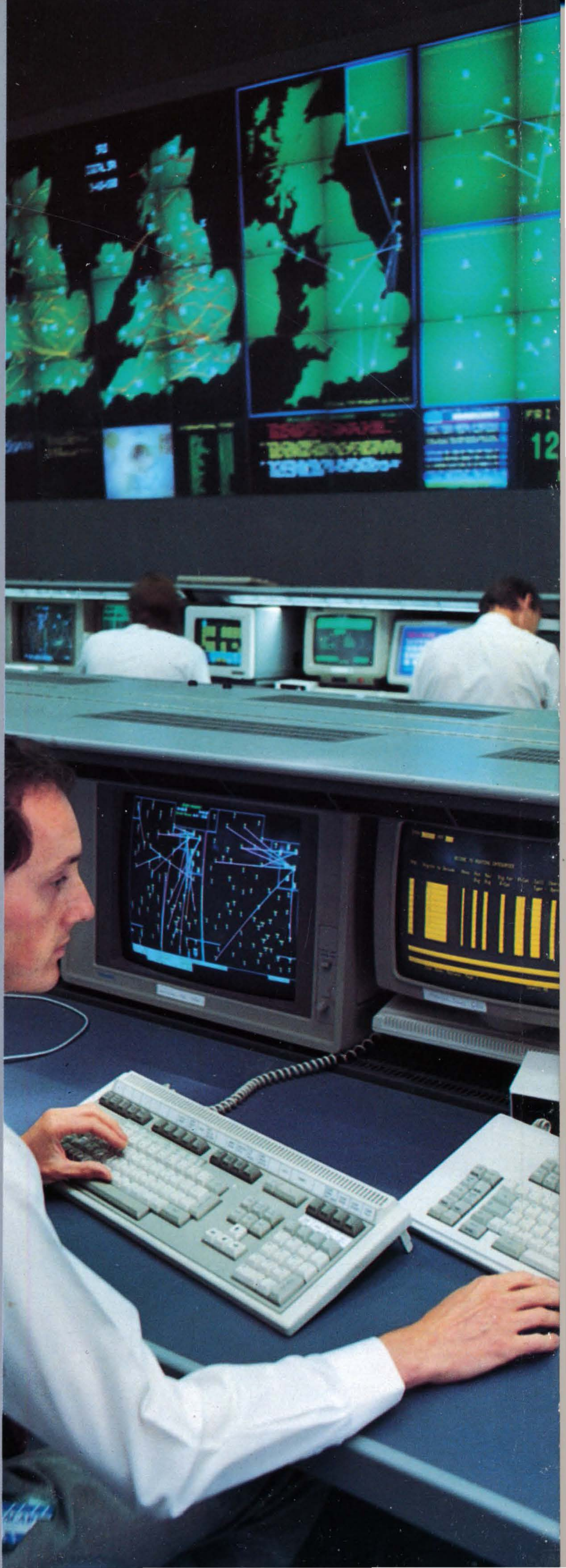

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