Towards a digital communications future

Andrew Muir, BSc, CEng, MIEE, *Head of Line & Radio Planning, British Telecom National Networks, Trunk Services.*

A massive programme is well under way by British Telecom to create a nationwide multi-function public switched digital network. It incorporates the latest technologies in integrated digital networks (ISDN), digital trunk networks, network control, signalling and transmission systems, and will be capable of meeting a variety of business communications needs. However, ISDN is only the first step in a trend that will continue into the 21st Century, and in the near future this on-going trend will lead to a merging of communication, computing, control, information and entertainment services.

The explosive demand for new, highly sophisticated means of processing and disseminating information has revolutionised communications, particularly in the modern business world. Facilities for handling data, text, facsimile, graphics, television pictures and the like are becoming as commonplace as those for ordinary telephone calls.

For several years, British Telecom has met these needs by providing a variety of separate customised networks and services. However, a more attractive approach is to establish a single telecommunications network which combines the qualities and requirements of all existing speech and non-speech services, as well as being capable of serving future needs. In the late 1960s, therefore, British Telecom decided to introduce a multi-function public switched digital network incorporating all the key elements of modern technology.

Integrated digital network

The backbone of this multi-purpose national digital communications network is the digital trunk network, interconnecting the principal towns and cities of the UK. This network, shown in Fig 1, will be fully operational by 1988 and already one third of it has been completed.

Connected to the trunk network will be an increasing number of digital local switching units, allowing customers to benefit directly from the advantages of end-to-end digital communications such as fast call set up and clearer, quieter connections. Extension of digital service from the local switching unit to customers' premises will enable a fully Integrated Services Digital Network (ISDN) to be established with the potential to provide a far ranging choice of digital facilities.

Digital trunk network switching units

The basis of the Digital Trunk Network is a matrix of fully interconnected System X switching units, overlayed by eight 5ESS switching units as shown diagrammatically in Fig 2. At November 1985, 17 System X units were in operation, with a further 16 expected to come on stream by Spring 1986. By the end of 1986, 54 out of the ultimate total of 55 System X trunk units will be in service.

An important feature of all modern digital switching units, including System X and 5ESS, is the use of stored programme control (SPC).

The essential task of the SPC function is to select a path through and out of the switching unit appropriate to the dialled digits. This involves storing the dialled digits, translating them into a routeing code and then initiating the activation of the necessary switches.

In the step-by-step switching systems used throughout much of the analogue network for many years, these functions were incorporated in the switches themselves and thus were distributed throughout the exchange. This placed limitations on the way in which calls were handled, and constrained the structure and

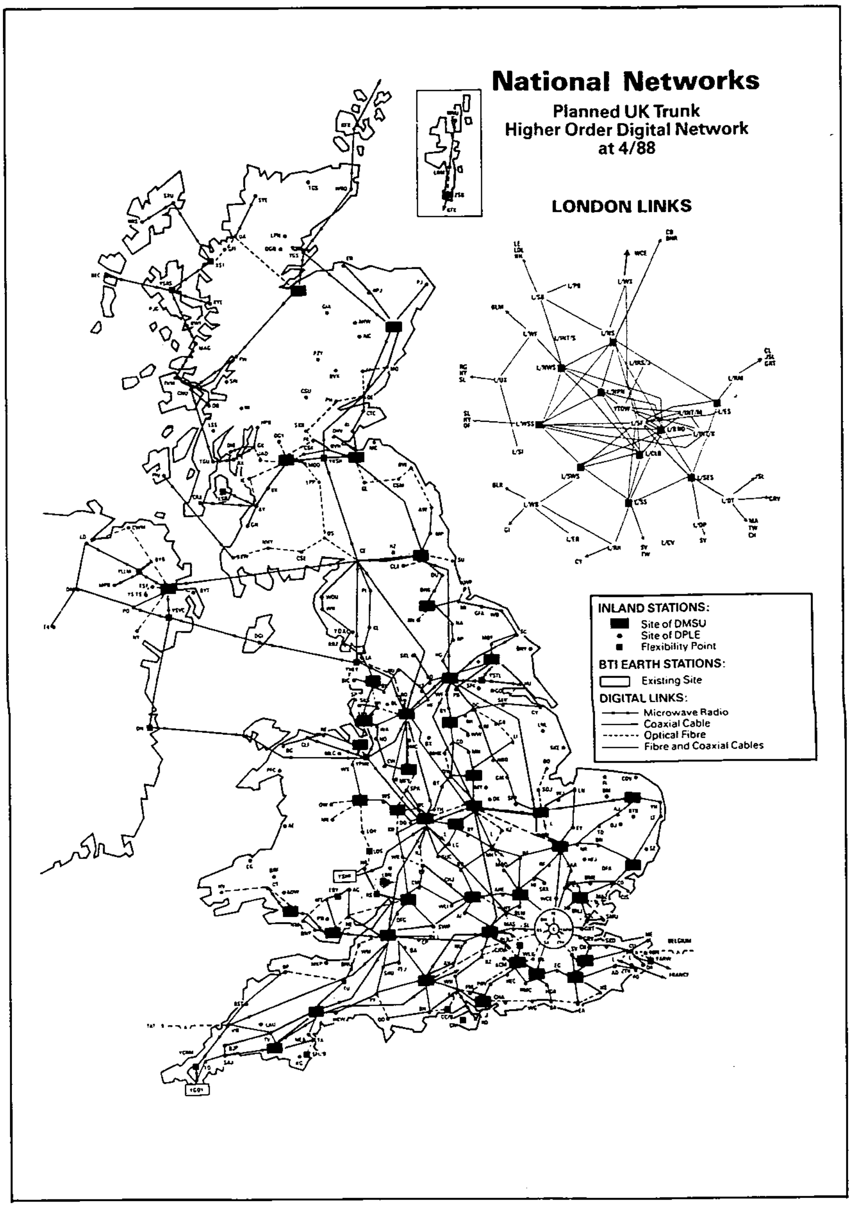

Fig 1 Digital trunk network planned for 1988

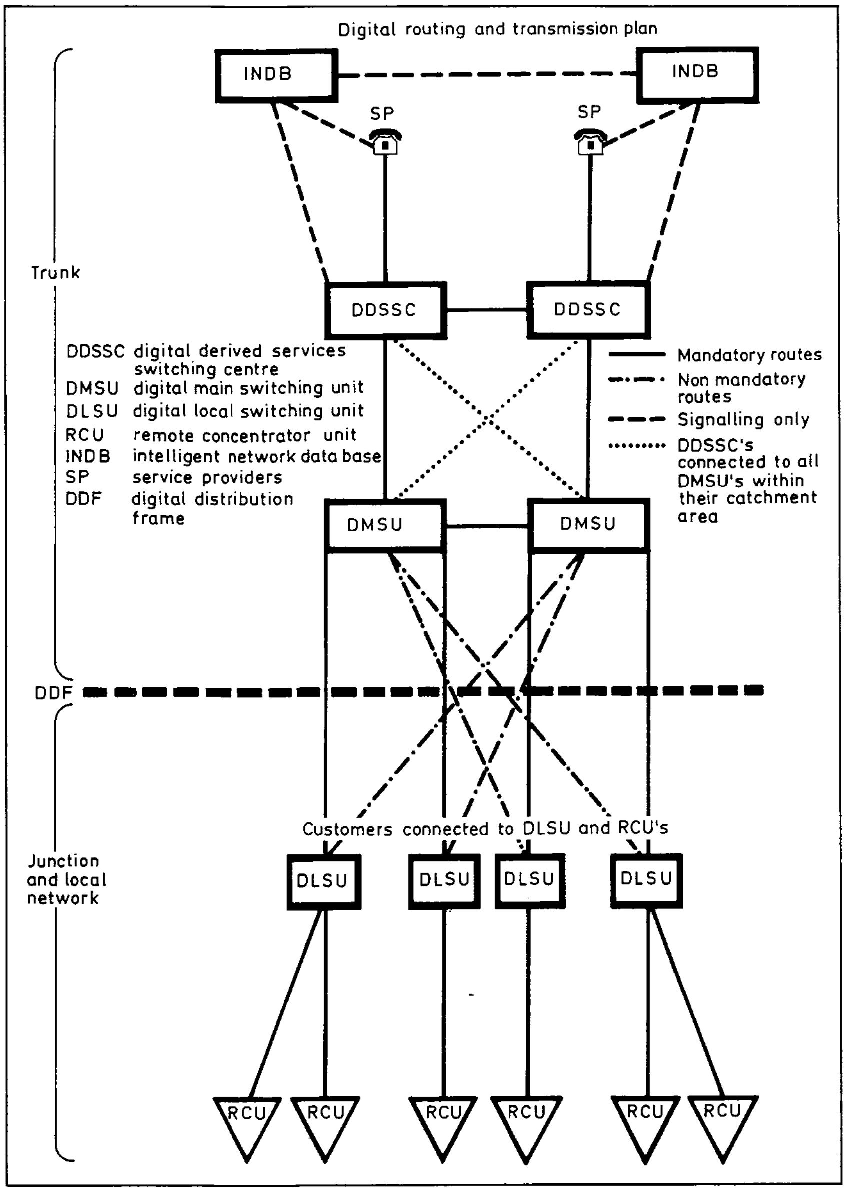

Fig 2 Digital switching hierarchy

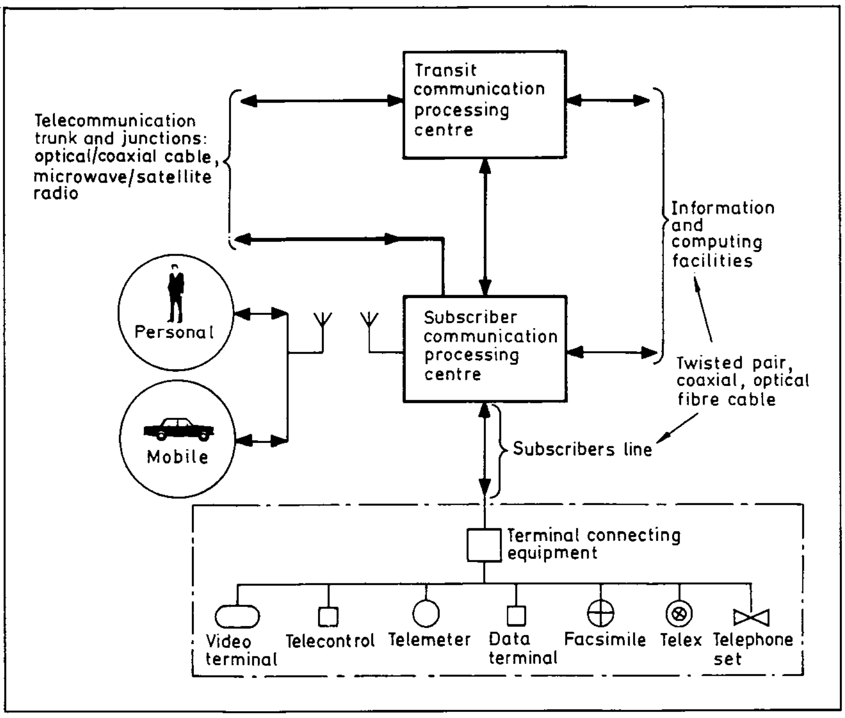

Fig 3 ISDN of the future

numbering schemes of the network.

In the System X and 5ESS switching units, the stored programme control function is centralised in a common pool of equipment shared by all switching stages in the unit. The flexibility offered by this centralised approach enables a wide range of new services and facilities to be offered, such as abbreviated dialling, traffic and utilisation statistics and automatic alternative routeing of calls through the network.

The flexibility offered by SPC has been further extended in the British Telecom trunk network by the introduction of Intelligent Network Databases (INDBs) which support the switching units in the manner shown in Fig 2. The INDBs enable the software of a large number of switches to be concentrated into a small number of units, and thereby introduce greater flexibility and overall economics into the network.

In designing the control hardware of a SPC system, particular attention must be paid to the maintenance of security levels consistent with high quality of service; a typical objective is an exchange system failure rate better than once in 30 years.

Most large modern SPC systems achieve high service quality through the use of multi-processor architecture, where a number of central processing units (CPUs) have full access to a set of immediate access and auxiliary stores via a common bus arrangement.

This mode of operation allows either geographical or functional allocation of traffic handling and offers maximum levels of switching unit reliability and growth. Typically one of several processors is operated in a standby mode, able to take over from any faulty processor—known as '1 in N' sparing.

Network control

The important feature of British Telecom's digital network is the integration of network control. Nine District Control Centres are being established in the UK which will ultimately enable all trunk switching and transmission systems in the District's network to be monitored. Each centre can therefore rapidly take measures to avoid major interruptions in traffic flow.

Surveilling the traffic flows in each District is the National Network Management Centre where a controller constantly reviews the whole network and can take vital decisions affecting several Districts. This will allow faults or congestion to be quickly located and action taken such as re-routeing calls on an alternative part of the network.

Signalling

Central to the successful operation of a digital switching network is a sophisticated message control system (MCS). British Telecom is leading the world in adopting the CCITT Signalling System No 7 as an MCS and augmenting it to meet additional requirements, including the ability to offer service to ISDN customers.

The CCITT No 7 system provides a high speed message based signalling system for use between SPC controlled digital switching units carried over 64 kbit/s digital channels.

The functional structure of the signalling system is based on the introduction of a division between that part of the system which acts as the transparent but secure message transfer mechanism and the part which provides and interprets the data being carried. These two parts are known as the Message Transfer Part and the User Part respectively.

Digital switching units often employ a number of User Parts to communicate messages about various types of calls—for example, there are separate User Parts available for telephone calls and data connections.

The separation of the User Parts from the Message Transfer Part provides the maximum scope for flexibility to add new functional modules to the signalling system for future applications.

Trunk transmission systems

The network of digital trunk transmission systems which will interconnect the trunk switching units and provide links to local switching units is shown in Fig 1. By the completion of the digital trunk implementation programme in Spring 1988, 44% of this network will consist of optical fibre systems with 32% radio and 24% coaxial cable. Already, by November 1985, some 68 000 km of optical fibre had been installed, as well as 5500 system km of digital microwave radio and 17 000 system km of digital coaxial cable systems.

Most of the optical fibre in the trunk network is of the monomode type, where an active core some 8 μm in diameter can carry data streams of 565 Mbit/s or higher at one or a multiplicity of wavelengths. Initially, the fibres are generally being exploited at 140 M/bits at a single wavelength, but British Telecom's first operational 565 Mbit/s system entered traffic at the end of 1985.

The rapid introduction of optical fibre systems is a reflection not only of the major advances in technology which have been pioneered over the past five years, but also of the considerable cost savings and improvements in reliability which are offered by optical transmission. The very low losses of monomode optical fibres also enable very long spacings to be adopted between successive repeater points of line transmission systems.

The advantages of long repeater spacings are being fully exploited in the British Telecom network and particularly on submarine cable routes within the British Isles. Currently, for example, a 120 km unrepeatered submarine cable is being planned to connect the South Devon coast with Guernsey in the Channel Islands.

Technological advances are also being exploited in British Telecom's digital radio network where the combination of high order modulation systems and adaptive equalisation techniques enables high spectrum efficiencies to be achieved at no loss of transmission quality. In common with switching units, the introduction of digital transmission techniques enables increasingly sophisticated network monitoring and management techniques to be introduced. An automatic digital switched service protection network is being introduced which enables a line system that has failed—due, for example, to being dug up during roadworks—to be bypassed within seconds.

Digital local and junction networks

Switching units

As with the trunk network, System X switching units will form the basis of the digital local network complemented, in accordance with recent BT procurement policies, by units of an alternative design, designated 'System Y'. Nearly 1000 digital local switching units (including remote concentrator units) will be in operation by the end of 1986, rising to 1400 by 1988.

As the digital local switching unit provisioning programme gathers momentum, more and more telephone customers will benefit from exchange-based facilities such as short code dialling, three-way calls, call diversion, call waiting, fixed destination cabling and itemised billing on demand.

The network of System X and System Y switching units will also open the door to the wider benefits of ISDN services. These will be revolutionary in improving business communications, being more efficient and flexible, simpler and completely multipurpose. They will include a fast and reliable circuit switched data service at a range of rates up to 64 kbit/s, fast facsimile at 64 kbit/s, slow-scan television and teletex at 2400 bit/s. Direct access to British Telecom's public data network will be made easier, as will access to the growing range of services such as electronic banking and electronic funds transfer.

A pilot integrated digital network service was launched in June 1985. By the end of 1987, ISDN services will be available at 190 centres around the country; by 1989 they will be available to 75% of business customers.

Local transmission systems

The digital local switching units will be interconnected by the digital junction network and connected to individual customers by the local network. Unlike the trunk network, a large proportion of digital junction and local transmission systems will re-exploit the existing metallic cables, reflecting the massive investment in cables built up over many years.

Novel techniques have been pioneered to transmit digital signals over the symmetric pair cables of the local networks and, in particular, to overcome the crosstalk limitations encountered in them.

Despite the investment in metallic cables, optical fibres are rapidly penetrating both the local and junction networks, with particular impetus being given in those areas where new cable television systems are being established.

The development of local junction and trunk digital transmission systems has also enabled British Telecom to establish a comprehensive network of digital private circuit services—collectively known as X-Stream and incorporating individual services such as KiloStream and MegaStream. The rapid growth of X-Stream is, once again, a clear indication of the benefits of digital technology to telecommunications network users.

Future developments

The establishment of an integrated digital network offering ISDN based services represents a major step in the expansion of the range and quality of telecommunications services available to network users. It is, however, only the first step in a trend which will continue through the 1990s and into the 21st century with ever increasing momentum. It is already apparent that, in the near future, the trend will lead to a merging of communication, computing, control, information and entertainment services.

The network carrying these integrated services will be increasingly dominated by new technologies such as optical transmission and switching, satellites, and cellular radio, in addition to the conventional technologies such as transmission over metallic cables and electronic switching.

Of particular note is the rapid interest shown in cellular mobile radio techniques. At the end of its first year of operation, for example, the Cellnet communications network expanded to cover more than 60% of the population and had almost 25,000 customers connected to it. The integration of these techniques into the ISDN of the future is depicted in Fig 3.

Acknowledgements

Acknowledgement is made to the Chief Executive, Trunk Services, British Telecom National Networks, for permission to publish this paper.