British Telecommunications Engineering

VOL 7 PART 1 APRIL 1988

CCITT Signalling System No.7

The Journal of
The Institution of British Telecommunications Engineers

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

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

Subscriptions and Back Numbers
Price: £1·50 (£2·00 including postage for UK; £2·50 including postage for overseas). Annual subscription (including postage and packaging): £8·00 (UK); £10·00 (overseas). Overseas customers can pay by sterling drafts drawn on London for £10.00. Payment by cheque drawn in US dollars will be accepted at the price of $22·00 to cover bank charges.

Price to British Telecom and British Post Office staff: 75p per copy.

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ISSN 0262-401X

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FOREWORD

The four corner-stones of modern telecommunications networks are digital transmission, digital switching, processor control and common-channel signalling. The importance of signalling has always been recognised within the telecommunications engineering profession and the introduction of the common-channel technique has increased this importance considerably, bringing signalling from the realms of point-to-point and circuit-by-circuit considerations to an all-pervasive influence throughout the network and the controlling software. Without common-channel signalling, we would be hard-pressed to provide many of the new and enhanced services our customers now expect, and network management would become increasingly difficult with the growing complexity of our operations. This issue of the *Journal* is devoted to the subject of the CCITT Signalling System No. 7, the internationally agreed approach to common-channel signalling which British Telecom has adopted extensively.

The concept of common-channel signalling for telecommunications first took shape during the 1964–68 CCITT study period and led to the CCITT Signalling System No. 6, devised primarily for use at 2·4 kbit/s over analogue bearers on international links. This system offered increased signalling speed and capacity and was an ideal means for exploiting the benefits of the new processor-controlled international switching centres.

The introduction of digital transmission and switching into new system developments such as System X necessitated some rethink of the type of common-channel signalling system required in digital networks. Fortunately, this was recognised as an international issue and during 1972–1976, CCITT Study Group XI addressed a question on 'Signalling arrangements for integrated digital telephone networks', and Signalling System No. 7 was conceived. In 1980, the major Recommendations were presented to the CCITT Plenary Assembly and Signalling System No. 7 was born, at least on paper. In parallel with the further development of these Recommendations, a number of organisations embarked on trial implementations, and one of the first working systems was introduced in September 1983 between the UK and Belgium. Also in 1983, British Telecom completed the necessary specification work for CCITT Signalling System No. 7 to become the mainstay of its extensive digitalisation programme, based initially on System X, but now including other systems.

This long period from initial concept to network realisation is one of the major challenges now facing the international standards-making process and, although the development of the Signalling System No. 7 Recommendations in the CCITT has involved considerable effort and dedication by the experts participating in the study groups, it has to be said that the complete output is still not available in time for the implementors. The result is the inevitable creation of national or interim standards based on the CCITT Recommendations, but extending and enhancing them in ways needed for system and network realisation. The consequence is that it then becomes more difficult to achieve international agreement on single solutions for which proprietary or regional specifications have already been produced or implemented. It must be recognised that implementation of such a complex and advanced system and its introduction into a network involves considerable investment of skilled resources and finance, and cannot easily be overturned by new agreements if these necessitate retrospective change. Thus, the challenge to the technical experts is to find ways of producing results more quickly, but at the same time to ensure that they will stand the test of time and provide the basis for yet further advance.

The basic concepts of Signalling System No. 7 are certainly standing the test of time as major new applications are being added. One of the key features enabling this to happen has been the adoption of a layered structure for the specifications. This predates the now famous OSI 7-layer model and in some respects differs from it but, nevertheless, is a practical and convincing demonstration of the value of such an approach. The articles in this *Journal* reveal the flexibility available at the Application Level (User Part), but also show the emergence of further sub-levels as a means of coping with the complexity of the new capabilities.

One of the current challenges facing network operators is the concept of the integrated services digital network (ISDN). The digital transmission and switching facilities now deployed in many telephone networks offer an important opportunity to carry non-voice services in a more efficient way than an audio signal. However, such use requires extensions to the network control and signalling capabilities. Signalling System No. 7 provides an ideal basis for this, but needs an enhanced or new user part to provide the required features. British Telecom's approach has been to include necessary features for ISDN in its national user part, and this enables the current digital network to operate as an ISDN. Internationally, work on an ISDN user part is progressing although considerable further work will be necessary during the 1988–1992 CCITT study period. In the meantime, the European administrations and network operators have agreed, in CEPT, an enhanced version of the telephony user part (known as *TUP+*) as a means of interconnecting their networks for provision of international ISDN within Europe at an early date, and then to evolve to the ISDN user part.

One of the key features of ISDN is the extension of common-channel signalling from network to terminal equipment. This makes considerable sense when one considers that the same digital revolution has taken place on both sides of the terminal–network boundary. However, the major challenge is to ensure that the signalling system and protocols used here complement the use of Signalling System No. 7 within the network. An additional challenge is that increasingly complex network configurations and applications are emerging, and the ISDN may only be one link in a chain involving local area networks, private networks and other forms of public network. The conceptual boundaries between public and private telecommunications and between information processing and telecommunications are fast disappearing even if the structural boundaries within and between organisations may last a while longer.

In the excitement of new concepts and the whirl of international discussion, it is all too easy to overlook the support activities that are essential for the successful introduction and operation of networks. In particular, a comprehensive testing capability is required both to assist with system development and proving, and also to help deal with the inevitable problems that emerge during service. As described in this *Journal*, British Telecom has built up extensive facilities and experience in this area in order to handle a situation involving several separate organisations and a number of major systems.

For British Telecom, CCITT Signalling System No. 7 is a considerable success and is now an established workhorse within our extensive digital network. We look forward to extending its field of application both for interconnection with other operators and for evolution of services. We are particularly interested in the development of standards in several areas including ISDN, mobile telecommunications and operations and maintenance. There is a need for these standards to be both timely and complete and British Telecom will continue to play a full part in the process of international standardisation based on our practical experience of network realisation and our commercial needs in an increasingly competitive market-place.

G. P. OLIVER
General Manager Standards, British Telecom Research and Technology

CCITT Signalling System No. 7: Overview

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UDC 621.395.34

This article is an overview of CCITT Signalling System No. 7 and its application to BT's evolving network. The structure of BT's current version of CCITT No. 7 signalling is described together with indications of proposed enhancements expected to take place in the late-1980s and early-1990s. Later articles describe in detail the various component parts which make up BT's CCITT No. 7 signalling and how it is tested within BT's network.

This article was originally published in the October 1987 issue of the Journal and is reprinted here as an introduction to this series of articles on CCITT No. 7 signalling.

INTRODUCTION

The CCITT Signalling System No. 7 (CCITT No. 7) is a common-channel signalling system in which information can be transported between two stored-program controlled (SPC) exchanges over a single high-speed communications channel (64 kbit/s) by means of labelled messages. The signalling information relates to a large number of circuits and provides the capability to implement a variety of new services, including many that are based on the integrated services digital network (ISDN). BT regards CCITT No. 7 signalling as one of the key elements in the development of its telecommunications network and as a result has been implementing this standard over the last three years on all its digital exchanges (System X *et al*).

This article gives an overview of the structure of CCITT No. 7 signalling, the national specifications currently being adopted in BT's network and gives an insight into likely future evolution in relation to ongoing CCITT studies during the 1984-88 period.

STRUCTURE OF THE SIGNALLING SYSTEM

When CCITT No. 7 signalling was first specified, its main purpose was to set up and release physical circuits between digital exchanges for telephony-type services.

To take account of the wide range of applications that were foreseen for the signalling system, it was designed on a very modular functional basis. The transport mechanism is application independent, and it is this feature that is one of the principal strengths of CCITT No. 7 signalling.

Figure 1 shows schematically the structure of CCITT No. 7 signalling.

BT's version currently comprises two main parts:

- *Message transfer part* (MTP) this is common for all applications. It transfers signalling messages over the network and performs subsidiary functions such as error control.

The MTP has a three-level hierarchical structure:

(*a*) Level 1—encompasses the physical signalling data link, which in a digital network consists of a 64 kbit/s time-slot in a PCM system. In most cases, time-slot 16 is used; however, there is nothing that prevents any time-slot except time-slot 0 from being used.

(*b*) Level 2—encompasses the signalling terminal together with functions for adaption between the processor software signals and the bit stream of the signalling data link. Fields for error detection and correction are added by the signalling terminal to ensure error-free transmission. These fields are analysed in the receiving signalling terminal, and repetition is requested if an error is detected.

(*c*) Level 3—comprises the signalling network functions, including transfer of messages, reconfiguration of routes after failure, or sending information about abnormal situations in the signalling network.

- *User part* this is application dependent. Within BT, this is termed the *national user part* (NUP) and is known as *Level 4*. The NUP defines the functions and procedures that control both telephone and ISDN-type calls and circuits; for example, the signalling information to be exchanged between the switching centres, and the various signals that should be used.

NATIONAL SPECIFICATIONS FOR CCITT SIGNALLING SYSTEM No. 7

Because of its intended versatility and reliability, the specification for CCITT No. 7 signalling is very complex, and occupies approximately 450 pages of text simply to cover the MTP and user part areas in CCITT

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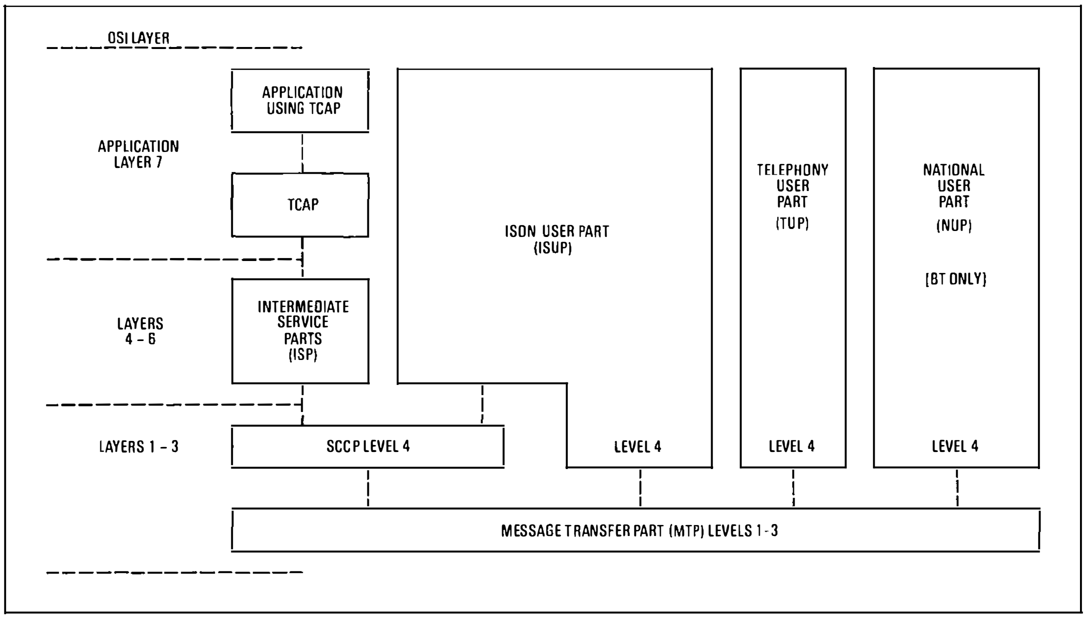
Figure 1
Relationship between CCITT No. 7 Functional Levels and OSI layering



OSI: open systems interconnection
SCCP: signalling connection control part
TCAP: transaction capabilities application part

Recommendations Q.701–Q.707 and Q.721–Q.725.

When BT decided to specify its network requirements for CCITT No. 7 signalling some four to five years ago, the CCITT Recommendations were used as base documents; however, the level of detail and the scope of the information was found to be inadequate for implementation purposes, hence BT produced its own series of specifications.

Message Transfer Part

The BT implementation of the MTP is specified in BTNR 146 (British Telecom Network Requirement) and BTNR 167 Issue 2 and is based very closely on the CCITT Recommendations. Even so, the MTP(BT) differs from that adopted in many other countries for two reasons:

(*a*) The CCITT Recommendations allow for a number of national options. An example of this is that the CCITT Recommendation allows load sharing either within a linkset or between linksets; BT has implemented load sharing with a linkset and requires an even distribution of traffic to available links.

(*b*) In some cases, the CCITT Recommendation is not sufficiently complete to allow implementation in practical networks. An example of this is that a load-sharing algorithm is necessary before implementation can take place; however, this is not specified in the CCITT Recommendations.

National User Part

The BT NUP specification (BTNR 167) differs from that of CCITT in a number of areas. The main reason for these differences is that when BT was specifying the requirements for its digital network in the late-1970s and early-80s, the CCITT was concentrating on the telephony user part (TUP). Hence, whilst using the studies as a basis for the NUP, additional features were added to incorporate ISDN capabilities. Examples of these are:

(*a*) The TUP procedures allowed information to be passed only on a link-by-link basis. In an ISDN environment, it is necessary to provide end-to-end procedures to allow services to be provided on the periphery of the network without changing all nodes in the network. These concepts are now being introduced in the CCITT.

(*b*) CCITT Recommendations do not take account adequately of the existence of more than one version of CCITT No. 7 signalling. BT adopted a 'confusion' message to determine the level of implementation in other nodes of a network. This concept has only recently been addressed in CCITT.

The adventurous decision to aim for an early implementation of the ISDN within BT's network has resulted in BT's MTP and NUP specifications of CCITT No. 7 signalling having to predict the direction CCITT would go in areas that had not been adequately specified.

The BT specifications for CCITT No. 7 signalling have recently been completed for the ISDN Phase 3 development programme of the network, and many sophisticated services have been incorporated. The process of deriving a specification which allows different exchange manufacturers to develop the signalling system independently of each other, whilst ensuring interworking occurs, is enormous. Currently the specification is in excess of 1000 pages of text and drawings.

EVOLUTION OF NO. 7 SIGNALLING AND ASSOCIATED SPECIFICATIONS

During the 1980–1984 study period, the CCITT extended No. 7 signalling by the introduction of three additional parts which were published in the 1984 Red Book:

- the signalling connection control part (SCCP),
- the operations and maintenance application part (OMAP),
- the ISDN user part (ISUP).

During the current CCITT study period 1984–1988, work is continuing on the above topics with the addition of another part called *transaction capabilities applications part* (TCAP).

A brief review of each of the newly specified parts is given below:

Signalling connection control part The SCCP has two basic purposes: it allows information to be exchanged between network nodes that are not connected by telephony circuits, and it provides addressing capabilities between nodes connected to the same or different signalling networks.

Operations and maintenance application part The OMAP defines procedures for supervising, controlling and testing a signalling network. In addition, it may also enable the transfer of bulk data to be undertaken by the signalling network and carry management commands relating to the operation of the main network.

ISDN user part The ISUP is designed basically for the provision of ISDN services within the switched network. It also defines new principles in network signalling, such as symmetrical release of circuits under calling- or called-party control etc. The ISUP is undergoing considerable revision in the current study period ready for publication in the 1988 Blue Book Recommendations.

Transaction capabilities application part The TCAP is somewhat unusual in that, although it is part of the application layer (the layer that provides real applications or services), it does not offer any real services. What it does offer is a standard structuring technique for non circuit-related applications which should simplify the task of defining application protocols.

Evolution of BT's CCITT No. 7 Signalling System

As mentioned earlier, one of the reasons why CCITT No. 7 signalling is such a powerful tool is that it was designed with evolutionary potential as a key objective. From an overall point of view, the circuit-related mode of BT's version of CCITT No. 7 signalling has become stabilised (MTP and NUP). One possible enhancement in the future would be the adoption of the ISUP. This is not foreseen for some time in BT's network since the NUP has greater capabilities than the present proposals for the CCITT Recommendation. The use of the ISDN user part at international gateways will rely on bilateral agreements with other countries and consequential commercial criteria.

The most likely enhancements will be for non-circuit-related transactions to support services expected to be introduced in the early 1990s, for example, access to databases etc. This implies the introduction of SCCP and TCAP protocols in the network.

SUMMARY

With the introduction of its digital exchanges, BT has been implementing CCITT No. 7 signalling as one of the key elements in the development of its telecommunications network. By virtue of this early implementation of the signalling sytem before the appropriate CCITT Recommendations had stabilised, an element of prediction was necessary for those areas that had not been completely specified. Other articles in this series describe how the various parts of the CCITT No. 7 signalling system have been implemented in BT's network.

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Biographies

Ken Fretten joined the Post Office Research Station at Dollis Hill in 1944 where he was variously employed on acoustics, transmission and magnetic circuit design until 1965. After four years on switching facilities, he headed a group concerned with all national signalling facilities. Since then he has been promoted within this discipline and was Head of Division covering all network-related standards until his recent retirement.

Colin Davies joined BT as an apprentice in 1964 in Gloucester Telephone Area. After a period on transmission, he joined Network Planning dealing with the provision of private wideband systems. In 1976, he was promoted to Level 2 on Special Defence Projects, and since 1980 he has been involved in the specification of both public and private network signalling systems. He is currently the Head of BT's CCITT No. 7 Standards Group and is responsible for all specifications (BTNRs) of CCITT No. 7 signalling system in BT's inland network.

CCITT Signalling System No. 7: Message Transfer Part

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UDC 621.395.34

This article is one of a series of articles on CCITT Signalling System No. 7 and its application to the British Telecom network. It considers the message transfer part (MTP). A description of the functions of the constituent levels of the MTP is given to provide an understanding of its purpose in CCITT No. 7 signalling. Differences between the signalling system as specified by the CCITT and the requirement for the British Telecom network are identified, together with the activity within the CCITT to achieve as close alignment as possible. The evolution of the MTP in the light of developments in other parts of CCITT No. 7 signalling is also examined.

INTRODUCTION

Communication between stored-program-controlled (SPC) exchanges in the British Telecom network requires a fast reliable high-capacity signalling system, capable of operating in a digital transmission environment. An article[1] in a previous issue of this *Journal* has described how this is realised in the BT network with a common-channel signalling system based on CCITT No. 7 signalling[2]. The modular nature of this signalling system makes it flexible and adaptable for a number of uses, but no matter what use is made of the signalling information carried, or what user part[3, 4] is implemented at an exchange, the message transfer part (MTP) is always required.

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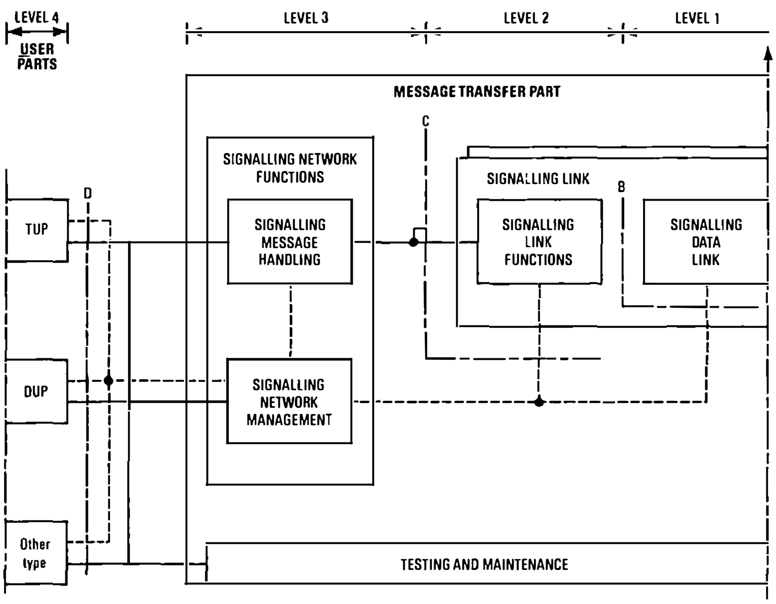
Figure 1
General structure of signalling system functions



—— Signalling message flow ---- Controls and indications
TUP Telephone user part DUP Data user part

The MTP provides the functions that enable user part significant information passed to the MTP to be transferred across the CCITT No. 7 signalling network in message signal units (MSUs) to the required destination. Mechanisms are provided in the MTP that ensure MSUs are received in the correct sequence, any errors detected, and, if required, messages retransmitted. In addition, further procedures ensure that the impact of network or system failures have minimal effect on the ability of the MTP to transfer MSUs.

The functions performed by the MTP are specified in terms of the level in which they are located; therefore the modular concept is as true of the MTP as the rest of CCITT No. 7 signalling. This 'level' approach is the basis of all the work in the MTP, and is used in this article to explain how the MTP functions and performs its data transfer and management tasks. There should be a clear understanding that levels in CCITT No. 7 signalling do not always relate directly to the equivalent OSI layer[5].

LEVELS IN THE MTP AND POSITION IN THE CCITT No. 7 ARCHITECTURE

The MTP consists of three levels (Levels 1–3 of CCITT No. 7), and this structure is depicted in Figure 1.

The Level 1 functions provide the data link, which is a bi-directional transmission path for signalling comprising two data channels operating together in opposite directions at the same data rate. The data rate normally chosen for CCITT No. 7 signalling is 64 kbit/s[6], but lower rates down to 4·8 kbit/s can be used.

The transmission path is normally provided over digital plant extracting a spare time-slot from a 32 time-slot 2048 kbit/s system. It is possible, however, to use analogue line plant with a suitable modem providing the appropriate interface to the signalling terminal (CCITT No. 7 Level 2 functions). The

Level 1 functions of the MTP, although included in the CCITT Recommendations, are not specific to the signalling system, and are more fully documented in the appropriate transmission Recommendations.

In the BT network, the signalling data links are normally provided by using time-slot 16 (TS16) from a 32 time-slot 2048 kbit/s system. This will normally be connected to the appropriate Level 2 realisation at an exchange by means of a semi-permanent path across the switch-block[7].

Level 2 of the MTP, the signalling link, provides the functions and procedures for the transfer of signalling messages over one signalling data link. The signalling link functions, together with the signalling data link as bearer, provide a signalling link for reliable transfer of signalling messages between two directly connected signalling points.

Level 3 of the MTP provides functions and procedures to allow for the transfer of signalling messages between signalling points which are part of the CCITT No. 7 signalling network. Specification of the Level 3 functional block assumes that signalling links and signalling data links are provided between the signalling points in the network.

SIGNALLING NETWORK

Basic Concepts

The telecommunications network served by common-channel signalling is composed of a number of switching and processing nodes interconnected by transmission links. To communicate using CCITT No. 7 signalling, each of these nodes requires to implement the necessary 'within node' features, making that node a signalling point within the CCITT No. 7 signalling network. In addition, there is a need to interconnect these signalling points so that signalling information (data) can be conveyed between them. These data links are the signalling links of the CCITT No. 7 signalling network.

The combination of signalling points and their interconnecting signalling links form the CCITT No. 7 signalling network.

Signalling Points

In specific cases, there may be a need to partition the common-channel signalling functions at such a (physical) node into logically separate entities from a signalling network point of view; that is, a given (physical) node may be defined as more than one signalling point. One example is an exchange at the boundary between the international and national signalling networks.

Any two signalling points, for which the possibility of communication between their corresponding user part function exists, are said to have a *signalling relation.*

Examples of nodes in a signalling network that constitute signalling points are:

(*a*) exchanges (switching centres),
(*b*) operation, administration and maintenance centres,
(*c*) intelligent network databases, and
(*d*) signalling transfer points.

All signalling points in a CCITT No. 7 signalling network are identified by a unique code known as a *point code.*

Signalling Links

The common-channel signalling system uses signalling links to convey the signalling messages between two signalling points. A number of signalling links that directly interconnect two signalling points which are used as a module constitute a *signalling link-set.*

Signalling Modes

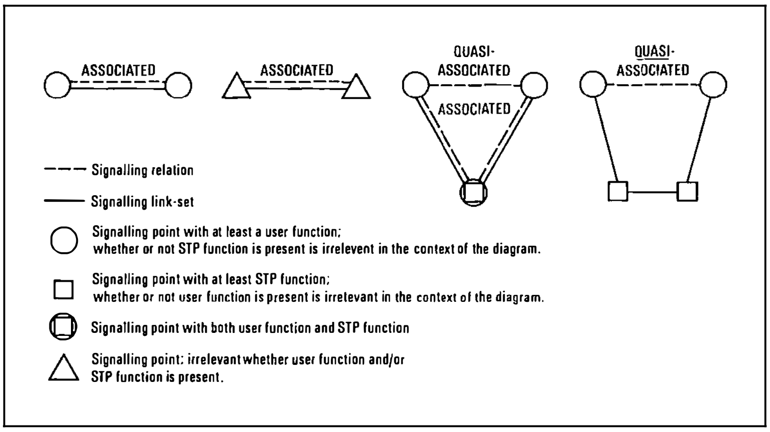
The term *signalling mode* refers to the association between the path taken by a signalling message and the signalling relation to which the message refers. In the ASSOCIATED mode of signalling, the messages relating to a particular signalling relation between two adjacent points are conveyed over a link-set, directly interconnecting those signalling points.

In the NON-ASSOCIATED mode of signalling, the messages relating to a particular signalling relation are conveyed over two or more link-sets in tandem, passing through one or more signalling points other than those which are the origin and the destination of the messages. This mode is not specified for CCITT No. 7 signalling.

The QUASI-ASSOCIATED mode of signalling is a limited case of the NON-ASSOCIATED mode where the path taken by the message through the signalling network is predetermined and, at a given point in time, fixed.

Examples of signalling modes are illustrated in Figure 2.

Figure 2
Example of associated and quasi-associated signalling modes and definition of signalling network symbols



Signalling Point Modes

A signalling point at which a message is generated (that is, the location of the source user part function) is known as the *originating point* of that message.

A signalling point to which a message is destined (that is, the location of the receiving user part function) is known as the *destination point* of that message.

A signalling point at which a message is received on a signalling link and then transferred to another link (that is, neither the location of the source nor the receiving user part function) is known as a *signal transfer point* (STP).

Signalling Routes

The predetermined path, consisting of a succession of signalling points and the interconnecting signalling links, that a message takes through the signalling network between the origination point and the destination point is the *signalling route* for that signalling relation.

All the signalling routes that may be used between an originating point and a destination point by a message traversing the signalling network is known as the *signalling route set* for that signalling relation.

Signalling Network Structure

The structure of the signalling network depends greatly on the type of network that has to be supported. For example, with a public switched network, the signalling network carries mainly call-control signalling traffic, and its structure closely follows that of the switching network; that is, predominantly associated signalling with some quasi-associated stand-by. For a network regarded as a common data transfer resource, the structure is likely to be quasi-associated with associated signalling on high-density routes. The world-wide signalling network structure comprises the individual national networks connected via the international network.

LEVEL 2

The MTP Level 2 comprises functions which facilitate the reliable transfer of messages over a single signalling link. These functions ensure that messages are delivered in the correct order, and without loss or duplication, on a link having line error rates up to a specified limit. Error rates higher than this specified limit cause the link to be failed.

Signal Units

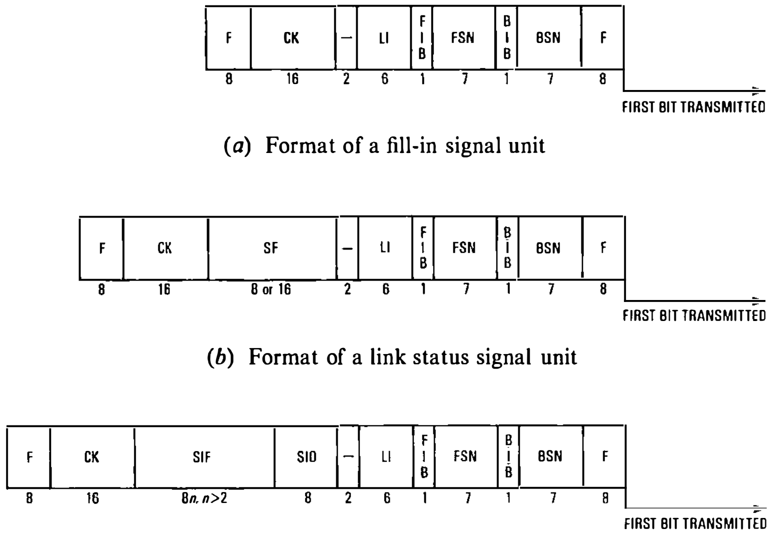
Signalling information is transferred between the nodes at each end of a signalling link in signal units. Each signal unit is delimited (the beginning and end marked) by a unique 8 bit pattern called a *flag*.

Three types of signal unit exist:

- *fill in signal units* (FISUs) which are normally sent when no messages are available for transmission,
- *link status signal units* (LSSUs) which are used in the control of the link, and
- *message signal units* (MSUs) which carry the user part information.

Signal formats are shown in Figure 3. Note that the coding of the length indicator, which is common to all types, is the means of identifying to which of the three types a signal unit belongs.

Figure 3
Signal unit formats



(*a*) Format of a fill-in signal unit

(*b*) Format of a link status signal unit

(*c*) Basic format of a message signal unit

BIB: Backward indicator bit
BSN: Backward sequence number
CK: Check bits
F: Flag
FIB: Forward indicator bit
FSN: Forward sequence number
LI: Length indicator
SF: Status field
SIF: Signalling information field
SIO: Service information octet

Fill In Signal Units

The forward and backward indicator bits, and forward and backward sequence numbers are used in the basic error control procedure to perform the signal unit sequence control and acknowledgement functions.

The check bits are used for error detection.

Link Status Signal Units

LSSUs have the same format as FISUs except for the addition of the status field which indicates the link status as follows:

Status indication 'out of alignment' (SIO) is transmitted when an initial alignment procedure has been started and none of the status indications SIO, SIN, or SIE is received from the signalling point at the far end of the link.

Status indication 'normal' (SIN) is transmitted when, after initial alignment has been started, status indication SIO, SIN, or SIE is received, and the terminal is in the NORMAL alignment state.

Status indication 'emergency' (SIE) is transmitted when, after initial alignment has been started, status indication SIO, SIN, or SIE is received, and the terminal is in the EMERGENCY alignment state.

Status indication 'out of service' (SIOS) is transmitted to inform the remote end of the link that the transmitting signalling link terminal cannot, for reasons other than processor outage, receive or transmit MSUs.

Status indication 'processor outage' (SIPO) is transmitted to inform the remote end of the link that the transmitting signalling link terminal cannot receive or transmit MSUs, owing to processor outage; that is, caused by failure conditions at a functional level above Level 2.

Status indication 'busy' (SIB) is transmitted to inform the remote end of the link that the transmitting signalling link terminal is operating under Level 2 congestion conditions.

Message Signal Units

MSUs have exactly the same format as a FISU except for the addition of a service information octet and the signalling information field which are used at levels above Level 2 as described in the section on Level 3 below.

Error Detection and Correction

Sixteen check bits are included at the end of each signal unit to enable errors to be detected. The transmitting signalling link terminal generates these check bits by operating on the preceding bits in the signal unit in accordance with a specified algorithm. The signalling unit and check bits are checked at the receiving signalling link terminal. Signal units found to be in error are discarded.

Two forms of error correction are recommended by the CCITT: the basic method which is suitable for signalling links where the one-way propagation delay is less than 15 ms; and the preventative cyclic retransmission method which is suitable for propagation delays in excess of 15 ms. BT uses the former type, which employs positive and negative acknowledgements indicated by the forward and backward sequence numbers and the forward and backward indicator bits.

When a signal unit is transmitted, a copy is retained at the transmitting signalling link terminal until a positive acknowledgement for that signal unit is received. If a negative acknowledgement is received, then the transmission of new signal units is interrupted until those signal units which have been transmitted but not positively acknowledged have been retransmitted. This retransmission commences with the signal unit indicated by the negative acknowledgement, and continues in the order they were first transmitted.

Alignment

Before a link can enter service, an alignment procedure is used to ensure that it is capable of operating above a certain performance. This procedure is used when a link is brought into service and when service is being restored after a break. It includes a proving period which, by instruction from Level 3, can be either a 'normal' period of the transmission time of 2^{16} octets, or an emergency proving period of the transmission time of 2^{12} octets. During the proving period, the error rate of the link is monitored.

Processor Outage

Processor outage procedure operates when use of a link is precluded owing to problems at a functional level higher than Level 2; for example, a centralised processor failure. When Level 2 recognises, or is informed of this state, it transmits SIPO on the link and discards received message signal units. The receiving Level 2 at the distant end, if it is in its NORMAL mode sending MSUs or FISUs, notifies its Level 3 and sends FISUs continuously. When the processor outage condition reverts to normal, SIPO is withdrawn and the transmitting end transmits MSUs or FISUs. The receiving end also returns to normal operation after informing Level 3.

Signalling Link Error Monitoring

Level 2 contains two link error rate monitor functions: one, the signal unit error rate monitor, which is used whilst a signalling link is in service to determine whether or not the link is fit for service; and the other, the alignment error rate monitor, which is used during the proving period of the initial alignment procedure.

Flow Control

When congestion at Level 2 is detected at the receiving end of the link (by an implementation-dependent means), both positive and negative acknowledgements are withheld and *status indication 'busy'* (SIB) is returned to the transmitting end, so that the latter can distinguish between failure and congestion conditions. A supervision timer is started on receipt of SIB and, should it mature before normal operation of the link is restored, link failure indication is generated.

LEVEL 3

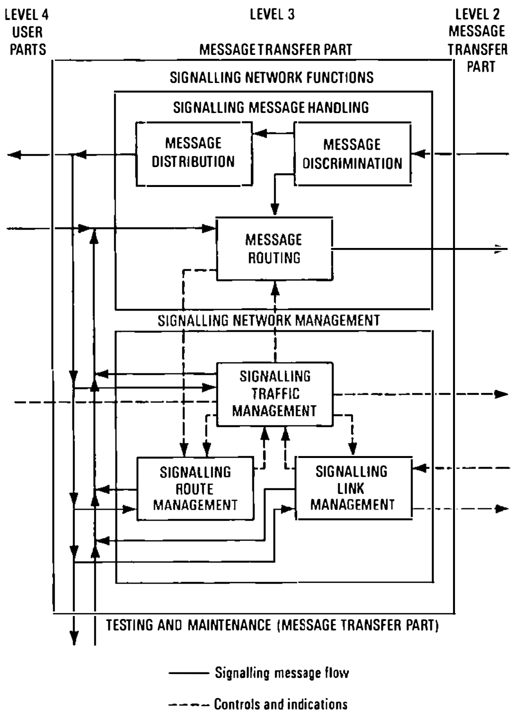
In addition to the ability to transfer messages under normal fault-free conditions, the signalling network functions (Level 3) of the MTP must ensure the reliable transfer of signalling messages to a specified standard even in the case of network failures; that is, failure of signalling links or signalling transfer points (STPs). Therefore, appropriate functions and procedures must be included at Level 3 which both inform the remote parts of the signalling network of the consequences of failures, and reconfigure the routing of messages through the signalling network to overcome them.

The signalling network functions can be divided into two basic categories:

- signalling message handling (SMH), and
- signalling network management (SNM).

The distribution of these functional blocks within Level 3 is shown in Figure 4.

Figure 4
Signalling network functions



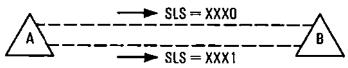
Signalling Message Handling

The SMH function enables signalling messages originated by a user part at a signalling point to be delivered to the corresponding user part at the required destination signalling point. Address information is contained in the routing label that is present in every message. The routing process is situated in the outgoing signalling point and, in accordance with the information contained in the message routing label, directs the message onto the correct route to reach the required destination.

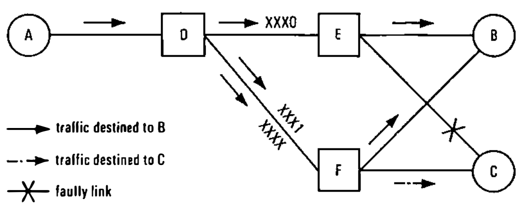
The other functional blocks situated in SMH on the incoming side at a signalling point are the message discrimination and message distribution processes. The message discrimination process examines the message routing label and, from the information contained in the destination address portion, determines whether the message should be onward routed (that is, the STP function invoked) or delivered to a user part at that signalling point.

Messages to be onward routed are delivered to the routing process, while those to be directed to a local user part are passed to the message distribution process. This latter process examines the part of the message that identifies the user part to which the message information refers and delivers the signalling information in the message to that user part.

Within the routing process there is a further mechanism which enables messages to be directed over a particular signalling link in a multi-link route. This is known as *load sharing* and determines the link to be used based on information contained in the message routing label and a locally-produced algorithm. For some network management messages, this load sharing information in the label identifies by its signalling link code (SLC) the actual link over which the message is to be sent (or not sent), and no algorithm is required. Two forms of load sharing are specified by the CCITT: *within link-set*, and *between link-sets*. These two scenarios are depicted in Figure 5. The BT network requirements call for the use of only within link-set load sharing.



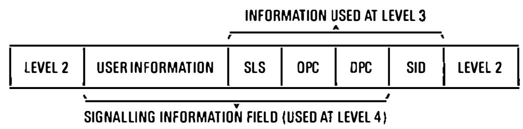
(*a*) Example of load sharing within a link set



(*b*) Example of load sharing between link sets

Figure 5—Load sharing

A message delivered to the MTP and processed by Level 2 (that is, Level 2 headers added) becomes a message signal unit (MSU) for transmission in the CCITT No. 7 signalling network. The components of the MSU used by SMH are shown in Figure 6. The routing label comprises the destination point

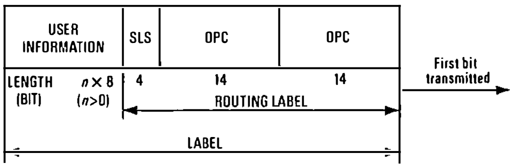


DPC: Destination point code
OPC: Originating point code
SIO: Service information octet
SLS: Signalling link selection

Figure 6—Components of MSU used by SMH

code (DPC), originating point code (OPC), and signalling link selection (SLS) and is shown in Figure 7.

The DPC is the information used by the routing process to determine the destination and, therefore, the signalling route over which the MSU should be directed. The SLS, which



DPC: Destination point code
OPC: Originating point code
SLS: Signalling link selection

Figure 7—Routing label structure

is the four least significant bits of the circuit identification code (CIC) when the messages are generated by the national user part (NUP), is used by the load-sharing mechanism to determine the actual link to be used. The OPC identifies the signalling point at which the MSU originated.

The DPC is also used by the message discrimination process to determine whether the MSU is for a local user part or is to be onward routed, using the node's STP function.

The service information octet (SIO), Figure 8, contains the service indicator, which determines the user part that the signalling information should be delivered to by the distribution function. In addition to the service indicator, the SIO also contains a 4 bit sub-service field, bits C and D of which form the network indicator (NI).

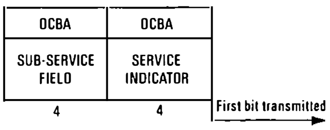


Figure 8—Service information octet

The NI can be used to distinguish between two signalling networks when an exchange is common to more than one; for example, an international switching centre, which is part of both the BT inland network and the international network, would use this feature. Messages can thus be delivered to the national or international user part as appropriate and, when required, the routing procedure modified by examining the NI.

Signalling Network Management (SNM)

The main purpose of the MTP Level 3 is contained in the SMH functions; that is, the delivery of MTP-user signalling messages to the correct destination in the CCITT No. 7 signalling network. To enable this objective to be achieved, however, it is essential to have mechanisms within the MTP to prevent any failures or dislocations within the signalling network from having any great impact. Signalling network management contains the functions that provide security against network conditions and enables the MTP to achieve the required level of reliable information transfer.

Signalling network management comprises three main functions:

- signalling traffic management,
- signalling link management, and
- signalling route management.

Signalling Traffic Management (STM)

STM enables the MTP to divert signalling traffic from a signalling link or route to one or more alternative links or routes as the current status of the signalling network demands for reliable message transfer to be maintained. In addition, signalling traffic flow towards an affected destination may be regulated should congestion occur at that point in the network. To achieve this function, STM incorporates the following procedures:

link changeover,
link changeback,
forced re-routing,
controlled re-routing (equates to changeback), and
signalling traffic flow control.

In most instances, these procedures take place without message loss, but where emergency procedures are required, some loss may be incurred.

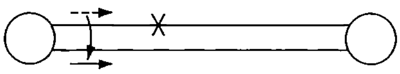
Link changeover is involved when the MTP detects that the concerned link is not providing the required level of reliable message transfer; for example, when the threshold for the signal unit error-rate monitor is breached. Messages destined for the link are stopped and placed in a buffer and the receiving end of the link is contacted. The handshake exchange of messages between the transmit and receive end of the link enables the alternative link to be determined and those messages that have been sent but not yet acknowledged (and held in the re-transmission buffer), to be identified. These identified messages are then retrieved from the re-transmission buffer and, together with the already buffered 'stopped' messages, sent over the alternative signalling link such that the message sequence is maintained. Where it is not possible for the transmit and receive ends of the link to communicate, an emergency procedure takes place (that is, without the handshake), and in this case some messages may be lost.

Link changeback is the reverse procedure to changeover and is invoked when the MTP detects or is informed that a previously unavailable signalling link can now carry the signalling traffic that was previously diverted from it.

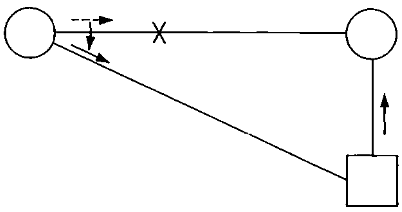
Transmission of the signalling traffic on the alternative link is stopped and the messages placed in the buffer. A handshake procedure then takes place between the transmit and receive ends of the newly available link and, when this has been successfully completed, the buffered traffic is started on the link. Should it not be possible for the two ends of the link to communicate, a time-controlled diversion ensures that messages sent on the alternative link are acknowledged before signalling traffic is sent on the re-started link. This procedure therefore avoids any mis-sequencing. During both changeover and changeback procedures, the current status of the affected links is always updated at the transmit and receive terminals; that is, AVAILABLE/UNAVAILABLE.

Network scenarios depicting the various changeover/changeback situations are shown in Figure 9.

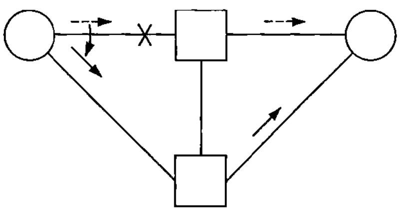
Figure 9
Examples of link changeover situations



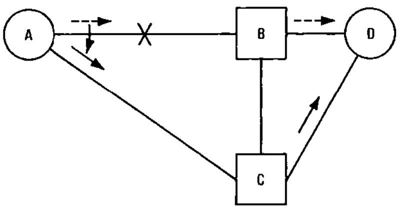
(*a*) Example of changeover to a parallel link



(*b*) Example of changeover to a signalling route passing through the remote signalling point



(*c*) Example of changeover to a signalling route not passing through the remote signalling point



(*d*) Example of time-controlled diversion procedure

Forced re-routing enables the signalling capability to be restored as quickly as possible between two points in the signalling network should the previous route have failed. The procedure ensures that communication is restored with the minimum of message loss. This is achieved by immediately stopping signalling traffic from being sent on the failed route as soon as this failure is detected. Detection is either by the receipt of a *transfer prohibited* message (TFP) or the failure of the last link in a link-set. When the alternative route has been determined, the buffered traffic is started on the appropriate link-set and the routing tables in the routing function updated. Should the signalling point re-routing also be an STP, it sends a TFP regarding the affected destination over the new route.

Controlled re-routing enables signalling traffic between two signalling points to be re-started on the original route when this becomes available. Availability is indicated either by the receipt of a *transfer allowed* message (TFA) or a previously unavailable link-set becoming available. The affected traffic on the alternative route is stopped, buffered, and a time-out started. When the time-out expires, a TFP is sent, if appropriate, on the original route relating to the affected destination and, starting with the buffered messages, signalling traffic re-started on the original route and the route marked as AVAILABLE. The purpose of the time-out is to prevent any mis-sequencing from occurring.

Signalling traffic flow control enables signalling traffic towards a particular destination to be reduced should that part of the network become congested. Congestion is detected at Level 2 in the MTP and indicated to Level 3 where the message routing process marks the affected destination as congested.

When message routing receives a message for a congested destination, as well as the message being passed to Level 2, the signalling traffic flow control is informed. This process causes the message originator (user part) to be informed by means of an MTP primitive that the destination is congested, or, if the originator is at a remote signalling point, by means of a signalling network management message.

When congestion at the destination abates, this change is detected by Level 2, which informs Level 3, and the congestion marking is then removed from the message routing table.

Similar procedures apply when congestion is detected within the signalling point.

Signalling Link Management (SLM)

SLM is used to restore failed signalling links, activate idle signalling links and de-activate aligned links. The following procedures are contained in SLM:

signalling link activation,
restoration,
deactivation,
link-set activation, and
automatic allocation of signalling terminals and data links.

Signalling link activation enables an inactive link to be brought into service. After the initiation of the activation procedure, Level 2 alignment takes place and when this has successfully been completed a signalling link test is started. On the successful completion of this test, the link is marked as AVAILABLE and signalling traffic started on it.

Should Level 2 alignment not be successful, a time-out is started and activation re-attempted. The value of the time-out is set so that the level alignment procedures are not compromised.

Signalling link restoration is used to bring a failed signalling link back into service. Failure may be as a result of an error rate monitor threshold being exceeded or an unsuccessful signalling link test. When restoration is initiated, the link is aligned at Level 2 and a signalling test carried out. The successful completion of the signalling link test causes the link to be marked as AVAILABLE and restoration is complete.

Signalling link deactivation enables a link to be taken out of service provided no signalling traffic is carried on that link.

Link-set activation incorporates two procedures for normal and emergency re-start. Normal activation applies when a link-set is brought into service for the first time, and re-start applies when a previously faulty link-set becomes available or nodal functions (such as processor re-start) makes it necessary to establish a non-emergency link-set. Link activation takes place on each link in parallel until all links are available. However, traffic can be started on each link in turn as it becomes available.

Emergency activation is required when signalling traffic is being blocked or it is not possible to communicate with a remote signalling point. In these instances, activation starts on as many links in the link-set as possible. Activation of the links, however, uses the emergency alignment and proving periods.

Automatic allocation of data links and terminals employs procedures based on normal activation, restoration etc., but since there is no fixed relation between signalling data links and terminals, greater flexibility in providing signalling links is achieved. The procedures are, therefore, more complex than with basic link management and, for automatic signalling data link allocation, additional signalling network management messages are required. These automatic procedures are not used in the BT CCITT No. 7 signalling network.

Management inhibiting is a procedure in addition to the normal signalling link management and allows a signalling link to be removed from service for normal signalling traffic while maintaining its availability for test traffic etc. The procedure consists of a handshake procedure between transmit and receive ends of the link to obtain permission to inhibit. When this is granted, normal signalling traffic to that link is diverted to a nominated stand-by and the link marked as INHIBITED. The link becomes uninhibited when the purpose for inhibiting has been satisfied or, should subsequent failures require it, a forced uninhibit procedure automatically restores the link to service.

Signalling Route Management (SRM)

The signalling route management (SRM) functional block contains procedures that are used to exchange signalling management information in the network regarding the network status so that the network may be reconfigured (by blocking/unblocking routes etc.) to provide the most efficient message routing. The following procedures are contained in SRM:

transfer prohibited procedure,
transfer allowed procedure,
signalling route-set test procedure,
transfer controlled procedure,
transfer restricted procedure, and) National options
signalling route-set congestion test.) not adopted by BT

Transfer prohibited procedure enables information to be sent to all concerned points that a signalling route is no longer available for the transport of signalling messages across the CCITT No. 7 network. Use is made of the *transfer prohibited* message (TFP), which is broadcast by an STP when it detects that signalling messages cannot be delivered to a specific destination. The TFP is also sent in the RESPONSE mode when a message is received (including test messages) for the affected destination, and over an alternative route before traffic is started on it to prevent abortive circular routing during multiple link failure. The receipt of a TFP causes the signalling point to update its routing tables and, should TFPs be received for all routes to a specific destination, local user parts are informed that the destination (route set) is unavailable.

Transfer allowed procedure enables the network to be informed that a previously unavailable route can once more be used to transport signalling messages across the CCITT No. 7 network. The *transfer allowed* message (TFA) is broadcast by an STP when it detects that signalling messages can be sent to a particular destination that previously could not be reached. The TFA is also sent in the RESPONSE mode when a test message, indicating that the destination is believed unavailable, is received. When a signalling point receives a TFA, the routing tables are updated accordingly. Should a TFA be received for a destination that was previously marked UNAVAILABLE, local users are informed that the concerned destination (route-set) is now available and signalling traffic can be re-started.

Route-set test procedure enables a signalling point to acquire knowledge of the status of the signalling network. The *route-set test* message (RST) is sent towards STPs for various reasons as follows:

(*a*) in response to a TFP from an adjacent STP,

(*b*) when a previously unavailable STP can once more be reached (this proves all routes via the STP before traffic is restarted), and

(*c*) as a periodic signalling network management message, enabling the status of the network to be continuously audited.

On receipt of an RST at the STP, should the status of the destination have changed (that is, now AVAILABLE), then an appropriate response (TFA) is made. If the destination status is unchanged, no response is made when an RST is received. The signalling point sending the RST, on receipt of a response, updates the status of the route concerned in the routing table.

Transfer controlled procedure is used to enable signalling traffic flow control to be exercised in the CCITT No. 7 network. The *transfer controlled* message (TFC) is sent by an STP towards the message origin whenever a message is received for a congested destination. The receipt of the TFC at the originating signalling point causes an indication that the destination is congested to be sent to the user parts.

Transfer restricted procedure makes use of the *transfer restricted* message (TFR) to inform signalling points in the CCITT No. 7 signalling network that an STP is having difficulty in transferring messages towards a particular destination. The originating signalling point then decides if a more advantageous route can be used. This procedure is a national option which is not used in the BT network.

Route-Set Congestion Test Procedure is used to determine the level of congestion in networks which employ a message priority procedure in the signalling traffic flow control mechanism. It is a national option not used in the BT network.

Signalling Network Management Message Formats and Codes

To enable management of the CCITT No. 7 signalling network to be exercised, messages are exchanged between the various SNM functional blocks in the signalling points within the network. The messages are handled by the MTP in a manner similar to user part generated messages with the exception that message routing will ensure that certain messages are sent/not sent over specific signalling links. The format of a signalling network management message is shown in Figure 10, the coding of messages in Table 1, and the list of parameters in Table 2.

Figure 10
Signalling network message format

	PARAMETER (NOT ALWAYS PRESENT)	HEADING CODE H1	HEADING CODE H0	SLC	DPC	DPC
LENGTH (bit)	8/16	4	4	4	14	14

First bit transmitted

DPC: Destination point code
OPC: Originating point code
SLC: Signalling link code

Signalling Link Test

In addition to signalling network management messages, the MTP also contains a procedure for validating signalling links. This procedure makes use of the *signalling link test* (SLT) signal which is applied to aligned and proved signalling links. Only when the test has been successfully completed by the SLT and correctly acknowledged is the link marked available for use and signalling traffic allowed onto the link. The SLT is differentiated from other test and management messages by having a different service indicator code in the SIO.

BT VERSION OF CCITT No. 7 MTP

The version of the MTP specified for CCITT No. 7 (BT) signalling aligns very closely with that of the CCITT Recommendations Q.701–704, Q.706 and Q.707. However, since the implementation of CCITT No. 7 signalling in the BT network is in advance of the majority of other national operators in the world, and is probably the largest in link/route/signalling point terms, operational problems have been encountered which the CCITT Red Book does not yet consider. In addition to departures to take account of those identified operational considerations, the MTP required is also dictated by the structure of the network, the services to be provided for the customers and the multi-operator environment that exists in the UK.

The main areas in which the MTP for CCITT No. 7 (BT) signalling departs from the current CCITT Recommendations are: compatibility, circular routing, congestion procedures, performance, and the procedures necessary to enable secure operation in a multi-PTO (public telecommunications operator) network. These departures are specified in British Telecom Network Requirement (BTNR 146) and are described briefly below.

Compatibility

As a consequence of the rate at which CCITT No. 7(BT) signalling is being introduced into the BT network, and of the rapid changes taking place in CCITT No. 7 signalling development, there will inevitably be a number of versions of CCITT No. 7(BT) signalling in the BT network at the same time. To achieve successful interworking between exchanges of different versions in the BT network, compatibility mechanisms are specified. These include the reception and treatment of messages that are not understood, a limitation on the sending of messages which are not answered, and an indication of the level of implementation when a message is not understood.

TABLE 1
Heading Code Allocation of Signalling Network Management Messages

Message Group	H0 \ H1	0000	0001	0010	0011	0100	0101	0110	0111	1000	1001	1010	1011	1100	1101	1110	1111
	0000																
CHM	0001		COO	COA			CBD	CBA									
ECM	0010		ECO	ECA													
FCM	0011		RCT*	TFC													
TFM	0100		TFP		TFR*		TFA										
RSM	0101		RST	RST*													
MIM	0110		LIN	LUN	LIA	LUA	LID	LFU									
	0111																
DLM	1000		DLC	CSS	CNS	CNP											
	1001																
	1010																
	1011																
	1100																
	1101																
	1110																
	1111																

CBA *changeover acknowledgement* signal
CBD *changeback declaration* signal
CHM *changeover* and *changeback* messages
CNP *connection not possible* signal
CNS *connection not successful* signal
COA *changeover acknowledgement* signal
COO *changeover order* signal
CSS *connection successful* signal
DLC *signalling data link connection order* signal
DLM *signalling data link connection order* message
ECA *emergency changeover acknowledgement* signal
ECM *emergency changeover* message
ECO *emergency changeover order* signal
FCM *signalling traffic flow control* messages
RCT *signalling route set congestion test* message*
RSM *signalling route test* message
RST *signalling route set test* signal
TFR *transfer restricted* signal*
TFA *transfer allowed* signal
TFC *transfer controlled* message
TFM *transfer prohibited/transfer allowed/ transfer restricted* messages
TFP *transfer prohibited* signal
MIM *management inhibit* messages
LID *link inhibit denied* signal
LFU *link forced uninhibit* signal
LIN *link inhibit* signal
LIA *link inhibit acknowledgement* signal
LUA *link uninhibited acknowledgement* signal
LUN *link uninhibited* signal

* National only options (second RST tests TFR)

TABLE 2
Signalling Network Management Message Parameters

Message	Parameter	Parameter Coding
Changeover	FSN of last accepted MSU	Bits A–G = FSN, bit H spare
Changeback	Changeback code	Bits A–H determined by SP
Transfer prohibited	Destination	Bits A–H first octet + A–F second octet as for destination point code, GH spare
Transfer allowed	Destination	As for destination point code, GH spare
Signalling route set test	Destination	As for destination point code, GH spare
Transfer controlled	Destination	As for TFA, TFP + GH = congestion
Transfer restricted	Destination	As for TFA and TFP

Circular Routing

The MTP feature which allows dynamic re-routing to overcome network failures can also create a problem. This can occur when two or more diversions take place which result in a closed loop being formed in the signalling network around which messages circulate. Hence no replies would be received by the node originating the message. This phenomenon, known as *circular routing*, although rare, cannot be allowed in the network, and mechanisms to prevent the multiple re-routings which lead to circular routing are built into the BT version of the CCITT No. 7 signalling MTP.

Performance

MTP performance is specified in CCITT Recommendations and allows for a message loss of 1 in 10^7, an error rate of 1 in 10^{10}, out-of-sequence messages 1 in 10^{10}, STP transfer of 20×10^{-3} s, and a route availability of 1 in $1 \cdot 9 \times 10^5$ (or 10 minutes per year). In addition, BT requirements specify timer values (in line with the latest CCITT proposals), signalling traffic throughput, and message transfer times.

Operational Requirements

BT's experience in operating the MTP in a network environment has resulted in load sharing requirements for multi-link link-sets being identified and specified. In addition, BT supports other facilities in its network to provide customer services, such as operator assistance. These additional MTP users need to be recognised and therefore supported by the MTP.

Multi-Operator Working

To ensure that signalling interchanges between BT and other PTOs are in line with interconnect agreements, special mechanisms are required in the MTP to allow only agreed signalling messages on the interconnect routes.

Activity in CCITT

With the considerable experience gained in both implementing and operating CCITT No. 7 signalling in the national network and through British Telecom International being one of the first operators to introduce CCITT No. 7 signalling into the international network, BT has been one of the leading contributors to the current discussion in the CCITT on the signalling system. The purpose of these discussions at both CCITT and in other international fora has been to update the existing recommendations for CCITT No. 7 signalling. The enhanced recommendation will be contained in the Blue Book (CCITT Recommendations 1985–1988), which will incorporate many modifications resulting from experience in operating CCITT No. 7 signalling based on inputs from BT. It is hoped that it may soon be possible to limit work on the MTP purely to these modifications required for operational purposes. The resulting CCITT recommendation should then be a stable document that is very closely aligned with the CCITT No. 7(BT) signalling MTP.

EVOLUTION OF MTP

Although it is BT's general aim to stabilise the MTP requirements, the following items need to be considered before the CCITT No. 7(BT) signalling system can be regarded as complete:

User Part Availability/Unavailability/Congestion

At present, CCITT No. 7(BT) signalling MTP has only one user — the NUP. However, as outlined in the earlier article[1] in this series, multiple use of the MTP is likely from early-1990. With the advent of multiple MTP users at BT nodes, it is desirable to have a mechanism to indicate to an originating MTP user, the availability, unavailability, or congestion level of a similar MTP user at a remote node. This would permit an indication to be given to an originating signalling connection control part (SCCP) say, when the destination SCCP was congested, but before the destination point code as a whole was indicated as congested. Thus interference with other MTP users at the originating node, for example, NUP, would be avoided. A UK contribution on a suitable mechanism is currently being considered by CCITT.

Test Process User Part

In order to test the MTP of CCITT No. 7 signalling, during both system development and in service maintenance activities, special facilities are needed. Many of these test facilities may be provided by the operations and maintenance application part (OMAP), but OMAP cannot be used until full network provision of the SCCP is realised. A major need is for a means of generating simulated signalling traffic to be carried by the MTP during testing. There is also a need for the provision of test and maintenance traffic to be carried by an inhibited link. Thus a requirement for a suitable test process user part (TPUP) exists, at least in the medium term.

The latest BT thoughts on TPUP require only a few nodes to be provided with the full testing mechanism, but do require the MTP to have the capability of 'turning round' received TPUP messages. Draft documentation for this capability has been prepared.

272 Octet SIF Capability

At present, CCITT No. 7(BT) signalling MTP has the capability of sending up to 62 octets of user data in messages. This capability will need to be extended to the CCITT agreed maximum value of 272 octets when certain supplementary services are supported by the SCCP. Segmentation and re-assembly of messages are not MTP functions.

Compatibility

The compatibility mechanisms outlined above may not be suitable for long-term use if the MTP is to be evolved in the future. Enhancement of the these basic mechanisms may therefore be required.

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BIOGRAPHIES

Bryan Law joined the Post Office City Area LTR as a Youth-in-Training in 1958. He spent nine years in City and Centre Areas, firstly on Strowger maintenance, and then on television network switching duties. In 1967, he joined THQ NPD working on main cable installation and FDM equipment commissioning. On promotion to Level 2 in 1980, he spent some time on information flow studies for System X, before joining his present group on the specification of CCITT No. 7 signalling. He is currently UK co-ordinator for CCITT studies on CCITT No. 7 signalling.

Cliff Wadsworth joined the Post Office Research Station at Dollis Hill in 1953 where he worked on frequency standards, microwave aerial and filter design, and submarine repeaters. In 1977, he was promoted to Level 2 on information flow studies for System X development. Since 1982, he has been involved in the specification of CCITT No. 7(BT) signalling with particular responsibilities for the MTP and SCCP.

CCITT Signalling System No. 7: National User Part

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UDC 621.395.34

This article is the third in the series of articles on CCITT Signalling System No. 7 and its application to the British Telecom network. It considers the national user part with relation to the support of the necessary protocols to set-up, monitor and clear down circuit-switched telephony and ISDN connections for basic and supplementary services within the public switched telephony network and ISDN environments. The message set and message contents needed to support these protocols are included along with typical message sequence charts indicating call set-up and release. The relationship with, and differences from, the internationally specified telephone user parts are also discussed.

INTRODUCTION

The transfer of call-control information between modern processor-controlled exchanges in an enhanced telecommunications network requires a fast, reliable and concentrated signalling system servicing many transmission paths in a digital transmission environment.

Other articles[1, 2] give an overview on how this has been achieved by the use of the CCITT No. 7 common-channel signalling system which has been adapted for use to support the national requirements of the British Telecom network. A further article[3] describes how this secure method of transferring messages is achieved by the message transfer part (MTP) of CCITT No. 7 signalling, which is based on a layered structure covering Levels 1, 2 and 3 of the signalling system specification.

The national user part (NUP) of CCITT No. 7 signalling, known as *Level 4* in the layered structure of the signalling system, is application dependent and includes the messages, message codings and protocols necessary to support basic telephony and ISDN call control. The NUP is also required to support an ever increasing number of supplementary services for both telephony and ISDN customers, either exclusively or in conjunction with the signalling connection control part (SCCP)[4] and its associated transaction capabilities[5], which are described in further articles in this series.

The protocols developed for the NUP are of an interactive nature which allow efficient use of thc signalling system in a fully-digital environment, but provide for optimum post-sending delays when interworking with the non-CCITT No. 7-signalling public switched telephone network (PSTN). This is considered an important aspect since it will be a number of years before the BT network will be enhanced to full CCITT No. 7 signalling.

Because of the evolving nature of the network and the need to introduce new facilities and services, the NUP is currently under continual enhancement. Periodically, new versions of the NUP requirements are published to support further packages of network and customer services, including the backwards-compatibility aspects necessary to allow interworking with earlier versions of the NUP.

Version 1 of CCITT No. 7(BT) was specified[6], in 1983, in conjunction with the System X family of exchanges. Version 1 offered basic telephony service, the facilities to support the operator services subsystem (OSSBT) and support of the initial ISDN service based on the Digital Access Signalling System No. 1[7] (DASS 1). DASS is the customer-to-exchange signalling system.

Work continued to produce version 2[8] of the CCITT No. 7(BT) signalling system leading to its publication in 1985. Version 2 included additional features for the ISDN services, the support of the Digital Access Signalling System No. 2[9, 10] (DASS 2) and the ability to interwork with version 1 of CCITT No. 7(BT) and DASS 1.

In July 1987, the specification work was completed for the version 3[11] of CCITT No. 7(BT) signalling and was followed by the competitive tendering exercise for the main network for the supply of System X and AXE 10 digital exchange equipment. British Telecom's digital derived services network (DDSN) was also involved in the version 3 tendering exercise for the 5ESS digital switch to enhance its overlay network. Version 3 provides for additional network and supplementary services as well as the ability to interwork with both version 1 and version 2. Both DASS 1 and DASS 2 are supported by version 3.

A brief résumé of the penetration of the NUP versions provided in the network is given below, but due to the continuing programme of updating exchanges, the figures given should only be considered as approximate.

There are 49 main and 500 local System X exchanges in service at version 1. With the

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provision of CCITT No. 7(BT), version 1, in TXE4E exchanges, enhanced signalling capabilities were provided to approximately 250–500 exchanges of the analogue network. This enhancement to the analogue network gives the advantages to the customer of a message-based signalling system; that is, shorter call set-up times.

There are six main and three local System X exchanges at version 2, but this will increase as the programme of enhancement updates all version 1 exchanges to version 2 by the end of 1988. Approximately 10–20 AXE 10 exchanges and all nine 5ESS exchanges of the DDSN (Freephone and premium rate services) supplied by APT are at version 2.

All implementations of version 3 have an expected in-service date by the end of 1989 to early-1990.

Each implementation does not necessarily conform to the complete specification of CCITT No. 7(BT), at each version, but uses a sub-set of the basic specification whilst ensuring that they interwork with all the other implementations.

At present, the other users of CCITT No. 7(BT) are Mercury Communications Ltd, Racal Vodafone, Telecom Securicor Cellular Radio, Eire, Kingston Communications (Hull) plc, Manx Telecom, Jersey and Guernsey. As their requirements differ slightly from British Telecom, they do not necessarily implement the complete CCITT No. 7(BT) but use a sub-set, whilst ensuring that they interwork between themselves and the BT network.

CCITT No. 7(BT) BASIC SERVICES

Below is a description of the basic services and a list of the supplementary services supported by version 3 of the NUP. A description of each the supplementary services is given later in this article.

ISDN Telephony

DASS 1 and DASS 2 ISDN terminals have the capability to originate normal telephony calls when suitable voice telephone equipment is connected at the terminal or the call is to a non-ISDN customer.

DASS 1 ISDN Digital Call

(*a*) *ISDN Digital Voice/Data Call* This is where a voice call is connected over a general digital path and, by mutual consent, the users can transmit data over this path.

(*b*) *ISDN Digital Data Path* This is provided to transmit data only between users if the terminals at either end are compatible, a voice connection is not available for this type of call.

DASS 2 Calls other then Telephony

(*a*) *ISDN Category 1 (Data) Calls* This is defined as a call between two ISDN terminals where a 64 kbit/s non-interruptable digital path is mandatory and is available for data. If analogue interworking is encountered, the call will fail and an appropriate indication sent to the calling customer. Under normal circumstances this would only occur if the calling party inadvertently attempted to set up a category 1 call to a non-ISDN line.

(*b*) *ISDN Category 2 (Voice) Calls* This is defined as a call from an ISDN terminal to a customer, who may or may not have an ISDN terminal, where an all digital path is preferred, but is not essential. Where the call terminates on an ISDN terminal and uses a digital path, full digital facilities are made available. If analogue interworking is encountered, the call reverts to telephony and an appropriate indication is sent to the calling customer.

Supplementary Services (Supported by Version 3)

User-to-user data
Closed user group
Calling/called line identity (CLI)
Network address extension
Diversion services
Selective barring of incoming calls
Distinctive ringing
Malicious call identification (MCI)
Operator priority access
3·1 kHz call
Swap

Network Supplementary Services (Supported by Version 3)

Record CLI off given routes
Call dropback
Service marks for OSSBT
Restart using circuit group reset
Circuit group blocking/unblocking
Nodal end-to-end data transfer

MESSAGE FORMATS

All the messages used between the message transfer part (MTP) and the national user part (NUP) are based on a standard format called a *message signalling unit*, which conforms to the formatting principles of the CCITT No. 7 telephone user part messages. Figure 1 shows the format of the message presented to or received from the message transfer part of CCITT No. 7(BT) signalling.

The top half of the diagram represents the message as transmitted to or received from the signalling link of the MTP. The lower half represents the message as transmitted or received by the NUP to/from the MTP.

Standard Telephony Label

The standard telephony label comprises 40 bits, and contains the originating and the destination point codes and the circuit identity code (CIC).

used in Version 3 of CCITT No. 7(BT) signalling.

As indicated in Figure 2, there are eight groups of messages, the first four of which are used to set up a basic telephony call. The next group of messages deals with the supervisory phase of the call. There is an additional group to deal with the circuit supervisory functions. The last group of messages is used to invoke ISDN services and to pass additional call information across the network between the originating and the terminating nodes.

MESSAGE SEQUENCES

Basic Telephony Call

Figure 3 shows the message sequence, together with a brief description of the messages used, for a non-ISDN call routed over unidirectional circuits. The call is routed by the local switching unit (LSU) to a digital main switching unit (DMSU-A). DMSU-A routes the call to the destination LSU via a second DMSU (DMSU-B), which requests additional dialling information. A call within the BT network would normally route via one or a maximum of two DMSUs.

A more detailed description of the contents and coding of the messages in this sequence is given in Appendix 1 of this article.

ISDN Call

Figure 4 shows the message sequence for an ISDN category 1 call, routed (via a DMSU in this example) over bi-directional circuits. For an ISDN call, the complete destination address is contained in the DASS 2 *initial service request* message (ISRM).

A more detailed description of the contents and coding of the messages in this sequence is given in Appendix 1 of this article.

SUPPLEMENTARY SERVICES SUPPORTED BY THE NUP

User-to-User Data

This service is invoked by negotiation during the call set-up and provides a means of transmitting data between two users. The data is transferred across the signalling network transparently. This is restricted by the use of flow control in the node to prevent the signalling network becoming overloaded with this type of message.

Closed User Group

This facility enables a group of users to intercommunicate only among themselves via the public network. One or more users may be provided with incoming/outgoing access to users outside the group.

Calling/Called Line Identity

Calling and called line identification (CLI) is supported automatically for ISDN category 1 and category 2 calls by an exchange of service

Note 1: At the local switching unit (LSU), the customer's OFF HOOK condition is recognised and some form of digit reception device is connected to the customer's line circuit. As soon as the calling party has dialled sufficient digits for the LSU to select an outgoing route/circuit, the LSU sends an *initial address* message (IAM) on the route selected to DMSU-A. This message contains information that enables DMSU-A to route the call; that is, calling party category, dialled digits and any special requirements for the call path. DMSU-A, after route/circuit selection, sends an IAM to the destination DMSU (DMSU-B).

Note 2: On inspection of the dialled digits, DMSU-B determines that additional digits are required to complete the call. DMSU-B sends to DMSU-A a *send N digits* message, *N* being the number of digits required. DMSU-A then sends the message to the calling party's LSU.

Note 3: When the required number of digits has been received from the customer, a *subsequent address* message (SAM) is sent to DMSU-B, via DMSU-A, containing the required digits. On reaching DMSU-B, which now has all the digits required, an *initial and final address* message (IFAM) is sent to the called party's LSU. The IFAM contains all the dialled digits, the calling customer's calling party category and any special call path routing requirements.

Note 4: On receipt of the IFAM, the called customer's LSU determines the state of line termination and, if FREE, sends an *address complete* message (ACM) to the calling party's LSU via the two DMSUs. The ACM is used to inform the originating LSU whether any interworking with a non-CCITT No. 7(BT) has occurred. When the ACM is received at the calling customer's LSU, the transmission path is connected; the ring tone connected at the called customer's LSU is heard by the calling customer and ringing current is applied to the called customer.

Note 5: When the called customer answers, the OFF HOOK condition is detected at the LSU and an *answer (charge)* message is sent, via the DMSUs, to initiate charging at the calling customer's LSU. There is no more involvement of the CCITT No. 7(BT) signalling system until either party goes ON HOOK.

Note 6: There are two possible options here, either the called or calling customer is first to go ON HOOK:

(*a*) If the called customer goes ON HOOK first, a *clear* message is sent by its LSU to the calling customer's LSU, the executive point for the call, where a called-subscriber-held timer is started. Either on the maturity of this timer or if the calling party goes ON HOOK, a *release (reason)* message is forwarded to the called customer's LSU; the reason in this case would be *subscriber call termination*. As soon as this *release (reason)* message is received by each node, it responds with a *circuit free* message to indicate that the circuit is now FREE and available for selection.

(*b*) If the calling customer goes ON HOOK first (not shown in the figure), the *release (reason)* message would be sent immediately to the called customer's LSU. The action at each node would be to release the call and send a *circuit free* message to the preceding node.

Figure 3—Message sequence

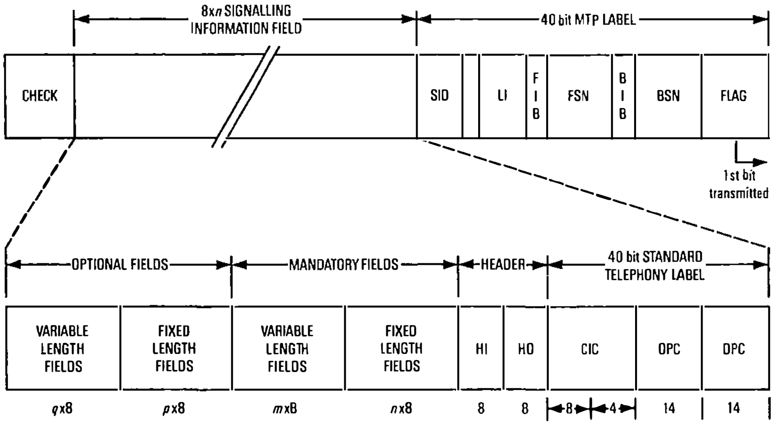


Figure 1
Standard format of the message signalling unit

DPC: Destination point code
OPC: Originating point code
CIC: Circuit identity code
H0: Heading code 0
H1: Heading code 1

Point Codes

Every node using CCITT No. 7(BT) has at least one unique point code. The destination point code (DPC) is used by the MTP to route the message to the correct node. The originating point code (OPC) is used by the receiving node to direct any replies to the correct node. Thus, for each NUP message, the destination point code and originating point code identifies the traffic route to which the message relates.

Circuit Identity Code

The circuit identity code uniquely identifies the particular circuit within the identified traffic route to which the signalling information contained in the message relates. It is important to remember that any node which performs a switching function between CCITT No. 7 signalling circuits will also perform a label translation for every NUP message relating to that call because different routes and circuits are involved in the switched connection.

Message Header

The message header is divided into two fields: H0 to indicate the group of messages, and H1 to indicate the actual message within that group. For some messages, no additional fields are required, but other messages, of a more complex nature, contain additional information in mandatory and/or optional fields.

Mandatory Fields

Mandatory fields are always present in a particular message type in a specified order, and may be of fixed or variable length. The variable-length fields contain information of varying length such as dialled-digit information. For each variable-length field there must be an immediately preceding fixed-length field that indicates the length of the variable field concerned.

Optional Fields

Certain messages may contain optional fields, which can be of fixed or variable length. These fields are usually associated with messages that provide additional information (if available) about the call. These messages must contain a mandatory field indicating which optional fields are present in the message. For a particular message type, optional fields, if present, are always included in a particular order. For each variable-length field there must be an immediately preceding fixed-length field to indicate the length of the variable field concerned.

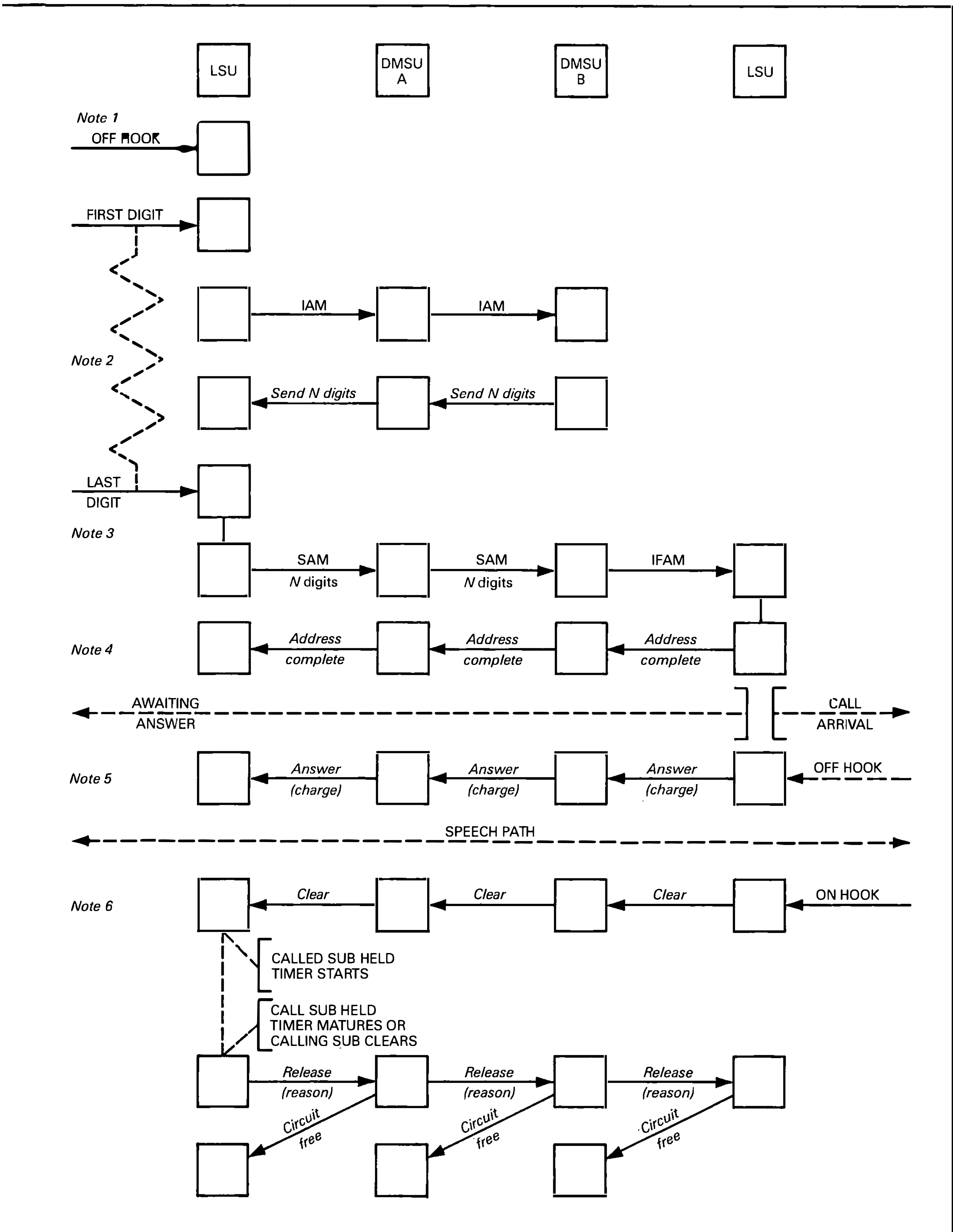
Header Fields

As mentioned above, the header is divided into two fields, H0/H1. Figure 2 shows the H0/H1 combinations for each of the messages

Figure 2
Allocation of H0/H1 codes

H0 \ H1	0	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16
0	IAM	IFAM	SAM	FAM													
1	*	*	*	*	ADDITIONAL SET-UP INFORMATION												
2	*	*	SEND 'N' DIGITS	SEND ALL DIGITS	SEND ADDITIONAL SET-UP INFORMATION												
3	ADDRESS COMPLETE (NUMBER RECEIVED)	*	CONGESTION	TERMINAL CONGESTION	CONNEXION NOT ADMITTED	REPEAT ATTEMPT	SUB ENGAGED	SUB OUT OF ORDER	SUBSCRIBER TRANSFERRED	( )	CALL DROP BACK						
4	ANSWER	CLEAR	RE-ANSWER	RELEASE	COIN AND FEE CHECK	OPERATOR OVERRIDE (TKO)	HOWLER	EXTEND CALL	*	( )	( )	( )	( )	( )			
5	CIRCUIT FREE	BLOCKING	UNBLOCKING	BLOCK ACK	UNBLOCK ACK	OVERLOAD	*	*	*	*	*	CCT GROUP BLOCKING	CCT GROUP UNBLOCKING	CCT GROUP BLOCKING ACK	CIRCUIT GROUP UNBLOCKING ACK	CIRCUIT GROUP RESET	CIRCUIT GROUP RESET ACK
6	*	*	*	*	*	*	*	*	RESERVED	RESERVED	RESERVED						
7	CONFUSION	ISDN COMPOSITE SERVICE INFORMATION	SEND SERVICE	SERVICE	ADDITIONAL CALL INFORMATION	OPERATOR CONDITION	USER TO USER DATA	SWAP	DIVERSION ACTIVATED	END-TO-END ADDRESS COMPLETE	RESERVED	NODAL END-TO-END DATA					

* Allocated for intra-exchange use only ( ) Reserved for non-BT use H0 Codes 8–255 spare H1 Codes 17–255 spare



for a non-ISDN call with extra digits required at second DMSU

Note 1: On receipt of the ISRM, the calling customer's LSU sends an IFAM with the service handling protocol (SHP) set to inform the destination LSU that this is an ISDN call and therefore ISDN protocol should be used; and the call path indicator (CPI) set to indicate, to each intermediate node, that a 64 kbit/s path with CCITT No. 7(BT) signalling is mandatory for this call.

The intermediate DMSU, on receipt of the IFAM, sends an IFAM to the called customer's LSU after route/circuit selection. Neither the SHP nor the CPI values are altered by the intermediate DMSU.

Note 2: The called customer's LSU, on receipt of the IFAM with the SHP of 1, sends a DASS 2 *channel seized* message to the called customer and invokes an ISDN *service information* message (SIM) interchange with the calling customer's LSU. These messages are passed from end-to-end without being reprocessed at any intermediate DMSUs, apart from the necessary label change.

The ISDN SIMs are used to pass information between the calling and called party's LSU. It is a three-message protocol referred to as the *SIM A*, *SIM B* and *SIM C interchange*. Thirteen types of ISDN SIM are defined to support the current range of ISDN services.

(*a*) SIM A is passed in the backward direction and typically contains the facility indicator code (FIC) of the called customer which indicates whether it supports closed user group (CUG), user-to-user data etc. It can also request the called customer's FIC, calling line identity (CLI) etc.

(*b*) SIM B is passed in the forward direction and typically contains the calling customer's FIC, CLI, service indicator code (supplied by the terminal via DASS 2), CUG interlock code etc. It can also request the called customer's CLI and FIC.

(*c*) SIM C is passed in the backward direction and typically contains the called customer's CLI and FIC. As it is the last message of the interchange, the SIM C does not request any information.

Note 3: The calling customer's LSU returns the requested information in a SIM B on receipt of the SIM A from the called customer's LSU. On receipt of the SIM B, an incoming call indication is sent via DASS 2 to the called customer.

Note 4: If the called customer's equipment accepts the call, then the ISDN SIM C is returned to the calling customer's LSU. In addition, the call arrival indication is sent to the called customer and the *address complete* message is sent to the calling customer's LSU, via the DMSU, where it is mapped to the DASS 2 message *number acknowledge*. The *address complete* message contains an interworking indicator, and in this case it is set to indicate that a fully digital path is available with CCITT No. 7(BT) signalling used throughout.

Note 5: On receipt of the *call connected* (DASS 2) message from the calling customer the *answer (charge)* message is sent to the calling customer's LSU and on to the calling customer in the *call connected* (DASS 2) message. At this stage a transparent digital path is provided. During a call, CCITT No. 7(BT) can also provide an additional two-way user-to-user data path via the signalling network. The rate at which the messages are transmitted is restricted by flow control at the outgoing LSU to prevent overloading of the signalling network.

Note 6: During this transfer of data, either customer can initiate swapping the call to speech, if supported by both terminals, by using the *swap* message. The call can then be swapped back to data again by using the *swap* message, with no restriction on the number of times that a call is swapped.

Note 7: At the end of the call, there are two possible options: either the calling or called customer is first to request the connection to be cleared.

(*a*) Assuming that the calling customer clears first, then the *clear request* is sent to the LSU via DASS 2. The calling customer's LSU then sends the *release (reason)* message to the next node, which responds with a *release (reason)* and *circuit free* message. On receipt of the *release (reason)* message, the calling customer's LSU responds with a *circuit free* message. This interchange is due to the circuit being bi-directional and so both ends of the circuit need to know its state. This is repeated over the successive links until the called customer's LSU is reached; then the *clear indication* (DASS 2) message is sent to the called customer.

(*b*) If the called customer is the first to request clearing of the call (not shown in the figure), then a *clear* message is returned to the calling customer's LSU, similar to the non-ISDN call, but in this case the CSH timer is set to 0. Hence the response is an immediate *release (reason)* from the calling customer's LSU.

Figure 4—Message sequence for an ISDN category 1 call

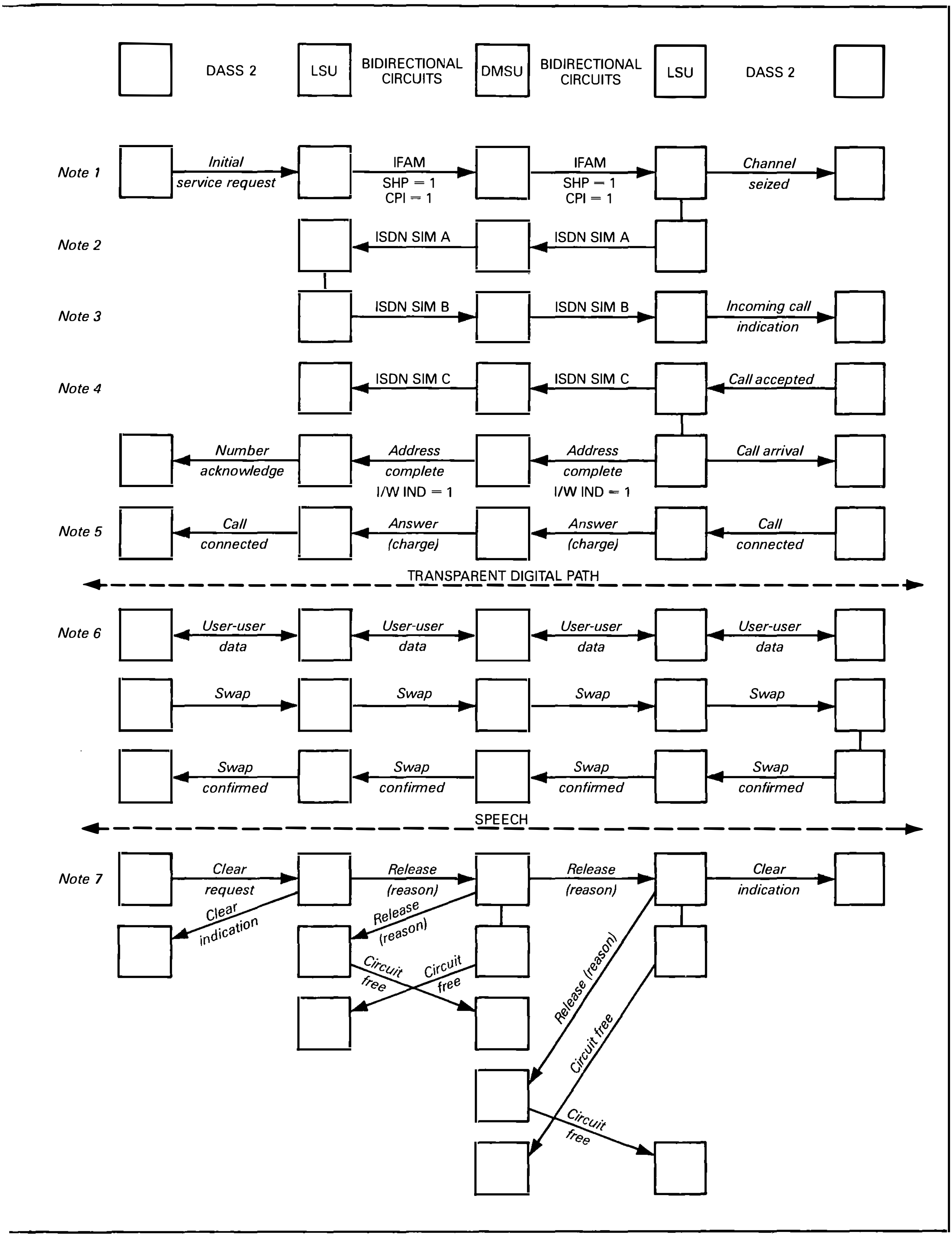


Figure 4—Message sequence for an ISDN category 1 call

information messages at call set-up. Where possible, all calls, including non-ISDN calls, have the calling line identity included in the *initial address* message/ *initial and final address* message (IAM/IFAM) to allow display at the called ISDN terminal if the customer subscribes to the CLI presentation service.

Both the calling and called line identities are available for network and other supplementary use, even if not provided in the IAM/IFAM, by the use of end-to-end request and response messages. If analogue interworking is encountered then the partial calling line identity, giving incoming route and circuit information, etc., from the interworking node, is provided by means of link-by-link messages.

Network Address Extension

This service is invoked by negotiation during the call set-up. Extended address information, for ISDN categories 1 and 2 (full digital path only) calls, is carried across the public network from the calling party to the called party. This extended address information consists of up to six alphanumeric characters and is used to select a destination beyond that indicated by the called national number.

Diversion Services

At present, the diversion service is available for telephony calls and category 2 calls. However, category 2 calls are reverted to telephony when diversion is active. The diverted leg of the call is treated by the CCITT No. 7(BT) as a separate call, but the calling line identity contained in the IFAM is the originating customer's number. An indicator is set to inform the terminating customer that this is a diverted call, to allow the called customer the option of requesting the diverting customer's calling line identity.

Selective Barring of Incoming Calls

This service requires all incoming calls to the subscribing customer to provide the calling line identity to allow the terminating node to selectively bar/accept calls from specific calling customers.

Distinctive Ringing

This service requires all incoming calls, to the subscribing customer, to provide the calling line identity to allow the terminating node to apply distinctive ringing to the called customer, dependent on the origin of the call.

Operator Priority Access

This service allows the operator to mark a call as priority access. This enables the call to have priority over non-priority calls and, in extreme circumstances, may cause non-priority calls to be released if no free circuits are available for the priority call.

Malicious Call Identification

Network support of this service is achieved by invoking last party release, in the address complete message, on all incoming calls to the customer concerned. If possible, the calling line identity of each incoming call is stored until the call is released so that if, during a call, an MCI indication is received from the called customer, the CLI is printed out and the call held in the backward direction.

3·1 kHz Call

A call marked as a 3·1 kHz call requires a specific transmission path for certain ISDN and data services. This marking ensures that the call is not routed via any speech processing equipment, such as, adaptive-differential pulse-code modulation (ADPCM), in the international network.

Swap

This is the DASS 2 facility to allow either user in an ISDN category 1 or category 2 call to change from VOICE to DATA mode or from one data mode to another whilst in the answered state.

NETWORK SUPPLEMENTARY SERVICES

Record CLI Off Given Routes

To support this requirement, the network is required to provide the calling line identity for all calls on a given route. The calling line identity is available for network use either in the IAM/IFAM or by the use of end-to-end or link-by-link request and response messages.

Call Dropback

This facility was provided for a call re-routed by the digital derived services network to a number in the PSTN. It is used to release the original call path until a node is reached where it is most economical to route to the new PSTN number.

Service Marks for OSSBT

To provide the OSSBT operator with additional information concerning incoming or outgoing calls, service marks are requested from the originating or terminating node by means of a service request/response interchange of messages.

Restart

After exchange failure, the call states of some of the circuits could be affected by memory mutilation. This procedure provides a method of resetting only the circuits that are affected by such a memory loss.

Group Blocking/Unblocking

This provides a method of blocking a group of circuits as a consequence of either fault situations or manual maintenance intervention. Group blocking/unblocking procedures prevent the signalling system from being overloaded by avoiding the sending of multiple single circuit blocking/unblocking messages.

Nodal End-to-End Data Transfer

This is at present used for the virtual private network (VPN) and business exchange services (BES) to enable the VPN/BES messages to be transparently passed across the public network.

TELEPHONE USER PART (TUP)

In the late-1970s, the CCITT forum was actively involved with the specification of the telephone user part (TUP) for the Yellow Book [12] Recommendations Q.721–Q.725 published in 1980. At this time, internationally, both the ISDN and supplementary services where not fully defined; therefore, the Yellow Book TUP did not support either the supplementary services or the ISDN facilities that British Telecom required. The TUP only supported the required messages and their respective formats and codes to provide basic telephony services based on earlier international signalling systems for use between international switching units. Further examples of the limitations of the TUP are listed below to illustrate the reasons why British Telecom found it necessary to specify a national user part which differed considerably from the CCITT specification available at the time:

- A restriction on the TUP, as far as British Telecom was concerned, was that the TUP could only support a total of 256 messages in 16 different groups so that future expansion of the number of messages was limited. British Telecom increased the size of the message header code to enable thc NUP to support 65536 messages in 256 different groups to provide a greater degree of expansion.
- To support an ISDN capability, there was a need to provide nodal end-to-end signalling in addition to the link-by-link signalling provided in the TUP; that is, the *service information* message (SIM) interchange in the NUP to support ISDN call set-up. Also, an ISDN call requires the circuit to be released by the first customer to clear, a facility not offered by the TUP.
- British Telecom required a more flexible approach to charging than the TUP offered.
- The TUP did not support the special facilities required for calls to, from and between the operator services subsystem (OSSBT) that British Telecom required.
- In the TUP, there is no version indicator or compatibility mechanism. This meant that both ends of a circuit would have to conform to the same version of TUP; that is, Yellow Book.
- The TUP was specified to cover both national and international use, but did not support the interactive signalling protocols considered essential in the BT network to make optimum use of the signalling network in both full CCITT No. 7 and analogue interworking situations.
- An item that was included in the TUP that was not considered necessary for the NUP was the continuity check of the speech path for use when CCITT No. 7 controls analogue circuits. As British Telecom only intends to use CCITT No. 7 signalling on digital routes, which have inbuilt error checking of the transmission path, this facility was not required in the NUP.
- When the CCITT Red Book was published in 1984[13], the TUP contained some supplementary services, but there was still not a complete and stable capability to support the full ISDN requirements. The Red Book also contained a separate basic set of Recommendations for a user part specifically to support ISDN capabilities known as the *integrated services digital network user part* (ISDN UP). However, this was not considered a stable Recommendation since certain areas, including supplementary services, were indicated as being for further study. A further article[14] in this series describes the ISDN user part including its enhancement for inclusion in the next series of CCITT Recommendations; that is, the Blue Book.
- As mentioned above, the TUP does not have a version indicator or a compatibility mechanism, therefore, the implementations that are based on the Yellow Book TUP are unable to directly interwork with Red Book TUP implementations on a route basis; for example, a Red Book TUP may send a message that is not recognised in the Yellow Book TUP, resulting in call failure. Also, a message containing supplementary service information sent from a Red Book TUP to a Yellow Book TUP may not be recognised.

The supplementary services that are supported by the Red Book TUP are:

Closed user group
User access to the calling/called line identification
Redirection of calls
Call completion to a busy customer
Network access to calling line identification (malicious call identification)
Digital connectivity (digital path required throughout the call)

TELEPHONE USER PART+ (TUP+)

During the mid-1980s, the EEC commissioned the Analysis and Forecasting Group (GAP) to produce a report on the coordinated introduction of an ISDN in 'The Community'. This recommended a phased introduction of an ISDN service in Europe with phase 1 to be implemented in the period

1988–1993. The result of this was the TUP+ specification[15] produced in 1987 by a working party of CEPT for use in the international network to interconnect countries in Europe. In addition to ISDN facilities, the TUP+ also provides for the following phase 1 supplementary services:

Closed user group
Calling line identification
Sub-addressing
User-to-user data transfer

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APPENDIX 1

NUP MESSAGE FORMATS AND CODES

Listed below are some typical examples of message formats and codes used by the CCITT No. 7(BT) NUP. The examples chosen are those used in the call sequences in this article. BTNR 167 contains the complete list of all the formats and codes used in the CCITT No. 7(BT) messages.

Initial Address Message/*Initial and Final Address* Message (IAM/IFAM)

This is the first message generated for any call and implies that the circuit identified in the message label has been seized for this call attempt. See Figure 5.

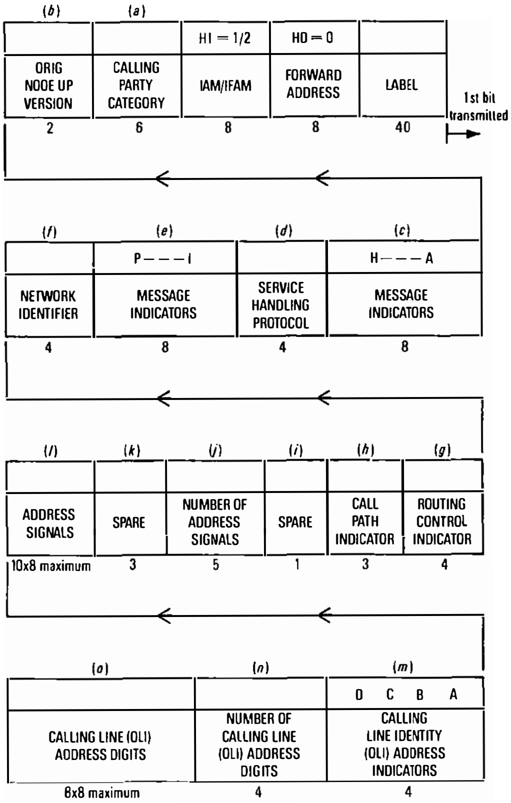

Figure 5
***Initial address* message and *initial and final address* message**

Listed below is typical information that is contained in the sub-fields shown in Figure 5, more detailed information can be found in BTNR 167 Issue 3.

(*a*) *Calling Party Category* Indicates what type of customer originated the call; that is, ordinary business, ordinary residential, ISDN business or ISDN residential etc.

(*b*) *Originating Node CCITT No. 7(BT) User Part Version Indicator* Provides an indication of the version of the originating CCITT No. 7(BT) node for use in ISDN diversion services.

(*c*) *Message Indicators* There are eight indicators, typically they indicate whether the call has originated from an international network, from another country not via an ISC (that is, cross border), or whether this call involves analogue interworking.

(*d*) *Service Handling Protocol* Indicates any special message interchange for this call; that is, service information messages for ISDN or request service for a call to the operator services subsystem.

(*e*) *Message Indicators* There are eight indicators, typically they indicate if a preceding node is Version 3 to determine the correct release procedures, and if the call has been routed via satellite.

(*f*) *Network Identifier* This indicates the network that this call originates in or the immediately preceding network in the case of a multi-network call.

(*g*) *Routing Control Indicator* This indicates whether the use of alternative routing for this call is allowed.

(*h*) *Call Path Indicator* This indicates whether CCITT No. 7(BT) signalling is essential for the routing or if it is only preferred. This indicator is also used to indicate a 3·1 kHz call type so that routes with ADPCM or other speech processing equipment may be avoided.

(*j*) *Number of Address Signals* A binary number indicating the quantity of digits in the address field.

(*l*) *Address Signals* The address signals are sent in 4 bit BCD. If the message is an IFAM, then it is implicit that there are no more address signals to follow.

(*m*) *Calling Line Identity Message Indicators* These indicate whether the CLI can be released to the called customer.

(*n*) *Number of Calling Line Address Digits* A binary number indicating the amount of digits in the calling line address digits.

(*o*) *Calling Line Address Digits* This indicates the calling line identity of the calling customer.

Subsequent Address Message

This message contains additional address digits for call routing (see Figure 6).

(*d*)	(*c*)	(*b*)	(*a*)				
				H1 = 2	H0 = 0		
ADDRESS SIGNALS	SPARE	NO. OF ADDRESS SIGNALS	SPARE	SAM/FAM	FORWARD ADDRESS	LABEL	1st bit transmitted →
9x8 maximum	3	5	8	8	8	40	

Figure 6
***Subsequent address* message**

Typical information that is contained in the sub-fields is shown below, for more detailed information see BTNR 167 Issue 3.

(*b*) *Number of Address Signals* A binary number indicating the quantity of digits held in the address signals sub-field.

(*d*) *Address Signals* The address signals are sent in 4 bit BCD.

Send N Digits Message

After examination of the received address message(s), this message is used by either an intermediate or terminating node to request additional digits (see Figure 7).

(*b*)	(*a*)				
		H1 = 2	H0 = 2		
SPARE	NUMBER DIGITS REQUESTED	SEND 'N' DIGITS	BACKWARD SET-UP REQUEST	LABEL	1st bit transmitted →
4	4	8	8	40	

Figure 7
***Send N digits* message**

Typical information that is contained in the sub-fields is shown below, for more detailed information see BTNR 167 Issue 3.

(*a*) *Number of digits Requested* The number requested can be from 1 to 15.

Address Complete (Number Received) Message

This message is sent from a terminating or an analogue interworking node indicating that all address signals required for routing the call to the called party have been received (see Figure 8).

(*b*)	(*a*)				
		H1 = 0	H0 = 3		
SPARE	CALLED PARTY CATEGORY	ADDRESS COMPLETE	BACKWARD SET-UP INFORMATION	LABEL	1st bit transmitted →
8	6	8	8	40	

(*i*)	(*h*)	(*g*)	(*f*)	(*e*)	(*d*)	(*c*)
SPARE	ECHO SUPP. IND	SPARE	INTERWORKING INDICATIONS	LAST PARTY RELEASE INDICATOR	SPARE	CHARGE INDICATOR (RESERVED FIELD)
1	1	1	4	1	1	1

Figure 8—*Address complete* message

Typical information that is contained in the sub-fields is shown below, for more detailed information see BTNR 167 Issue 3.

(*a*) *Calling Party Category* This indicates what type of customer originated the call; that is, ordinary business, ordinary residential, ISDN business or ISDN residential.

(*c*) *Charge Indicator* This could be used to indicate no-charge or charge for this particular call. Currently, this value is always set to charge.

(*e*) *Last Party Release Indicator* Two values only are available; namely, normal release and last party release.

(*f*) *Interworking Indicators* These are used to inform the originating exchange if analogue interworking or interworking to an earlier version of the software has occurred.

(*h*) *Echo Suppressor Indicator* This indicates whether an incoming half echo suppressor has been fitted in the backward transmission path for this call.

Answer Message

This message is sent through the network when the called party answers and it is used to initiate charging (see Figure 9).

(*b*)	(*a*)				
		H1 = 0	H0 = 4		
SPARE	TYPE OF ANSWER	ANSWER	CALL SUPERVISION	LABEL	1st bit transmitted →
4	4	8	8	40	

Figure 9—*Answer* message

Typical information that is contained in the sub-fields is shown below, for more detailed information see BTNR 167 Issue 3.

(*a*) *Type of Answer* The type of answer, at present, could be either charge or no charge. This indication supersedes any conflicting charge/no charge indicator received in the address complete message.

ISDN Service Information Message

There are 13 ISDN SIMs which are used to request and carry information between originating and terminating nodes with no interrogation at the intermediate nodes. Two types request and carry information in the backward direction. Eight types are used to request and carry information in the forward direction. The final three types are used to carry additional information in the backward direction. A complete list of the detailed contents of each of the ISDN service information messages (see Figure 10) is contained in BTNR 167 Issue 3.

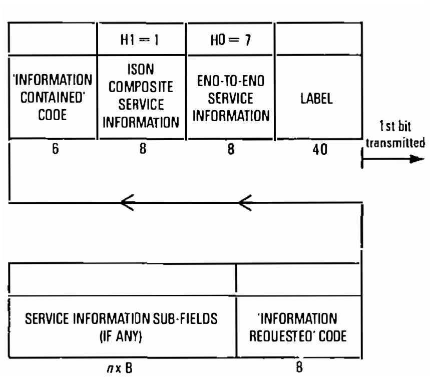

Figure 10—General format of ISDN composite service information messages

Below is a list of typical information carried by the SIMs in either direction:

Calling and called line identity
Service indicator code (for a complete list see BTNR 190 DASS 2)
Closed user group interlocking code
Facility indicator code (that is, user-to-user data service available)
Six character network address extension (provides the ability to pass additional digits from one terminal to another for use by the customer)
Business group identity

Swap Message

The *swap* message (Figure 11) is used to support the DASS 2 swap facility on ISDN category 1 and category 2 calls. The swap facility is controlled by the called and calling customers and enables them to transfer between speech and data, or different data modes, whilst remaining in the answered state.

This message is passed from end-to-end without the need for intermediate node interrogation. Listed below is typical information that is contained in the sub-field, more detailed information can be found in BTNR 190 (DASS 2).

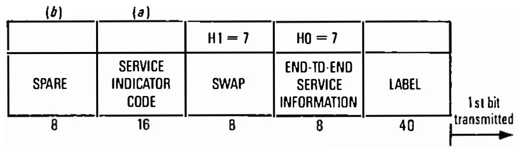

Figure 11
***Swap* message**

(*a*) *Service Indicator Code* This indicates the mode to which the initiating terminal wishes to swap, and the swap confirmation from the receiving terminal.

User-to-User Data Message

The *user-to-user data* message is used to support the DASS 2 requirement to transparently transport user data between the calling and called party in either direction (see Figure 12).

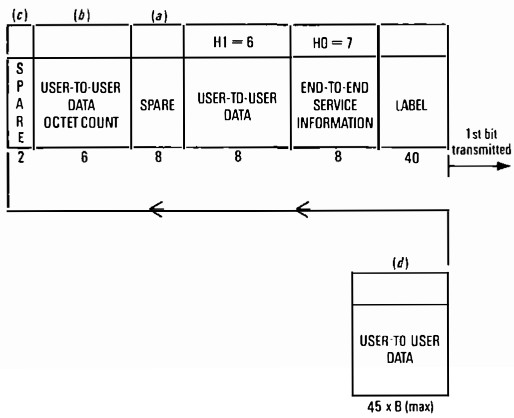

Figure 12
***User-to-user data* message**

This message is passed between originating and terminating nodes without interrogation by the intermediate nodes. Listed below is typical information that is contained in the sub-fields; more detailed information can be found in BTNR 167 Issue 3.

(*b*) *User-to-User Data Octet Count* This indicates the number of digits contained in the user-to-user data sub-field.

(*d*) *User-to-User Data* This sub-field contains the actual data as supplied by the customer's terminal.

Clear Message

This message is passed in either direction after a network terminal has initiated the clear procedure; on reaching the executive point, the call is released using the appropriate protocols.

This message (see Figure 13) does not include any additional sub-fields

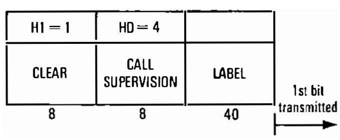

Figure 13
***Clear* message**

Release (Reason) Message

This message causes release of the complete call and connection of suitable tones and/or announcements to the calling party on speech calls; on data calls, message-based clearing reasons will be passed to the ISDN terminal equipment. This message can occur at any stage of the call (see Figure 14).

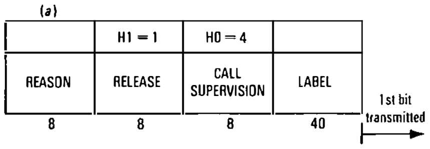

Figure 14
Release (reason) **message**

Typical information that is contained in the sub-fields is shown below, for more detailed information see BTNR 167 Issue 3.

(*a*) *Reason* There are a number of reasons that could be included in this message; such as, number unobtainable, incoming calls barred, and customer engaged.

Circuit Free Message

This message is sent following the receipt of a release message on an incoming or bothway circuit after the switch connection has been successfully released and the circuit is free to accept a new call (see Figure 15).

This message does not include any additional sub-fields.

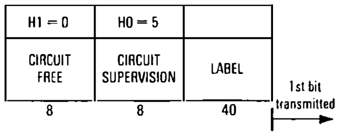

Figure 15—*Circuit free* message

BIOGRAPHIES

Dave Mitchell joined BT as an apprentice in 1971 in the Canterbury Telephone Area. After a period on exchange maintenance, he transferred to BTTC, Stone, as an Instructor Engineering dealing with public exchange training. On promotion, he transferred to the training design services at BTTC, Stone. In 1986, he transferred to his present duties dealing with the national and international standards for the user parts of the CCITT No. 7 signalling.

Brian Collar entered the Post Office LTR South West Area in 1958 as a Youth-in-Training. He worked for nine years in the LTR South West and South areas, initially on exchange maintenance and then area special faults investigation duties. In 1967, he joined the Headquarters Development Department dealing with international signalling and switching facilities for TXK2 ISCs. In 1975, he transferred to the Network Definitions Division responsible for producing strategic network plans for interworking and numbering. From 1978, he has been engaged on inter-nodal signalling and has worked on the user part aspects of CCITT No. 7 since being promoted to Level 2 in 1982.

CCITT Signalling System No. 7: Signalling Connection Control Part

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UDC 621.395.34

This article describes the operation of that part of CCITT Signalling System No. 7 which provides the enhancements necessary to enable signalling networks to support the internodal transfer of data and signalling information which is not directly related to the concurrent establishment of switched telephony or ISDN connections.

INTRODUCTION

An earlier article [1] contained an overview of the CCITT Signalling System No. 7. This article describes the purpose and functions of the signalling connection control part (SCCP), and how it interacts with the other parts of CCITT No. 7 signalling.

CCITT Recommendations (Q.711–Q.714) for the SCCP were first published in 1984 [2]. However, the 1985–1988 Study Period has seen further development of the Recommendations, which will be published in the Blue Book in 1988/9. In particular, protocol class 4 has been deleted, and comprehensive management procedures have been added. This article is based on the SCCP as it is expected to appear in the Blue Book.

It should be noted that, if and when BT wishes to introduce an SCCP into its network, it is possible that not all of the protocol classes and functions specified by CCITT will be needed. In addition, some features not currently specified by CCITT may be required.

ORIGINS OF THE SCCP

Consideration of the evolution of telecommunications networks over the next decade has highlighted the need for a flexible data transfer mechanism within and between those networks. Particular applications which could make use of this mechanism include:

- interrogation of centralised databases by call processors,
- updating of vehicle location registers in the mobile telephone service,
- remote activation of supplementary services, and
- data transfer between network management centres.

It should be noted that these applications do not necessarily involve the establishment of a telephone call or circuit-switched transmission path at the same time. Furthermore, even where a transmission path is required, there is no reason (in general) why the data of the type referred to above should need to share any portion of the same routing as the transmission path or call to which it relates.

The limitations of the user part, for example, telephony user part (TUP) and message transfer part (MTP) configuration in this context are as follows:

- The TUP was developed for the establishment of telephony connections between local exchanges. Signalling cannot take place between those terminal exchanges without using the TUP for the allocation of a speech circuit at each exchange (including intermediate exchanges) used to make the connection. The transfer of messages by this 'pass-along' method uses processing resources inefficiently and introduces additional delay into the message transfer process.
- The scope of the MTP addressing scheme (signalling point code plus service indicator code) [3] is limited in three respects:

(*a*) signalling point codes do not have global significance: each point code is relevant only within a given national network or within the international network interconnecting individual national networks;

(*b*) the total number of signalling point codes available in a single signalling network is limited to 16 384;

(*c*) the maximum number of signalling point codes that may be allocated to one signalling point has been set to four in the BT network;

(*d*) the range of values of the service indicator code permits distribution of messages to only 16 users of the MTP for a single signalling point code.

- Some applications may require the establishment of virtual calls or connections, similar to those of the packet-switched data service. Such a facility cannot be provided by the TUP plus MTP combination.

Concurrently with realisation of the above, work was proceeding in various national and international fora on the concept of the open systems interconnection (OSI) model [4] for

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the specification of communication protocols. Of particular relevance is the network layer service, which aligns closely with the data communication facilities required for the applications listed above. In essence, the OSI network layer service was defined in such a way that the user of the service would not need to be aware of the nature of the underlying physical network(s) used to provide communication in a given instance.

The SCCP was conceived with the stated objective of providing an OSI network layer service, using the MTP network as its underlying physical network, and providing a standard OSI network layer primitive interface to the users of that network layer service.

FUNCTIONS OF THE SCCP

The primary function of the SCCP is to provide a means for the transfer of messages between any two signalling points in the same or different (but interconnected) CCITT No. 7 networks. To do this, it may transfer data in a connectionless mode, establish temporary signalling connections, and/or use permanent signalling connections.

The services provided by the SCCP to its users are specified in the form of four protocol classes as follows:

- Class 0—Connectionless, message sequence not guaranteed;
- Class 1—Connectionless, message sequence guaranteed;
- Class 2—Basic connection-oriented with message segmentation and reassembly; and
- Class 3—Connection-oriented with message segmentation, reassembly, flow control and detection of message loss or missequencing.

Connectionless Data Transfer

In the connectionless mode of operation, the SCCP transfers messages independently of each other, and provides no means of correlating one with another, or of verifying the ability of the destination user to receive them.

Inability of the SCCP to deliver a message to the destination user may be indicated to the originating user by means of a further connectionless message.

This mode of operation applies to protocol classes 0 and 1 only.

Establishment of Temporary Signalling Connections

Some applications, particularly those involving the transfer of large amounts of *en bloc* data, require the establishment of virtual, or logical, connections. This mode of operation benefits both the user and the network because it verifies the ability of an intended recipient of data to actually receive it at that time, thereby ensuring that large amounts of data are not launched willy-nilly into a signalling network which, through no fault of its own, cannot deliver that data.

The SCCP has the ability to establish and release temporary (virtual) signalling connections under the control of the user. The need or otherwise for this connection-oriented type of service is indicated to the SCCP by selection of the appropriate primitive by the originating user.

This mode of operation applies to protocol classes 2 and 3 only.

A virtual signalling connection set up by the SCCP may consist of several SCCP–SCCP links in tandem, each of which may be in a different CCITT No. 7 network. In this case, each SCCP–SCCP link is referred to as a *connection section*, and the intermediate SCCPs act as relay points for the overall SCCP–SCCP 'connection'. At each relay point, the SCCP performs the task of 'association' of the two concatenated connection sections, to achieve the required effect of an end-to-end connection.

Permanent Signalling Connections

The SCCP also has the ability to support permanent (virtual) signalling connections, similar to the permanent virtual circuits of the packet switched service. These are established by administrative action.

This mode of operation applies to protocol classes 2 and 3 only.

Translation

The SCCP regards all of its users as *subsystems*, and they are addressed using a *subsystem number* (SSN). Provision is made for translation from an appropriate *global title* (global address) to the signalling point code of the destination SCCP plus an SSN to identify the destination user. The global title may consist of a national telephone (or ISDN) number, an international telephone (or ISDN) number, a Telex number, a data network terminal number, or a number from any other specified scheme. Which numbering scheme(s) is/are supported in any particular case is determined at the planning stage and is a function of the data build of the SCCP.

Destination Diversity

One of the applications identified above for the SCCP is the communication between the call processor at an exchange and a remote centralised database. This procedure may be used, for example, in the operation of a Freephone service, to provide the exchange with a translation of the dialled digits; that is, from the Freephone number of the required destination of the call to the actual PSTN address of the call destination.

Centralisation of this translation function clearly has benefits in terms of efficiency over its provision for all Freephone numbers at all exchanges, but because a single database would then be relied upon by all exchanges for support of a Freephone service, failure of that database would have a catastrophic effect on the Freephone service. Consequently, it is usual to duplicate the databases in such a way that either one of the pair can take over completely in the event of failure, or planned withdrawal from service, of the other.

As a consequence of the duplication of databases, means must be provided to ensure that messages from exchanges always go to the database which is in operation at the time. One way of achieving this would be for each database to broadcast messages to all exchanges in the network whenever it takes over from another database. However, this could flood the network with messages every time a small software update is necessary at a database.

The recommended solution to this problem is to make use of the translation capabilities of the SCCP at one of a smaller number of intermediate nodes to provide the translation for the final destination of the message. Thus, a local exchange would address the message initially by global title. The local SCCP would provide the appropriate destination point code (DPC) for the MTP to route the message to an intermediate node; for example, a DMSU. The SCCP at that node, having knowledge of the availability status of both of the subsystems that could deal with the message, would then address the message to the subsystem which is actually up and running at that time, by providing the appropriate final DPC and SSN.

Message Sequencing

For some applications, it is necessary that messages are delivered to the destination user in the same order in which they are received by the SCCP at the originating end. The SCCP achieves this by assignment of the same value to the signalling link selection (SLS) code passed to the originating MTP, for all messages required to be delivered in the same sequence.

The need or otherwise for this facility in any particular instance is indicated to the SCCP by the originating user setting an appropriate parameter in the primitive used to request data transfer.

In addition, protocol class 3 provides an enhanced message sequencing procedure that detects message loss and missequencing.

Message Segmentation and Reassembly

The CCITT Recommendations for the SCCP that will appear in the Blue Book (1988/9) are based on a MTP signalling information field (SIF) length of 272 octets. Taking into account the overheads of the SCCP message, this allows a user data field length of approximately 255 octets in a *data* message. To allow for the transfer of longer messages, segmentation and reassembly are specified as features of protocol classes 2 and 3. Segmentation and reassembly are not applicable to the connectionless protocol classes.

Message Flow Control

The SCCP includes message flow control procedures which are applicable to the flow of *data* messages in protocol class 3 only. The purpose of the procedures is to prevent the transmission of data on a signalling connection at a rate greater than that at which the receiving end can accept the data. It is achieved by setting a limit (the 'window') at the end originating the data, on the number of messages it may send to the same destination for which acknowledgement has not yet been received. The value of the limit is negotiated during establishment of the connection. Different window sizes may be applied to the two directions of transmission on the same connection.

Expedited Data Transfer

In addition to message flow control, protocol class 3 provides an expedited data-transfer facility. This allows the priority transfer of up to 32 octets of user data, which by-passes the flow-control procedures applied to normal data messages.

Management Procedures

The SCCP contains management procedures whose purpose is to keep track of the availability/unavailability status of signalling points, of local subsystems (that is, those located at the same node as the SCCP), and of remote subsystems. The procedures are also capable of tracking the congestion status of signalling points, and CCITT study is continuing on the inclusion of mechanisms concerned with subsystem congestion.

In response to information of the type referred to above, the SCCP is able to reroute traffic to alternative subsystems at the same or alternative signalling points.

The SCCP management procedures also allow the controlled withdrawal from service of a duplicated subsystem, by redirecting signalling traffic to its backup subsystem.

Detailed description of the SCCP management procedures is contained in a subsequent section of this article.

ARCHITECTURE AND PRIMITIVES USED BY THE SCCP

General

Understanding of the operation of the SCCP will be greatly enhanced by a thorough appreciation of the roles played by messages and primitives, and how they are employed in conjunction with specified procedures to form the signalling protocol. The Glossary at the end of this article explains these aspects, along

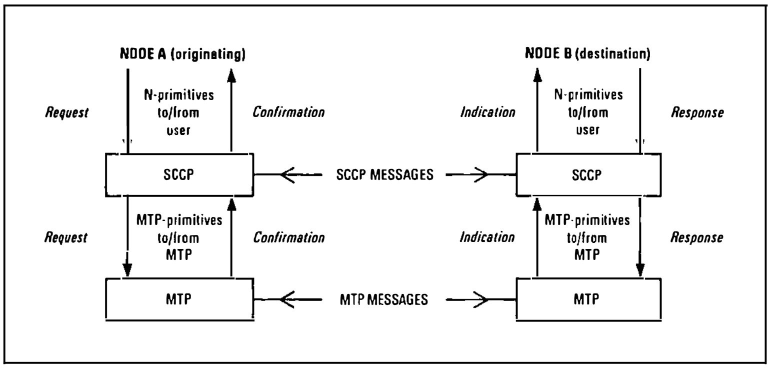


Figure 1
Primitives used by the SCCP

with some clarification of other frequently used terms.

Although the open systems interconnection (OSI) layered protocol reference model referred to above was conceived as applying to communication between computers using any 'open' communication network, many of its principles and techniques are applicable to the communication protocols between call-control processors at exchanges; that is, to CCITT No. 7 signalling. Within this context, the SCCP is considered to provide an OSI network layer service to its users. Because of this, the primitives between the SCCP and its users are referred to as *network layer service primitives*, and the name of each primitive is often preceded by 'N-', to indicate that it relates to network layer service; for example, 'N-CONNECT *request*'. Similarly, the names of the primitives between the SCCP and the MTP are usually prefixed by 'MTP-'; for example, 'MTP-TRANSFER *indication*'.

The application of the foregoing approach to the specification of the SCCP may be represented diagrammatically as shown in Figure 1.

SCCP User Primitives

Nine types of SCCP user primitive are specified (excluding those for SCCP management). Their names and applicability to the four protocol classes are shown in Table 1, with details of the parameters included in each. A '?' in the Table indicates that the use of the primitive in the manner implied is still under study in the CCITT.

TABLE 1
Summary of SCCP User Primitives and their Applicability to Protocol Classes

Generic Name	Specific Name	Protocol Class				Parameters
		0	1	2	3	
N-UNITDATA	*Request*	*	*			CDA CGA SEQ RO UD
	Indication	*	*			CDA CGA UD
N-NOTICE	*Indication*	*	*	?	?	CDA CGA RR UD
N-CONNECT	*Request* *Indication*			* *	* *	CDA CGA RCS EDS QOS UD CI
	Response *Confirmation*			* *	* *	RA RCS EDS QOS UD CI
N-DISCONNECT	*Request*			*	*	RA REA UD CI
	Indication			*	*	OR RA REA UD CI
N-DATA	*Request* *Indication*			* *	* *	CR UD CI
N-DATA ACKNOWLEDGE	*Request* ? *Indication*				* *	CI
N-EXPEDITED DATA	*Request* *Indication*				* *	UD CI
N-RESET	*Request*				*	REA CI
	Indication				*	OR REA CI
	Response *Confirmation*				* *	CI
N-INFORM	*Request* *Indication*			* *	* *	REA QOS CI

Note: With the exception of N-CONNECT and N-DISCONNECT, all of the primitives applicable to protocol classes 2 and 3 are also applicable to permanent signalling connections.

CDA : called address
CGA : calling address
CI : connection identification
CR : confirmation request
EDS : expedited data selection
OR : originator
QOS : quality of service parameter set
RA : responding address
RCS : receipt confirmation selection
REA : reason
RO : return option
RR : reason for return
SEQ : sequence control
UD : user data

MTP Primitives

Four generic primitives are specified for the interface between the SCCP and the MTP. They are listed in Table 2, with details of the parameters included in each. Further explanation may be found in a companion article [3].

TABLE 2

Summary of SCCP–MTP Primitives

Generic Name	Specific Name	Parameters
MTP-TRANSFER	*Request* *Indication*	OPC DPC SLS SIO User Data
MTP-PAUSE	*Indication*	Affected DPC
MTP-RESUME	*Indication*	Affected DPC
MTP-STATUS	*Indication*	Affected DPC Congestion (Level)

SCCP MESSAGES AND PROCEDURES

Summary of Types of SCCP Message

Sixteen types of SCCP message are currently identified (excluding those for SCCP management), covering all of the four protocol classes. Their names, abbreviations and applicability to the protocol classes are shown in Table 3. Details of the parameters included in each message may be found in CCITT Recommendation Q.713, Tables 3–18. The functions of messages and the relationships between the messages and associated primitives are described below.

Messages and Procedures for Connectionless Protocol Classes (0 and 1)

Unitdata (UDT)

This message is the means of conveying data in the CONNECTIONLESS mode. It is generated by the SCCP (at the end originating the data) on reception of an N-UNITDATA *request* primitive from the SCCP user. On reception of a *unitdata* message, the SCCP at the destination node passes an N-UNITDATA *indication* primitive to the relevant user. A return option is provided to facilitate the return of a message which cannot be delivered.

Unitdata Service (UDTS)

This message is the means by which the SCCP at an intermediate or destination node indicates to the SCCP which has originated a *unitdata* message, that it is unable to deliver the *unitdata* message. It contains an indication of the reason for non-delivery, and the contents of the undelivered message. On receiving this message, the SCCP passes an N-NOTICE *indication* primitive to the user that originated the N-UNITDATA *request* primitive.

Messages and Procedures for Connection-Oriented Protocol Classes (2 and 3) (Temporary Signalling Connections)

Connection Request (CR)

This message is sent by the SCCP on reception of an N-CONNECT *request* primitive from one of its users, to set up a signalling connection to a remote SCCP user. The destination SCCP, on reception of the *connection request* message, passes an N-CONNECT *indication* primitive to the required SCCP user. Any intermediate SCCPs receiving this message pass it to the next appropriate SCCP to establish the connection.

Connection Confirm (CC)

On reception of an N-CONNECT *indication* primitive, an SCCP user normally responds by passing an N-CONNECT *response* primitive to its SCCP. The SCCP then sends a *connection confirm* message back to the SCCP that originated the message. That SCCP, on reception of the *connection confirm* message, passes an N-CONNECT *confirmation* primitive to the user

TABLE 3

Summary of Message Types and their Applicability to Protocol Classes

Name	Abbreviation	Protocol Class			
		0	1	2	3
Unitdata	UDT	*	*		
Unitdata service	UDTS	*	*		
Connection request	CR			*	*
Connection confirm	CC			*	*
Connection refused	CREF			*	*
Released	RLSD			*	*
Release complete	RLC			*	*
Data form 1	DT1			*	
Data form 2	DT2				*
Data acknowledgement	AK				*
Expedited data	ED				*
Expedited data ack.	EA				*
Reset request	RSR				*
Reset confirm	RSC				*
Protocol data unit error	ERR			*	*
Inactivity test	IT			*	*

Note: With the exception of *connection request, connection confirm, connection refused, released* and *release complete*, all of the messages applicable to protocol classes 2 and 3 are also applicable to permanent signalling connections.

that originated the N-CONNECT *request* primitive. Any intermediate SCCPs receiving this message send it to the next SCCP in the connection.

Connection Refused (CREF)

This message is the means by which an SCCP that has received a *connection request* message indicates to the SCCP that originated the message that it is unable to establish the connection. Its generation may be initiated by an intermediate SCCP or by the destination SCCP, owing to, for example, lack of resources. Its generation may also be initiated by the destination user, if the user so wishes, by passing to its local SCCP an N-DISCONNECT *request* primitive instead of an N-CONNECT *response* primitive.

When the SCCP that originated a *connection request* message receives a corresponding *connection refused* message, it passes a N-DISCONNECT *indication* primitive to the appropriate originating local user.

Released (RLSD) and Release Complete (RLC)

When an SCCP user at either end of a signalling connection wishes to release the connection, it passes to its local SCCP an N-DISCONNECT *request* primitive. The local SCCP initiates release of the connection by sending a *released* message to the next SCCP in the connection. On reception of a *released* message, any intermediate SCCP sends a further *released* message to the next SCCP, and returns a *release complete* message to the SCCP from which it received the *released* message. This process is repeated at all intermediate SCCPs until the SCCP at the remote end of the connection receives a *released* message. The remote SCCP, also, sends a *release complete* message back, but in addition passes an N-DISCONNECT *indication* primitive to the appropriate local user.

Data Form 1 (DT1) and Data Form 2 (DT2)

These are the basic *data* messages by which an SCCP transfers user data to another SCCP using a signalling connection. Which type is applicable depends on the protocol class selected. An SCCP user wishing to send data over an established connection passes an N-DATA *request* primitive (which contains, as a parameter, the data to be transferred) to its local SCCP, which assembles the data in the appropriate *data* message. On reception of the *data* message, the receiving SCCP passes an N-DATA *indication* primitive (containing the transferred data) to the appropriate user.

Data Acknowledgement (AK)

Data acknowledgement messages are originated by an SCCP that is receiving *data* messages, as a means of acknowledging reception of those *data* messages and for regulating their flow. The acknowledgement of *data* messages takes place independently on all of the connection sections comprising the signalling connection. An option is provided whereby the SCCP user can receive acknowledgement by means of an N-DATA ACKNOWLEDGE *indication* primitive. Whether this option is exercised by means of the confirmation request parameter in the N-DATA *request* primitive, or by means of a separate N-DATA ACKNOWLEDGE *request* primitive is currently under study by the CCITT.

Expedited Data (ED) and Expedited Data Acknowledgement (EA)

The expedited data transfer facility may be used on an established signalling connection to send urgent messages so that they are not subject to the flow-control mechanisms applicable to *data* messages. The maximum permitted length of the user data field in an *expedited data* message is 32 octets, and no segmentation/reassembly is possible.

An SCCP user wishing to use the facility passes an N-EXPEDITED DATA *request* primitive (containing as a parameter the data to be sent) to its local SCCP. The local SCCP then assembles an *expedited data* message and sends it to the destination SCCP. An intermediate or destination SCCP, on receiving the *expedited data* message, sends an *expedited data acknowledgement* message back to the preceding SCCP. The destination SCCP also passes an N-EXPEDITED DATA *indication* primitive (containing the data as a parameter) to the appropriate local user.

The SCCP that sent the first *expedited data* message is not allowed to send a further *expedited data* message until it has received an *expedited data acknowledgement* message relating to the first message.

Reset Request (RSR) and Reset Confirm (RSC)

The purpose of the reset procedure is to reinitialise the message sequence numbers on an established signalling connection. It may be initiated by the SCCP user or by the SCCP itself at either end of the connection, or by an intermediate SCCP.

An SCCP user wishing to initiate a reset passes an N-RESET *request* primitive to its local SCCP. The local SCCP sends a *reset request* message to the SCCP at the remote end of the connection section. If the SCCP initiates a reset, it passes an N-RESET *indication* primitive to the local user. The local user should then pass an N-RESET *response* primitive to the SCCP.

An intermediate SCCP, on reception of the *reset request* message, sends a *reset confirm* message back to the SCCP which sent the *reset request* message, and sends a *reset request* message on the associated connection section.

The destination SCCP, on reception of the *reset request* message, passes an N-RESET *indication* primitive to the appropriate local user. When the destination SCCP receives an N-RESET *response* primitive from the local user, it sends a *reset confirm* message to the SCCP from which it received the *reset request* message

On reception of the *reset confirm* message, the originating SCCP passes an N-RESET *confirmation* primitive to the local user.

Protocol Data Unit Error (ERR)

This message is sent on detection of protocol errors, of which three types are currently identified:

(*a*) *syntax errors* in which the format of a received message does not conform to the rules;

(*b*) *logical errors* in which a received message is inappropriate to the state of the connection; and

(*c*) *transmission errors* for example, message loss or excessive delay.

Various actions may be taken on reception of a *protocol data unit error* message, depending on the nature of the error.

Inactivity Test (IT)

The *inactivity test* message may be sent periodically by the SCCP at either end of an established signalling connection to verify that the connection is still active. The procedure is desirable to allow recovery from the loss of a *connection confirm* message, or from the unsignalled termination of a signalling connection, or from a discrepancy between the connection data held at the two ends of the connection.

The procedure operates by setting time-outs at each end of each connection section. Whenever a message is sent, the send timer is reset, and whenever a message is received, the receive timer is reset. If the send time-out expires, an *inactivity test* message is sent, and if the receive time-out expires, the connection is released.

Messages and Procedures for Permanent Signalling Connections

With the exception of the procedures associated with the *connection request*, *connection confirm*, *connection refused*, *released*, and *release complete* message, all of the procedures applicable to protocol classes 2 and 3 are also applicable to permanent signalling connections. However, if, during the inactivity test procedure, the receive time-out expires, the connection is not released but management is informed.

Structure of SCCP Messages

The SCCP formats messages to be fitted into the standard SIF of the MTP, which in future will allow for up to 272 octets. Each message consists of the following parts:

- a *service information octet* (SIO) as specified for the MTP;
- a standard *routing label* as specified for the MTP;
- a *message type* octet to indicate the type of SCCP message;
- a *mandatory fixed* (length) part;
- a *mandatory variable* (length) part; and
- an *optional* part (if required).

Mandatory Fixed Part

For a given message type, certain parameters must be included and are of fixed length, and these are contained in the mandatory fixed part of the SCCP message. Not only the length, but also the position of these parameters is specified by the message type octet.

Mandatory Variable Part

For a given message type, certain parameters must be included, but are of a length which cannot be anticipated by the SCCP. These are contained in the mandatory variable part of the SCCP message. Because of the unpredictable length, the position of the start of each parameter is indicated by a pointer (PNTR) octet. The name of each parameter, and the order of the pointers are implicit in the message type. The names of the parameters in this part of the message are therefore not included.

If the message type indicates that the message may contain also an optional part, the mandatory variable part will include a pointer to indicate the start of the optional part. If, in a particular instance, the option for inclusion is not exercised, the coding of the pointer is all zeros.

Optional Part

The option for inclusion or otherwise of these parameters is exercised by the user of the SCCP.

Within the optional part of the message, whose start is indicated by a pointer as described above, each optional parameter is identified by a discrete 'name' which is coded as a single octet. Its length is indicated by a further length indicator (L.IND) octet. The order is determined by the rule 'name, length, value'. In other words, each optional parameter immediately follows its own name and length octets. No pointers are used within the optional part of the message.

A further octet (all zeros) is added at the end of the last optional parameter to indicate the end of the set of optional parameters.

SCCP Message Fields

Seventeen parameter fields are specified for possible inclusion in SCCP messages. Their inclusion or otherwise in any particular message depends on the message type and on

TABLE 4
Summary of Parameter Fields included in SCCP Messages

Parameter Fields	Messages															
	UDT	UDTS	CR	CC	CREF	RLSD	RLC	DT1	DT2	AK	ED	EA	RSR	RSC	ERR	IT
Message type	M	M	M	M	M	M	M	M	M	M	M	M	M	M	M	M
Dest. loc.ref.				M	M	M	M	M	M	M	M	M	M	M	M	M
Source loc.ref.			M	M		M	M						M	M		M
Called address	M	M	M	O	O											
Calling address	M	M	O													
Protocol class	M		M	M												M
Segment. & Reass.								M								
Rec.seq. number										M						
Seq. & segment									M							M
Credit			O	O						M						M
Release cause						M										
Diagnost		M				O							O		O	
Reset cause													M			
Error cause															M	
User data	M	M	O	O	O	O		M	M		M					
Refusal cause					M											
End of opt.pars			O	O	O	O							O		O	

the options exercised by the SCCP user. A summary of the mandatory (M) and optional (O) fields for inclusion in the SCCP messages is given in Table 4, followed by an explanation of their contents.

● *Message type* The message type code field is present in all SCCP messages. It uniquely identifies the type of message (for example, UDT, UDTS, or CR, etc.) as described above.

● *Destination local reference number* (Dest.Loc.Ref.) This field uniquely identifies a signalling connection at its destination. It is an internal working number chosen by the destination of the connection independently of the origin of the connection.

● *Source local reference number* (Source Loc.Ref.) This field uniquely identifies a signalling connection at its origin. It is an internal working number chosen by the origin of the connection independently of the destination of the connection.

● *Called address* The called (party) address contains sufficient information to identify uniquely the destination signalling point of the SCCP message, and a particular subsystem at that signalling point.

In connectionless messages, the called address identifies the destination of the message. In connection-oriented messages the called address identifies the terminating end of the signalling connection.

It may consist of any combination of global title (for example, dialled digits), signalling point code and/or subsystem number. For ease of interpretation, it contains additional information to indicate which type of addressing elements are present. Figure 2 shows an example of the format where a global title is present, with an indication of the number of bits allocated to each parameter.

The translation type octet is used by a

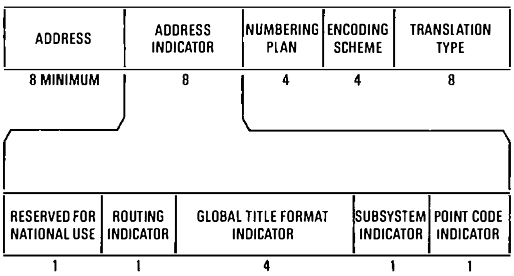


Figure 2—Format of called address field in SCCP message

receiving SCCP to select the translation table appropriate to the address information. It may relate to a particular service; for example, Freephone.

The encoding scheme field indicates whether the address information consists of binary-coded decimal (BCD) or International Alphabet No. 5 (IA5) characters.

The numbering plan field is used to indicate whether the global title uses the telephone/ ISDN, Telex, data network, mobile network or other numbering plan.

The composition of the address indicator octet is also shown in Figure 2. The first two bits are used to indicate the presence or otherwise of a signalling point code and of a subsystem (SCCP user) number. The four bits of the global title format indicator indicate the presence or otherwise of a global title, and identify any one of up to 15 different types of global title. The routing indicator is used by a receiving SCCP to determine whether onward routing should be based on signalling point code plus subsystem number, or on global title (in which case local translation would be required). The last bit may be used to indicate whether the address is an international number/point code or a national number/point code.

The address field contains the digits of the address.

- *Calling address* The calling (party) address contains sufficient information to identify uniquely the originating signalling point of the SCCP message.

In connectionless messages the calling address identifies the origin of the SCCP message. In connection-oriented messages the calling address identifies the origin of the signalling connection.

Its composition is similar to that of the called address.

- *Protocol class* For connectionless service, this is used to indicate whether a message should be returned in the event of the detection of an error by the receiving SCCP.

For connection-oriented service, it is the means by which the protocol class is negotiated between the two ends of a signalling connection.

- *Segmenting/reassembling* (Segment.& Reass.) This field is set by the SCCP sending data to indicate to the destination SCCP whether more data will follow in a subsequent message, and consequently whether reassembly of the data will be required at the receiving end. The first bit is used as a 'more data' indicator.
- *Receive sequence number* (Rec.Seq. Number) This is used in the *data acknowledgement* message as a means of flow control.
- *Sequencing/segmenting* (Seq.& Segment.) This field contains information required for: sequence numbering, flow control, segmentation and reassembly. It consists of the sequence number of the message sent, the receive sequence number and the 'more data' indicator.
- *Credit* This is used in a *data acknowledgement* message to indicate to the sending SCCP how many messages it may send on that signalling connection without awaiting acknowledgement. It is also used in a *connection request* message to propose a credit value, and in the *connection confirm* message to select a credit value.
- *Release cause* This is used in the *released* message to indicate the reason for the release.
- *Diagnostic* (Diagnost) For connectionless protocol classes, this is used in the *unitdata service* message to indicate the reason for the return of a *unitdata* message.

The use of this field in connection-oriented protocol classes is still under study in the CCITT.

- *Reset cause* This field is used in a *reset request* message to indicate the reason for invoking the reset procedure.
- *Error cause* This field is used in the *protocol data unit error* message to indicate the nature of the protocol error.
- *User data* This field contains any information that is to be transferred transparently from the originating SCCP user to the destination SCCP user.
- *Refusal cause* This field is used in a *connection refused* message to indicate the reason why the connection cannot be established.
- *End of optional parameters* (End of Opt.Pars.) This field is present in all messages which contain optional parameters, to indicate the position of the end of the set of optional parameters in the message.

Example of an SCCP Message

Figure 3 shows how the SCCP constructs a *unitdata* message from the parameters supplied by the user in the N-UNITDATA *request* primitive. The resultant message is then assembled into a MTP-TRANSFER *request* primitive and passed to the MTP for transmission. A companion article describes the composition of MTP messages in more detail [3].

SCCP MANAGEMENT PROCEDURES

General

SCCP management (SCMG) provides procedures to maintain network performance by re-routing or throttling signalling traffic in the event of failure or congestion of signalling points, or of subsystems within the signalling points. These SCMG procedures apply to both connection-oriented and connectionless services of the SCCP, and rely on nodal failure, recovery, and congestion information provided by MTP primitives, and on subsystem failure and recovery information received in SCMG messages.

Current SCMG procedures are designed to manage solitary nodes/subsystems and repli-

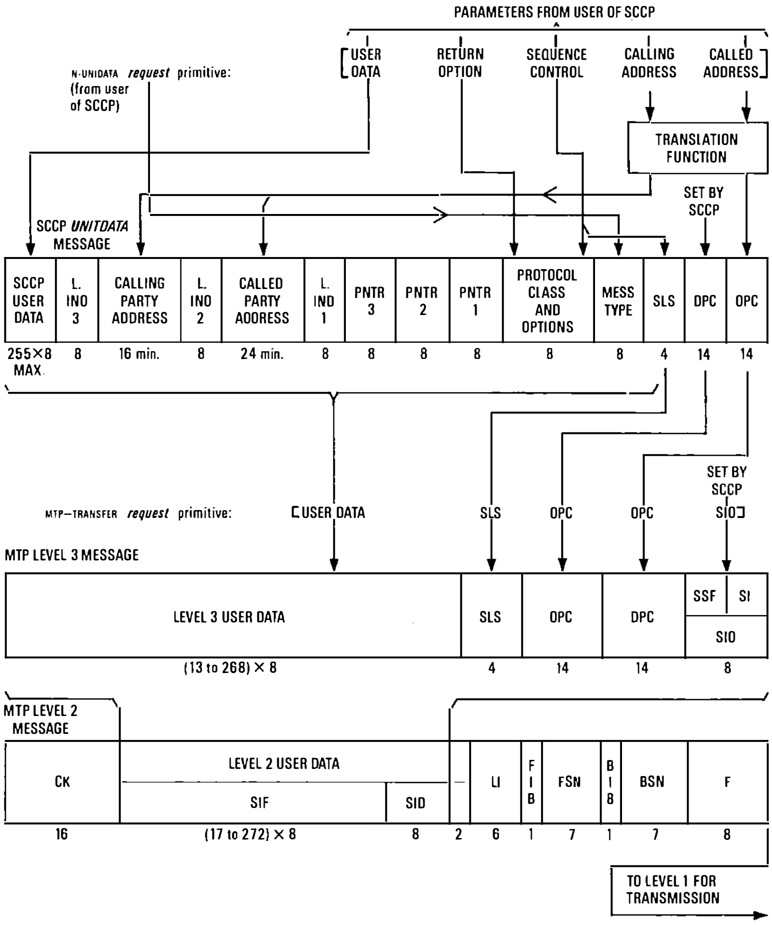


Figure 3
Total composition of an SCCP unitdata message

cated nodes/subsystems which operate in a dominant mode and for which any given primary node/subsystem has only one back-up (that is, duplicated nodes/subsystems). Management procedures for operating in a mode other than the dominant mode, or for nodes/subsystems which have more than one backup, are for further study. (Dominant mode means that when a failed primary node/subsystem recovers, signalling traffic which has been diverted to its duplicate is returned to the primary.)

Messages which have the called party address specified in the form of a global title, can be routed to different signalling points and/or subsystems, depending on network or subsystem status.

In order to limit the number of management messages propagated by these procedures, SCMG utilises the concept of a 'concerned' subsystem or signalling point. Management messages are broadcast from a node only to a 'concerned' entity. A 'concerned' entity means an entity with an immediate need to be informed of a particular signalling point/subsystem status change, independently of whether SCCP communication is in progress between the 'concerned' entity and the affected entity whose status has changed.

SCMG is organised into two subfunctions: signalling point status management and subsystem status management.

Signalling Point Status Management

Signalling point status management facilitates the alternative routing of signalling traffic to backup signalling points and/or backup subsystems if applicable. The SCCP translation function and status marks are updated, based on the information of network failure, recovery or congestion provided by the MTP-PAUSE, MTP-RESUME, or MTP-STATUS *indication* primitives, and messages received are subsequently re-routed if appropriate.

Based on the information received, local subsystems are informed of every change of signalling point status, so that the relevant action can be taken by the SCCP users.

Subsystem Status Management

Subsystem status management allows alternative routing to backup subsystems should a primary subsystem fail. The SCCP translation function and status marks are updated based on received information relating to failure, withdrawal, and recovery of subsystems. Enhancements to take account also of subsystem congestion are presently under study. Local users are informed of the status of their backup subsystems, since they have the responsibility for reducing or inhibiting signalling traffic for the affected subsystem.

Primitives

The SCMG primitives used between the SCCP and its users are:

N-COORD

The N-COORD primitive is used by replicated subsystems to co-ordinate the withdrawal from service of one of the subsystems.

N-STATE

The N-STATE *request* primitive is used to inform SCMG about the status of the originating SCCP user. The N-STATE *indication* primitive is used to inform an SCCP user accordingly.

N-PCSTATE

The N-PCSTATE *indication* primitive is used to inform an SCCP user about the status of a signalling point.

Table 5 gives an overview of the primitives to the SCCP user and the corresponding parameters for SCMG.

- *Affected subsystem* This parameter identifies an SCCP user which is FAILED, WITHDRAWN, CONGESTED, or ALLOWED. The affected subsystem parameter contains the same type of information as the called address and calling address.
- *Subsystem multiplicity indicator* The parameter subsystem multiplicity indicator identifies the number of replications of a subsystem.

TABLE 5

SCCP Management Primitives and Parameters

Primitives		Parameters
Generic Name	Specific Name	
N-COORD	*Request* *Indication* *Response* *Confirmation*	Affected subsystem Subsystem multiplicity indicator
N-STATE	*Request* *Indication*	User status Affected subsystem Subsystem multiplicity indicator
N-PCSTATE	*Indication*	Affected point code Signalling point status

TABLE 6

SCCP Management Message Format

Parameter	
Message type (= *unitdata*)	
Protocol class and options (= Class 0, no message return)	
Called party address (SSN = SCCP management)	
Calling party address (SSN = SCCP management)	
SCMG format identifier	*Note 1*
Affected subsystem number	*Note 1*
Affected point code	*Note 1*
Subsystem multiplicity indicator	*Note 1*

Note 1: These parameters are conveyed in the data field of the *unitdata* message.

- *User status* The parameter user status is used to inform an SCCP user of the status of the affected subsystem. User status may assume the values: USER-IN-SERVICE and USER-OUT-OF-SERVICE.
- *Affected point code* This parameter identifies a signalling point which is failed, congested, or allowed. The affected point code parameter contains unique identification of a signalling point.
- *Signalling point status* The parameter signalling point status is used to inform a user of the status of an affected signalling point. Signalling point status may assume the following values: SIGNALLING POINT INACCESSIBLE, SIGNALLING POINT CONGESTED, and SIGNALLING POINT ACCESSIBLE.

SCMG Messages

SCMG messages are transferred by means of the connectionless service of the SCCP. *Unitdata (UDT)* messages are employed using protocol class 0 with the 'discard message on error' option selected. The SCMG message information is contained in the data parameter of the *unitdata* message, as shown in Table 6.

The parameter 'SCMG format identifier' uniquely defines the function and format of each SCMG message. These messages are:

Subsystem allowed (SSA),
Subsystem prohibited (SSP),
Subsystem status test (SST),
Subsystem out-of-service request (SOR), and
Subsystem out-of-service grant (SOG).

With the exception of user (subsystem) status information, the data parameters in each SCMG message are used to convey the information contained in the corresponding parameters of the appropriate primitive. User status information is conveyed by means of the SCMG format identifier.

Subsystem Status Test Procedure

The subsystem status test procedure provides a means of checking the status of a subsystem marked PROHIBITED.

Periodically, a *subsystem status test* (SST) message is sent to SCMG at the node which has previously indicated the failure of a local subsystem. If that subsystem is now ALLOWED, a *subsystem allowed* (SSA) message is returned; if that subsystem is still PROHIBITED, no indication is returned.

Co-ordinated State Change Procedure

This procedure allows one member of a group of duplicated subsystems to go out of service for software updates or modifications, without interfering with normal network operation. In essence, it requires that a subsystem that has to be taken out of service first verifies that its duplicate can take over the load. Only on reception of a positive indication that it is able to do so will the first subsystem go out of service voluntarily.

A subsystem wishing to go out of service passes an N-COORD *request* primitive to its local SCMG. SCMG then sends a SOR message to SCMG at the node of the backup subsystem, which then passes an N-COORD *indication* primitive to the backup subsystem. If the backup subsystem is able to take over, it passes an N-COORD *response* primitive to its local SCMG, which then sends a SOG message to the requesting node. On reception of the SOG message, the requesting SCMG passes an N-COORD *confirmation* primitive to the requesting subsystem, and initiates a broadcast of SSP messages to concerned signalling points. If the backup subsystem is unable to take over, the requested node does not reply to the SOR message.

Local Broadcast Procedure

The local broadcast procedure is used to inform local subsystems, of any related subsystem status information received at, or observed by, the node. The information which can be locally broadcast is: user-out-of-service, user-in-service, signalling point inaccessible, signalling point accessible, and signalling point congested. This information is contained in the N-STATE *indication* primitive.

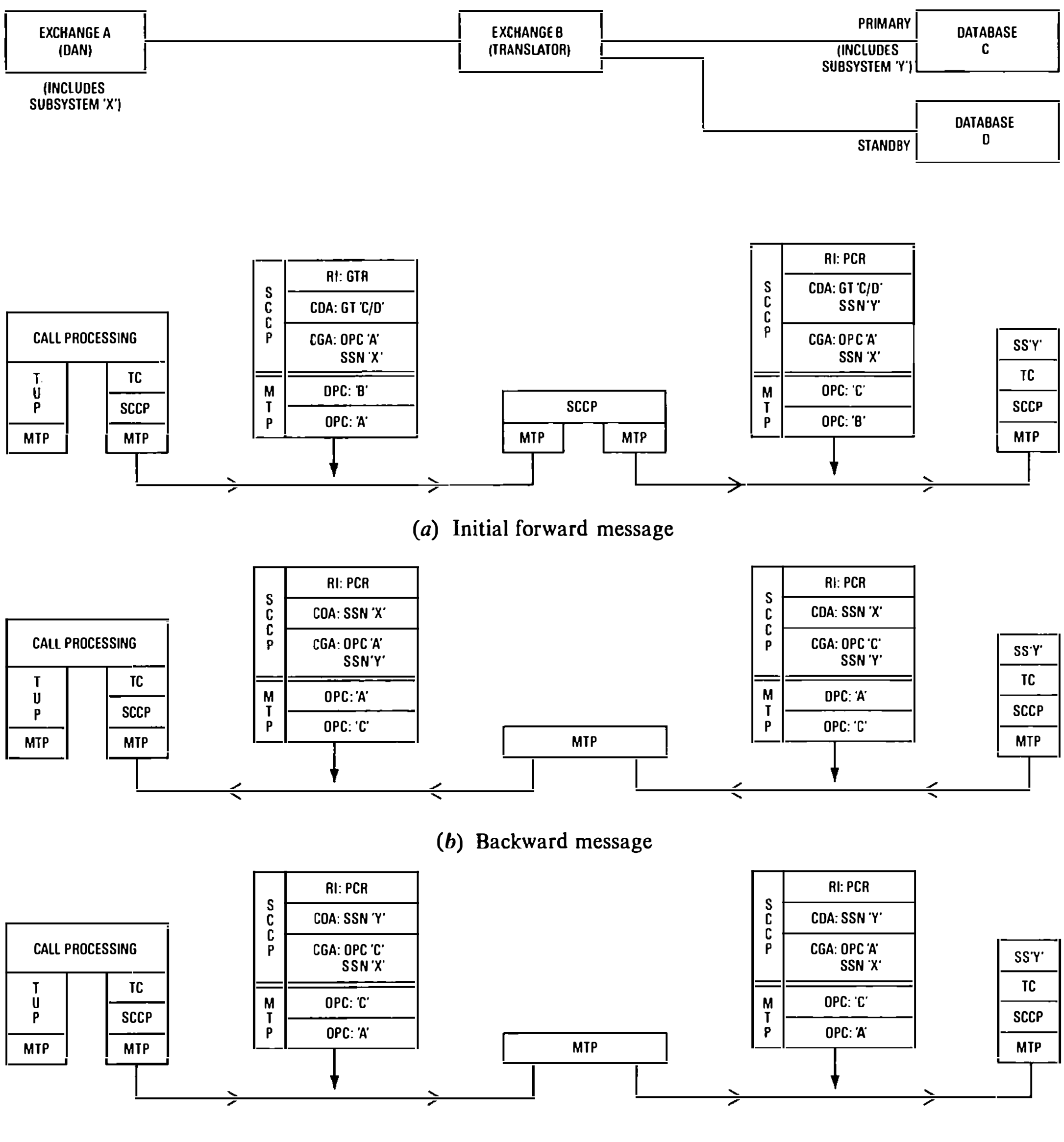
Broadcast Procedure

The broadcast procedure provides a mechanism that may be used to inform concerned signalling points of any related subsystem status change at local or adjacent signalling points. The messages that may be broadcast are *subsystem prohibited* and *subsystem allowed.* In some network situations, the number of concerned signalling points will be zero, and no broadcast of SCMG messages will occur. In these cases, SCMG messages will be transferred to signalling points, when they originate messages, by means of a response mechanism only.

ADDRESSING AND ROUTING OF SCCP MESSAGES

Figure 4 shows a possible application of one of the connectionless protocol classes of SCCP service for routing messages. The example chosen is a limiting case of an exchange applying to a remote database for information. Exchange (A), which initiates the request to the database, is referred to as the *database access node* (DAN). The intermediate exchange (B), which is the one kept up-to-date on the availability status of the two databases (C and D), is referred to as the *translator*. (The DAN and translator functions are shown implemented at different nodes to indicate clearly how these functions interact. These functions could be performed by the same node).

Figure 4
Typical addressing and routing of SCCP messages



(*a*) Initial forward message

(*b*) Backward message

(*c*) Subsequent forward message

The sequence of events is described in the following paragraphs.

Although it is not shown in the figure, it is necessary to assume that a circuit-switched path has been set up in the usual way from the originating customer to the DAN (exchange A), which may be a local exchange or a DMSU. The DAN recognises, typically, from the dialled digits that information is required from a database before establishment of the call can proceed.

Call processing at the DAN passes an N-UNITDATA *request* primitive to the SCCP, using the dialled digits as a global title (GT) for the called address (CDA) parameter. The calling address (CGA) consists simply of the signalling point code of the DAN together with subsystem number (SSN) X to identify the relevant call processing entity at the DAN that originated the message.

The SCCP at the DAN assembles a *unitdata* message. Using the global title supplied in the N-UNITDATA *request* primitive, it refers to its translation table, which in this case indicates that the message should be sent to exchange B. It therefore assigns DPC 'B' to the MTP-TRANSFER *request* primitive, together with OPC 'A'. The translation function at the DAN also sets the routing indicator (RI) to 'global title routing' (GTR). This is used by the receiving SCCP (in this case the translator) as an indication that it should perform a translation on the global title to determine the onward routing of the message.

The SCCP at the translator, examines the routing indicator and applies to its translation function with the global title as called address. The translation function refers to its table showing the availability status of the databases and their subsystems which could deal with the request. It selects the active subsystem which is to deal with this particular request, adds its subsystem number (SSN) to the called address, passes the DPC to the MTP, and sets the routing indicator to 'point code routing' (PCR).

The SCCP at the database (C), noting that the message is point code routed, by-passes its translation function and passes the message directly to subsystem 'Y'. Subsystem 'Y' then operates on the user data within the message to derive the information required by call processing at the DAN. It then assembles a *unitdata* message containing the required information as user data. The routing indicator is set to PCR and the message is point code routed to the DAN, by-passing the SCCP at the translator node, and using as DPC in the called address, the OPC of the received message.

Any subsequent messages in the forward direction relating to the same transaction are also point code routed directly to database 'C', since the DAN now knows the identity of the database and of its subsystem which is dealing with the request.

CONCLUSIONS

This article describes the operation of the signalling connection control part of CCITT Signalling System No. 7, based on the latest documentation available from the CCITT. Despite the effort devoted to the CCITT activities on the SCCP in the 1985–1988 Study Period, there are several aspects of the SCCP which are not yet fully specified. Some additional work will therefore be required before the CCITT Recommendations can be implemented. Also, the Recommendations that will appear in the CCITT Blue Book in 1988/9 contain some options which have been omitted from this article for clarity. It should not be assumed that the options which are included in this article are necessarily those which BT would wish to implement. It is possible that the initial implementation of the SCCP by BT will support only protocol classes 0 and 1, and will also provide some additional SCCP management procedures to ensure satisfactory operation under subsystem congestion conditions.

GLOSSARY

Connection-Oriented Data Transfer

This is data transfer in which an association is established between sender and receiver before any attempt is made to transfer the data. It avoids the risk of flooding the network with undeliverable messages if the intended recipient is unable to receive them at that time. The association could take the form of a physical connection, but this is not essential. The most usual form of association is that of a logical (or virtual) connection. In this, the originator sends a request to the intended recipient of the data to ask whether the data can be accepted. If the intended recipient responds with confirmation that it is able to receive the data, the logical connection is considered to be established, and data transfer may start. A complementary procedure is used to release the logical connection.

The packet-switched service uses this mode of operation.

Connection-oriented procedures are useful when a large amount of data needs to be transferred.

Connectionless Data Transfer

This is data transfer which takes place without confirmation that the intended recipient is able to receive it at that time. Where small amounts of data are to be transferred, this method can be efficient, because it avoids the overhead of the additional messages which would be required to establish and release a logical or physical connection.

(Communication) Protocol

This embraces all that is necessary to facilitate communication between two nodes in a network. Its specification consists of the definition of messages, primitives and procedures.

Protocol Specification

A feature of the layered approach to protocol specification is that each layer is considered to provide services to the layer above, which is referred to as a *user* of those services. An aspect of particular importance is the method of distinguishing inter-node messages (which have to be specified in the finest detail), from signals between protocol layers within each communicating node (which need to be specified only in sufficient detail to define their essential information content). For the purpose of writing the specification, each of these signals is referred to as a *primitive*, and each piece of essential information conveyed by it is referred to as a *parameter*.

Messages

Messages are the quintessence of modern signalling systems, being the sole means by which information is transferred from one node to another. Because each node in a network or between networks may have been obtained from different suppliers, it is necessary to specify messages precisely. Consequently, protocol specifications include detailed message formats, and coding of the individual bits representing the values of all parameters included in each message.

Primitives

The nature of primitives is entirely the concern of the designer of the node, and should consequently not be constrained by the protocol specification. A primitive comprises information or instructions passed between protocol layers within a node. On the assumption that the entire node is designed and built by the same supplier, there is no need for the purchaser of the system to specify, or be aware of, the electrical nature of the primitives. Only the meaning of the primitives needs to be specified, including the parameters which are essential for conveying that meaning.

Primitives are often described by the name of the layer of the underlying functional block which supports them.

Each generic primitive associated with a particular function may exist in up to four basic forms, depending on the nature of the function. These are: *request*, *indication*, *response* and *confirmation*. They are used in the following way:

Request This type of primitive is generated by a user to request that a specified function be performed.

Indication This is passed to the user to inform that user that a specified function is being performed. The same primitive is used whether execution of the function was initiated by the network or by another user invoking the corresponding request primitive.

Response This is passed from the user to the network to indicate that the user acknowledges reception of the corresponding Indication primitive.

Confirmation This is passed from the network to the user to indicate to the user that the action required as a result of passing an earlier request primitive has been carried out.

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Biographies

Peter Clarke joined the Post Office Engineering Department in 1962. He graduated from the University College of North Wales in 1965 with a B.Sc. degree in Electronic Engineering. After several years of involvement with the maintenance, testing and development of strowger switching and signalling systems, he joined the Advisory Group on Systems Definition (AGSD), contributing to the establishment of the principles for switching, signalling and transmission on which the digital network is based. When AGSD was reborn as the Telecommunication Systems Strategy Department, he was responsible for the performance requirements for the digital network. He is now in the UKC Network Planning and Works Department, and is currently Head of a Group whose responsibilities include signalling system evolution.

Cliff Wadsworth joined the Post Office Research Station at Dollis Hill in 1953 where he worked on frequency standards, microwave aerial and filter design, and submarine repeaters. In 1977, he was promoted to Level 2 on information flow studies for System X development. Since 1982, he has been involved in the specification of CCITT CCITT No. 7(BT) with particular responsibilities for the MTP and SCCP.

CCITT Signalling System No. 7: Integrated Services Digital Network User Part

C. G. DAVIES, M.B.I.M.†

UDC 621.395.34

The specification of the CCITT Signalling System No. 7 integrated services digital network user part (ISUP) is about to be defined by the CCITT in the 1988 Blue Book Recommendations (Q.761–764 and Q.730). This article gives an overview of the ISUP and describes the basic call-control and signalling procedures necessary for the establishment, supervision and the clearing of a connection in an ISDN environment. In addition, the services expected to be specified in the 1988 CCITT Recommendations are listed.

OVERVIEW OF THE ISDN USER PART

The integrated services digital network user part (ISUP) is the protocol which provides the signalling functions required by CCITT No. 7 signalling to support basic bearer services and supplementary services for voice and non-voice applications in an integrated services digital network (ISDN).

The ISUP is suited for application in dedicated telephone and circuit-switched data networks and in analogue and mixed analogue/digital networks. In particular, the ISUP meets the requirements defined by the CCITT for world-wide international semi-automatic and automatic telephone and circuit-switched data traffic.

The ISUP can be used for national and international applications. The signalling procedures, information elements and message types specified are for both applications. Coding space has been reserved to allow national administrations and recognised private operating agencies to introduce network-specific signalling messages and elements of information within the protocol structure.

The ISUP makes use of the services provided by the message transfer part (MTP)[1] and, in some cases, by the signalling connection control part (SCCP)[2] of CCITT No. 7 signalling for the transfer of information between ISDN user parts.

SERVICES SUPPORTED BY THE ISDN USER PART

The ISUP protocol supports the basic bearer service; that is, the establishment, supervision and release of 64 kbit/s circuit-switched network connections between customer line exchange terminations.

In addition to the basic bearer service, the ISUP is expected to support (in the 1988 Recommendations) the following supplementary services:

- calling line identification (presentation and restriction),
- call forwarding,
- closed user group,
- direct dialling-in, and
- user-to-user signalling.

GENERAL PROCEDURES

In general, the call set-up procedures for both voice and non-voice calls are similar and may use both *en bloc* and overlap (digit-by-digit) signalling.

The basic call-control procedures are divided into three phases: call set-up, data/conversation, and call clear down. Messages on the signalling link are used to establish and terminate the different phases of the call. Five basic connection types may be established:

(*a*) speech,
(*b*) 3·1 kHz audio,
(*c*) 64 kbit/s unrestricted,
(*d*) alternate speech/64 kbit/s unrestricted, or
(*e*) alternate 64 kbit/s unrestricted/speech

Inband tones and/or recorded announcements are returned to the caller on speech and 3·1 kHz connections to provide information on call progress. Calls originating from ISDN terminals may be supplied with more detailed call-progress information by means of additional messages in the access protocol (D-channel).

SIGNALLING PROCEDURES FOR CALL ESTABLISHMENT AND CLEARING

The procedure used to establish a voice or non-voice call is similar to that described in a companion article on BT's national user part (NUP)[3]; however, a number of differences do exist. A brief description of the call-establishment and clearing procedures is given below.

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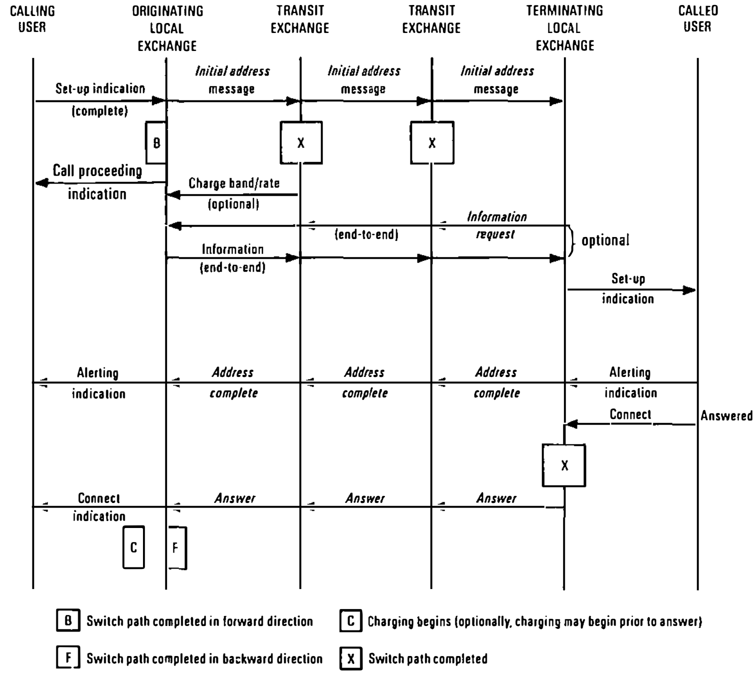
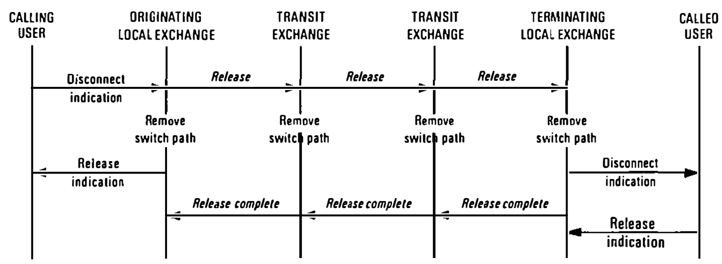
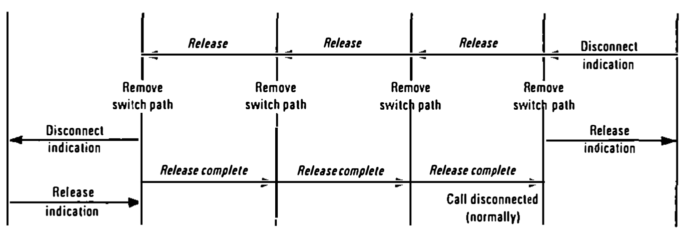


Figure 1
Call establishment example

Figure 2
Normal call release



(*a*) Calling user clears



(*b*) Called user clears

Figures 1 and 2 show the basic call-establishment and release procedures for a successful call together with the ISUP messages used.

Appendix 1 details the structure of an ISDN message and lists the messages and parameters names. Appendix 2 details the general functions of the ISUP messages. Appendix 3 details the signalling information parameters and functions.

Successful Call Set-up Procedures at the Originating Exchange

When the originating exchange has received sufficient selection information (for example, digits from the calling user to route the call) selection of a free inter-exchange circuit takes place and an *initial address* message (IAM) is sent to the succeeding exchange (see Appendix 1 for formats and codes). The selection of the route depends on the called-user number, the type of connection required and the network signalling capability required.

The IAM may contain all or part of the information necessary to determine the routing of the call; for example, digits, transmission medium requirement and forward call indicators etc. If the IAM contains only part of the routing information, one or more *subsequent address* messages (SAM) are sent containing the remaining information.

Through connection of the transmission path is generally completed in the backward direction at the originating exchange immediately after the sending of the *initial address* message, so that tones and announcements can be received by the calling user, if appropriate.

When the originating exchange has sent the *initial address* message, an awaiting-address-complete timer is started, in anticipation of a backward message, a number of responses are possible:

(*a*) If the originating exchange receives an *address complete* message, the awaiting-address-complete timer is stopped and an awaiting-answer timer is started. Ringing tone is applied at the destination exchange (if appropriate) and sent to the calling user.

(*b*) If the originating exchange receives a *call progress* message (CPM), this indicates that no state change should occur. The information carried in the access transport parameter should be sent to the calling user if this is an ISDN terminal.

(*c*) If an *answer* message is received indicating that the required connection has been completed, the transmission path is connected through in the forward direction (if not already connected). The awaiting-answer timer is stopped. If the originating exchange is the controlling node, charging begins, if applicable.

(*d*) If, however, a *connect* message is received, which indicates a composite *address complete* and *answer* message, then the awaiting-address-complete timer is stopped, the transmission path is completed and the call is regarded as being in the answer/data phase, and charging commences.

Call Handling Actions at an Intermediate Exchange

An intermediate exchange, on receipt of an *initial address* message, analyses the called user number and the other information to determine the routing of the call. If the intermediate exchange can route the call by using the connection type specified in the transmission medium requirement parameter, a free inter-exchange circuit is seized and an *initial address* message is sent to the succeeding exchange.

Within a network, if the intermediate exchange cannot route the call by using just the connection type specified in the transmission medium requirement parameter, the exchange will also examine the user service information (if available) to determine if a suitable route can be selected. In this case, if a new connection type is provided, the transmission medium requirement parameter may be modified to a new connection type.

For calls between different networks, the gateway exchange (for example, outgoing international switching centre) ensures that the transmission medium requirement parameter is set according to the service requested by the customer, and this parameter is then carried unchanged within the international network.

An intermediate exchange may modify signalling information received from the preceding exchange according to the capabilities used on the outgoing route. Signalling information that may be changed are the nature of connection indicator, end-to-end method indicator, the most significant digits in the called user number (these may be amended or omitted), and a change of the end-to-end method used. Other signalling information is passed on transparently; for example, the access transport parameter, user service information etc.

Through connection of the transmission path is generally completed in both directions at an intermediate exchange immediately after the *initial address* message has been sent.

Call Handling Actions at the Destination Exchange

On receipt of an *initial address* message, a number of checks are generally performed on the called user's line to determine if the call can be allowed; in the case of ISDN terminals, this includes compatibility and service marking checks. In some cases, additional information may be needed to be obtained from the originating or controlling exchange; for example, calling line identity. Examination of the protocol control indicator shows whether end-to-end information is necessary before further processing of the call can take place. If so, one of the end-to-end signalling methods may be used; namely, SCCP, *pass-along*, or *information request* and *information* messages.

If the connection is allowed, the destination exchange sets up a connection to the called user.

Sending of an *Address Complete* Message/*Call Progress* Message from the Destination Exchange

An *address complete* message (ACM) is sent from the destination exchange under one of the following conditions:

(*a*) as soon as it has been determined that the complete called-user number has been received, for example, where the called user is a PSTN number;
(*b*) if tones or announcements are applied, for example, ringing tone;
(*c*) an *alerting* or *call proceeding* message is received from an ISDN terminal; or
(*d*) an indication is received from the called user (for example, from an ISPBX) that an inband tone is being connected.

An awaiting answer indication (for example, ring tone) is applied at the destination exchange on speech and 3·1 kHz calls on the transmission path to the calling user.

If an ACM has been sent when the called user answers, the destination exchange connects through the transmission path and the ringing tone is removed (if applicable); an *answer* message is sent to the preceding exchange.

In addition to the procedure detailed above, a *call progress* message (CPM) may also be sent, either before or after an ACM, indicating that an event has occurred during call set-up which should be relayed to the calling user. For example:

(*a*) an indication is received that the called user is being alerted, or
(*b*) a progress indication is received from the called user.

Sending of an *Connect/Answer* Message from the Destination Exchange

If a connect indication is the first response from an ISDN terminal and an ACM has not yet been returned, a *connect* message is sent to the originating exchange. The *connect* message signifies both address complete and answer conditions.

UNSUCCESSFUL CALL SET-UP AND RELEASE PROCEDURES

If at any time during call set-up the connection cannot be completed, a *release* message (containing a 'reason' indicating the cause of the call failure) is returned, and the release procedure is then commenced.

The release procedure is based on a two message interchange (*release*, *release complete*) whereby the *release* message initiates release of the circuit-switched connection.

The same procedure is used in the network irrespective of whether it is initiated by the calling user, the called user or the network. Charging is stopped upon receipt of the *release* message.

OTHER PROCEDURES ASSOCIATED WITH CALL ESTABLISHMENT

Information Messages

Information messages *(information request/information)* can be used typically in association with supplementary services; for example, obtaining the calling line identity (CLI) if not contained in an IAM. In this case, an *information request* message would be sent to any exchange in the backward direction requesting the CLI. After sending an *information request* message, a timer is started. (No second *information request* message may be sent in the same direction until a response *information* message is received.)

An outgoing distant exchange would respond with an *information* message as follows:

(*a*) If all the information requested is available, an information message containing all the required information is sent in response.

(*b*) If all the information is not available, then an information message containing only the available information is sent.

The *information request/information* message interchange is a general procedure which can be used for a number of different services.

Sending Unsolicited Information

In addition to the procedure defined above, if information is available at an exchange and this does not correspond to information which has been requested by an *information request* message, this can be sent in the *information* message with the solicited information indicator set to signify that the message has been sent unsolicited.

The unsolicited *information* message can be used only if the ISUP has been used all the way. It can be sent in any direction in any call state except in the awaiting release complete state.

Suspend and Resume Procedures

The suspend procedure allows a user (typically an ISDN terminal) to temporarily suspend the communication without releasing the call. It can only be accepted during the conversation/data phase. A *suspend* message is used and can be either generated in response to a *suspend request* from the calling/called user or generated by the network in response to clearback or ON HOOK condition, respectively, from an interworking node.

A resume procedure is used when a user wishes to recommence communication. A *resume* message is used for this purpose.

Note: a request to release the call received from the calling or called user will override these procedures.

In-Call Modification

For certain types of connection, it is possible during the call to change the mode of the connection; for example, from speech to data. To provide this type of capability, it is required at the start of the call to know whether the call is an alternate speech/64 kbit/s unrestricted call request or vice versa. During call set-up, the network chooses a suitable route (for example, 64 kbit/s and CCITT No. 7 ISUP signalling) according to information included in the *initial address* message.

Other Procedures Incorporated in the ISUP

- supervision procedures to remove circuits or groups of circuits from service to permit testing etc.,
- compatibility procedures for the receipt of unrecognised messages and parameters, and
- procedures for congestion control; for example, when an exchange goes into overload.

SIGNALLING METHODS

The ISUP has two methods available for ISDN end-to-end signalling:

(*a*) the pass-along method; and

(*b*) the signalling connection control part (SCCP) method.

The choice of method depends, to some extent, on the size and architecture of the signalling network. Both methods may coexist in a given network.

The pass-along method and the SCCP method are specified for circuit-switched connections.

In the pass-along method, use is made of an ISUP end-to-end signalling connection which, in fact, is being set up whenever a physical connection between two end points is established.

The pass-along method defines, section by section, the appropriate routing label for the message to be passed along via ISUP connections. The content of *pass-along* messages is only evaluated and possibly changed at the end points. The *pass-along* message group is characterised by a special message type code.

The SCCP method employs the services of the signalling connection control part for the transfer of end-to-end signalling information. A companion article describes the SCCP procedures[2].

SUMMARY

The ISDN user part has undergone considerable revision since its first publication in the 1984 CCITT Red Book (Recommendations Q.761–764). The ISUP is designed basically to support ISDN services using the 64 kbit/s switched telephony network. Its use for other applications such as the support of packet and broadband services will be the subject of discussions in the next CCITT Plenary Period 1988–1992. The way the ISDN user part evolves in the near future will be crucial to all modern telecommunication network developments as it is this component part of CCITT No. 7 signalling that must give the flexibility and durability to support the wide range of services and facilities required by customers and network providers in the future.

ACKNOWLEDGEMENTS

The author would like to thank Ian Spiers (GEC Coventry) and Roger Neame (BNR Canada) for their work as editors of the CCITT Recommendations Q.764 and Q.762/3, respectively, extracts of which have been used in this article.

References

1 LAW, B., and WADSWORTH, C. A. CCITT Signalling System No. 7: Message Transfer Part. *Br. Telecommun. Eng.*, Apr. 1988 (this issue).

2 CLARKE, P. G., and WADSWORTH, C. A. CCITT Signalling System No. 7: Signalling Connection Control Part. *ibid.*, Apr. 1988 (this issue).

APPENDIX 1

FORMATS AND CODES

The signalling information field of each ISUP message consists of an integral number of octets and encompasses the following parts (see Figure 3).

(*a*) routing label
(*b*) circuit identification code
(*c*) message type code
(*d*) mandatory fixed part
(*e*) mandatory variable part
(*f*) the optional part, which may contain fixed-length and variable-length parameter fields.

Routing Label
Circuit Identification Code
Message Type Code
Mandatory Fixed Part
Mandatory Variable Part
Optional Part

Figure 3—ISDN user part message structure

A description of the various message parts is given in the following sections.

Routing Label

For each individual circuit connection, the same routing label must be used for each message that is transmitted for that connection.

Circuit Identification Code

The format of the circuit identification code (CIC) is shown in Figure 4.

	8	7	6	5	4	3	2	1
1	Circuit identification code (least significant bits)							
2	Spare				CIC (most significant bits)			

Figure 4
Circuit identification field

The allocation of circuit identification codes to individual circuits is by bilateral agreement and/or in accordance with predetermined rules.

Allocations for certain applications are defined below:

(*a*) *2048 kbit/s digital path* For circuits which are derived from a 2048 kbit/s digital path, the circuit identification code contains, in the five least significant bits, a binary representation of the actual number of the time-slot which is assigned to the communication path.

(*b*) *8448 kbit/s digital path* For circuits which are derived from a 8448 kbit/s digital path, the circuit identification code contains, in the seven least significant bits, an identification of the circuit (see Table 1).

TABLE 1

Circuit Identification Codes

0 0 0 0 0 0 0	circuit 1
0 0 0 0 0 0 1 : 0 0 1 1 1 1 1	circuit 2 : circuit 32
0 1 0 0 0 0 0 : 1 1 1 1 1 1 0	circuit 33 : circuit 127
1 1 1 1 1 1 1	circuit 128

The remaining bits in the circuit identification code are used, where necessary, to identify these circuits uniquely among all other circuits of other systems interconnecting an originating and destination point.

Message Type Code

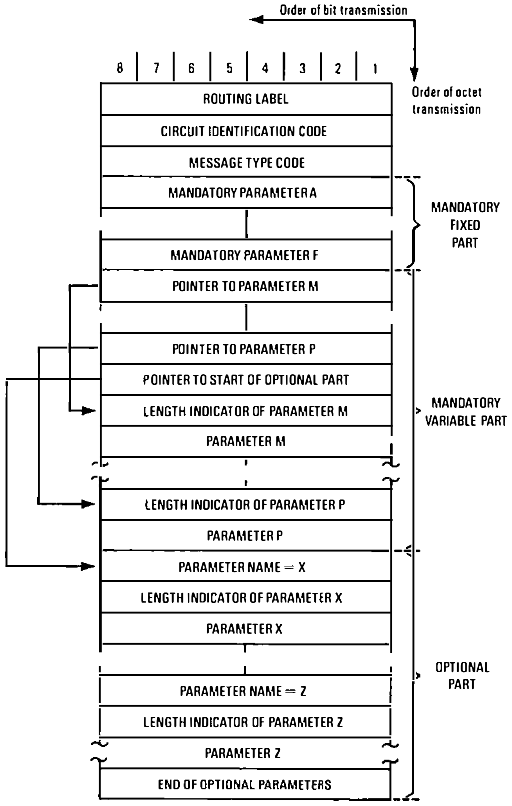
The message type code consists of a one octet field and is mandatory for all messages. The message type code uniquely defines the function and format of each ISUP message.

Formatting Principles

Each message consists of a number of *parameters*. Each parameter has a *name*, which is coded as a single octet. The length of a parameter may be fixed or variable, and a *length indicator* of one octet for each parameter may be included as described below.

A general format diagram is shown in Figure 5.

Figure 5
General format of signalling information field



Mandatory Fixed Part

Those parameters that are mandatory and of fixed length for a particular message type are contained in the *mandatory fixed part*. The position, length and order of the parameters are uniquely defined by the message type; thus the names of the parameters and the length indicators are not included in the message.

Mandatory Variable Part

Mandatory parameters of variable length are included in the *mandatory variable part*. Pointers are used to indicate the beginning of each parameter. Each pointer is encoded as a single octet. The name of each parameter and the order in which the pointers are sent are implicit in the message type. Parameter names are, therefore, not included in the message. The number of parameters, and thus the number of pointers is uniquely defined by the message type.

A pointer is also included to indicate the beginning of the optional part. If the message type indicates that no optional part is allowed, then this pointer is not present. If the message type indicates that an optional part is possible, but there is no optional part included in this particular message then a pointer field containing all zeros is used. All the pointers are sent consecutively at the beginning of the mandatory variable part. Each parameter contains the parameter length indicator followed by the contents of the parameters.

Optional Part

The optional part consists of parameters that may or may not occur in any particular message type. Both fixed-length and variable-length parameters may be included. Optional parameters may be transmitted in any order. Each optional parameter includes the parameter name (one octet) and the length indicator (one octet) followed by the parameter contents.

End of Optional Parameters Octet

If optional parameters are present and after all optional parameters have been sent, an 'end of optional parameters' octet containing all zeros is transmitted.

Order of Transmission

Since all the fields consist of an integral number of octets, the formats are presented as a stack of octets. The first octet transmitted is the one shown at the top of the stack and the last is the one at the bottom (see Figure 5).

Within each octet and subfield, the bits are transmitted with the least significant bit first.

ISDN User Part Message Types and Parameters

The message set used in ISUP and the range of parameters which may be used within each of the messages are shown in Table 2.

ISDN User Part Parameters

The parameter names are given in Table 3.

APPENDIX 2

GENERAL FUNCTION OF MESSAGES

Signalling Messages Used in the ISDN User Part

Address Complete Message (ACM)

A message sent in the backward direction indicating that all the address signals required for routing the call to the called party have been received.

Answer Message (ANM)

A message sent in the backward direction indicating that the call has been answered. In semiautomatic working this message has a supervisory function. In automatic working this message is used in conjunction with charging information in order to:

(*a*) start metering the charge to the calling customer, and

(*b*) start measurement of call duration for international accounting purposes.

TABLE 2

Message Type

Address complete
Answer
Blocking
Blocking acknowledgement
Call modification completed
Call modification requested
Call modification reject
Call progress
Circuit group blocking
Circuit group blocking acknowledgement
Circuit group query
Circuit group query response
Circuit group reset
Circuit group reset acknowledgement
Charge information (national use)
Confusion
Connect
Continuity
Continuity check request
Delayed release (national use)
Facility accepted
Facility reject
Facility request
Forward transfer
Information
Information request
Initial address
Loop back acknowledgement (national use)
Overload (national use)
Pass-along
Release
Release complete
Reset circuit
Resume
Subsequent address
Suspend
Unblocking
Unblocking acknowledgement
Unequipped CIC (national use)
User-to-user information

TABLE 3

Parameter Name

Access transport
Automatic congestion level
Backward call indicators
Call modification indicators
Call reference
Called party number
Calling party number
Calling party's category
Cause indicators
Circuit group supervision message type indicator
Circuit state indicator
Closed user group interlock code
Connected number
Connection request
Continuity indicators
End of optional parameters
Event information
Facility indicator
Forward call indicators
Information indicators
Information request indicators
Nature of connection indicators
Optional backward call indicators
Optional forward call indicators
Original called number
Range and status
Redirecting number
Redirection number
Redirection information
Signalling point code (Note 1)
Subsequent number
Suspend/Resume indicators
Transit network selection (Note 1)
Transmission medium requirement
User service information
User-to-user indicators
User-to-user information

Note 1: For national user only

Blocking Message (BLO)

A message sent only for maintenance purposes to the exchange at the other end of a circuit, to cause an engaged condition of that circuit for subsequent calls outgoing from that exchange. When a circuit is used in the bothway mode of operation, an exchange receiving the *blocking* message must be capable of accepting incoming calls on the concerned circuit unless it has also sent a *blocking* message. Under certain conditions, a *blocking* message is also a proper response to a *reset circuit* message.

Blocking Acknowledgement Message (BLA)

A message sent in response to a *blocking* message indicating that the circuit has been blocked.

Call Modification Completed Message (CMC)

A message sent in response to a *call modification request* message indicating that the requested call modification (for example, from voice to data) has been completed.

Call Modification Reject Message (CMRJ)

A message sent in response to a *call modification request* message indicating that the request has been rejected.

Call Modification Request Message (CMR)

A message sent in either direction indicating a calling or called party request to modify the characteristics of an established call (for example, change from data to voice).

Call Progress Message (CPG)

A message sent in the backward direction indication that an event has occurred during call set-up which should be relayed to the calling party.

Circuit Group Blocking Message (CGB)

A message sent to the exchange at the other end of an identified group of circuits to cause an engaged condition of this group of circuits for subsequent calls outgoing from that exchange. An exchange receiving a *circuit group blocking* message must be able to accept incoming calls on the group of blocked circuits unless it has also sent a *blocking* message. Under certain conditions, a *circuit group blocking* message is also a proper response to a *reset circuit* message.

Circuit Group Blocking Acknowledgement Message (CGBA)

A message sent in response to a *circuit group blocking* message to indicate that the requested group of circuits has been blocked.

Circuit Group Reset Message (GRS)

A message sent to release an identified group of circuits when, due to memory mutilation or other causes, it is unknown whether for example, a *release* or *release complete* message is appropriate for each of the circuits in the group. If at the receiving end, a circuit is remotely blocked, reception of this message should cause that condition to be removed.

Circuit Group Reset Acknowledgement Message (GRA)

A message sent in response to a *circuit group reset* message and indicating that the requested group of circuits has been reset. The message also indicates the maintenance blocking state of each circuit.

Circuit Group Unblocking Message (CGU)

A message sent to the exchange at the other end of an identified group of circuits to cause cancellation in that group of circuits of an engaged condition invoked earlier by a *blocking* or *circuit group blocking* message.

Circuit Group Unblocking Acknowledgement Message (CGUA)

A message sent in response to a *circuit group unblocking* message to indicate that the requested group of circuits has been unblocked.

Circuit Group Query Message (CQM)

A message sent on a routine or demand basis to request the far-end exchange to give the state of all circuits in a particular range.

Circuit Group Query Response Message (CQR)

A message sent in response to a *circuit group query* message to indicate the state of all circuits in a particular range.

Confusion Message (CFN)

A message sent in response to any message (other than a *confusion* message) if the exchange does not recognise the message or detects a part of the message as being unrecognised.

Connect Message (CON)

A message sent in the backward direction indicating that all the address signals required for routing the call to the called party have been received and that the call has been answered.

Continuity Message (COT)

A message sent in the forward direction indicating whether or not there is continuity on the preceding circuit(s) as well as on the selected circuit to the following exchange, including verification of the communication path across the exchange with the specified degree of reliability.

Continuity Check Request Message (CCR)

A message sent by an exchange for a circuit on which a continuity check is to be performed, to the exchange at the other end of the circuit, requesting continuity checking equipment to be attached.

Delayed Release Message (DRS) (National Use)

A message sent in either direction indicating that the called or calling party has disconnected, but that the network is holding the connection.

Facility Accepted Message (FAA)

A message sent in response to a *facility request* message indicating that the requested facility has been invoked.

Facility Reject Message (FRJ)

A message sent in response to a *facility request* message to indicate that the facility request has been rejected.

Facility Request Message (FAR)

A message sent from an exchange to another exchange to request activation of a facility.

Forward Transfer Message (FOT)

A message sent in the forward direction on semi-automatic calls when the outgoing international exchange operator wants the help of an operator at the incoming international exchange. The message normally serves to bring an assistance operator into the circuit if the call is automatically set up at the exchange. When the call is completed via an operator (incoming or delay operator) at the incoming international exchange, the message should preferably cause this operator to be recalled.

Information Message (INF)

A message is sent to convey information in association with a call, which may have been requested in an *information request* message.

Information Request Message (INR)

A message sent by an exchange to request information in association with a call.

Initial Address Message (IAM)

A message sent in the forward direction to initiate seizure of an outgoing circuit and to transmit number and other information relating to the routing and handling of a call.

Loop Back Acknowledgement Message (LPA) (National Use)

A message sent in the backward direction in response to a *continuity check request* message indicating that a loop (or transceiver in the case of a 2-wire circuit) has been connected.

Overload Message (OLM) (National Use)

A message sent in the backward direction, on non-priority calls in response to an IAM, to invoke temporary trunk blocking of the circuit concerned when the exchange generating the message is subject to load control.

Pass-Along Message (PAM)

A message that may be sent in either direction to transfer information between two signalling points along the same signalling path as that used to establish a physical connection between those two points.

Release Message (REL)

A message sent in either direction, to indicate that the circuit is being released because of the reason (cause) supplied and is ready to be put into the IDLE state on receipt of the *release complete* message. In case the call was forwarded or is to be re-routed, the appropriate indicator is carried in the message together with the redirection address and the redirecting address.

Release Complete Message (RLC)

A message sent in either direction in response to the receipt of a *release* message, or if appropriate, to a *reset circuit* message, when the circuit concerned has been brought into the idle condition.

Reset Circuit Message (RSC)

A message sent to release a circuit when, because of memory mutilation or other causes, it is unknown whether, for example, a *release* or a *release complete* message is appropriate. If at the receiving end the circuit is remotely blocked, reception of this message should cause that condition to be removed.

Resume Message (RES)

A message sent in either direction indicating that the calling or called party, after having been suspended, is reconnected.

Subsequent Address Message (SAM)

A message that may be sent in the forward direction after an *initial address* message, to convey additional called party number information.

Suspend Message (SUS)

A message sent in either direction indicating that the calling or called party has been temporarily disconnected.

Unblocking Message (UBL)

A message sent to the exchange at the other end of a circuit to cancel, at that exchange, the engaged condition of the circuit caused by a previously sent *blocking* or *circuit group blocking* message.

Unblocking Acknowledgement Message (UBA)

A message sent in response to an *unblocking* message indicating that the circuit has been unblocked.

Unequipped Circuit Identification Code Message (UCIC) (National Use)

A message sent from one exchange to another when it receives an unequipped circuit identification code.

User-to-User Information Message (USR)

A message to be used for the transport of user-to-user signalling independent of call-control messages.

APPENDIX 3

SIGNALLING INFORMATION PARAMETERS

Access Transport

Information generated on the access side of a call and transferred transparently in either direction between originating and terminating local exchanges. The information is significant to both users and local exchanges.

Address Presentation Restricted Indicator

Information sent in either direction to indicate that the address information is not to be presented to a public network user, but can be passed to another public network. It may also be used to indicate that the address cannot be ascertained.

Address Signal

An element of information in a network number. The address signal may indicate digit values 0 to 9, code 11 or code 12. One address signal value (ST) is reserved to indicate the end of the called party number.

Automatic Congestion Level

Information sent to the exchange at the other end of a circuit to indicate that a particular level of congestion exists at the sending exchange.

Call Forwarding Indicator

Information sent in the backward direction indicating that call forwarding may occur, depending on the response received (or lack thereof) from the called party.

Call Identity

Information sent in the call reference parameter indicating the identity of a call in a signalling point.

Call Reference

Circuit independent information identifying a particular call.

Called Party Number

Information to identify the called party.

Called Party's Category Indicator

Information sent in the backward direction indicating the category of the called party; for example, ordinary customer or payphone.

Called Party's Status Indicator

Information sent in the backward direction indicating the status of the called party; for example, customer free.

Calling Party Number

Information sent in the forward direction to identify the calling party.

Calling Party Address Request Indicator

Information sent in the backward direction indicating a request for the calling party address to be returned.

Calling Party Address Response Indicator

Information sent in response to a request for the calling party address, indicating whether the requested address is included, not included, not available or incomplete.

Calling Party Number Incomplete Indicator

Information sent in the forward direction indicating that the complete calling party number is not included.

Calling Party's Category Indicator

Information sent in the forward direction indicating the category of the calling party and, in case of semi-automatic calls, the service language to be spoken by the incoming, delay and assistance operators.

Calling Party's Category Request Indicator

Information sent in the backward direction indicating a request for the calling party's category to be returned.

Calling Party's Category Response Indicator

Information sent in response to a request for the calling party's category indicating whether or not the requested information is included in the response.

Circuit Identification Code

Information identifying the physical path between a pair of exchanges.

Circuit State Indicator

Information indicating the state of a circuit according to the sending exchange.

Closed User Group Call Indicator

Information indicating whether or not the concerned call can be set up as a closed user group call and, if a closed user group call, whether or not outgoing access is allowed.

Closed User Group Interlock Code

Information uniquely identifying a closed user group within a network.

Coding Standard

Information sent in association with a parameter (for example, cause indications) identifying the standard in which the parameter format is described.

Connected Number

Information sent in the backward direction to identify the connected party.

Connection Request

Information sent in the forward direction on behalf of the signalling connection control part requesting the establishment of an end-to-end connection.

Continuity Check Indicator

Information sent in the forward direction indicating whether or not a continuity check will be performed on the circuit(s) concerned or is being (has been) performed on a previous circuit in the connection.

Continuity Indicator

Information sent in the forward direction indicating whether or not the continuity check on the outgoing circuit was successful. A continuity check successful indication also implies continuity of the preceding circuits and successful verification of the path across the exchange with the specified degree of reliability.

Credit

Information sent in a *connection request*, indicating the window size requested by the signalling connection control part for an end-to-end connection.

Diagnostic

Information sent in association with a cause value and which provides supplementary information about the reason for sending the message.

Echo Control Device Indicator

Information indicating whether or not a half echo control device is included in the connection.

End-to-End Information Indicator

Information sent in either direction indicating whether or not the sending exchange has further call information available for end-to-end transmission. In the forward direction, an indication that end-to-end information is available implies that the destination exchange may obtain the information before alerting the called party.

End-to-End Method Indicator

Information sent in either direction indicating the available methods, if any, for end-to-end transfer of information.

Event Indicator

Information sent in the backward direction indicating the type of event which caused a *call progress* message to be sent to the originating local exchange.

Event Presentation Restricted Indicator

Information sent in the backward direction indicating that the event should not be presented to the calling party.

Extension Indicator

Information indicating whether or not the associated octet has been extended.

Facility Indicator

Information sent in facility-related messages identifying the facility or facilities with which the message is concerned.

Holding Indicator (National Use)

Information sent in either direction indicating that holding of the connection is requested.

Hold Provided Indicator (National Use)

Information sent in either direction indicating that the connection will be held after the calling or called party has attempted to release.

In-band Information Indicator

Information sent in the backward direction indicating that in-band information or an appropriate pattern is now available.

Internal Network Number Indicator

Information sent to the destination exchange indicating whether or not the call is allowed should the called party number prove to be an internal network number (for example, mobile access point).

Interworking Indicator

Information sent in either direction indicating whether or not CCITT No. 7 signalling is used in all parts of the network connection.

ISDN User Part Indicator

Information sent in either direction to indicate that the ISUP is used in all parts of the network connection.

ISDN User Part Preference Indicator

Information sent in the forward direction indicating whether or not the ISUP is required or preferred in all parts of the network connection.

Local Reference

Information sent in the *connection request*, indicating the local reference allocated by the signalling connection control part to an end-to-end connection.

Location

Information sent in either direction indicating where an event (for example, release) was generated.

Malicious Call Identification Request Indicator (National Use)

Information sent in the backward direction to request the identity of the calling party for the purpose of malicious call identification.

Modification Indicator

Information sent in the call modification indicators parameter indication whether the call modification is to service 1 or service 2.

National/International Call Indicator

Information sent in the forward direction indicating in the destination national network whether the call has to be treated as an international call or as a national call.

Nature of Address Indicator

Information sent in association with an address indicating the nature of that address; for example, ISDN international number, ISDN national significant number, or ISDN customer number.

Numbering Plan Indicator

Information sent in association with a number indicating the numbering plan used for that number (for example, ISDN number, Telex number).

Odd/Even Indicator

Information sent in association with an address, indicating whether the number of address signals contained in the address is even or odd.

Original Called Number

Information sent in the forward direction when a call is redirected more than once and identifies the original called party.

Original Redirection Indicator

Information sent in either direction indicating, in the case of calls undergoing multiple redirections, whether the call was forwarded or re-routed, and whether presentation of the original redirection information to the calling party is restricted.

Original Redirection Reason

Information sent in either direction indicating, in the case of calls undergoing multiple redirections, the reason why the call was originally redirected.

Point Code

Information sent in the call reference parameter indicating the code of the signalling point in which the call identity allocated to the call reference is relevant.

Protocol Class

Information sent in the connection request parameter indicating the protocol class requested by the signalling connection control part for the end-to-end connection.

Protocol Control Indicator

Information consisting of the end-to-end method indicator, the interworking indicator, the end-to-end information indicator, the SCCP method indicator and the ISUP indicator. The protocol control indicator is contained in both the forward and backward call indicators parameter field and describes the signalling capabilities within the network connection.

Range

Information sent in a circuit group supervision message (for example, *circuit group blocking*) to indicate the range of circuits affected by the action in the message.

Recommendation Indicator

Information sent in association with a cause value identifying the Recommendation to which the cause value applies.

Redirecting Indicator

Information sent in either direction indicating whether the call has been fòrwarded or re-routed and whether or not presentation of redirection information to the calling party is restricted.

Redirecting Number

Information sent in the forward direction indicating the number from which the call was last redirected.

Redirecting Reason

Information sent in either direction indicating the reason why the call has been redirected.

Redirection Counter

Information sent in either direction indicating the number of redirections which have occurred on a call.

Redirection Number

Information sent in the backward direction indicating the number towards which the call must be re-routed or has been forwarded.

Routing Label

Information provided to the message transfer part for the purpose of message routing.

Satellite Indicator

Information sent in the forward direction indicating the number of satellite circuits in the connection.

SCCP Method Indicator

Information sent in either direction indicating the available SCCP methods, if any, for end-to-end transfer of information.

Screening Indicator

Information sent in either direction to indicate whether the address was provided by the user or network.

Signalling Point Code (National Use)

Information sent in a *release* message to identify the signalling point in which the call failed.

Solicited Information Indicator

Information sent in an *information* message to indicate whether or not the message is a response to an *information request* message.

Status

Information sent in a circuit group supervision message (for example, *circuit group blocking*) to indicate the specific circuits, within the range of circuits stated in the message, that are affected by the action specified in the message.

Suspend/Resume Indicator

Information sent in the *suspend* and *resume* messages to indicate whether suspend/resume was initiated by an ISDN customer or by the network.

Temporary Trunk Blocking After Release (National Use)

Information sent to the exchange at the other end of a circuit (trunk) to indicate low level of congestion at the sending exchange and that the circuit (trunk) should not be re-occupied by the receiving exchange for a short period of time after release.

Transit Network Selection (National Use)

Information sent in the *initial address* message indicating the transit network(s) requested to be used in the call.

Transmission Medium Requirement

Information sent in the forward direction indication the type of transmission medium required for the connection (for example, 64 kbit/s unrestricted, speech etc.).

User Service Information

Information sent in the forward direction indicating the bearer capability requested by the calling party.

User-to-User Indicators

Information sent in association with a request (or response to a request) for user-to-user signalling supplementary service(s)

User-to-User Information

Information generated by a user and transferred transparently through the inter-exchange network between the originating and terminating local exchanges.

Biography

Colin Davies joined BT as an apprentice in 1964 in Gloucester Telephone Area. After a period working on transmission, he joined Network Planning dealing with the provision of private wideband systems. In 1976, he was promoted to level 2 on Special Defence Projects, and since 1980 has been involved in the specification of both public and private network signalling systems. He is currently Head of BT's CCITT No. 7 Standards Group and is responsible for all specifications (BTNRs) of CCITT No. 7 signalling in BT's inland network.

CCITT Signalling System No. 7: Transaction Capabilities

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UDC 621.395.34

Transaction capabilities (TC) is the CCITT Signalling System No. 7 protocol used, in conjunction with the signalling connection control part and the message transfer part, to convey non-circuit-related information between signalling nodes. This article gives an outline description of TC and identifies the need for such a protocol, the functions within the TC protocol and how it may be used by services; in particular, two examples of its use are described: in the support of mobile services, and operations and maintenance.

INTRODUCTION

Today's telecommunications customers have come to expect and demand more than a basic telephone service. With the advent of mobile telephones and the services offered by modern digital PABXs, it will not be long before customers demand similar services from the public switched telephone network (PSTN). For these advanced services, the signalling information must not be restricted to a telephony circuit, and therefore a non-circuit-related signalling protocol is required. Similarly, the management of complex digital networks requires fast, flexible and reliable communication such as that offered by a non-circuit-related CCITT signalling system protocol.

Rather than define its own non-circuit related signalling protocol, British Telecom is contributing significantly to a CCITT-specified Signalling System No. 7 non-circuit-related protocol known as *transaction capabilities* (TC). The first CCITT TC Recommendation will be available later in 1988 as Q.771–Q.774.

Unlike the message transfer part (MTP) and the national user part (NUP) which are currently implemented within the PSTN, TC is very much at the specification stage. TC is intended to complement rather than compete with the existing NUP or with data protocols such as X.409.

TRANSACTION CAPABILITIES OVERVIEW

The TC protocol is intended to be used for many different applications such as:

(*a*) mobile network support,
(*b*) operations and maintenance,
(*c*) network management,
(*d*) enhanced supplementary and value-added services, and
(*e*) customer-to-customer data transfer.

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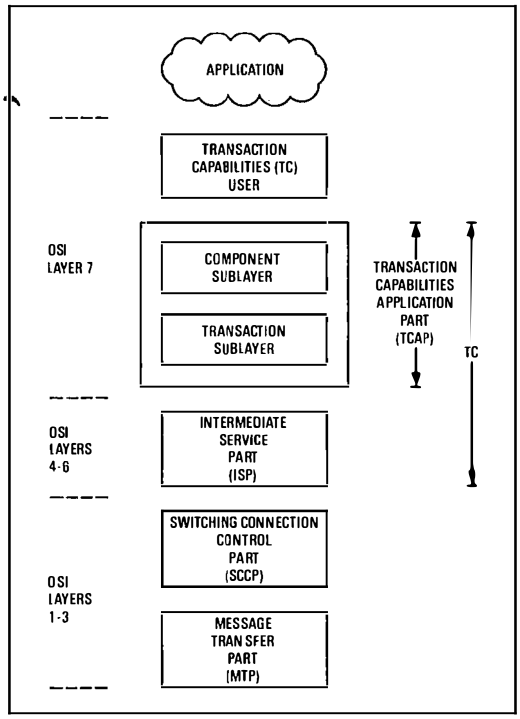


OSI: Open Systems Interconnection

Figure 1
Transaction capability architecture

To achieve flexibility for a wide number of applications, TC has been structured in line with the Open Systems Interconnection (OSI) 7-layer model[1]. (See Figure 1.)

TC uses the underlying services of the MTP[2] and the switching connection control part (SCCP)[3] described in other articles in this issue of the *Journal*. In the future, TC may be able to use other network services such as X.25.

TC itself has been sub-divided into the intermediate service part (ISP) and the transaction capabilities application part (TCAP). The ISP is required only when large amounts of data, possibly over an extended period of time, are to be transferred by using an underlying connection-orientated protocol as described in the article on SCCP. The applications currently being studied by CCITT involve relatively short or time-sensitive messages where it is not practical to set up a connection and consequently use an underlying connectionless service. For this reason, this article concentrates on TCAP rather than the ISP.

TCAP is unlike traditional telephony signalling protocols and bears some similarity to the English language and to expert systems. On expert systems, the user sets up a dialogue with the system requesting a specific action to which the system responds. The response might be a request to the user, a result (successful or unsuccessful) or an indication that the request was not understood. This dialogue continues until the problem is resolved. In the same way that sentences are made up of words, TCAP messages are made up of components. Consequently, a large number of messages can be created from a relatively small number of components. The application-specific information within a component, and the order of components within a message, are defined by the TC user; this allows TCAP to be independent of the application.

STRUCTURE OF TCAP

To provide control of the dialogue, TCAP is divided into two sublayers: the transaction sublayer and the component sublayer.

Transaction Sublayer

The transaction sublayer is responsible for initiating, maintaining and terminating communication between nodes. This communication or dialogue is known as a *transaction*; hence the name *transaction capabilities*. Although the contents of a message are application dependent, messages are grouped into one of four types:

(*a*) *Begin* This message type initiates a transaction with a distant node.

(*b*) *Continue* This message type maintains an existing transaction.

(*c*) *End* This message type terminates a transaction in normal circumstances.

(*d*) *Abort* This message type ends a transaction in abnormal situations.

In order to correlate messages and allow more than one transaction between nodes at any one time, each message has at least one transaction identity. The transaction identity is locally assigned by a node and works in a manner similar to references in letter correspondence. The originating transaction identity is a reference generated by the node sending the message, while the destination transaction identity is the node receiving the message.

Table 1 shows the transaction identities present in each message type.

TABLE 1
Presence of Transaction Identity in TC Message Types

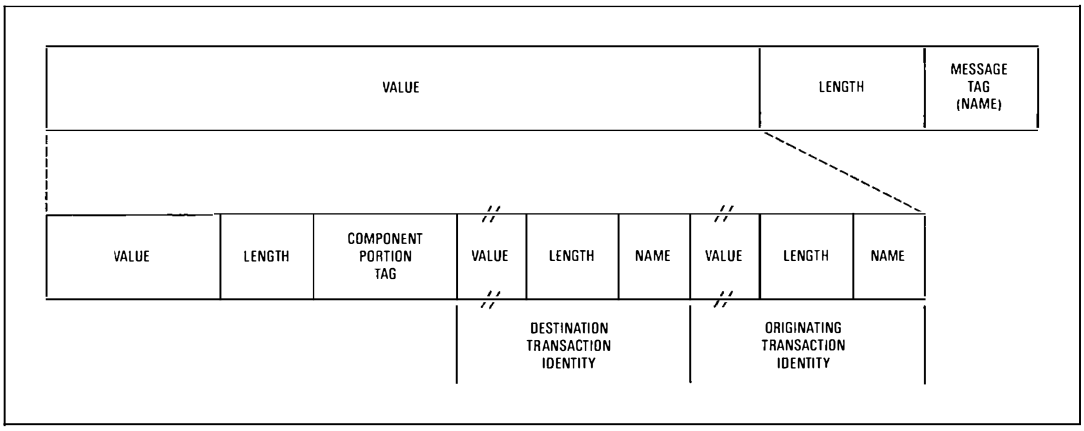
Message Type	Transaction Identity	
	Originating	Destination
Begin	Yes	No
Continue	Yes	Yes
End	No	Yes
Abort	No	Yes

All information elements within TC use the name, length, value encoding technique. Although this increases the size of messages and can increase processing overheads, these disadvantages are small compared with the flexibility offered by the name, length, value concept. Taking the originating transaction identity as an example, the first field indicates that the information element is an originating transaction identity, the next field would indicate the number of octets for the value of the transaction identity and the value field would indicate the originating transaction identity. This means that the maximum number of transactions a node can perform is not constrained by fixed length fields—a problem with the NUP, which has a 12 bit circuit identification code field.

After the transaction identities in the *begin*, *continue* and *end* message types is another information element known as the *component portion*. This information is provided by the component sublayer and is carried transparently through the transaction portion (See Figure 2).

The *abort* message type differs from the other message types in that it does not have a component portion information element.

Figure 2
Transaction portion



Instead, it has either a provider abort cause or a user abort cause. This depends on whether the transaction sublayer aborted the transaction, in which case a provider abort cause is given, or the user aborted the transaction where a user abort cause and optional user information is given.

On a new transaction, the user, via the component sublayer, provides the transaction sublayer with an originating and destination address along with the information to be transmitted. The transaction sublayer maintains a record of transaction identities and the corresponding address for use by the SCCP. Similarly, the SCCP may pass TC messages to the transaction sublayer, which maintains and correlates the transaction identities and address information before passing the user information to the component sublayer.

Receipt of an *end* message from the SCCP or an indication from the user terminates the transaction.

Component Sublayer

The component sublayer is responsible for correlating responses to requests and providing basic error detection. Although the information within a component is application dependent, components are grouped into one of five types:

(*a*) *invoke*;
(*b*) *return result—last*;
(*c*) *return result—not last*;
(*d*) *return error*; and
(*e*) *reject*.

The *invoke* component type requests information or action by the distant user. So that responses can be associated with an invocation, all *invoke* components contain an *invoke* identity. In some cases an *invoke* component type may be a response to an earlier invocation and includes a linked identity which associates it with the earlier invocation. *Invoke* component types also contain an operation code and optional parameters which are defined by the TC user (see Figure 3).

The *return result* component types not only indicate a success but may also contain a response or a result. Two *return result* component types allow results to be segmented where a single message would exceed the underlying message length capability of the underlying network layer. The only or last response is always sent in a *return result—last* component type. Any intermediate segmented response is sent in a *return result—not last* component type.

The *return error* component type is used to indicate that the associated invocation was unsuccessful. The reason the invocation was unsuccessful is indicated to the TC user by means of an error code and any associated parameters.

A *reject* component type is used by the TC user or by TCAP when information is corrupted, mis-sequenced or not understood. As this could be detected by either, the problem codes are defined within TCAP.

In some applications, a response to an invocation may not be necessary and it is the responsibility of the user to indicate this by means of a class. There are four classes corresponding to the four possible combinations of the *return result* and *return error* component types:

Class 1: Report success or failure Either a *return result* or a *return error* component must be returned.

Class 2: Report failure A *return error* component is returned if the invocation failed.

Class 3: Report success A *return result* component is returned if the invocation succeeded.

Class 4: Report neither success nor failure Neither a *return result* nor *return error* component is returned.

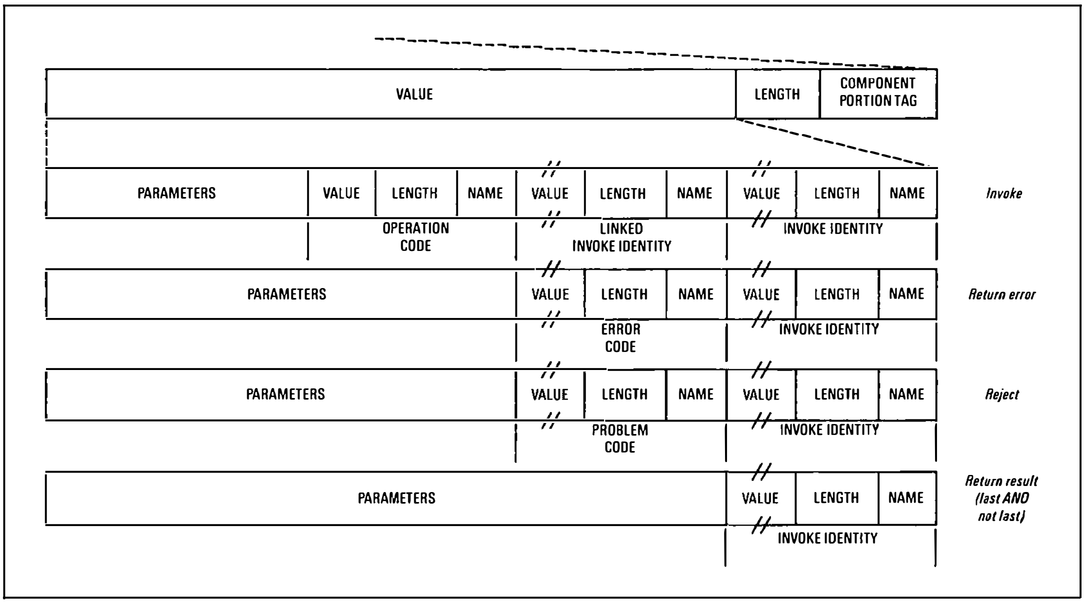
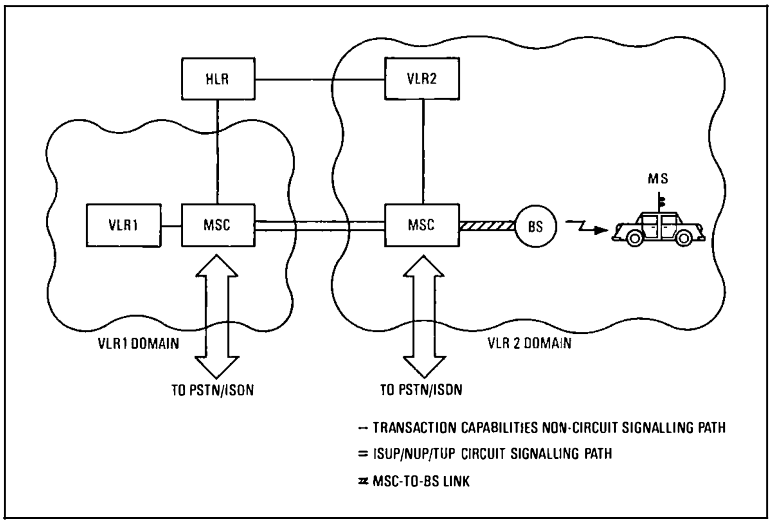


Figure 3
Component portion

The component sublayer runs a time-out for all four classes. Under normal conditions, this time-out never matures for class 1 *invoke* component types. If the time-out does mature for class 1, an error condition is detected and the user is informed. If the time-out matures for classes 2 and 3, the user is informed; this implies that the invocation was either successful or unsuccessful, respectively. A time-out is run only on class 4 invocations to associate a *reject* component with it.

The *invoke* identity is freed when the time-out matures, a *return result—last* or a *return error* component type is received.

The component sublayer receives information from the user, packaged in the correct component type, and a record of the active *invoke* identities within a transaction is kept. The user also indicates the type of message in which the components should be transmitted, and all associated components are sent in this indication to the transaction sublayer. Information from the transaction sublayer is examined by the component sublayer and all valid components passed to the user in the order received.



MS: Mobile station
BS: Base station
MSC: Mobile switching centre
HLR: Home location register
VLR: Visitor location register

Figure 4—Public land mobile network

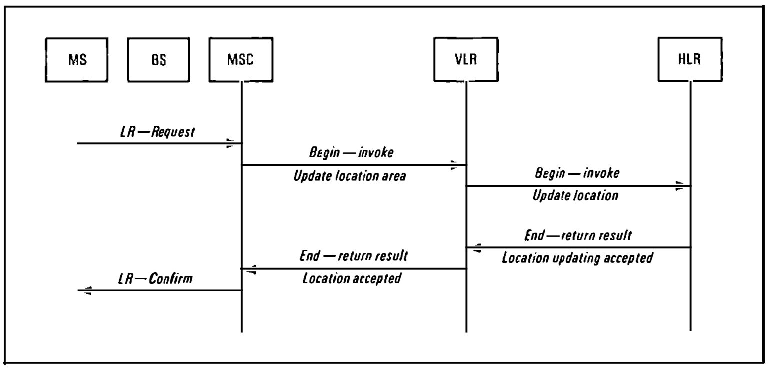


Figure 5—Updating involving both VLR and HLR

APPLICATIONS

USE OF TC PROTOCOL BY MOBILE SERVICES

As stated earlier, one use of TCAP is in the support of the signalling required for mobile services. TCAP is used to support such procedures as location registration, handover and the handling of supplementary services.

An earlier article in this *Journal* described the Cellnet cellular radio network [4]; however, for the purposes of this example, a brief outline of the mobiles network is given below.

A public land mobile network may consist of four functional entities as shown in Figure 4.

Information about the mobile customer is held in a home location register (HLR). The visitor location register (VLR) holds the information necessary to support the services required by a mobile station (MS) when roaming in the domain covered by that VLR. Whenever a MS roams into a mobile switching centre (MSC) area covered by a new VLR domain, the information required to support that MS is copied from the HLR to the VLR.

When a call is made from a PSTN to a MS, the local exchange (or transit exchange) analyses the mobile service national destination code dialled. If the number dialled has an international prefix, then the call is routed directly to an international switching centre, otherwise the HLR of the MS is interrogated. The HLR returns the roaming number of the called MS, to enable the local exchange to route the call to the MSC covering the area in which the MS is situated. The MSC, in turn, interrogates its associated VLR to determine the correct base station and frequency channel for the call.

For calls made by a mobile customer, the signalling information is detected by the base station and passed to the nearest MSC. The MSC interrogates the VLR before routing the call.

The VLR, HLR and MSC each contain a mobile application part (MAP) which holds all the operations and associated parameters needed to support the procedures required by that entity. It is these operations and parameters that are packaged and conveyed by TCAP.

Location Register Updating

On recognition of a location registration request from a MS, the MSC invokes an *update location area* operation, see Figure 5. The MAP within the MSC initiates the procedure by first assigning a dialogue and invoke identity to the operation. The dialogue identity is mapped to the transaction identity by the component sublayer. The invoke identity is used by the VLR to correlate its reply to the initial invocation.

The operation, its parameters and identities are passed to and stored in the component sublayer until a *begin* request with the same dialogue identity is received.

On receipt of the *begin* request from MAP, the component sublayer passes the *update location area* operation and associated data to the transaction sublayer in a composite *begin* request. A record of the invoke identity is kept in the component sublayer to correlate return results or return errors.

The *update location area* operation is implicitly understood as a class 1 invocation by both communicating entities; therefore, a response (of success or failure) is expected.

A time-out is started in the component sublayer; this gives the time by which an indication of success or failure is expected. The expiry of this time-out indicates a failure in the network.

The *begin* message passed to the SCCP by the transaction sublayer contains the component type, the operation and associated parameters, the transaction identity and the originating and destination addresses.

On receipt of the *begin* message at the VLR, the underlying transaction sublayer sets up a record and allocates a local transaction identity for reference within the VLR. The message is then sent to the component sublayer. The component sublayer extracts and validates the *invoke* component before passing it onto MAP. MAP, in turn, processes the *update location area* operation and associated parameters.

If it is found that the VLR has no record of the mobile station, information needed to support that MS is retrieved from the relevant HLR. The VLR therefore opens a transaction using a new transaction identity with the HLR. The operation is *update location* using an *invoke* component; associated parameters are the international mobile subscriber identity and roaming number.

The HLR in turn responds with *return result* within an *end* message, and containing those parameters necessary to support the mobile station.

The *end* message closes the transaction between the VLR and HLR.

A *return result—last* component type is sent from the VLR to the MSC in an *end* message. Parameters included in the *return result—last* component type are temporary mobile subscriber identity and the signalling encryption key. The invoke identity included in the *return result—last* component type is that assigned to the original *update location area* request.

The *end* message closes the transaction between the MSC and the VLR.

Outgoing Call Set-up

When a MSC receives an indication from a MS requesting call set-up, the MSC transmits a *send information for outgoing call set-up* operation to its associated VLR requesting all the parameters required for call set-up, see Figure 6. The operation is sent in a *begin* message and the TCAP procedure is the same as that shown for location register updating.

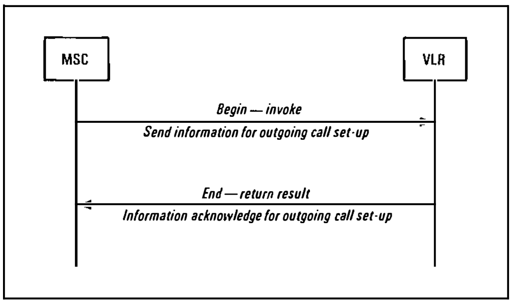


Figure 6
Procedure for information retrieval for outgoing call set-up

The VLR responds with an *information acknowledge for outgoing call set-up* result, containing those parameters relevant for call set-up. The information is sent in an *end* message, which, in turn, closes the transaction. The MSC then sets up the call via the fixed network.

Incoming Call Set-up

For a mobile terminating call, the MSC receives, via the fixed network, a connection request giving the roaming number of the MS. The MSC forwards a *begin* message containing a *send information for incoming call set-up* operation with the MS roaming number parameter to its associated VLR, see Figure 7.

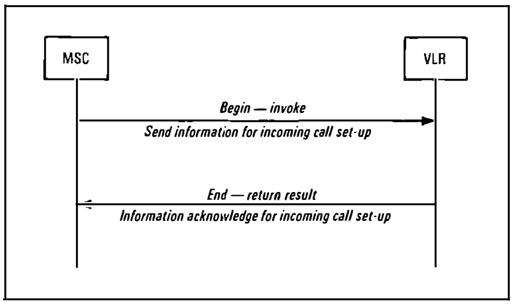


Figure 7
Procedure for information retrieval for incoming call set-up

The VLR responds with an *end* message containing an *information acknowledge for incoming call set-up* result having those parameters required for call set-up. The MSC then forwards the connection request to the MS via the base station by using information acquired from the VLR.

ADMINISTRATIVE USE OF TC PROTOCOL BY OPERATIONS AND MAINTENANCE

The above example is an illustration of how TC is used in the support of a customer service. However, the TC protocol, because of its generic nature, is not limited to supporting customer services. One example of its diversity is in its support of network administration.

The operations and maintenance application part (OMAP) of CCITT No. 7 is specified in CCITT Recommendation Q.795 and contains those procedures and functions required to manage the operation and maintenance of the signalling system, the signalling network, exchanges and other nodes supported by the signalling network. In future, it may also provide the communications interface for the telecommunications management network (TMN), and thus enable CCITT No. 7, through TC, to provide the data communications network (DCN) for TMN.

Operations and Maintenance Procedures for the Signalling Network

This area of OMAP, because of its direct impact on the performance of CCITT No. 7, has been given the highest priority for specification. The activities that have been identified are as follows:

- *Management of routing data* concerns the creation, modification, deletion, interrogation, activation and deactivation of routing data at nodes within the CCITT No. 7 network. The activity can be applied to many signalling routing relations or to a single signalling routing relation. The specification of the information elements in this function are for further study.

- *Circuit validation test (CVT)* is to ensure that the two exchanges in a signalling relation have sufficient and consistent translation data in the telephony user part and ISDN user part for placing a call on a specific circuit of an inter-exchange circuit group. This means in practice that the circuit identification code and routing label produced from input call control data is always consistent with the physical circuit that is also identified by the input data.

A CVT may be initiated by either exchange on demand or from maintenance and operating staff by a suitable man–machine interface. The test is performed before any circuit continuity test on the initialisation of a circuit to ensure that reason for failure of the continuity test can immediately be attributed to the circuit hardware. Similarly, for the CVT to give an unambiguous result, it is necessary to prove the capability of the supporting mechanisms in CCITT No. 7 (the MTP and SCCP). This is achieved by the MTP routing verification test (MRVT) and the SCCP routing verification test (SRVT).

- *MTP routing verification test (MRVT)* is used to determine whether the data held within the MTP routing tables in the CCITT No. 7 signalling network is consistent and correct. The test enables all possible signalling routes within a signalling network from the initiating node to the destination node to be proved, including an audit of all signalling transfer points (STPs) used. This procedure is applied only when the underlying MTP internal tests have been successfully completed.

The test procedure is terminated by any node in the test when that node detects an error. Should an inconsistency or failure be detected, local actions are taken and the initiator signalling point (SP) of the test alerted. Use is made of the following test messages:

(*a*) MTP *routing verification test* (RVT) is sent from one SP to an adjacent SP. Among the information contained in the message is the destination node under test, to facilitate onward routing; the initiating node and the maximum number of STPs which may be transmitted by the test.

(*b*) MTP *routing verification test acknowledgement* (RVA) is returned to the adjacent SP which sent the RVT. This indicates test success or failure with reason.

(*c*) MTP *routing verification result* (RVR) is sent from an SP to the initiating SP to indicate the success or failure of the test giving the reasons and other data required. When sent from an intermediate SP it indicates failure; when sent from the test destination it indicates success or failure as appropriate.

The MRVT procedure is initiated manually by the local operations and maintenance (O & M) system management process (SMAP) or automatically on receipt of a message for an SP which is unknown or when an RVT is received by OMAP at an SP. The message flow across the CCITT No. 7 signalling network generated by the MRVT is shown in Figure 8.

- *SCCP routing verification test (SRVT)* in a manner similar to the MRVT, checks the SCCP routing data within the CCITT No. 7 signalling network. This also results in the proving of all recognised SCCP routes from an SP and the verification of the global title translation function and data within the SCCP. The detailed specification of SRVT procedures, messages and initiation of the procedure are for further study.

- *Long-term measurement collection* deals with establishing sets of data (as defined in Recommendation Q.791) to be collected in a SP over a period of time. The procedures also enable the transfer of data when requested by a controlling function. This activity takes place periodically at all SPs in the signalling network, the data collected being transferred to an O & M centre either on demand or according to a set schedule.

The functions contained are parameter initialisation and parameter modification such as to allow or inhibit measurement collection.

The information elements in the procedure are command, controlling address and measurement.

● *On-occurrence measurement reporting* deals with the transfer and control of the measurements specified in Q.791 that are required to be reported to an O & M centre on occurrence. The record of an on-occurrence measurement is referred to as an *indicator* or *event indicator*.

The functions contained are parameter, initialisation, parameter modification (that is, create a logging file, inhibit event logging, change event reporting threshold etc.), event indicator reporting and recovery of recent on-occurrence measurement history.

The information elements required are controlling address, controlled address, effected address, command, file name, size, event type, threshold, time stamp and additional information as required.

● *Delay measurements* deal with the measuring of delays across the signalling network on both a point-to-point and loop basis. The detailed specification of functions and information elements is for further study.

● *Clock initialisation* provides a means for setting clocks in an SP for O & M and other purposes. This allows the signalling network to be synchronised to a unique time. The specification of functions and information elements required is for further study.

● *Real-time control* allows automatic or manual control in a controlled SP to be taken based on an input from the controlling SP. The controlling SP may initiate this procedure when it receives, for example, an input from an occurrence measurement reporting. The functions and information elements for this procedure are for further study.

● *Operations* provide a capability to perform operations such as activation of links, within the signalling network. The detailed specification of functions and information elements required is for further study.

Operations and Maintenance Procedures for Exchanges

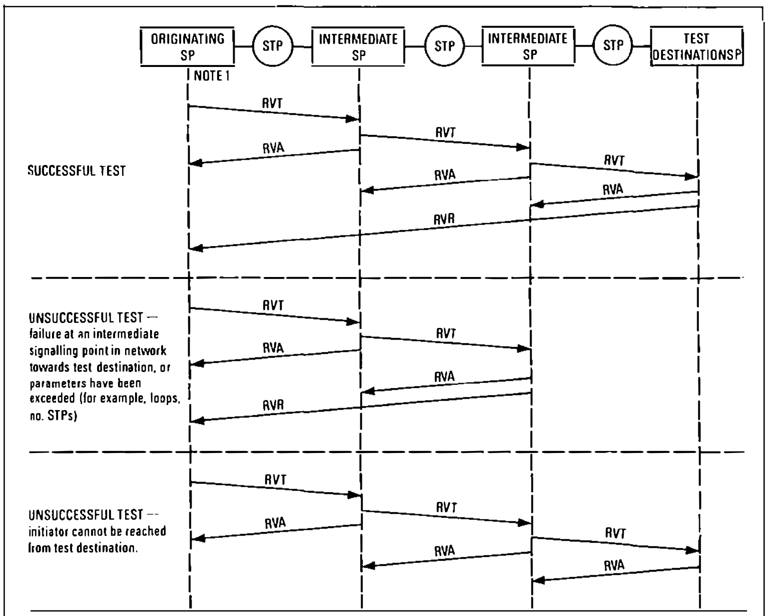
OMAP will eventually contain procedures to allow O & M control of exchanges supported by the CCITT No. 7 network. Procedures will also be specified within OMAP for O & M aspects that are common to both exchange and signalling network functions.

Support of General Operations and Maintenance Procedures in a Network

OMAP is seen as not only providing O & M support for the CCITT No. 7 network, but also, together with TC and SCCP, providing general data carrying capability for generic O & M activity in the main network. Studies are now being initiated on producing a TMN for digital networks and OMAP will provide the necessary protocol; this will enable the CCITT No. 7 network to provide the required data communications network. To achieve this, OMAP requires the following capabilities:

● *Addressing* allows the user of OMAP (for example, SMAP) to address applications in nodes in the signalling network or to address applications in nodes in any interconnected network.

● *Distribution* enables the transported information to be delivered to the appropriate O & M application within the destination node.



SP: Signalling point STP: Signalling transfer point

Note 1: Operations and maintenance part (OMAP) is located at all SPs where messages are terminated.

MTP *routing verification test* (RVT) message contains:
identifying code,
originating and test destination point codes,
threshold *N* giving maximum number of STPs allowed,
result expected for all cases, or result expected on failure identification only.

MTP *routing verification acknowledgement* (RVA) message contains:
identifying code,
list of STPs crossed by acknowledged RVT,
RVR SENT/NOT SENT indicator,
test result: success,
partial success,
detected loop,
detected excessive route length,
unknown destination point code,
RVT not sent (inaccessiable destination),
RVA received timer expired,
unknown originating point code,
test failed due to local SP.

MTP *routing verification result* (RVR) message contains:
identifying code,
test destination point code,
test result,
information field: point codes of STPs crossed on success,
point codes of STPs crossed when excessive route length detected,
no information when test destination point is unknown,
RVA not received or failure at SP,
if RVT not sent point code of inaccessible SP,
SP unknown—point code of RVA SP.

Figure 8
Examples of MRVT generated message flows across the CCITT No. 7 network

● *Connection-oriented communication* enables a connection, whether physical or logical, to be established between two signalling points. This is required when the amount of O & M information to be transported is such that the overheads required for a connectionless transaction would make data carrying inefficient. An example of its use would be for transfer of statistical data that is not real-time sensitive from an exchange to the operations and maintenance centre (OMC).

● *Connectionless communication* allows the transfer of O & M information between two SPs without establishing a connection. An example of the use of this capability is the transfer of event indicators as used in on-occurrence measurement reporting. This procedure avoids delay in establishing a connection for this real-time sensitive activity.

● *File transfer* provides the means for communication between O & M applications which require file transfers. An example of its use is the transport of files generated by long-term measurement collection.

With the progress of studies in TMN and O & M, the capabilities required in OMAP and by OMAP may well increase. However, as can be seen from those capabilities required at present, TC provides the ideal underlying support, and OMAP is a highly appropriate user of TC.

OMAP, as presently specified in CCITT Recommendation Q.795, is an application using TC that contains the MRVT. Other procedures may be required to provide O & M capability for the telecommunications network.

At present, no decision has been taken by BT to introduce OMAP into the network.

CONCLUSION

This article has shown that modern digital signalling systems are necessary to keep pace with customer and administration demands for new services. By making use of modern stored-program control exchanges, TC not only meets the customers' and administrators' needs for a powerful and flexible signalling system, but, because use is made of the underlying CCITT No. 7 signalling system which already exists in the BT network, TC has also proved to be a cost-effective solution.

With the liberalisation of the communications network and the demand for efficient and cost-effective international services by BT's customers, it is necessary for BT to be actively involved in defining internationally recognised signalling protocol standards.

The current specification of TCAP is suitably stable for administrations to offer some non-circuit-related services at an early stage. Much work still has to be done on the intermediate service part and on the service specific functions residing above TC.

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Biographies

Trevor Johnson joined BT in May 1982 after commissioning TXE2 exchanges and System X processors with GEC for nearly three years. He worked on the proving of System X digital main switching units until November 1984, when he joined the System X Requirements Authority responsible for signalling and call processing. In November 1986, he joined his current group responsible for CCITT No. 7 signalling and has concentrated on the NUP and, more recently, on TC.

Patson Anius joined British Telecom International as a Trainee Technician (Apprentice) in 1976. After three years of general training, he was transferred to the international accounting and traffic analysis equipment staff in Mondial House as a computer maintenance technician. In 1986, he gained an honours degree in Electrical and Electronic Engineering and joined his present group as an Assistant Executive Engineer with particular interest in TC.

Bryan Law joined City Area as a Youth-in-Training in 1958. He spent nine years in City and Centre Areas, firstly on Strowger maintenance, and then on television network switching duties. In 1967, he joined Telecommunications Headquarters working on main cable installation and FDM equipment commissioning. On promotion to Level 2 in 1980, he spent some time on information flow studies for System X, before joining his present group on the specification of CCITT No. 7. He is currently UK co-ordinator for CCITT studies on CCITT No. 7.

CCITT Signalling System No. 7: Testing Strategy for the British Telecom Network

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UDC 621.395.34

This article provides an overview of the background, philosophies and objectives for the testing of CCITT No. 7 (BT) common-channel signalling into the British Telecom UK network. The successful proving of the signalling system is a critical factor in BT's aim to rapidly modernise the public switched network. This article shows how BT has successfully introduced various implementations of CCITT No. 7 signalling into a live and complex network.

INTRODUCTION

Other articles in this issue of the *Journal* describe the various technical aspects of British Telecom's implementation of the common-channel signalling system known as *CCITT No. 7 (BT)*. This article describes the elements of the testing and proving of CCITT No. 7 (BT) signalling systems in order to give sufficient confidence for introduction and interconnection into the BT public switched network.

In November 1987, BT achieved its programme of a fully digitally interconnected trunk network by bringing into service the fifty-third System X trunk exchange. BT also has in excess of 600 concentrator units parented over approximately 230 processor sites using CCITT No. 7 common-channel signalling. These processor sites (local exchanges) are dual parented into the trunk network by using CCITT No. 7 signalling. BT is installing new local digital units/exchanges interconnected by CCITT No. 7 at the rate of two each working day, to give a fully integrated digital switching and signalling network by 1992.

In addition, BT has introduced CCITT No. 7 (BT) signalling between an AXE 10 international exchange and the trunk network, and is to bring into service, during early-1988, a digital international switching centre and operator services complex with an international and national interface by using CCITT No. 7 (BT) signalling; a further international switching centre interfacing the trunk network via CCITT No. 7 (BT) signalling is currently being installed and is planned to come into service during 1988. From late-1987, CCITT No. 7 will also increasingly be used from each international switching system to replace and augment the current international network. BT already has an extensive international network based on CCITT No. 6 signalling.

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It is believed that BT has the largest and most complex CCITT No. 7 common-channel signalling network in the world; it comprises an estimated 5500 CCITT No. 7 signalling links. The early experiences of the introduction and interconnection of different implementations of CCITT No. 7 signalling, and the development of appropriate testing strategies and test equipment, has provided BT with a high degree of confidence in realising the interconnection of various implementations of CCITT No. 7 into an active network.

BACKGROUND

CCITT No. 7 is a complex signalling system; its specification is provided to manufacturers for development and implementation, but any specification regardless of its completeness will be subject to slight differences of interpretation between implementors.

The problem is compounded by the fact that there will be a large number of different CCITT No. 7 realisations (see Table 1)

TABLE 1
Interworking Situations

ORGANISATION	SYSTEM			
	System X	AXE 10	5ESS	Motorola EMX
British Telecom UK Communications	Yes	Yes	Yes	
British Telecom International		Yes	Yes	
Telecom Securicor Cellular Radio				Yes
Racal Vodaphone		Yes		
Telecom Eireann		Yes		
Hull	Yes			
Manx		Yes		
Mercury	Yes			
Channel Isles	Yes			

resulting from the introduction of various switching systems within the BT network, and resulting from interconnection to networks of other licensed operators and administrations. The CCITT No. 7 signalling system is evolving and will continue to do so to support new customer and network features by means of new user parts (for example, the ISDN user part (ISUP)) or enhancements to existing user parts. At any one time, therefore, there are within each system (that is, System X, AXE 10, etc.) various versions of implementation at various stages of evolution and at different levels of development.

Switch manufacturers design their switch-recovery actions around their own system architecture, and the signalling system recovery actions are normally designed to interwork to the same implementation. However, both of these actions are independent of the signalling network and the interaction between the two must be taken into account in order to identify any possible incompatibilities.

For the above reasons, it was necessary for BT to define a coherent testing strategy that ensured that systems being introduced or enhanced:

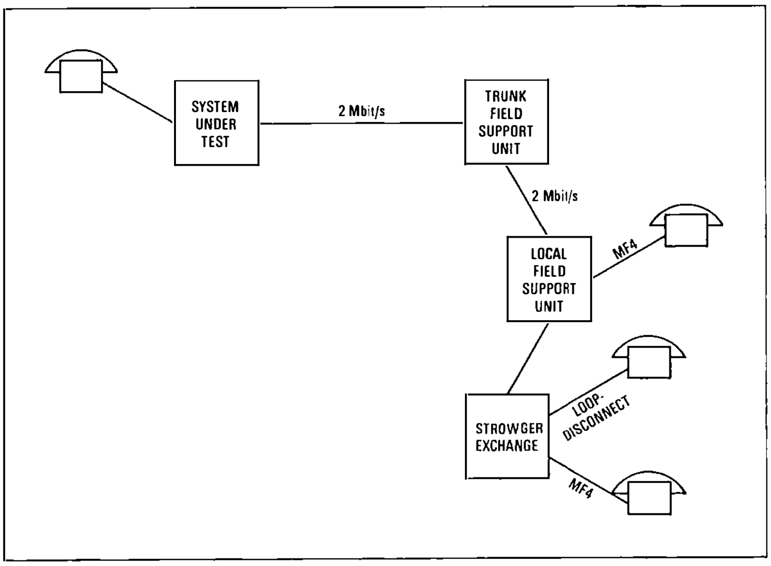
- met BT's interface specification on CCITT No. 7,
- successfully interworked with other systems in the network,
- did not jeopardise the security and stability of the network, and
- were subject to the same criteria of validation.

TESTING PHILOSOPHY

The testing philosophy agreed within BT consists of three main elements:

- test specifications,
- test strategy, and
- test tools.

Figure 1
Typical network interworking test configuration



Test Specification

Three types of testing were identified and these are described in British Telecom Network Requirement (BTNR) 954:

(*a*) interface validation testing,
(*b*) interworking testing, and
(*c*) commissioning testing.

It is important to note that the responsibility for specification conformance and validation of new systems of CCITT No. 7 lies entirely with the manufacturer. Manufacturers of BT-supplied systems undertake a comprehensive programme of testing before the system is handed over to BT; this testing makes use of BT-produced specifications and test tools.

Interface Validation Testing

The purpose of interface validation testing is to prove that a particular realisation of the interface conforms to protocols as defined in the specification and can satisfactorily work to an already proven implementation. The tests are divided into protocol, provocative and functional tests. Protocol and provocative tests are performed by using test tools developed by BT (described below) which can generate and receive messages from the system under test. Protocol tests are concerned with the validation of the sequence and contents of messages passing over the CCITT No. 7 interface under test, and to prove that these are compliant with the CCITT No. 7 interface specifications. The purpose of a provocative test is to test the function of the system under test when invalid messages or invalid values are sent to it, to check that it can handle these sequences in a controlled manner without affecting service.

Functional tests are those which use two exchanges or captive exchange models which are identical, in terms of their software and hardware, to the exchanges either being used or planned for use in the network. The objective of the tests is to prove that, in as near a live environment as is possible, the realisation of signalling system CCITT No. 7 used at each exchange is fully compatible with the version used at the other exchange. See Figure 1.

In effect, this testing provides BT with a high degree of confidence that a product is likely to be acceptable to interface to the network.

Interworking Tests

The purpose of interworking testing is to ensure that a new exchange system incorporating CCITT No. 7 signalling interworks with the rest of the network over its CCITT No. 7 links. These tests are made into the BT network from the particular exchange type requiring connection by using test traffic to exercise the necessary functions of the CCITT No. 7 interface. There might be tests which could endanger the service provided by an operational exchange carrying live traffic and therefore these interworking tests are performed on an exchange not yet carrying live traffic or on a non-operational exchange (captive model).

The objective is to pass at least one test call from each exchange type, each signalling type and customer type connected in the existing network to the system under test via the CCITT No. 7 signalling system. Testing normally takes place at the first network exchange at which the system under test first connects to the BT network with CCITT No. 7. Some of the tests are repeated at subsequent connections to the BT network.

There are also tests of an operations and maintenance, provocative, and overload nature designed to prove that actions on an exchange at one end of a CCITT No. 7 link do not have undesirable effects upon a system at the other end of the link. These tests are performed on operational exchanges not carrying live traffic or on a non-operational exchange or model.

Commissioning Tests

The purpose of commissioning tests is to allow CCITT No. 7 signalling routes to be added to an exchange (which may or may not be in-service) or to allow changes to be made to existing signalling routes and the network. The tests prove that the correct data has been loaded in the exchanges concerned so that calls can be correctly established, and simple tests are performed to prove that the basic security functions within the signalling system operate successfully.

TEST STRATEGY

BT has produced a single 'generic' test specification for CCITT No. 7 (BT) signalling (BTNR 954) which covers the complete set of tests for interface validation, interworking and commissioning testing; bilateral discussions are required between respective interconnect parties to agree a subset of tests from the generic set appropriate for the specific implementation and interconnect situation. These would exercise those protocols appropriate to the interconnect to give an administration a high degree of confidence that the system would perform satisfactorily when carrying live signalling traffic.

For new implementations, comprehensive testing is performed to prove the total implementation of CCITT No. 7 signalling protocols; for enhancements, an agreed level of retest and regression testing is performed on captive units prior to loading onto a working live system. This is to give the level of confidence necessary before loading the new software or installing new or modified hardware for trialling the build on a working unit prior to interconnection to the network.

The first connection of a new system to the network requires a comprehensive set of interface validation, interworking, and commissioning tests to be conducted. For subsequent connections of that system to the network only a limited subset of interworking tests and commissioning tests need be done. Also, if a new system has been introduced to the network by proving to one type of existing exchange in the network (say System X), then its connection to a second existing exchange in the network (say AXE 10 local) does not require all the tests to be repeated. Only a limited set of interworking and commissioning tests need be done. Any other course of action would result in every exchange type being tested to every other exchange type, and this would lead to a never ending programme of testing as new systems and variants of existing systems are introduced into the network.

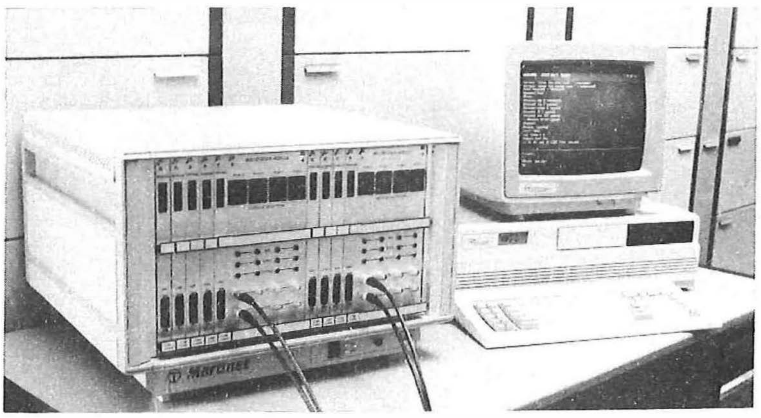
TEST TOOLS

Testing all protocols of a new signalling system specification, including provocative actions resulting from out-of-sequence or corrupted sequences, is a very extensive activity and is specially difficult without the proper test equipment. Testing a complete system as complex as CCITT No. 7 is thought to be impracticable without complex flexible protocol testing equipment. Implementations of CCITT No. 7 do not have the capability to generate or receive corrupt, out-of-sequence or provocative messages/protocols to test reactions on receipt or generation of such messages or protocols. Implementations can contain dormant software faults or protocol incompatibilities that only become apparent on interconnection to other implementations. Therefore, specialised testers were considered necessary to perform this level of flexibility of testing.

BT Tester—Martinet

BT has developed a CCITT No. 7 tester called *Martinet* (Figure 2) which is capable of exercising all Level 2, 3 and 4 protocols, and is capable of generating messages in any

Figure 2
Martinet



sequence to test how the product would perform under mis-sequencing and fault conditions. The use of this tester has proved invaluable to BT in the testing of systems before interconnection or going live and has allowed interworking difficulties to be resolved before live interconnect is established. Martinet is designed to enable a large amount of testing to be carried out in a short time. Tests of both normal and, possibly more importantly, provocative signalling protocols can be performed.

As indicated in earlier articles, the operation of CCITT No. 7 can be expressed as sequences of messages between the systems in a network. Within each exchange system, CCITT No. 7 is divided into levels, each of which communicates with the corresponding levels of other exchange systems. Martinet is capable of stimulating a network of exchange systems and performing many possible messages, both normal and abnormal, at all levels. It is therefore possible to test the protocols and facilities of the message transfer part, telephony and ISDN user parts, signalling connection control part and transaction capabilities.

Each test or message sequence to be performed is written as a test script. This is a series of commands to send messages, check the receipt of messages, start and stop timers etc. as needed to test the required message flow. The values of the fields within the messages are easily alterable to values appropriate for the test concerned. See Figure 3.

In addition to performing message sequences, Martinet is capable of generating high signalling traffic loads, of several hundred messages per second on each link to be handled by the system under test.

The results of a test run—messages sent and received, incorrect field values, expired time-outs, messages lost or mis-sequenced etc.—can be output to screen, disc or printer. The amount of data which is displayed is selectable; this enables the output of information to be tailored to meet specific requirements.

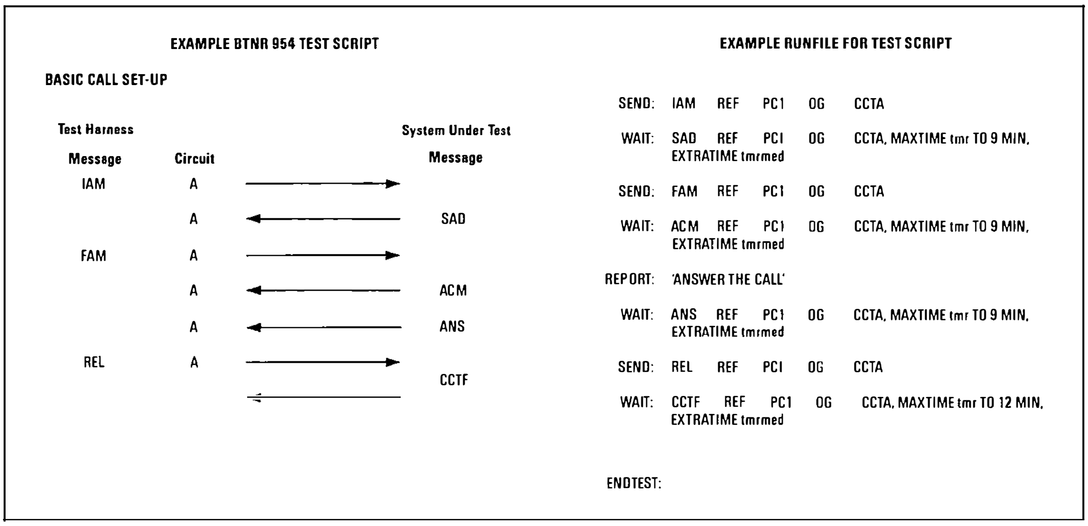
FUTURE TESTING REQUIREMENTS

Testing New Implementations in a Fully Interconnected Network

Currently, enhancements or new implementations are introduced into the network with a limited number of interconnected signalling and traffic routes to the rest of the network. This was allowed by the use of exchanges that were either installed, but not carrying live traffic or had low traffic levels. With the current plans for off-loading analogue traffic, the entire trunk network traffic should be carried digitally by 1989, and all of the digital local exchanges will be in place by 1992. This implies that a lightly loaded node with limited interconnections will not be available to be used as a trial system for the introduction of more enhanced versions of CCITT No. 7 signalling. The current strategy will therefore need to be modified to cater for this situation in order to give adequate confidence that a new implementation of CCITT No. 7 signalling does not make the total network unstable on its introduction.

A proposal currently being examined by Network Systems Engineering (Switching and Signalling) Department is to use available captive exchanges. These will be used initially for the interface validation and interworking tests specified in BTNR 954. Systems which have gone through BTNR 954 tests will then be subject to a period of network trial by being loaded on these captive models, which will have a limited number of connections to

Figure 3
Example BTNR954 test script and runfile



IAM: *Initial address* message
SAD: *Send all digits*
FAM: *Final address* message
ACM: *Address complete* message
ANS: *Answer*
REL: *Release*
CCTF: *Circuit free*

In the runfile, the information following the message refers to the particular circuit; that is, PC1: point code 1; OG: outgoing; CCTA: circuit A. MAXTIME and EXTRATIME refer to software timers specified in the runfile. 'tmr' refers to timer, and 'tmrmed' to timer medium.

the digital public switched network. This will ensure that any problems in the new implementation which could lead to instability of the network are quickly identified and will have only a limited adverse effect on the network. This will also ensure that disruption to customer service is minimised or avoided.

Testing of New User Parts

The current test specification (BTNR 954) contains tests only for the national user part and the message transfer part. With the future introduction of transaction capability and the signalling connection control part, as described in other articles in this *Journal*, new test specifications and enhancements to test tools will be introduced.

SUMMARY

CCITT No. 7 is a complex signalling system which requires extensive validation and testing before it can be confidently introduced into the public switched network. BT has adopted a philosophy of testing CCITT No. 7 which is consistent with the requirement to have a number of various switch types in the network and the need to subject each system to a uniform criteria of validation. The test philosophy has resulted in the formulation of a test strategy, the production of test specifications, and the development of specialised test tools. This has allowed the successful introduction of the world's largest and most complex CCITT No. 7 signalling network.

ACKNOWLEDGEMENTS

The authors would like to thank the Research and Technology Martinet development group at Martlesham Heath for technical advice.

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Biographies

Derek Ritson joined the Post Office as a Youth-in-Training. After a period on internal construction, he joined Headquarters Development Department and was employed on the development of early electronic telephone exchanges. He was then involved in CCITT studies into levels of impulsive noise induced in switching systems and helped to draft the CCITT Recommendations on impulsive noise design limits. In 1976, he was attached to the System X development team working on the digital main network switching unit. He was promoted to Level 3 in 1985 as Head of Trunk System X Requirement Authority with additional responsibilities on CCITT No. 7 (BT) interconnect testing. During 1986/87, he provided a digital network evaluation consultancy to the Belize Telecommunication Authority on behalf of Overseas Division. He is now Head of Group in Network Systems Engineering (Switching and Signalling) with responsibility for CCITT No. 7 testing and network coherence testing for System X, AXE 10 and 5ESS-PRX systems.

Sohail Qadri joined BT as an Assistant Executive Engineer in 1982 to work on the specification and system design of call processing for System X. He was promoted in 1984 to work on CCITT No. 7 interconnect testing. He also had an involvement with the specification of the CCITT No. 7 interface for the 5ESS-PRX system. Recently, he has moved to work on the intelligent network database project.

Glossary of Abbreviations

ACM	*Address complete* message
ADPCM	Adaptive differential pulse-code modulation
AK	*Data acknowledgement*
BCD	Binary coded decimal
BES	Business exchange services
BT	British Telecom
BTNR	British Telecom Network Requirement
CC	*Connection confirm*
CCITT	International Telegraph and Telephone Consultative Committee
CDA	Called address
CGA	Calling address
CIC	Circuit identification code
CLI	Calling line identity
CPI	Call path indicator
CPM	*Call progress* message
CR	*Connection request*
CREF	*Connection refused*
CUG	Closed user group
CVT	Circuit validation test
DAN	Database access node
DASS	Digital access signalling system
DDSN	Digital derived services network
DMSU	Digital main switching unit
DPC	Destination point code
DT1	Data form 1
DT2	Data form 2
EA	*Expedited data acknowledgement*
ED	*Expedited data*
ERR	*Protocol data unit error*
FIC	Facility indicator code
FISU	Fill in signal unit
GT	Global title
GTR	Global title routing
HLR	Home location register
IA5	International Alphabet No. 5
IAM	*Initial address message*
IFAM	*Initial and final address* message
ISDN	Integrated services digital network
ISP	Intermediate service point
ISRM	*Initial service request* message
ISUP	ISDN user part
IT	*Inactivity test*
LSSU	Link status signal unit
LSU	Local switching unit
MAP	Mobile application part
MCI	Malicious call identification
MRVT	MTP routing verification test
MS	Mobile station
MSC	Mobile switching station
MSU	Message signal unit
MTP	Message transfer part
NI	Network indicator
NUP	National user part
O&M	Operations and maintenance
OMAP	Operations and maintenance application part
OMC	Operations and maintenance centre
OPC	Originating point code
OSI	Open systems interconnection
OSS	Operator services subsystem
PCR	Point code routing
PSTN	Public switched telephone network
PTO	Public telecommunications operator
RI	Routing indicator
RLC	*Release complete*
RSC	*Reset confirm*
RSLD	*Released*
RSR	*Reset request*
RST	Route-set test
RVA	*Routing verification acknowledgement*
RVR	*Routing verification result*
RVT	*Routing verification test*
SAM	*Subsequent address* message
SCCP	Signalling connection control part
SCMG	SCCP management
SHP	Service handling protocol
SIB	Status indication busy
SIE	Status indication emergency
SIF	Signalling information field
SIM	*Service information* message
SIN	Status indication normal
SIO	Service information octet (Level 3 function)
SIO	Status indication out of alignment (Level 2 function)
SIOS	Status indication out of service
SIPO	Status indication processor outage
SLC	Signalling link code
SLM	Signalling link management
SLS	Signalling link selection
SLT	Signalling link test
SMAP	System management process
SMH	Signalling message handling
SNM	Signalling network management
SOG	*Subsystem out-of-service grant*
SOR	*Subsystem out-of-service request*
SP	Signalling point
SPC	Stored-program control
SRM	Signalling route management
SRVT	SCCP routing verification test
SSA	*Subsystem allowed*
SSN	*Subsystem number*
SSP	*Subsystem prohibited*
SST	*Subsystem status test*
STM	Signalling traffic management
STP	Signal transfer point
TC	Transaction capabilities
TCAP	Transaction capabilities application part
TFA	*Transfer allowed*
TFC	*Transfer controlled*
TFP	*Transfer prohibited*
TFR	*Transfer restricted*
TMN	Telecommunications management network
TPUP	Test process user part
TUP	Telephony user part
UDT	*Unitdata*
UDTS	*Unitdata service*
VLR	Visitor location register
VPN	Virtual private network

THE INSTITUTION OF BRITISH TELECOMMUNICATIONS ENGINEERS

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

General Secretary: Mr. J. H. Inchley, NPW2.1.6, 4th Floor, 84–89 Wood Street, London EC2V 7HL; Telephone: 01–250 9816.
(Membership and other enquires should be directed to the appropriate Local-Centre Secretary as listed on p. 211 of the October 1987 issue.)

SUBSCRIPTIONS TO THE INSTITUTION AND TO THE FEDERATION OF TELECOMMUNICATIONS ENGINEERS OF THE EUROPEAN COMMUNITY (FITCE)

The Council of the Institution has determined that, with effect from 1 May 1988, the annual subscription for Membership of the Institution will be increased from £4·92 to £6·60, or by 14p per month.

The annual subscription for Membership of FITCE remains at £5·00.

MEMBERSHIP BROCHURE

The Institution has produced a brochure outlining the benefits of Membership of the Institution. If you are not currently a Member and wish to know more about the services and facilities, or know of a colleague who might be interested, please contact your Local-Centre Secretary for a copy.

AMENDMENTS TO THE RULES OF THE INSTITUTION

Institution Rules concerning the presenting of Local Awards in respect of lectures given by Members of the Local Centre, and the presenting of National Awards have been amended. The changes have been certified by the Chairman of Council as clarification of the existing Rules, and become effective forthwith. The changes are as follows:

Rule 47

'Lectures of a sufficient standard given by a Member of a Local Centre shall be considered by that Centre for a Local Centre Award, which will consist of a cash prize of such a sum as is determined from time to time by Council, accompanied by an Institution Scroll. No Centre shall make more than one Local Award in a Session.

Lectures reaching the required standard given by Members of a Centre other than the Local Centre shall be recommended to the National Awards Committee for consideration for a National Award, of which no more than two may be made in any one Session. In the case of a lecture unsupported by a paper, this shall consist of a Medal and an Institution Scroll. Where a lecture is supported by a written paper, the National Awards Committee may recommend one major Institution Award per Session, which shall consist of a prize in a form other than cash to the value of not more than £500, accompanied by a Medal and Institution Scroll.

Medals and Scrolls for the National Awards shall be presented at the Annual General Meeting of the Institution at the end of the succeeding Session.'

OFFICERS OF THE INSTITUTION

At a recent Meeting of Council in Westward Centre, Council created a new post of Secretary, FITCE, charged with fostering and developing interest in FITCE with the IBTE. Dr. P. Bailes, Deputy Director Networks, was formally appointed to the post. The following nominations were also endorsed:

Honorary Treasurer: Mr. P. Allen, replacing Mr. R. New.

Assistant Secretary, Finance: Mr. J. White, replacing Mr. J. E. Short.

Assistant Secretary, FITCE: Mr. T. K. Ray, replacing Mr. P. A. P. Joseph (effective immediately).

Secretary/Treasurer, *BTE Journal*: Mr. C. Fennell, replacing Mr. B. Farr.

The posts will, with the exception of the Assistant Secretary, FITCE, become vacant at the end of the current Session with the resignation of the present postholders. Grateful thanks are due to the departing Officers, who have each made significant contribution to the successful and smooth running of the Institution.

NEW ASSISTANT SECRETARY (FITCE)

Future correspondence relevant to FITCE matters should be addressed to the new Assistant Secretary (FITCE): Tapash Ray, UKC/NPW4.1.6, 3rd Floor, Wing D, The Angel Centre, 403 St John's Street, London EC1V 4PL; Telephone: 01–239 0810.

RETIRED MEMBERS

The following Members have retained their membership of the Institution under Rules 10(*a*) and 13 (*a*).

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H. Yearl	191 Tamworth Road, Kettlebrook, Tamworth, Staffordshire B77 1BT

J. H. INCHLEY
Secretary

The Federation of Telecommunications Engineers of the European Community

The Federation des Ingénieurs des Télécommuncations de la Communauté Européenne (FITCE) was established by European telecommunications engineers to improve the standing of engineers throughout the EEC, to activate friendships across the frontiers to the benefit of the public telecommunications service and to suggest means of resolving mutual technical problems in a national and uniform way.

FITCE was formally constituted as a chartered institution in October 1961 with six founder member countries. Its Rules are based on the concept that members admitted to FITCE from different countries should go through their national association of telecommunications engineers and should, as far as possible, have a similar level of responsibility and common work interests. Full membership was offered to those holding a responsible position in a public telecommunications service who had been educated to university level.

There are now 12 member countries in FITCE including the UK, which is represented by the IBTE:

West Germany	Denmark
Belgium	Spain
France	Greece
Italy	Ireland
Luxembourg	Portugal
Netherlands	UK

To realise its objectives, FITCE organises a technical Congress which is held in a different European city each year. Each Congress is devoted to a technical theme with the presentation of papers followed by discussion. Multilingual translation facilities enable all those present to participate. Some time is also devoted to technical visits and cultural events and a programme of visits is also organised for the partners of Congress members.

The 1987 Congress, the twenty-sixth, was held in Athens, Greece. As usual, it was a prestigious occasion attended by nearly 600 members and accompanying persons. The theme chosen for the Congress was 'European Telecommunications Objectives'. Thirty papers were presented including papers from Tony Valdar (Private Circuit Services, British Telecom UK Communications), and Peter Jones (Central Territory, British Telecom UK Communications). At the end of each Congress, an award is given to the 'best paper': Peter Jones was the worthy recipient on this occasion.

The 1988 Congress is to be held in Cork, Ireland, and IBTE/FITCE members should have already received advanced notification. Further information on the Congress will be given in the *FITCE Revue* magazine, but members wishing to attend may contact Jon Inchley, IBTE Secretary, for further advice.

Members may also wish to note that FITCE is planning to hold its 1990 Congress in the UK. Planning has already begun in BT to ensure that the event compares well with the efforts of our European colleagues. More detailed information will be announced in due course.

A. B. WHERRY
Membre de Comitê de Direction, and Vice-Chairman, IBTE Council

Institution of British Telecommunications Engineers

Associate Section National Committee

NATIONAL PROJECTS COMPETITION

The Associate Section's National Projects Competition was started in 1974 with a poster design competition. This was followed in 1975 with one to design a new membership form. In 1976, the first project competition of a more technical nature was announced, the object being to design and build an electronic quiz timer and scorer. Since then, the competition has been held every year, some with a fixed subject, others being left open.

With the advent of home computers in the early-1980s, computer software entries started to appear. This made the judging much more complex; it was difficult enough trying to judge entries of electrical projects against mechanical ones. Consequently, for the 1983 competition, the judging panel included someone from the Data Processing Executive. In 1984, London Centre offered an additional trophy to the National Committee. This was accepted, and the projects competition was divided into two: the E. W. Fudge Trophy for hardware projects and the London Trophy for software projects.

The competitions are open to all members of the Associate Section and, except when there is a 'theme', any project can be entered. As examples of the range of entries received, previous winners have included a TXE4 simulator, packet-switching floor alarm, hot-metal castings, quiz timer/scorer, Edgeley electronic queueing equipment, auto-dialler, membership program, to mention but a few. Entry to the competitions does not exclude members from including the project in any BT-sponsored competition.

There follows a brief description of last year's entry from Edinburgh Centre, which, incidentally, won both the London and Fudge Trophies, entitled *Digitally Interfaced Call-sending Equipment* (DICE) by Steven Leask and David McLean.

Digitally Interfaced Call-Sending Equipment

S. LEASK, and D. McLEAN

INTRODUCTION

This article describes the concept and development of interface circuitry and associated software designed to control the operation of test-call sending equipment.

Primarily, the interface, known as *digitally interfaced call-sending equipment* (DICE), allows a test-call sender to be linked to a computer in such a way that the call sending can be controlled from that computer. The project was begun as an aid for the Edinburgh Woodcroft report-and-investigation point to accelerate the localisation of faults based on results produced by the Edinburgh measurement and analysis centre (MAC).

Previously, MAC failures were processed on a day-to-day basis, with local units receiving a daily print-out of the previous day's results. In some situations, this meant that the figures could be up to 24 hours out of date, which left a significant gap in the procedure. It could be seen that it would be beneficial to maintenance staff if these results could be analysed and acted upon on a 'real time' basis.

Further to this idea, it was suggested to look into the possibility of designing a system which could analyse the MAC failures as they occur and, if necessary, automatically initiate test-call sending on troublesome routes. In order to achieve this, it was necessary to construct a suitable item of equipment to interface the processing equipment to the test-call sender. The original development work was carried out on equipment already available in Woodcroft, namely a DMS Hi-Net computer system and a particular test-call sender (TRT284A). Further development since that time has shown that other processors (for example, Merlin/IBM PCs) and testers (for example, TRT285A) can also be used.

SYSTEM OPERATION

Figure 1 shows a block diagram of the current system in use. The DICE interface is shown connected to the parallel

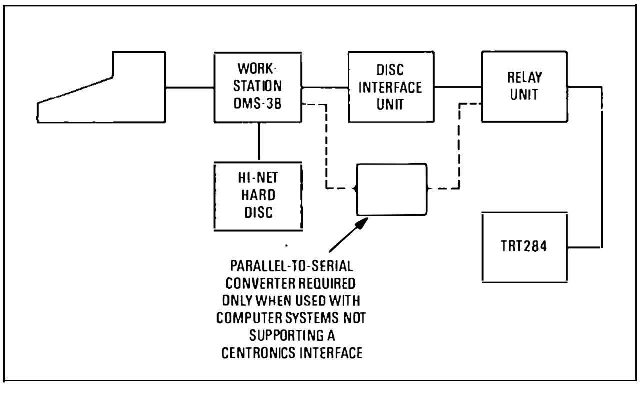


Figure 1—DICE system configuration

port of a Hi-Net workstation by means of a ribbon cable. The interface is then cabled to the test-call sender via a switching unit containing relays which duplicate the functions of various keys on the call sender. All manual input is done at the terminal, is menu driven and is fully user friendly.

Data sent from the terminal is decoded by the interface (see Figure 2) to operate a relay to simulate a required key operation. The binary, hexadecimal and output values of the data being decoded are displayed on light-emitting diodes (LEDs) on the front of the interface unit.

The interface had been designed as a separate 'stand alone' unit (see Figure 3) capable of being controlled by a wide range of software-based applications. It consists, essentially, of a series of 16 binary-controlled switches, the binary data being output by the DMS Hi-Net in parallel form as an 8 bit word. As only sixteen variables are required, only the four least significant bits (LSBs) are decoded, the remainder being either ignored or used to drive another interface unit. For example, for the word 1011 0101, the LSBs 0101 are decoded by the interface, and 1011 is ignored.

From this, it can be seen that the values 0 to F (hex) can be obtained from the 16 permutations of binary values 0000 to 1111. Further expansion could utilise the four unused bits to select, for example, one of up to 16 different call senders if a multiple testing system was required; that is, if more than one test-call sender was required to be controlled via a single interface at any one time.

The 4 bit characters used in the prototype are detailed in Table 1.

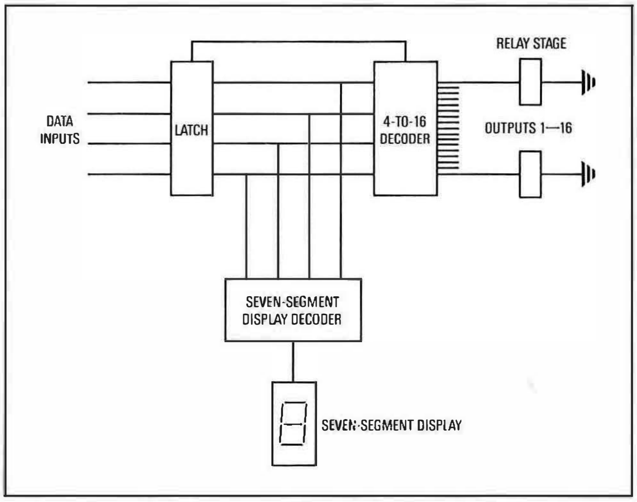


Figure 2—Block diagram of interface circuitry

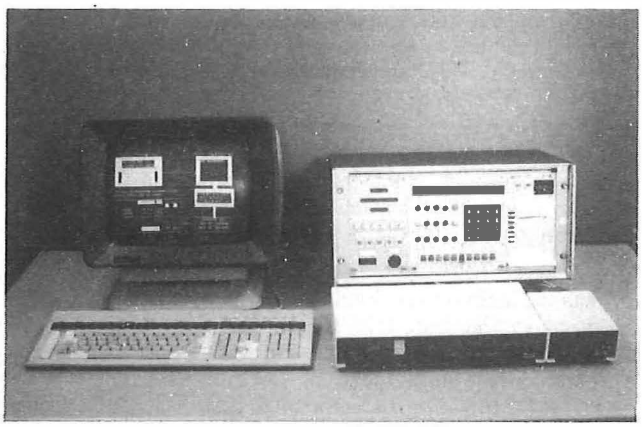


Figure 3—DICE interface units (foreground, right) shown with Tester 284A (back, right), VDU and keyboard

TABLE 1
DICE Control Characters

Character	Binary 0–7	Oct.	Dec.	Hex.	DICE operation
0	00110000	060	048	30	Digit 0 (ZERO)
1	00110001	061	049	31	Digit 1 (ONE)
2	00110010	062	050	32	Digit 2 (TWO)
3	00110011	063	051	33	Digit 3 (THREE)
4	00110100	064	052	34	Digit 4 (FOUR)
5	00110101	065	053	35	Digit 5 (FIVE)
6	00110110	066	054	36	Digit 6 (SIX)
7	00110111	067	055	37	Digit 7 (SEVEN)
8	00111000	070	056	38	Digit 8 (EIGHT)
9	00111001	071	057	39	Digit 9 (NINE)
J	01001010	112	074	4A	Null value
K	01001011	113	075	4B	Dash (-)
L	01001100	114	076	4C	RESET key
M	01001101	115	077	4D	ROUTE STORE key
N	01001110	116	078	4E	STEP ROUTE key
O	01001111	117	079	4F	START key

The above character set was chosen for no other reason than to give a series of LSBs in the range 0–F (hex).

SOFTWARE

The software used to drive the DICE interface is written entirely in Microsoft BASIC 80, although it has been compiled and linked into object code. The program resides on a Hi-Net system running the HiDos 6.1C multi-user operating system. The main functions of the software are:

(*a*) to read numbers and parameters from a data file,
(*b*) to store the relevant test numbers in the Tester 284A, and
(*c*) to create a file of currently stored numbers.

These functions are described below:

(*a*) The Edinburgh MAC uses a GEC 2050 mini-computer to measure the performance of telephone exchanges within the District. The teletype output from this computer is fed into the Hi-Net system and processed every morning at approximately 07.30 hours. This produces an ASCII file containing call failures detected over the previous 24 hours. The file is accessed by DICE software which extracts the telephone number and information concerning the type of call failure. In the event of the data file containing insufficient information, the backup file is read; this contains test numbers of 'known troublesome routes' through the exchange.

(*b*) The digits are output on the Centronics parallel port along with various control codes for RESET, START SENDING, ROUTE STORE etc. Because of the speed of operation of the DICE interface, the software introduces a delay between each output code.

(*c*) The program produces an output file containing information about when the Tester 284A was last programmed and which 16 numbers are stored.

FUTURE DEVELOPMENT

Since the original project, the DICE concept has been applied to system data-build testing. A Tester TRT285A has been modified and a solid-state digital interface installed. This allows bi-directional transfer of data between the tester and a Merlin personal computer. It can be used to test the integrity of system data after bulk reloads. The complete system runs unsupervised, checking every national number group code for plant defects, plant congestion and correct tariff application. This job was previously performed manually and took several days to complete.

Notes and Comments

INCREASE IN SUBSCRIPTION RATES

The price of the *Journal* to British Telecom and British Post Office staff will be increased to 90p per copy from the July 1988 issue.

BT NEWS MISCELLANY

BT is supplying in Kenya a network of 113 digital electronic UXD5 telephone exchanges to serve rural communities. The exchanges and associated transmission equipment are being supplied at a cost of more than £30M under a contract between the Kenyan Telecommunications Authority and the London-based firm Communications Supplies Ltd. (CSL). As part of the project, BT will supervise the installation of the equipment and train Kenyan telecommunications engineers to operate and maintain it.

A CONTRACT valued at £1·3M has been awarded to British Telconsult, BT's overseas consultancy service, to develop and improve telecommunications in Sierra Leone, West Africa. The contract, funded by the European Economic Community, was won against strong competition from German, French and Italian consultancies.

Under the project, which is being carried out for the Sierra Leone National Telecommunications Company, British Telconsult is responsible for the overall management of some 20 separate equipment contracts, including the provision of a new digital exchange for the capital of Freetown and digital junctions for the greater Freetown area.

Other major tasks cover the rehabilitation of Sierra Leone's national trunk system, and the introduction of solar power at remote radio sites. A wide range of telecommunications, power and environmental control plant will also be refurbished.

IN JANUARY, BT's Value-Added Services Division announced a major restructuring of its data services activities in an enlarged Dialcom Group. This will have four marketing arms, serving the US, the UK, Europe and other countries world-wide. Mr. John Morris, president of the US-based Dialcom, Inc., has been appointed chairman of the new international group, which, as a combined unit, will employ more than 900 people with initial annual revenues of $100M.

The new Dialcom Group, due to be fully operational in April 1988, will combine Dialcom Inc; Telecom Gold, the UK's prime public messaging service; BT's value-added business services, which include Prestel; and the computer network services division which provides technical support for the UK operation.

BT has placed further orders on Thorn Ericsson for AXE 10 digital exchanges worth in excess of £20M and representing a total of 226 000 lines for its local exchange replacement programme.

BT is to establish a £5M centre of excellence in advanced technology in Scotland after its decision to site its latest Systems and Software Centre in Glasgow. The new centre—the fifth to be established by Research and Technology Executive—will employ graduates from Scottish universities and polytechnics to meet BT's continually expanding need for expertise in developing high-technology systems.

These centres undertake the design and development of computer-based systems and their associated software for other parts of BT. About 15 staff will be employed when the Glasgow centre starts work in April this year. This is expected to grow to 60 by 1990 and eventually to more than 100.

BT has awarded contracts worth over £12M to Landis & Gyr Communications Ltd—part of the Landis & Gyr group—for the supply of Payphones 100 and 200 Mark II. The Payphone 100 is a compact table-top coin-operated payphone that can be used by owner or renter as a normal telephone. The Payphone 200 Mark II is a wall-mounted version that provides all of the features of the Payphone 100, but with a larger cash container appropriate for the higher revenue environment.

CONTRACTS worth approximately £5M have been won by BT to install data cable networks in 1220 branches of Lloyds Bank. The networks are being supplied as part of the bank's £570M information technology project designed to streamline office systems in the bank's UK branches. As part of the project, Lloyds Bank is to install approximately 28 000 terminals and controllers. In turn, these will link the terminals to the bank's new nationwide integrated voice and data network being set up under the project, to give access to more than 6000 computer devices.

The cabling is planned to act as a token-ring local area network capable of operating at rates up to 16 Mbit/s. BT is also installing a large patch frame in each branch. This will be the hub of the cabling network in the branch, to give full flexibility in the interconnection of terminals and other equipment with controllers. Cabling has already been installed in 320 branches under an earlier contract. BT has been contracted to cable a further 900 branches. Work is expected to be finished by the end of September; on completion, BT will have cabled about half of Lloyds Bank branch sites in the UK.

BT has announced a joint venture with Systems Designers plc to market secure administrative and messaging computer systems. The new company—Secure Information Systems Ltd. (SISL)—already has a portfolio of major contracts from the Minstry of Defence, civil departments and commerce.

A NEW range of science computer software packages for science classes in secondary schools is featured in BT's 1988/89 Education Resource catalogue. The software, aimed at 15–18 year olds, gives pupils real-life problems to solve and is intended to bring some industrial applications into school syllabuses. As well as a range of brochures, posters and work packs, the catalogue gives details of educational videos available for loan or purchase. The materials are designed to suit a wide ability range at both primary and secondary levels. Copies of the new resources catalogue are available free to schools and educational establishments from: British Telecom Education Service, PO Box 10, Wetherby, Yorkshire LS23 7EL.

BT is also sponsoring a wide range of educational activities during 1988. A series of weekend workshops have been planned to provide some industrial dimension to in-service training for teachers as well as a teacher fellowship scheme to be run jointly with the Association for Science Education.

BT has announced the following appointments: Mr. Barry Romeril to the Board of BT in the new post of Group Finance Director; Mr. David Day as Deputy Managing Director, UK Communications Division; Mr. Brian Rigby as Deputy Managing Director of British Telecom Enterprises; Mr. Mike Armitage as Assistant Managing Director (Operations) of the UK Communications Division, and Mr. Kenwyn Brown as Director of British Telecom Property.

Product News

Marquis Executive Terminal

BT has launched the new Marquis Executive Terminal. The new terminal, which combines an attractive new-look design with an enhanced loudspeech facility, has been developed by BT in response to customer need for a top-end executive loudspeaking featurephone.

Marquis, a 6-line 12-extension key system, incorporates all the features expected of a modern telephone system. A Standard (monitor only) terminal is available, and the new Executive Terminal is aimed at business users who require an attractive terminal on their desk which also allows efficient hands-free working. The new Executive Terminal's upgraded loudspeech facility has been achieved by using new circuitry. Busy executives can now enjoy clear hands-free conversation even several feet away from their desks. The added benefit of this facility is that it allows several people to have a group discussion via the same telephone. The loudspeaker and mini-microphone are neatly integrated into the new terminal's sleek low-profile styling.

The terminal also features, as part of its new look, an improved key-pad layout which makes press-button dialling quicker and simpler. The tone-caller volume control has also been repositioned to make it easier to manage and adjust. The terminal also features call transfer and hold; automatic return to calls on hold; up to 16 telephone numbers can be stored and subsequently dialled at the touch of a few buttons; automatic last number redial; on-hook dialling, enabling one to carry on working until the call is answered; conference call facility; a paging facility; and call barring.

BT's new Marquis Executive Terminal

All-CMOS High-Temperature STEbus Processor

The first all-CMOS processor board for the STEbus has been announced by British Telecom Microprocessor Systems. Based on Intel's 8031 CPU with CMOS memory and input/output (I/O), the minimal power consumption and inherent noise immunity of the board makes it ideally suited to the implementation of computer systems for battery-powered or harsh-environment applications.

The board, designated the *4040-00*, accepts up to 32K ROM and 32K RAM, and offers 24 lines of digital I/O, two 16 bit counter-timers, two external interrupts, a battery-backed real-time clock with watch-dog timer, and power-fail circuitry. I/O facilities are brought out on a ribbon-cable connector conforming to the STE industry-standard 'signal-conditioning bus' scheme, which allows connection to a wide variety of real-world off-the-shelf interfaces.

The 4040-00 operates over −40 to +85°C, working from a single 5 V supply and consuming just 40 mA. Combined with CMOS technology's excellent noise immunity, the board is an ideal basis for the design of computer system applications such as remote data loggers, factory-floor data collection terminals or portable test instrumentation. Remote applications are supported by BT's STEbus modem for connection to the public-switched telephone network.

Computing on the Move

British Telecom's M5183 Personal Computer

A new powerful portable computer—no bigger than a brief-case—has been added to British Telecom's growing M5000 computer range. The M5183 is a hard-disc version of the popular M5181 laptop with a massive storage capacity comparable to a conventional desk-top computer. Ideal for people who need to process data but do not always have access to the office computer, the new laptop computer weighs less than 16 lb and can be carried easily by its built-in handle. It is supplied complete with a rechargeable battery pack for use when travelling, and a mains power supply adapter.

The M5183 has a dual-speed processor and 640 Kbyte memory sufficient for all MS-DOS applications. The 20 Mbyte hard disc gives the M5183 huge storage capacity for running a full complement of application programmes with power to spare for storing a large database. The 3·5 inch 720 Kbyte floppy disc provides twice the storage capacity of its 5·25 inch predecessor as well as being more robust and reliable. A full-size illuminated screen gives outstanding display and can be fitted and adjusted for brightness and contrast.

An optional internal modem enables the computer to be used to access remote computer systems. An additional adaptor enables the user to send data from a car or portable telephone over the cellular network.

New High-Performance Low-Cost Transmission Systems from British Telecom International Products

British Telecom International Products has developed the BT System 2, a new optical fibre digital line system for short-haul 2 Mbit/s transmission. BT System 2 gives unsurpassed performance at very low cost; this makes it ideal for a wide variety of data transmission functions including telephone network local-line access, inter- and intra-office communications, computer-to-computer links, and local area networking.

Each BT System 2 line system comprises two line terminating units (LTUs), which are interconnected by a pair of optical fibres, one for each direction of transmission. By adopting the CCITT-specified HDB3 interface code for transmission over the optical path, a 2 Mbit/s signal achieves the desired system requirements of signal transparency, adequate timing information and error monitoring.

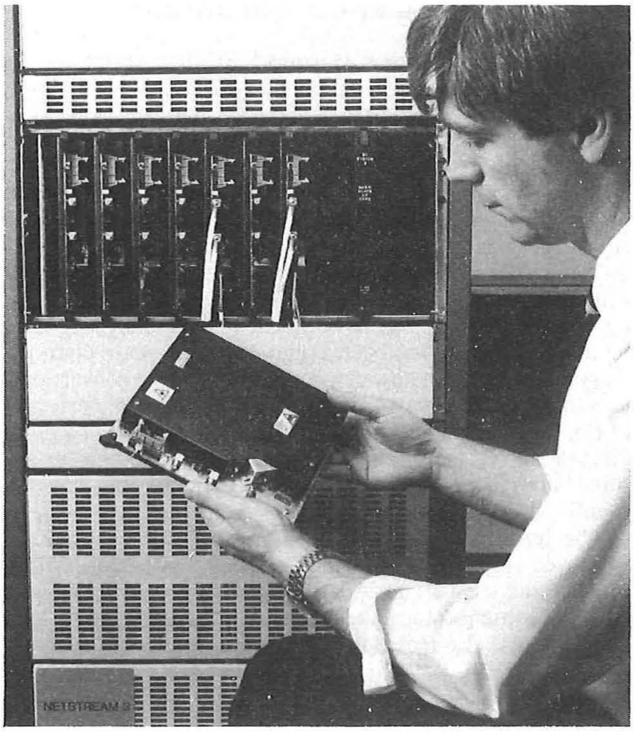
The BT System 2 line transmission system can operate over both single-mode and multimode graded index, optical-fibre pairs, without the need for optical attenuators. Single-mode transmission caters for distances up to 5 km with 9/125 optical fibre, whilst multimode operates up to 10 km with 50/125 optical fibre.

BT System 2 is packaged in a TEP-1E equipment shelf which can accommodate eight separate LTUs, together with an alarm interface card and an optional shelf-interconnection card. Each LTU has its own power supply for improved fail-safe operation, with the DC power supply distributed via the shelf backplane. The shelf backplane design excludes any active components and has been specially constructed to help overcome the operational problems associated with radio-frequency interference susceptibility. BT System 2 meets BS6527 Class B for the emission of spurious signals.

The unit provides users with sophisticated system monitoring and supervisory features to ensure fail-safe operation. LTU status is checked 1000 times per second, and ten separate alarm lights, each with a lamp-lock facility, give visual indication of transient fault conditions, such as power-off, signal failure and far-end fault. Transmission performance monitoring can also be provided by replacing the alarm interface card with a central network monitoring interface.

Advanced end-to-end supervisory features provided by BT System 2 include alarm extension, remote loop back and user-definable end-to-end flags.

Alarm extension is a switchable option which provides more information about the fault status of remote LTUs, allowing unmanned stations to be monitored effectively. Remote loop back is another switchable option on each LTU which enables the traffic path to be looped back at the remote unit to isolate possible transmission faults. This feature is especially useful for installation checking, and is software-controllable for central network monitoring. End-to-end flagging is a user-definable facility which uses BT System 2's four specifiable inputs, refreshed once a second, to monitor or control remotely sited equipment.



BT System 2—a new optical-fibre digital line system for short-haul 2 Mbit/s transmission

Each LTU is manufactured to the highest standards, and is protected by a metal housing to ensure EMC and ESD protection both during manufacture and in service. The electrical interface of the LTU provides for transparent transmission of 2048 kbit/s HDB3-encoded PCM or computer data traffic, and conforms to CCITT Recommendations G.703, G.823 and G.921. The optical source is an 880 nm LED suitable for both 9/125 single-mode and 50/125 multimode optical-fibre types. Physical connection is via two STRATOS optical connectors.

BT System 2 and the TEP-1E equipment shelf are particularly easy to install, and LTU replacement and servicing can be completed on-site within an hour.

X.400 Electronic Messaging Application

PC400 is BT's new X.400 electronic messaging application for PC local area networks (LANs), based on the international X.400 standard. PC400 marks a significant breakthrough in the expanding LAN environment, being the first X.400 messaging application available on microcomputer-based LAN systems.

Running on BT's M5000 PC range or other IBM compatibles, PC400 operates under Novell's Netware on BT's T-Net 1000 series of LAN solutions. PC400, which was developed by BT at its Martlesham Heath Research Laboratories, is a powerful messaging application that gives users national and international access to other X.400 systems.

PC400 gives users access to a wide range of communications facilities including electronic mail via a user-friendly icon interface. In addition, PC400 provides secure transmission, delivery notification, originator identification, as well as the concept of envelope and contents. PC400 also gives users access to X.400-related public messaging services including Gold 400. Via the X.400 gateway, users can send into, and receive messages from, this comprehensive service.

Book Reviews

Memoirs of a Telecommunications Engineer
John Bray.
199 pp. 39 ills. £7·00.

This book, by a former Director of Research of the Post Office (now British Telecom), spans the period from the 1920s to 1975—a period he describes as 'one of the most exciting and significant in the history of telecommunications'.

It gives a first-hand account of people and events that have led to major technological advances in telecommunications, ranging from pre-war developments in short-wave radio; electronic warfare; the evolution of microwave radio-relay inter-city systems, transoceanic submarine cables and optical-fibre systems; the progression from electro-mechanical to computer-controlled electronic exchange switching systems; to the beginnings of satellite communication.

A side-line in the story describes how the timely creation of the first Post Office television receiver detection van saved a Postmaster General from some embarrassment and brought in millions of pounds of additional license revenue.

During the period covered by the Memoirs, there were advances in device technology of immense significance, including the transistor and the micro-chip, and the revolutionary move forward from analogue to digital transmission and switching. It was a period when the telegraph/telephone service expanded its horizons to include data communications and new visual telecommunication services such as Prestel and conference television. The full implication of these advances—and the growth of information technology generally—on the way people live, work and use their leisure has yet to be felt.

This book is not a formal history of the period: it is essentially one man's account of the people and developments that he was fortunate enough to observe at close hand, and the sometimes strange and fortuitous events that decided the shape of things to come.

This book is available from the *Journal* office; see the advertisement on p. 80 for details.

Goal Directed Project Management
Erling S. Anderson, Kristoffer V. Grude, Tor Haug, and J. Rodney Turner.
Kogan Page. 196 pp. 40 ills. £16·95.
ISBN 1-85091-315-3.

There is hardly any sphere of activity nowadays which does not have as a vital topic the problems of change. The need for change evokes a range of reactions from exhilaration, through resistance, to panic; but it does not go away. To be successful, any change must be managed with care and led with skill.

This book sets out from the basic premise that any project, whatever its objective, creates change of some sort. The vast majority of projects require changes in a company's people (numbers, skills, competencies), systems (the way the company works and uses its technology) and organisation (the structure that supports the procedures). Ignoring these requirements in the initial planning stages either spells the death of many potentially good projects and the waste of so much effort and expertise or results in frantic fire-fighting in the later stages to save the project.

The eleven chapters of the book cover project characteristics; pitfalls in project management; planning, organising and co-ordinating the elements of milestones, roles, responsibilities and activities. They also address the vital questions of control and leadership. Although the authors are fairly economical with the prose (no bad thing), they build in reviews and summaries at various stages to ensure that messages are not lost. Ample diagrams and illustrations of completed report forms demonstrate how the paperwork attached to projects need not be voluminous but can carry all the vital information required at different levels. The usefulness of computers in project management is recognised, as is the danger of assuming that they will substitute for proper management. The authors have therefore proceeded on a 'manual' basis throughout the book, leaving readers to choose whatever software package they deem appropriate once they have a clear understanding of the needs to be achieved.

Apart from the detailed steps that the book takes us through regarding, for instance, the planning and scheduling stages, several key messages come across loud and clear. Firstly, the selection and development of the project leader is not something to be taken lightly; the role is much more difficult than management of the steady state and requires specialist skills and knowledge. Managing change is a complex task and it needs skilled people. Secondly, proper training must be scheduled in, not only for the project members, but also for the staff who are going to be part of the change—otherwise its implementation will be flawed. Thirdly, projects must be properly managed as opposed to allowing the team to get caught in a vicious circle of continuous re-planning. Lastly, careful thought must be given before deciding to appoint a management group to which the project leader has to report. On occasion this could lead to unnecessary diffusion of responsibility; the leader should take his/her remit from, and report to, the owner of the problem even if it is the managing director.

The authors state that the book is aimed at project managers and project members and the concepts are illustrated with examples taken from projects on which the authors themselves have worked. I would, however, widen the audience to many managers of the 'steady state', who realise that change is nigh. Familiarisation with the concepts and procedures of project management as laid out in this book should lead to managers realising that change itself, whether cultural, procedural or technical can, or ought to be, project managed into their own area of responsibility and thereby avoiding a lot of the confusion and resentment that would otherwise arise.

The four authors are very credible in terms of credentials and their practical experience shows through. The only real criticism I have of the book is the authors' decision to allocate the whole of chapter 3 to dire warnings about potential pitfalls. Coming so early in the book, before the respective words of wisdom on each topic, gave the same feel as those old maps of Africa where vast tracts of uncharted land were covered with the sinister words: '*Hic sunt Leones!*' (Here there are lions!). I cannot help feeling that the admonitions would have had better effect by being separated out and placed at the end of the relevant chapters. Nevertheless, this book is well worth reading and then keeping for reference. It is not a comprehensive study of all project management knowledge and practice, but if managers had only this book to go on, it would be very difficult to come up with valid excuses for not achieving their project goals.

D. P. O'DONOVAN

(Reviewed in this Journal on p.79)

"ADVANCED TECHNOLOGY FROM APT IS THE MOST COMPREHENSIVE AVAILABLE TODAY, AND HAS MADE ADVANCED LINKLINE POSSIBLE." (BRITISH TELECOM).

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