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MAY 1981

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This Technical Information Bulletin (TIB) reprints CCITT Study Group XI Document 393, which was Part III B of the Study Group XI report to the VIIth CCITT Plenary Assembly. Signalling System #7 is the international standard common channel signalling system for exchanging telephone signalling and supervisory information between digital telephone central offices.

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SPECIFICATIONS OF

CCITT SIGNALLING SYSTEM No. 7

MAY 1981

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FOREWORD

Among the responsibilities assigned to the Office of the Manager, National Communications System, is the management of the Federal Telecommunication Standards Program, which is an element of the overall GSA Federal Standardization Program. Under this program, the NCS, with the assistance of the Federal Telecommunication Standards Committee, identifies, develops, and coordinates proposed Federal Standards which either contribute to the interoperability of functionally similar Federal telecommunication systems or to the achievement of a compatible and efficient interface between computer and telecommunication systems. In developing and coordinating these standards a considerable amount of effort is expended in initiating and pursuing joint standards development efforts with appropriate technical committees of the Electronic Industries Association, the American National Standards Institute, the International Organization for Standardization, and the International Telegraph and Telephone Consultative Committee of the International Telecommunication Union. This Technical Information Bulletin presents an overview of an effort in the international telecommunication standards arena on common channel signalling. It has been prepared to inform interested Federal activities of the progress of this effort. Any comments, inputs or statements of requirements that could assist in the advancement of this work are welcome and should be addressed to:

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Introduction

Signalling System No. 7 consists of:

- the Message Transfer Part, specified in Recommendations Q.701 to Q.707
- the Telephone User Part, specified in Recommendations Q.721 to Q.725
- the Data User Part, specified in Recommendation X.61 Q.741.

An overall description of the signalling system and the division of functions and intertactions between the Message Transfer Part and the user parts is given in Recommendation Q.701.

General signalling network considerations are contained in Recommendation Q.705.

The user of Signalling System No. 7 in call control applications of the telephone service is recommended in Recommendations Q.7 and Q.110, Volume VI.1.

The use of Signalling System No. 7 in call control applications of the circuit switched data transmission service is recommended in Recommendation X.60, Volume VIII... The call control and signalling procedures applicable for international data transmission user facilities and network utilities are defined in Recommendation X.87.

Recommendation Q.701

FUNCTIONAL DESCRIPTION OF THE SIGNALLING SYSTEM

1 General

1.1 Objectives and fields of application

The overall objective of Signalling System No. 7 is to provide an internationally standardized general purpose common channel signalling (CCS) system:

- optimized for operation in digital telecommunications networks in conjunction with stored program controlled exchanges;
- that can meet present and future requirements of information transfer for inter-processor transactions within telecommunications networks for call control, remote control, and management and maintenance signalling;
- that provides a reliable means for transfer of information in correct sequence and without loss or duplication.

The signalling system meets requirements of call control signalling for telecommunication services such as the telephone and circuit switched data transmission services. It can also be used as a reliable transport system for other types of information transfer between exchanges and specialized centres in telecommunications networks (e.g. for management and maintenance purposes). The system is thus applicable for multi-purpose uses in networks that are dedicated for particular services and in multi-services networks. The signalling system is intended to be applicable in international and national networks.

The signalling system is optimized for operation over 64 kbit/s digital channels. It is also suitable for operation over analogue channels and at lower speeds. The system is suitable for use on point-to-point terrestrial and satellite links. It does not include the special features required for use in point-to-multipoint operation but can, if required, be extended to cover such an application.

1.2 General characteristics

Common channel signalling is a signalling method in which a single channel conveys, by means of labelled messages, signalling information relating to, for example, a multiplicity of circuits, or other information such as that used for network management. Common channel signalling can be regarded as a form of data communication that is specialized for various types of signalling and information transfer between processors in telecommunications networks.

The signalling system uses signalling links for transfer of signalling messages between exchanges or other nodes in the telecommunication network served by the system. Arrangements are provided to ensure reliable transfer of signalling information in the presence of transmission disturbances or network failures. These include error detection and correction on each signalling link.

The system is normally applied with redundancy of signalling links and it includes functions for automatic diversion of signalling traffic to alternative paths in case of link failures. The capacity and reliability for signalling may thus be dimensioned by provision of a multiplicity of signalling links according to the requirements of each applications.

1.3 Modularity

The wide scope of the signalling system requires that the total system includes a large diversity of functions and that further functions can be added to cater for extended future applications. As a consequence only a sub-set of the total system may need to be used in an individual application.

A major characteristic of the signalling system is that it is specified with a functional structure to ensure flexibility and modularity for diverse applications within one system concept. This allows the system to be realized as a number of functional modules which could ease adaptation of the functional content of an operating Signalling System No. 7 to the requirements of its application.

The CCITT specifications of the signalling system specify functions and their use for international operation of the system. Many of those functions are also required in typical national applications. Furthermore, the system to some extent includes features that are particular to national applications. The CCITT specifications thus form an internationally standardized base for a wide range of national applications of common channel signalling.

System No. 7 is one common channel signalling system. However, as a consequence of its modularity and its intended use as a standard base for national applications the system may be applied in many forms. In general, to define the use of the system in a given national application, a selection of the CCITT specified functions must be made and the necessary additional national functions must be specified depending on the nature of the application.

2 Signalling system structure

2.1 Basic functional division

The fundamental principle of the signalling system structure is the division of functions into a common Message Transfer Part (MTP) on one hand and separate User Parts for different users on the other. This is illustrated by Figure 2-1 (Q.701) below.

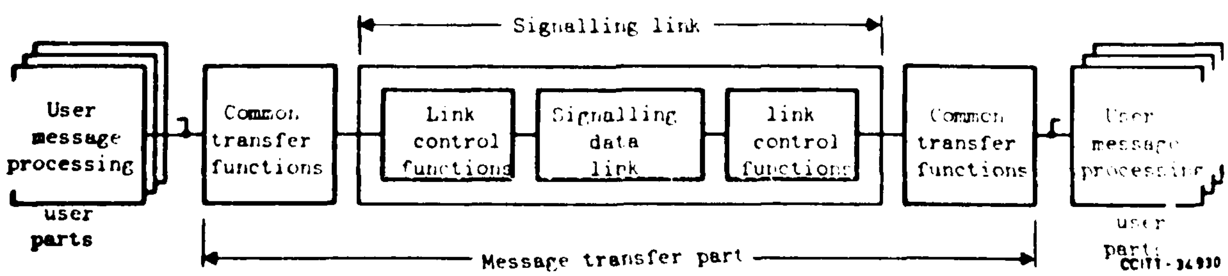


Figure 2-1 (Q.701) - Functional diagram for the common channel signalling system

The overall function of the Message Transfer Part is to serve as a transport system providing reliable transfer of signalling messages between the locations of communicating user functions.

The term user in this context refers to any functional entity that utilizes the transport capability provided by the Message Transfer Part. A User Part comprises those functions of, or related to, a particular type of user that are part of the common channel signalling system, typically because those functions need to be specified in a signalling context.

The basic commonality in signalling for different services resulting from this concept is the use of a common transport system, i.e. the Message Transfer Part. Also, a degree of commonality exists between certain User Parts, e.g. the Telephone User Part (TUP) and the Data User Part (DUP).

2.2 Functional levels

2.2.1 General

As a further separation, the necessary elements of the signalling system are specified in accordance with a level concept in which:

- the functions of the Message Transfer Part are separated into three functional levels, and
- the User Parts constitute parallel elements at the fourth functional level.

The level structure is illustrated in Figure 2-2 (Q.701).

The system structure shown in Figure 2-2 (Q.701) is not a specification of an implementation of the system. The functional boundaries B, C and D may or may not exist as interfaces in an implementation. The interactions by means of controls and indications may be direct or via other functions. However, the structure shown in Figure 2-2 (Q.701) may be regarded as a possible model of an implementation.

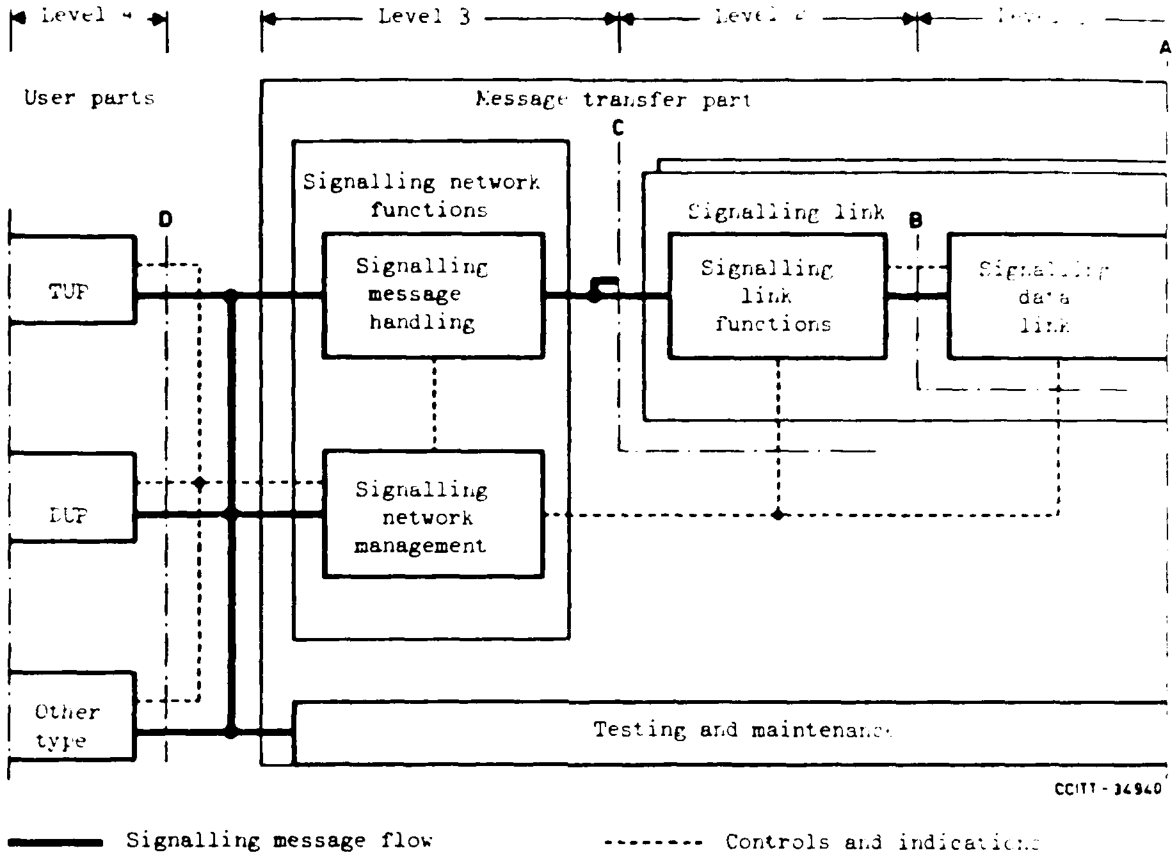


Figure 2-2 (Q.701) - General structure of signalling system functions

2.2.2 Signalling data link functions (Level 1)

Level 1 defines the physical, electrical and functional characteristics of a signalling data link and the means to access it. The level 1 element provides a bearer for a signalling link.

In a digital environment 64 kbit/s digital paths will normally be used for the signalling data link. The signalling data link may be accessed via a switching function, providing a potential for automatic reconfiguration of signalling links. Other types of data links, such as analogue links with modems, can also be used.

The detailed requirements for signalling data links are specified in Recommendation (Q.702) [1].

2.2.3 Signalling link functions (Level 2)

Level 2 defines the functions and procedures for and relating to the transfer of signalling messages over one individual signalling data link. The level 2 functions together with a level 1 signalling data link as a bearer provides a signalling link for reliable transfer of signalling messages between two points.

A signalling message delivered by the higher levels is transferred over the signalling link in variable length signal units. For proper operation of the signalling link the signal unit comprises transfer control information in addition to the information content of the signalling message.

The signalling link functions include:

- delimitation of signal unit by means of flags,
- flag limitation prevention by bit stuffing,
- error detection by means of check bits included in each signal unit,
- error correction by retransmission and signal unit sequence control by means of explicit sequence numbers in each signal unit and explicit continuous acknowledgements,
- signalling link failure detection by means of signal unit error rate monitoring and signalling link recovery by means of special procedures.

The detailed requirements for signalling link functions are given in Recommendation (Q.703) [2].

2.2.4 Signalling network functions (Level 3)

Level 3 in principle defines those transport functions and procedures that are common to and independent of the operation of individual signalling links. As illustrated in Figure 2-2 (Q.701) these functions fall into two major categories:

a) Signalling message handling functions - these are functions that, at the actual transfer of a message, direct the message to the proper signalling link or User Part.

b) Signalling network management functions - these are functions that, on the basis of predetermined data and information about the status of the signalling network, control the current message routing and configuration of signalling network facilities. In the event of changes in the status they also control reconfigurations and other actions to preserve or restore the normal message transfer capability.

The different level 3 functions interact with each other and with the functions of other levels by means of indications and controls as illustrated in Figure 2-2 (Q.701). This Figure also shows that the signalling network management as well as the testing and maintenance actions may include exchange of signalling messages with corresponding functions located at other signalling points. Although not User Parts these parts of level 3 can be seen as serving as "User Parts of the Message Transfer Part". As a convention in these specifications, for each of description, general references to User Parts as sources or sinks of signalling message implicitly include these parts of level 3 unless the opposite is evident from the context or explicitly stated.

A description of the level 3 functions in the context of a signalling network is given in Section 3 below. The detailed requirements for signalling network functions are given in Recommendation (Q.704) [3]. Some means for testing and maintenance of the signalling network are provided and the detailed requirements are given in Recommendation (Q.707) [4].

2.2.5 User Part functions (Level 4)

Level 4 consists of the different User Parts. Each User Part defines the functions and procedures of the signalling system that are particular to a certain type of user of the system.

The extent of the User Part functions may differ significantly between different categories of users of the signalling system, such as:

- Users for which most user communication functions are defined within the signalling system. Examples are telephone and data call control functions with their corresponding Telephone and Data User Parts.

- Users for which most user communication functions are defined outside the signalling system. An example is the use of the signalling system for transfer of information for some management or maintenance purpose. For such an "external user" the User Part may be seen as a "mailbox" type of interface between the external user system and the message transfer function in which for example the user information transferred is assembled and disassembled to/from the applicable signalling message formats.

2.3 Signalling message

A signalling message is an assembly of information, defined as level 3 or 4, pertaining to a call, management transaction, etc., that is transferred as an entity by the message transfer function.

Each message contains service information including a service indicator identifying the source User Part and possibly additional information such as an indication whether the message relates to international or national application of the User Part.

The signalling information of the message includes the actual user information, such as one or more telephone or data call control signals, management and maintenance information, etc., and information identifying the type and format of the message. It also includes a label that provides information enabling the message:

- to be routed by the level 3 functions and through a signalling network to its destination, and

- to be directed at the receiving User Part to the particular circuit, call, management or other transaction to which the message is related.

On the signalling link, each signalling message is packed into Message Signal Units (MSU's) which also includes transfer control information related to the level 2 functions of the link.

2.4 Functional interface

The following functional interface between the Message Transfer Part and the User Parts can be seen as a model illustrating the division of functions between these parts. The interface [see Figure 2-3 (Q.701)] is purely functional and need not appear as such in an implementation of the system.

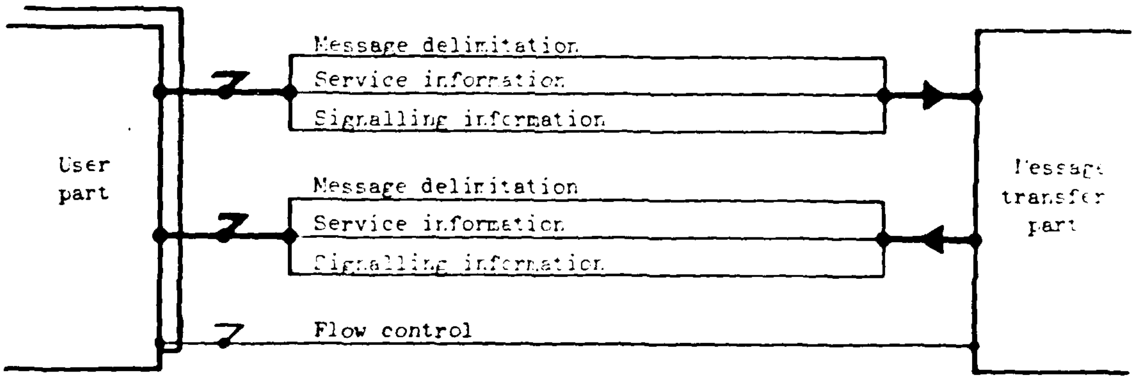


Figure 2-3 (Q.701) - Functional interface between the message transfer part and the user parts

The main interaction between the Message Transfer Part and the User Parts is the transfer of signalling messages across the interface; each message consisting of service information and signalling information as described above. Message delimitation information is also transferred across the interface with the message.

In addition to the transfer of messages and associated information the interaction may also include flow control information, e.g. an indication from the Message Transfer Part that it is unable to serve a particular destination.

A description of the characteristics of the Message Transfer Part as seen from the functional interface and the requirements to be met by potential users of the message transfer function is given in Section 4.

3 Signalling network

3.1 Basic concepts and features

3.1.1 Signalling network components

A telecommunication network served by common channel signalling is composed of a number of switching and processing nodes interconnected by transmission links. The nodes in the telecommunication network that are provided with common channel signalling are in the context of signalling referred to as 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; i.e. 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 a national signalling network.

Any two signalling points, for which the possibility of communication between their corresponding User Part functions exists, are said to have a signalling relation.

An example is when two telephone exchanges are directly connected by a bundle of speech circuits. The exchange of telephone signalling relating to these circuits then constitutes a signalling relation between the telephone User Part functions in those exchanges in their role as signalling points.

Another example is when administration of customer and routing data in a telephone exchange is remotely controlled from an operation and maintenance centre by means of communication through the common channel signalling system. This communication then constitutes a signalling relation between the applicable operation and maintenance User Part functions at the telephone exchange and the corresponding functions at the operation and maintenance centre.

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. Although a link set typically includes all parallel signalling links it is possible to use more than one link set in parallel between two signalling points. A group of links within a link set that have identical characteristics (e.g. the same data link bearer rate) are called a link group.

Two signalling points that are directly interconnected by a signalling link set are, from a signalling network structure point of view, referred to as adjacent signalling points. Correspondingly, two signalling points that are not directly interconnected are non-adjacent signalling points.

3.1.2 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 signalling 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.

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

Signalling System No. 7 is specified for use in the associated and quasi-associated modes. The Message Transfer Part does not include features to avoid out-of-sequence arrival of messages or other problems that would typically arise in a fully non-associated mode of signalling with dynamic message routing.

Examples of signalling modes are illustrated in Figure 3-1 (Q.701).

3.1.3 Signalling point modes

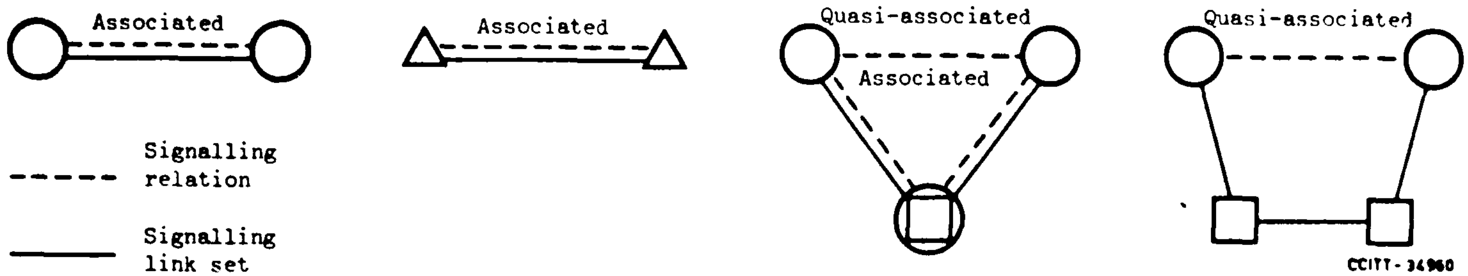
A signalling point at which a message is generated, i.e. the location of the source User Part function, is the originating point of that message.

A signalling point to which a message is destined, i.e. the location of the receiving User Part function, is the destination point of that message.

A signalling point at which a message received on a signalling link is transferred to another link, i.e. neither the location of the source nor the receiving User Part function, is a signalling transfer point (STP).

For a particular signalling relation the two signalling points thus function both as originating and destination points for the messages exchanged in the two directions between them.

In the quasi-associated mode the function of a signalling transfer point is typically located in a few signalling points which may be dedicated to this function or may combine this function with some other (e.g. switching) function. A signalling point serving as a signalling transfer point functions as an originating and a destination point for the messages generated and received by the level 3 function of the Message Transfer Part also in cases when no user functions are present.



- - - - Signalling relation

——— Signalling link set

○ Signalling point with at least user function; whether or not STP-function is present is irrelevant in the context of the graph.

□ Signalling point with at least STP-function; whether or not user function is present is irrelevant in the context of the graph.

⧠ Signalling point with both user function and STP-function.

△ Signalling point; irrelevant whether user function and/or STP-function is present.

Figure 3-1 (Q.701) - Examples of associated and quasi-associated signalling modes and definition of signalling network graph symbols

3.1.4 Message labelling

Each message contains a label. In the standard label the portion that is used for routing is called the routing label. This routing label includes:

a) Explicit indications of destination and originating points of the message, i.e. identification of the signalling relation concerned.

b) A code used for load sharing which may be the least significant part of a label component that identifies a user transaction at level 4.

The standard routing label assumes that each signalling point in a signalling network is allocated a code according to a code plan, established for the purpose of labelling, that is unambiguous within its domain. Messages labelled according to international and national code plans are discriminated by means of an indication in the service information included in each message.

The standard routing label is suitable for national applications also. However, the signalling system includes the possibility for using different labels nationally.

3.2 Signalling message handling functions

Figure 3-2 (Q.701) illustrates the signalling message handling functions.

3.2.1 Message routing

Message routing is the process of selecting, for each signalling message to be sent, the signalling link to be used. In general, message routing is based on analysis of the routing label of the message in combination with predetermined routing data at the signalling point concerned.

Message routing is destination code dependent with typically an additional load sharing element allowing different portions of the signalling traffic to a particular destination to be distributed over two or more signalling links. This traffic distribution may be limited to different links within a link set or applied to links in different link sets.

Each succession of signalling links that may be used to convey a message from the originating point to the destination point constitutes a message route. Signalling route is the corresponding concept for a possible path, referring to a succession of link sets and signalling transfer points, between the originating and destination points.

In Signalling System No. 7 message routing is made in a manner by which the message route taken by a message with a particular routing label is predetermined and, at a given point in time, fixed. Typically, however, in the event of failures in the signalling network, the routing of messages, previously using the failed message route, is modified in a predetermined manner under control of the signalling traffic management function at level 3.

Although there are in general advantages in using a uniform routing of messages belonging to different User Parts, the service indicator included in each message provides the potential for using different routing plans for different User Parts.

3.2.2 Message distribution

Message distribution is the process which, upon receipt of a message at its destination point, determines to which User Part the message is to be delivered. This choice is made on analysis of the service indicator.

3.2.3 Message discrimination

Message discrimination is the process which, upon receipt of a message at a signalling point, determines whether or not the point is the destination point of that message. This decision is based on analysis of the destination code in the routing label in the message. If the signalling point is the destination point the message is delivered to the message distribution function. If it is not the destination point, i.e. in the case when it serves as a signalling transfer point for that message, the message is delivered to the message routing function for further transfer to a signalling link. Message discrimination thus is a function required only at a signalling point that acts as a signalling transfer point.

3.3 Signalling network management functions

Figure 2-3 (Q.701) illustrates the signalling network management functions.

3.3.1 Signalling traffic management

The tasks of the signalling traffic management function are:

a) to control message routing; this includes modification of message routing to preserve, when required, accessibility of all destination points concerned or to restore normal routing;

b) in conjunction with modifications of message routing, to control the resulting transfer of signalling traffic in a manner that avoids irregularities in message flow;

c) flow control.

Control of message routing is based on analysis of predetermined information about all allowed potential routing possibilities in combination with information, supplied by the signalling link management and signalling route management functions, about the status of the signalling network (i.e. current availability of signalling links and routes).

Changes in the status of the signalling network typically result in modification of current message routing and thus in transfer of certain portions of the signalling traffic from one signalling link to another. The transfer of signalling traffic is performed in accordance with specific procedures. These procedures - changeover, changeback, forced rerouting and controlled rerouting - are designed to avoid, as far as the circumstances permit, such irregularities in message transfer as loss, mis-sequencing or multiple delivery of messages.

The changeover and changeback procedures involve communication with other signalling point(s). For example, in the case of changeover from a failing signalling link, the two ends of the failing link exchange information (via an alternative path) that normally enables retrieval of messages that otherwise would have been lost on the failing link. However, as further explained later, these procedures cannot guarantee regular message transfer in all circumstances.

A signalling network has to have a signalling traffic capacity that is higher than the normal traffic offered. However, in overload conditions (e.g. due to network failures or extremely high traffic peaks) the signalling traffic management function takes flow control actions to minimize the problem. An example is provision of an indication to the local user functions concerned that the Message Transfer Part is unable to transport messages to a particular destination in the case of total breakdown of all signalling routes to that destination point. If such a situation occurs at a signalling transfer point a corresponding indication is given to the signalling route management function for further dissemination to other signalling points in the signalling network.

3.3.2 Signalling link management

The task of the signalling link management function is to control the locally connected link sets. In the event of changes in the availability of a local link set it initiates and controls actions aimed at restoring the normal availability of that link set.

The signalling link management function also supplies information about the availability of local links and link sets to the signalling traffic management function.

The signalling link management function interacts with the signalling link function at level 2 by receipt of indications of the status of signalling links. It also initiates actions at level 2 such as, for example, initial alignment of an out-of-service link.

The signalling system can be applied with different degrees of flexibility in the method of provision of signalling links. A signalling link may for example consist of a permanent combination of a signalling terminal device and a signalling data link. It is also possible to employ an arrangement in which any switched connection to the remote end may be used in combination with any local signalling terminal device. It is the task of the signalling link management function in such arrangements to initiate and control reconfigurations of terminal devices and signalling data links to the extent such reconfigurations are automatic. In particular, this involves interaction, not necessarily direct, with a switching function at level 1.

3.3.3 Signalling route management

Signalling route management is a function that relates to the quasi-associated mode of signalling only. Its task is to transfer information about changes in the availability of signalling routes in the signalling network to enable remote signalling points to take appropriate signalling traffic management actions. Thus a signalling transfer point may, for example, send messages indicating inaccessibility of a particular signalling point via that signalling transfer point thus enabling other Signalling Points to stop routing messages into an incomplete route.

3.4 Testing and maintenance functions

Figure 2-3 (Q.701) illustrates that the signalling system includes some standard testing and maintenance procedures that use level 3 messages. Furthermore, any implementation of the system typically includes various implementation dependent means for testing and maintenance of equipment concerned with the other levels.

3.5 Use of the signalling network

3.5.1 Signalling network structure

The signalling system may be used with different types of signalling network structures. The choice between different types of signalling network structures may be influenced by factors such as the structure of the telecommunication network to be served by the signalling system and administrative aspects.

In the case when the provision of the signalling system is planned purely on a per signalling relation basis, the likely result is a signalling network largely based on associated signalling, typically supplemented by a limited degree of quasi-associated signalling for low volume signalling relations. The structure of such a signalling network is mainly determined by the patterns of the signalling relations. International signalling is an example of an application for which this approach is suitable.

Another approach is to consider the signalling network as a common resource that should be planned according to the total needs for common channel signalling. The high capacity of digital signalling links in combination with the needs for redundancy for reliability then typically leads to a signalling network based on a high degree of quasi-associated signalling with some provision for associated signalling for high volume signalling relations. The latter approach to signalling network planning is more likely to allow exploitation of the potential of common channel signalling to support network features that require communication for purposes other than the switching of connections.

Further considerations about the use of a signalling network are given in Recommendation (Q.705) [5].

3.5.2 Provision of signalling facilities

In general, the most important factor for the dimensioning of the signalling network is the need for reliability by means of redundancy. Depending on the signalling network structure and the potential for reconfiguration of signalling equipment the required redundancy may be provided by different combinations of:

- redundancy in signalling data links (e.g. nominated reserves or switched connections),

- redundancy in signalling terminal devices (e.g. a common pool of terminals for the whole signalling point),

- redundancy of signalling links within a link set (typically operating with load sharing),

- redundancy in signalling routes for each destination (possibly operating with load sharing),

The loading capacity of a digital signalling link is high in relation to the signalling traffic generated for call control signalling. Therefore, in many typical applications the links will be lightly loaded and signalling traffic volume will be a secondary factor for the dimensioning of the signalling network. However, in high signalling traffic applications or when analogue links with lower speeds are used it may be necessary to dimension the traffic capacity by provision of additional signalling links. The message routing principles adopted for the signalling system allow partitioning of the total signalling traffic into different portions based on load sharing, destination point code and service information. Such partitioning provides a useful means of controlling the load and dimensioning of the capacity of different sections of a signalling network, as it allows distribution of different portions of the signalling traffic. It can also be used to dedicate certain parts of a signalling network to signalling traffic related to a particular user.

3.5.3 Application of signalling network functions

The signalling network functions provided by the signalling system are designed to cater for a range of signalling network configurations. All of those functions need not necessarily be present at all signalling points. The necessary functional content at level 3 at a particular signalling point depends for example on what signalling mode(s) are used, whether or not it is a signalling transfer point, what type of signalling equipment redundancy is employed, etc. It is thus feasible to implement level 3 functions with modularity for different capabilities corresponding to different signalling network configurations. As a special case it is even possible to apply the signalling system without using the level 3 element at all, e.g. in a small exchange or private automatic branch exchange which can only be reached via one primary pulse code modulation system.

4 Message transfer capability

4.1 General

The Message Transfer Part recommendations specify methods by which different forms of signalling networks can be established. The requirements for the Message Transfer Part have primarily been determined by the requirements of call control signalling for the telephone and circuit switched data transmission services. However, the Message Transfer Part is also intended to have the ability to serve as a transport system for other types of information transfer. The following summarises the typical characteristics of the transport service that may be offered by the Message Transfer Part to a potential user of this ability.

All information to be transferred by the Message Transfer Part must be assembled into messages. The linking of the source and sink of a message is inherent in the label in combination with the signalling routes existing between the two locations. From a transportation point of view each message is self-contained and handled individually. The nature of the transport service offered by the Message Transfer Part is therefore similar to that offered by a packet switched network. In addition, all messages containing the same label constitute a set of messages that is handled in a uniform manner by the Message Transfer Part, thus ensuring, in normal circumstances, regular delivery in the correct sequence.

4.2 User location in system structure

A potential user of the transport service is typically included in the system structure by provision of a separate User Part. This requires allocation of a service indicator code, the specification of which is part of both the Message Transport Part and User Part concerned.

As an alternative, a potential user may be catered for, together with other similar users, by an already existing or new User Part. In such a case the discrimination between messages belonging to this and the other is an internal matter within the User Part concerned. It then follows that all messages belonging to such a User Part are necessarily handled, e.g. as regards routing, in a uniform manner by the Message Transfer Part.

4.3 Message content

4.3.1 Code transparency

Information with any code combination generated by a user can be transferred by the Message Transfer Part provided that the message respects the requirements described in the following sections

4.3.2 Service information

Each message must contain service information coded in accordance with the rules specified in [6].

4.3.3 Message label

Each message must contain a label consistent with the routing label of the signalling network concerned. See also [7].

4.3.4 Message length

The information content of a message should be an integral number of octets.

The total amount of signalling information transferable in one message is limited by some parameters of the signalling system; although normally limited to about 60 octets the signalling system can, if required in certain national applications, accept transfer of user information blocks in the order of 256 octets in single messages.

Depending on the signalling traffic characteristics of a user and of other users sharing the same signalling facilities, there may be a need to limit message lengths below the system limit based on queueing delay considerations.

In the case when information blocks generated by a user function exceed the allowed message length, it is necessary to implement means for segmentation and blocking of such information blocks within the User Part concerned.

4.4 User accessibility

The accessibility of user functions through a signalling network depends on the signalling modes and routing plan employed in that network.

In the case when only the associated mode of signalling is employed, only user functions located at adjacent signalling points may be accessed.

In the case when quasi-associated signalling is employed, user functions located at any signalling point may be accessed provided that the corresponding message routing data is present.

4.5 Transport service performance

Further detailed information is provided in Recommendation (Q.706) [8].

4.5.1 Message transfer delay

The normal delay for transfer of messages between user locations depends on factors such as distance, signalling network structure, signalling data link type and bit rate and processing delays.

A small proportion of messages will be subject to additional delay because of transmission disturbances, network failures, etc.

4.5.2 Message transfer failures

The Message Transfer Parts has been designed to enable it to transfer messages in a reliable and regular manner even in the presence of network failures. However, inevitably some failures will occur the consequences of which cannot be avoided with economic measures. Below, the types of failures that may occur and some typical probabilities of their occurrence are described. [8] provides further detailed information that can be used to estimate failure rates for particular cases.

In the case when a potential user function requires a reliability of the transport service that cannot be guaranteed by the Message Transfer Part, the reliability for that user may be enhanced by adoption of appropriate level 4 procedures, possibly including some means of supplementary end-to-end error control.

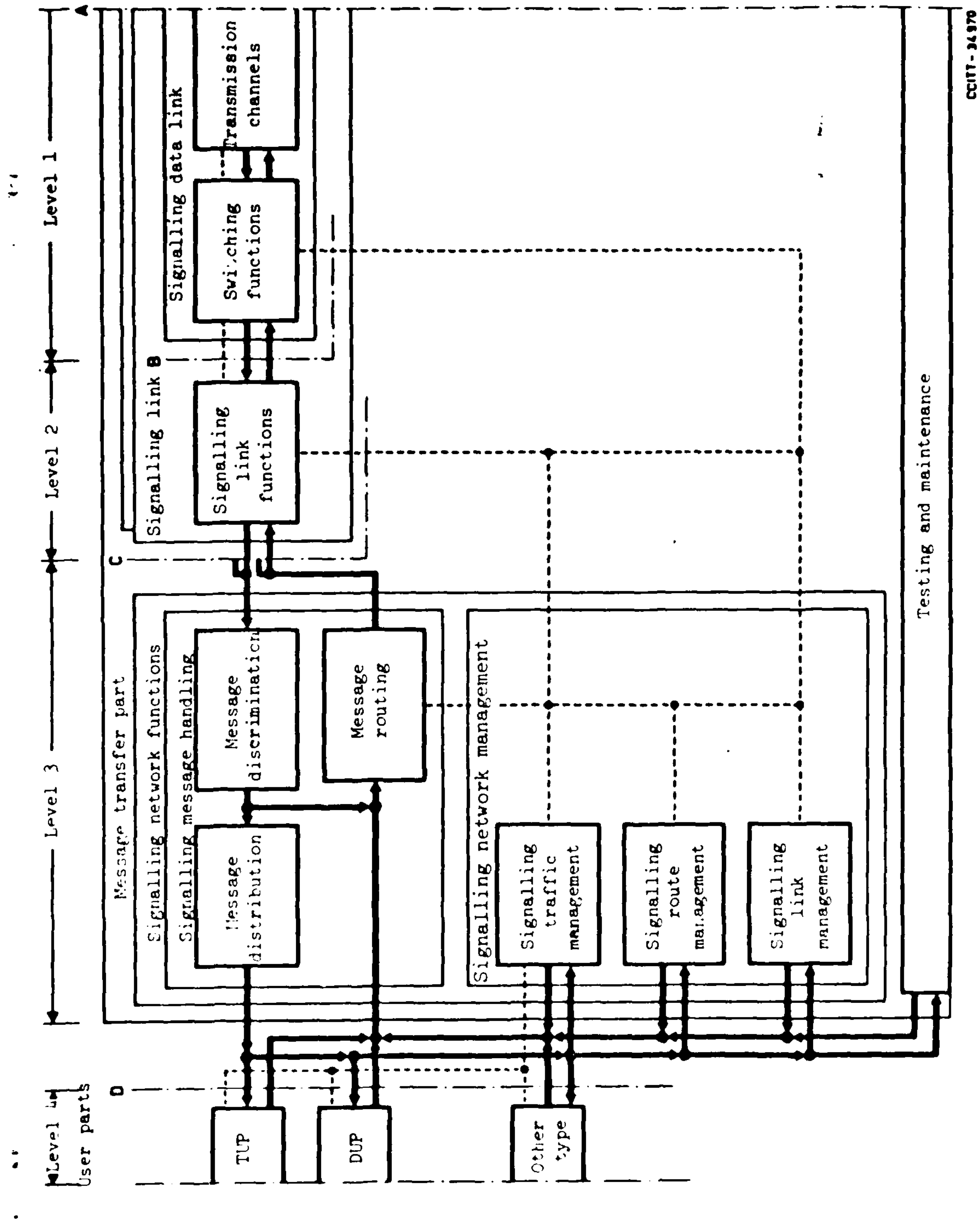
The following types of message transfer failures are possible, and expected probabilities for such failures in typical applications are indicated, see also [8]:

a) Unavailability of the transport service to one or more locations - the availability of the message transfer capability depends on the redundancy provided in the signalling network; the availability can therefore be dimensioned.

b) Loss of messages - the probability of loss of messages mainly depends on the reliability of signalling equipment; typically it is expected to be lower than 10^{-7}.

c) Mis-sequencing of messages - may in certain configurations of quasi-associated signalling occur with rare combinations of independent failures and disturbances. The probability, in such configurations, of a message being delivered out-of-sequence depends on many factors but is expected to be lower than 10^{-10}.

d) Delivery of false information - undetected errors may lead to delivery of false information; the possibility of an error in a message delivered is expected to be lower than 10^{-10}.



Signalling message flow
-------- Controls and indications

Figure 3-2 ([illegible]) - Detailed structure of signalling system functions

References

[1] CCITT Recommendation Signalling Data Link, Yellow Book, Vol. VI.7, Rec. (Q.702).

[2] CCITT Recommendation Signalling Link, Yellow Book, Vol. VI.7, Rec. (Q.703).

[3] CCITT Recommendation Signalling Network Functions and Messages, Yellow Book, Vol. VI.7, Rec. (Q.704).

[4] CCITT Recommendation Testing and Maintenance, Yellow Book, Vol. VI.7, Rec. (Q.707).

[5] CCITT Recommendation Signalling Network Structure, Yellow Book, Vol. VI.7, Rec. (Q.705).

[6] CCITT Recommendation Signalling Network Functions and Messages, Yellow Book, Vol. VI.7, Rec. (Q.704), Section 12.

[7] CCITT Recommendation Signalling Network Functions and Messages, Yellow Book, Vol. VI.7, Rec. (Q.704), Section 2.

[8] CCITT Recommendation Signalling System Performance, Yellow Book, Vol. VI.7, Rec. (Q.706).

Recommendation Q.702

SIGNALLING DATA LINK

1 General

1.1 A signalling data link is a bidirectional transmission path for signalling, comprising two data channels operating together in opposite directions at the same data rate. It constitutes the lowest functional level (level 1) in the Signalling System No. 7 functional hierarchy.

1.2 Functional configuration of a signalling data link is shown in Figure 1-1 (Q.702).

1.3 A digital signalling data link is made up of digital transmission channels [1] and digital switches or their terminating equipment providing an interface to signalling terminals. The digital transmission channels may be derived from a digital stream having a frame structure as specified for digital exchanges and for pulse code modulation multiplex equipment (Recommendations G.732 [1], G.733 [2], G.734 [3], G.744 [4], G.746 [5], G.73A [5 *bis*], G.73B [6], G.73C [6 *bis*] G.73Y [7], etc.), or from digital streams having a frame structure specified for data circuits (Recommendations X.50 [8], X.51 [9], X.50 *bis* [10], X.51 *bis* [11]).

1.4 An analogue signalling data link is made up of voice-frequency analogue transmission channels either 4 kHz or 3 kHz spaced, and modems.

1.5 Signalling System No. 7 is capable of operating over both terrestrial and satellite transmission links [1].

1.6 The operational signalling data link shall be exclusively dedicated to the use of a Signalling System No. 7 signalling link between two signalling points. No other information should be carried by the same channel together with the signalling information.

1.7 Equipment such as echo suppressors, digital pads, or A/μ law convertors attached to the transmission link must be disabled in order to assure full duplex operation and bit integrity of the transmitted data stream.

1.8 64 kbit/s digital signalling channels entering a digital exchange via a multiplex structure shall be switchable as semi-permanent channels in the exchange.

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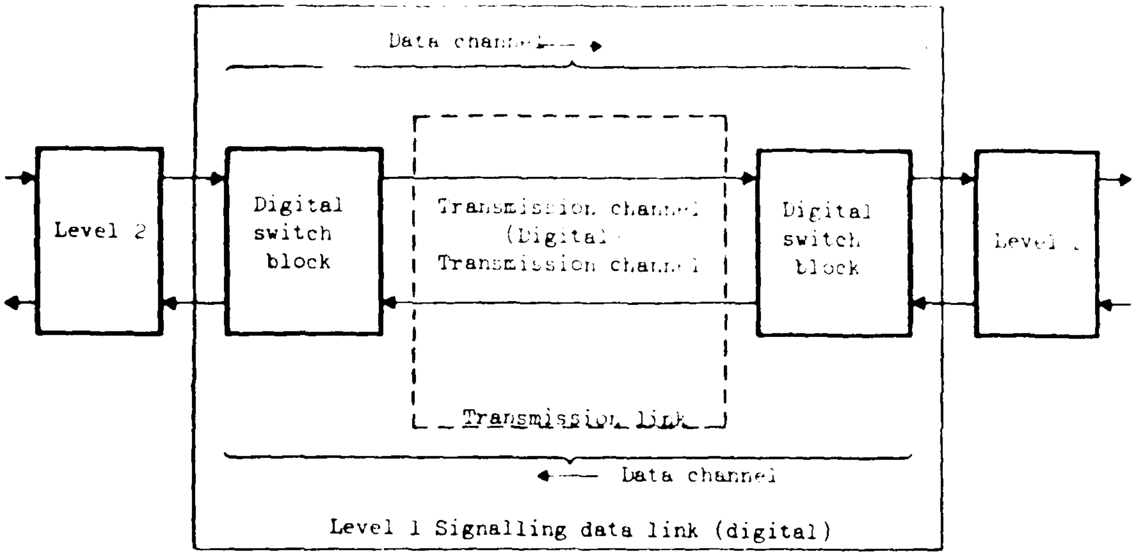
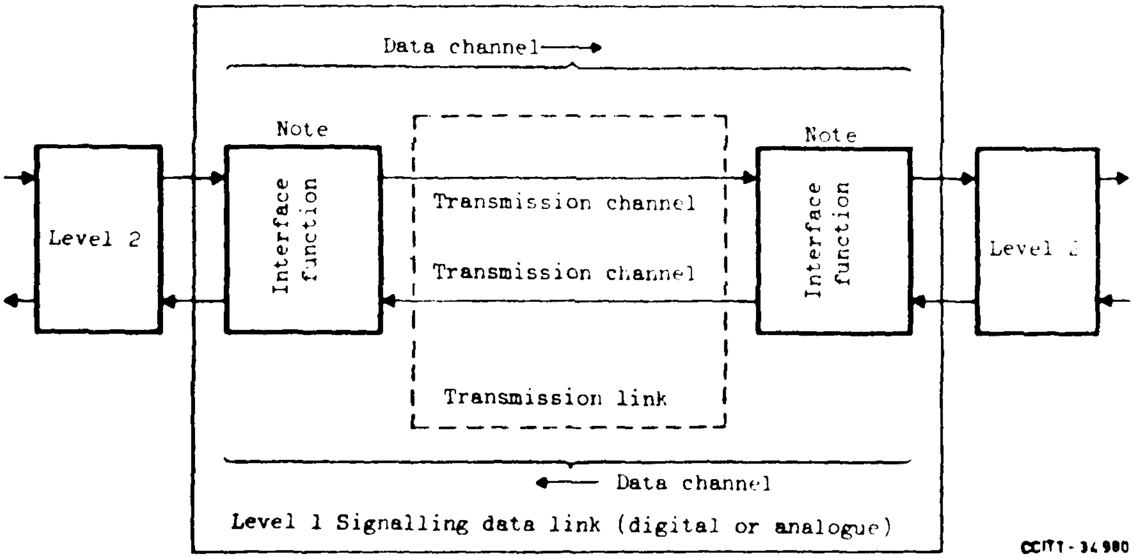
1) The terms transmission channel and transmission link are used in Signalling System No. 7 instead of transfer channel and transfer link used in Signalling System No. 6.



a. Example 1 : Digital signalling data link via digital switch block



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<u>Note</u> - The interface function is provided, for example, by a modem in an analogue signalling data link, a data circuit terminating equipment (DCE) or a timeslot access equipment in a digital signalling data link.

b. Example 2 : Signalling data link (digital or analogue) via interface equipment

Figure 1-1 ($\boxed{Q.702}$) - Functional configuration of a signalling data link

2 Signalling bit rate

2.1 General

2.1.1 The standard bit rate on a digital bearer will be 64 kbit/s.

2.1.2 Lower bit rates may be adopted for each application, taking into account the user part requirements and the capability of available transmission links.

2.1.3 Minimum signalling bit rate for telephone call control applications will be 4.8 kbit/s. For other applications such as network management, bit rates lower than 4.8 kbit/s can also be used.

2.2 Use of bit rates lower than 64 kbit/s

2.2.1 For national telephone call control applications, use of Signalling System No. 7 at bit rates lower than 64 kbit/s shall take account of the requirement to minimize the answer signal delay when in-band line signalling systems are involved (Recommendation Q.27 [12]).

2.2.2 Signalling System No. 7 can be used for direct international application at bit rates lower than 64 kbit/s between countries which have no in-band line signalling systems in their national extension networks (see Section 2.1.3).

2.2.3 The possible use of Signalling System No. 7 at bit rates lower than 64 kbit/s between countries which have in-band line signalling systems in their national extension networks is for further study.

3 Error characteristics and availability

Error characteristics and availability requirements will conform to relevant Recommendations (for example, Recommendation G.8XZ [13] on digital circuits). No additional characteristics or requirements will be specified in this Recommendation.

4 Interface specification points

4.1 Interface requirements may be specified at one of three points, A, B or C in Figure 4-1 (Q.702). The appropriate point depends on the nature of transmission links used and the approach toward the implementation of interface equipment adopted by each Administration.

4.2 For the international application, interface requirements at either Point B, or Point C will apply.

4.3 Interface requirements for an international digital signalling data link will be specified at Point C in accordance with the specific structure used. (See Section 5.)

4.4 Interface requirements for an international analogue signalling data link will be specified at Point B on a single channel basis, and thus are independent of multiplex equipment used. (See Section 6.)

4.5 Interface at Point A may or may not appear in particular implementations, as each Administration may adopt different approaches towards the implementation of interface equipment. If it does appear in implementations, then the interface requirements specified in Recommendations V.10 [14], V.11 [15], V.24 [16], V.28 [17], V.35 [18], V.36 [19], X.24 [20] and G.703 [21] (for 64 kbit/s interface) should be followed as appropriate.

4.6 Implementations which do not follow all the requirements in the relevant Recommendation cited above should nevertheless take into account those requirements that are specified for testing and maintenance actions which require communication between the two ends of a data link. Interface requirements for testing and maintenance are specified in Recommendation (Q.707) [22].

5 Digital signalling data link

5.1 Signalling data link derived from the 2048 kbit/s digital path

When a signalling data link is to be derived from a 2048 kbit/s digital path, the following shall apply:

a) The interface requirements, specified at Point C in Figure 4-1 (Q.702), should comply with Recommendations G.703 [21] for the electrical characteristics and G.732 [1] and G.734 [3] for the frame structure.

b) The signalling bit rate shall be 64 kbit/s.

c) The standard channel timeslot for the use of a signalling data link is timeslot 16. When Timeslot 16 is not available, any channel timeslot available for 64 kbit/s user transmission may be used.

d) No bit inversion is performed.

5.2 Signalling data link derived from the 8448 kbit/s digital path

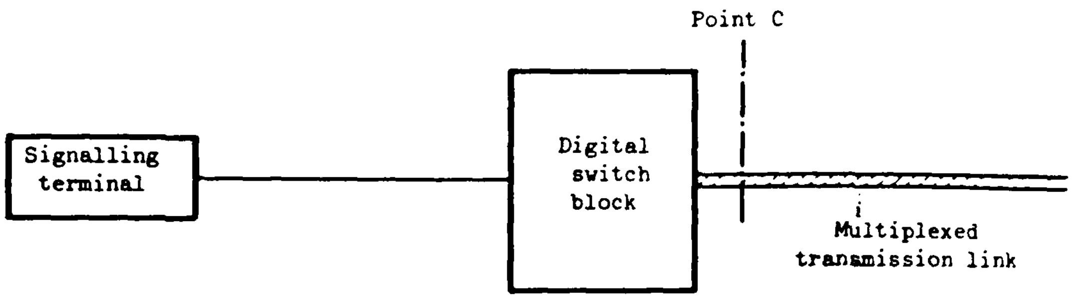
When a signalling data link is to be derived from a 8448 kbit/s digital path, the following shall apply:

a) The interface requirements, specified at Point C in Figure 4-1 (Q.702), should comply with Recommendations G.703 [21] for the electrical characteristics and G.744 [4] and G.746 [5] for the frame structure.

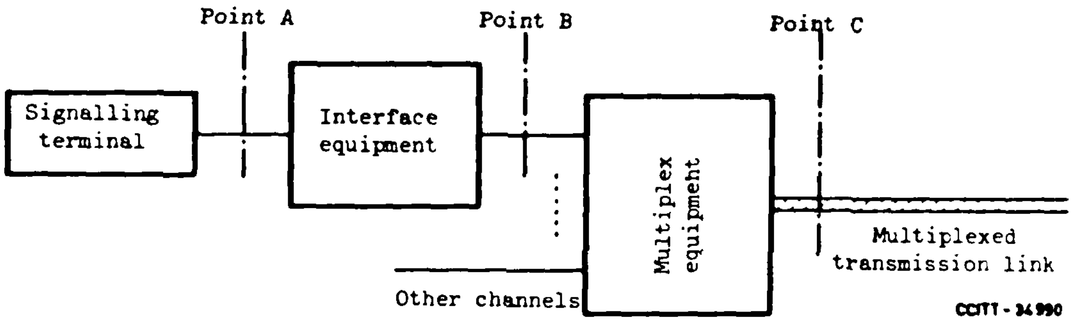
b) The signalling bit rate shall be 64 kbit/s.

c) The standard channel timeslots for the use of a signalling data link are timeslots 67 to 70 in descending order of priority. When they are not available, any channel timeslot available for 64 kbit/s user transmission may be used.

d) No bit inversion is performed.



a. Example 1 : Digital signalling data link via a digital switch block



b. Example 2 : Signalling data link (digital or analogue) via interface equipment

Figure 4-1 (Q.702) - Interface specification points

5.3 <u>Signalling data link derived from the 1544 kbit/s digital path</u>

(For further study.)

<u>Note</u> - When a signalling bit rate of 64 kbit/s is adopted, the values of bits should be inverted within the signalling terminal or the interface equipment in order to meet the minimum mark density requirements of the Recommendation G.733 [2] based PCM systems.

5.4 <u>Signalling data link established over a digital path made up by digital sections based on different (A,μ) encoding laws</u>

(For further study.)

5.5 Signalling data link established over data circuits

When a signalling data link is to be established over data circuits derived from a 64 Kbit/s digital stream having a frame structure as specified in such Recommendations as X.50 [8], X.51 [9], X.50 bis [10] and X.51 bis [11] the following shall apply:

a) The interface requirements, specified at Point C in Figure 4-1 (Q.702), should comply with relevant requirements in one of the above mentioned Recommendations, applicable to the environment of the intended use.

b) When 64 kbit/s multiplexed streams are carried on 2048 kbit/s or 1544 kbit/s digital path, Recommendations G.73A [5 bis], G.73b [6], G.73C [6 bis] and G.73y [7] should apply.

6 Analogue signalling data link

6.1 Signalling bit rate

6.1.1 Applications of the analogue signalling data link must take account of the delay requirements described in Section 2.2.

6.1.2 For telephone call control applications, signalling bit rate over an analogue signalling data link shall be higher or equal to 4.8 kbit/s.

6.2 Interface requirements

In case of 4.8 kbit/s operation, interface requirements specified at the interface point B in Figure 4-1 (Q.702) should comply with relevant requirements specified for 4.8 kbit/s modems in Recommendations V.27 [23] and V.27 bis [24]. In addition, the following shall apply:

a) Application of either Recommendations V.27 [23] or V.27 bis [24] depends on the quality of the analogue transmission channels used. Recommendation V.27 [23] shall apply only to transmission channels conforming to Recommendation M.1020 [25], while Recommendation V.27 bis [24] to transmission channels conforming to Recommendation M.1020 [25] or of lower quality.

b) Full duplex operation over a four-wire transmission link should be adopted.

c) If a separate modem is to be used, the interface requirements specified in Recommendations V.10 [14], V.11 [15], V.24 [16] and V.28 [17], applicable at Point A in Figure 4-2 (Q.702), should be followed as much as possible.

References

[1] CCITT Recommendation, characteristics of primary PCM multiplex equipment operating at 2048 kbit/s, Yellow Book, Vol. III . . . , Rec. G.732.

[2] CCITT Recommendation, characteristics of primary PCM multiplex equipment operating at 1544 kbit/s, Yellow Book, Vol. III . . . , Rec. G.733.

[3] CCITT Recommendation, characteristics of 2048 kbit/s frame structure for use with digital exchanges, Yellow Book, Vol. III . . . , Rec. G.734.

[4] CCITT Recommendation, second order PCM multiplex equipment operating at 8448 kbit/s, Yellow Book, Vol. III . . . , Rec. G.744.

[5] CCITT Recommendation, characteristics of 8448 kbit/s frame structure for use with digital exchanges, Yellow Book, Vol. III . . . , Rec. G.746.

[5 bis] CCITT Recommendation, characteristics of primary PCM multiplex equipment operating at 2048 Kbit/s and offering synchronous 64 Kbit/s digital access options, Yellow Book, Vol. III . . ., Rec. G.73A.

[6] CCITT Recommendation, characteristics of a synchronous digital multiplex equipment operating at 2048 kbit/s, Yellow Book, Vol. III . . . , Rec. G.73b.

[6 bis] CCITT Recommendation, characteristics of an external access equipment operating at 2048 Kbit/s and offering synchronous digital accesses at 64 Kbit/s, Yellow Book, Vol. III . . ., Rec. G.73C.

[7] CCITT Recommendation, characteristics of a digital multiplex equipment operating at 1544 kbit/s, Yellow Book Vol. III . . . , Rec. G.73y.

[8] CCITT Recommendation, fundamental parameters of a multiplexing scheme for the international interface between synchronous data networks, Yellow Book, Vol. VIII . . . , Rec. X.50.

[9] CCITT Recommendation, fundamental parameters of a multiplexing scheme for the international interface between synchronous data networks using 10-bit envelope structure, Yellow Book, Vol. VIII . . . , Rec. X.51.

[10] CCITT Recommendation, fundamental parameters of a 48 kbit/s user data signalling rate transmission scheme for the international interface between synchronous data networks, Yellow Book, Vol. VIII . . . , Rec. X.50 bis.

[11] CCITT Recommendation, fundamental parameters of a 48 kbit/s user data signalling rate transmission scheme for the international interface between synchronous data networks using 10-bit envelope structure, Yellow Book, Vol. VIII . . . , Rec. X.51 bis.

[12] CCITT Recommendation, transmission of the answer signal, Yellow Book, Vol. VI . . . , Rec. Q.27.

[13] CCITT Recommendation, error performance objectives on an international digital connection, Yellow Book, Vol. III . . . , Rec. G.8X2.

[14] CCITT Recommendation, electrical characteristics for unbalanced double-current interchange circuits for general use with integrated circuit equipment in the field of data communications, Yellow Book, Vol. VIII . . . , Rec. V.10.

[15] CCITT Recommendation, electrical characteristics for balanced double-current interchange circuits for general use with integrated circuit equipment in the field of data communications, Yellow Book, Vol. VIII . . . , Rec. V.11.

[16] CCITT Recommendation, list of definitions for interchange circuits between data-terminal equipment and data circuit-terminating equipment, Yellow Book, Vol. VIII . . . , Rec. V.24.

[17] CCITT Recommendation, electrical characteristics for unbalanced double-current interchange circuits, Yellow Book, Vol. VIII . . . , Rec. V.28.

[18] CCITT Recommendation, data transmission at 48 kbit/s using 60-108 kHz group band circuits, Yellow Book, Vol. VIII . . . , Rec. V.35.

[19] CCITT Recommendation, modems for synchronous data transmission using 60-108 kHz group band circuits, Yellow Book, Vol. VIII . . . , Rec. V.36.

[20] CCITT Recommendation, list of definitions for interchange circuits between data terminal equipment (DTE) and data circuit-terminating equipment (DCE) on public data networks, Yellow Book, Vol. VIII . . . , Rec. X.24.

[21] CCITT Recommendation, general aspects of interfaces, Yellow Book, Vol. III . . . , Rec. G.703.

[22] CCITT Recommendation, testing and maintenance, Yellow Book, Vol. VI . . . , Rec. Q.707.

[23] CCITT Recommendation, 4800 bit/s modem with manual equalizer standardarized for use on leased telephone-type circuits, Yellow Book, Vol. VIII . . . , Rec. V.27.

[24] CCITT Recommendation, 4800 bit/s modem with automatic equalizer standardized for use on leased telephone-type circuits, Yellow Book, Vol. VIII . . . , Rec. V.27 bis.

[25] CCITT Recommendation, characteristics of special quality international leased circuits, Yellow Book, Vol. IV . . . , Rec. M.1020.

Recommendation Q.703

SIGNALLING LINK

1 General

1.1 Introduction

1.1.1 This Recommendation describes the functions and procedures for and relating to the transfer of signal messages over one signalling data link. The signalling link functions, together with a signalling data link as bearer, provide a signalling link for reliable transfer of signalling messages between two directly connected signalling points.

Signalling messages delivered by superior hierarchical levels are transferred over the signalling link in variable length signal units. The signal units include transfer control information for proper operation of the signalling link in addition to the signalling information.

1.1.2 The signalling link functions comprise:

a) Signal unit delimitation.

b) Signal unit alignment.

c) Error detection.

d) Error correction.

e) Initial alignment.

f) Signalling link error monitoring.

All these functions are coordinated by the link state control, see Figure 1-1 (Q.703).

1.2 Signal unit delimitation and alignment

The beginning and end of a signal unit are indicated by a unique 8 bit pattern, the flag. Measures are taken to ensure that the pattern cannot be imitated elsewhere in the unit.

Loss of alignment occurs when a bit pattern disallowed by the delimitation procedure (more than six consecutive ones) is received, or when a certain maximum length of signal unit is exceeded.

Loss of alignment will cause a change in the mode of operation of the signal unit error rate monitor.

1.3 Error detection

The error detection function is performed by means of 16 check bits provided at the end of each signal unit. The check bits are generated by the transmitting signalling link terminal by operating on the preceding bits of the signal unit following a specified algorithm. At the receiving signalling link terminal 1) the received check bits are operated on using specified rules, which correspond to that algorithm.

If consistency is not found between the received check bits and the preceding bits of the signal unit, according to the algorithm, then the presence of errors is indicated and the signal unit is discarded.

1.4 Error correction

1.4.1 Two forms of error correction are provided, the basic method and the preventive cyclic retransmission method. The following criteria should be used for determining the international fields of application for the two methods:

a) the basic method applies for signalling links using non-intercontinental terrestrial transmission means and for intercontinental signalling links where the one-way propagation delay is less than 15 ms,

b) the preventive cyclic retransmission method applies for intercontinental signalling links where the one-way propagation delay is greater than or equal to 15 ms and for all signalling links established via satellite.

In cases where one signalling link within an international link set is established via satellite, the preventive cyclic retransmission method should be used for all signalling links of that link set.

1.4.2 The basic method is a non-compelled, positive/negative acknowledgement, retransmission error correction system. A signal unit which has been transmitted is retained at the transmitting signalling link terminal until a positive acknowledgement is received. If a negative acknowledgement is received then the transmission of new signal units is interrupted and those signal units which have been transmitted but not yet positively acknowledged starting with that indicated by the negative acknowledgement will be retransmitted once, in the order in which they were first transmitted.

1.4.3 The preventive cyclic retransmission method is a non-compelled, positive acknowledgement, cyclic retransmission, forward error correction system. A signal unit which has been transmitted is retained at the transmitting signalling link terminal until a positive acknowledgement for that signal unit is received. During the period when there are no new signal units to be transmitted all the signal units which have not yet been positively acknowledged are retransmitted cyclically.

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1) A signalling link terminal refers to the means of performing all of the functions defined at level 2 regardless of their implementation.

The forced retransmission procedure is defined to ensure that forward error correction occurs in adverse conditions (e.g. high error rate and/or high traffic loading).

When a predetermined number of retained, unacknowledged signal units exist the transmission of new signal units is interrupted and the retained signal units are retransmitted cyclically until the number of unacknowledged signal units is reduced.

1.5 Initial alignment

The initial alignment procedure is appropriate to both first time initialization (e.g. after "switch-on") and alignment in association with restoration after a link failure. The procedure is based on the compelled exchange of status information between the two signalling points concerned and the provision of a proving period. No other signalling link is involved in the initial alignment of any particular link, the exchange occurs only on the link to be aligned.

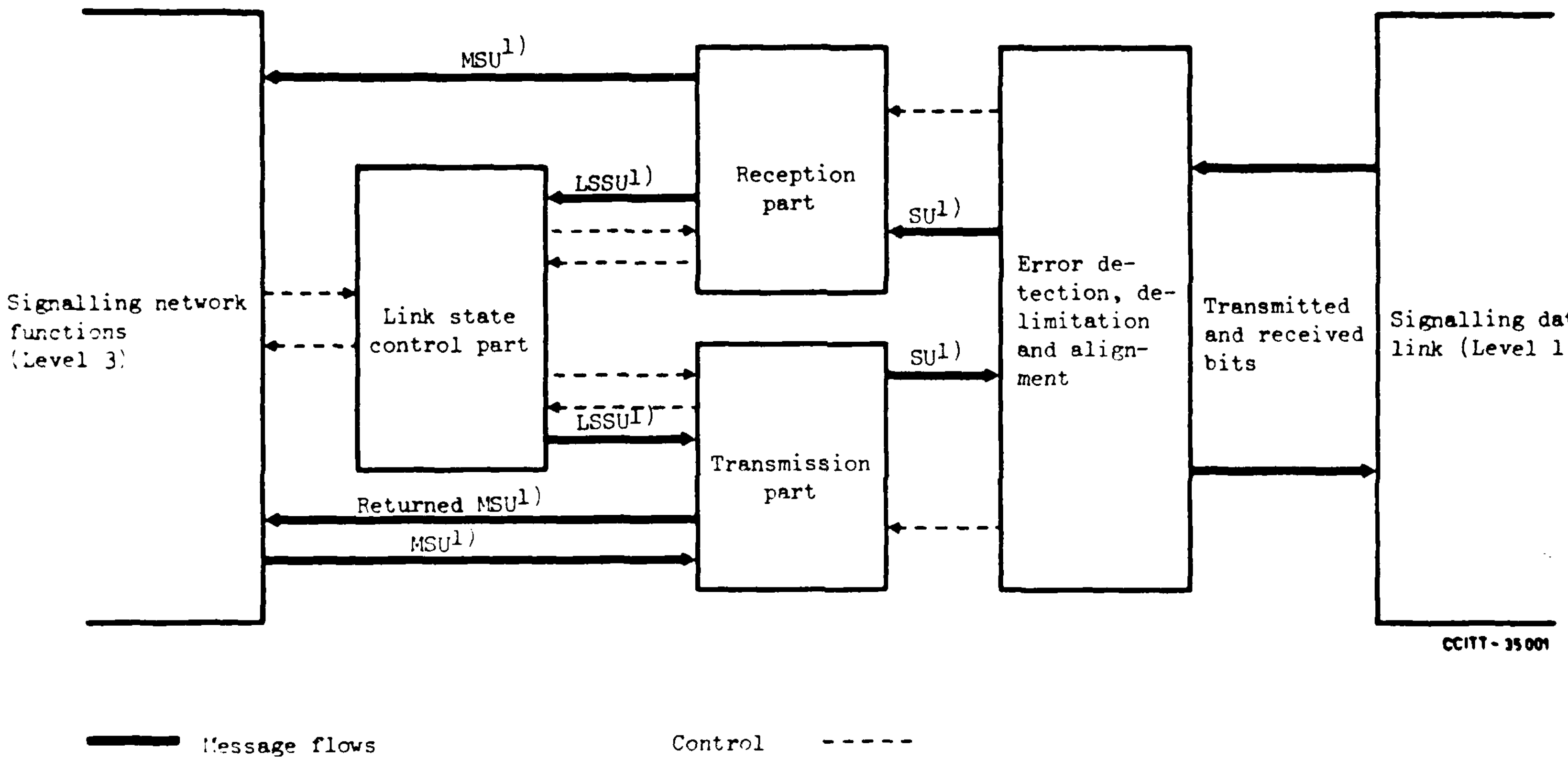
1.6 Signalling link error monitoring

Two signalling link error rate monitor functions are provided; one which is employed whilst a signalling link is in service and which provides one of the criteria for taking the link out of service, and one which is employed whilst a link is in the proving state of the initial alignment procedure. These are called the signal unit error rate monitor and the alignment error rate monitor respectively. The characteristics of the signal unit error rate monitor are based on a signal unit error count incremented and decremented using the "leaky bucket" principle whilst the alignment error rate monitor is a linear count of signal unit errors. During loss of alignment the signal unit error rate monitor error count is incremented in proportion to the period of the loss of alignment.

1.7 Link state control functions

Link state control is a function of the signalling link which provides directions to the other signalling link functions. The interfaces with link state control are shown in Figure 1-1 (Q.703) and Figure 1-2 (Q.703). The split into the functional blocks shown in the Figures is made to facilitate description of the signalling link procedures and should not be taken to imply any particular implementation.

The link state control function is shown in the overview diagram, Figure 1-2 (Q.703), and the detailed state transition diagram, Figure 11-2 (Q.703).



1) These signal units do not include all error control information.

Figure 1-1 (Q.703) - Signalling link control functional specification block interactions

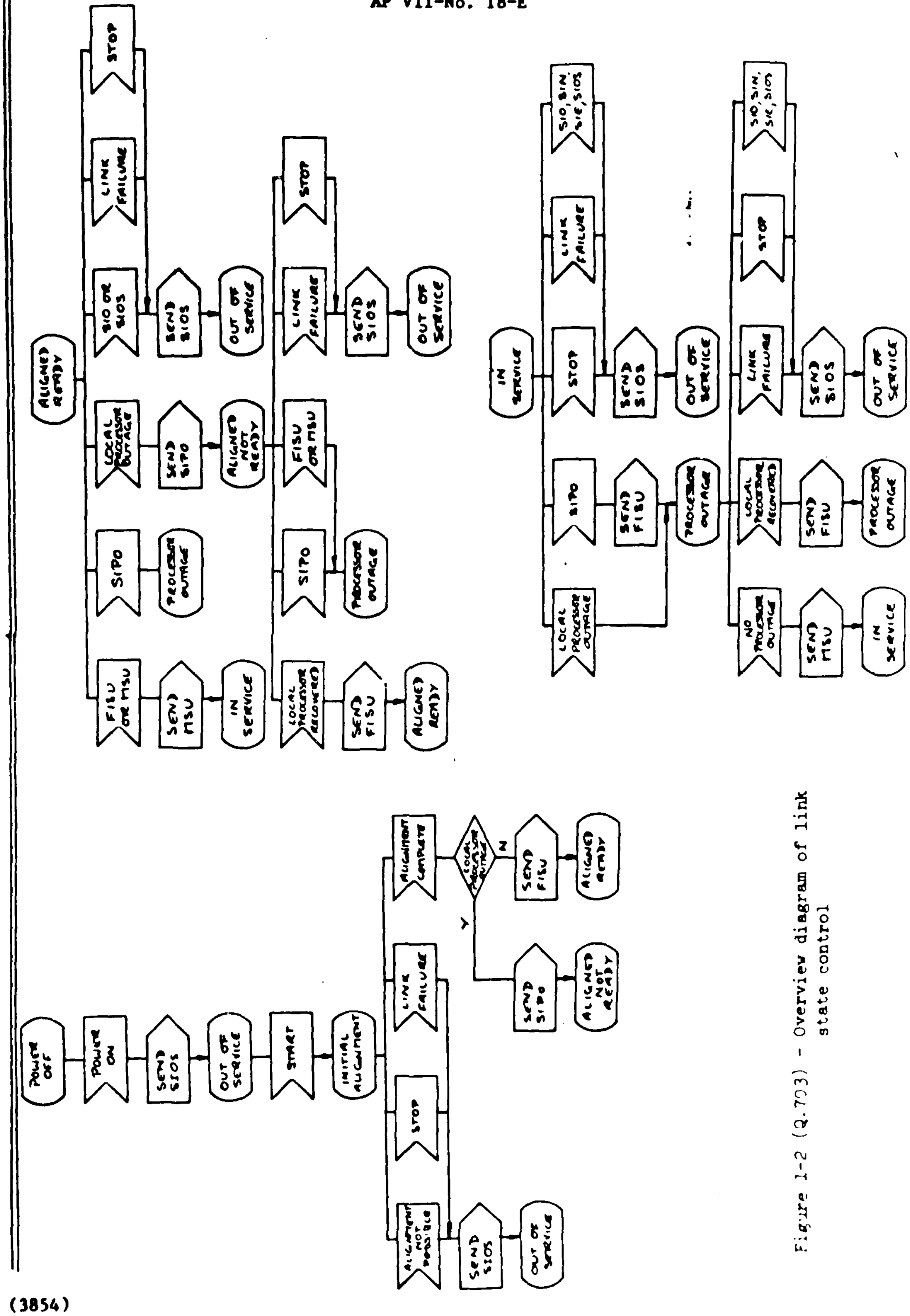


Figure 1-2 (Q.703) - Overview diagram of link state control

2 Basic signal unit format

2.1 General

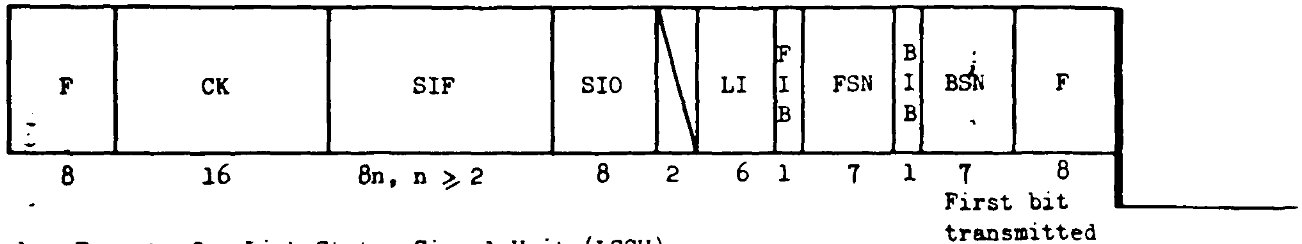
Signalling and other information originating from a user part is transferred over the signalling link by means of signal units.

A signal unit is constituted of a variable length signalling information field which carries the information generated by a user part and a number of fixed length fields which carry information required for message transfer control. In the case of link status signal units the signalling information field is replaced by a status field which is generated by the signalling link terminal.

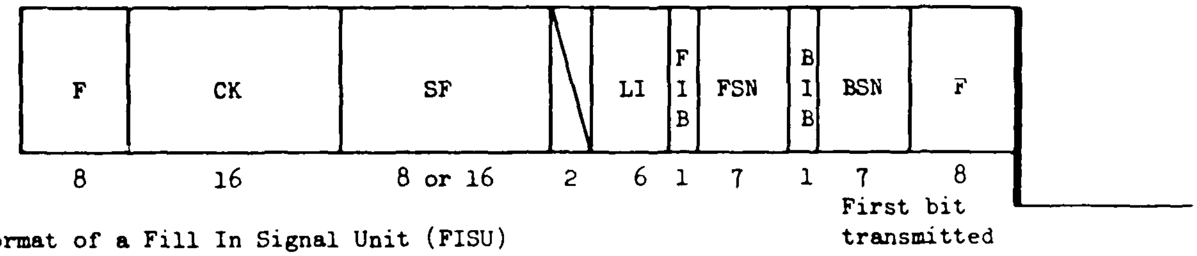
2.2 Signal unit format

Three types of signal unit are differentiated by means of the length indicator contained in all signal units, i.e.: Message Signal Units, link status signal units and fill in signal units. Message signal units are retransmitted in case of error, link status signal unit and fill in signal units are not. The basic formats of the signal units are shown in Figure 2-1 (Q.703).

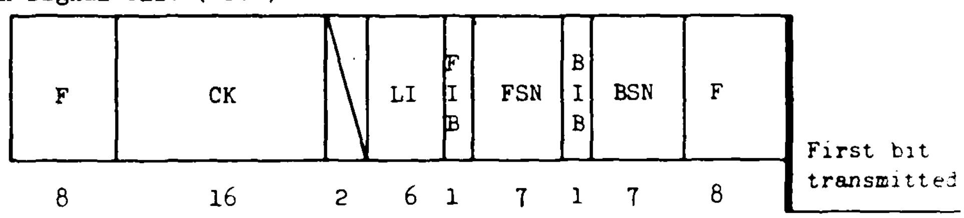
a. Basic format of a Message Signal Unit (MSU)



b. Format of a Link Status Signal Unit (LSSU)



c. Format of a Fill In Signal Unit (FISU)



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

Figure 2-1 (Q.703) - Signal unit formats

2.3 Function and codes of the signal unit fields

2.3.1 General

The message transfer control information encompasses 8 fixed length fields in the signal unit which contain information required for error control and message alignment.

2.3.2 Flag

The opening flag indicates the start of a signal unit. The opening flag of one signal unit is normally the closing flag of the preceding signal unit. The closing flag indicates the end of a signal unit. The bit pattern for the flag is 01111110.

2.3.3 Length indicator

The length indicator is used to indicate the number of octets following the length indicator octet and preceding the check bits and is a number in binary code in the range 0-63. The length indicator differentiates between the three types of signal unit as follows:

Length indicator = 0 : fill in signal unit

Length indicator = 1 or 2 : link status signal unit

Length indicator = 2 : message signal unit

In national signalling networks, in the case that a signalling information field spanning more than 62 octets is included in a message signal unit, the length indicator is set to 63.

2.3.4 Service information octet

The service information octet is divided into the service indicator and the sub-service field.

The service indicator is used to associate signalling information with a particular user part and is present only in message signal units.

The content of the sub-service field is described in Recommendation Q.704, Section 12.2.2 [1].

Note - The Message Transfer Part may handle messages for different users (i.e. messages with different service indicators) with different priorities. These priorities are for further study.

2.3.5 Sequence numbering

The forward sequence number is the sequence number of the signal unit in which it is carried.

The backward sequence number is the sequence number of a signal unit being acknowledged.

The forward sequence number and backward sequence number are numbers in binary code from a cyclic sequence ranging from 0 to 127 (see Sections 5 and 6).

2.3.6 Indicator bits

The forward indicator bit and backward indicator bit together with the forward sequence number and backward sequence number are used in the basic error control method to perform the signal unit sequence control and acknowledgement functions. (See Sections 5.2 and 6.)

2.3.7 Check bits

Every signal unit has 16 check bits for error detection. (See Section 4.)

2.3.8 Signalling information field

The signalling information field consists of an integral number of octets, greater than or equal to 2 and less than or equal to 62.

In national signalling networks it may consist of up to 272 octets [1].

The format and codes of the signalling information field are defined for each user part.

2.3.9 Status field

The formats and codes of the status field are described in Section 9.

2.4 Order of bit transmission

Each of the fields mentioned in Section 2.3 will be transmitted in the order indicated in Figure 2-1 (Q.703).

Within each field or sub-field the bits will be transmitted with the least significant bit first. The 16 check bits are transmitted in the order generated (see Section 4).

----

1) The value 272 allows a single message signal unit to accommodate information blocks of up to 256 octets in length accompanied by a label and possible additional housekeeping information which may, for example, be used by level 4 to link such information blocks together.

3 Signal unit delimitation

3.1 Flags

A signal unit includes an opening flag (see Section 2.2). The opening flag of a signal unit is normally considered to be the closing flag of the preceding signal unit (however, see Note to Section 5). In certain conditions (e.g. signalling link overload) a number of flags may be generated between two consecutive signal units.

3.2 Zero insertion and deletion

To ensure that the flag code is not imitated by any other part of the signal unit the transmitting signalling link terminal inserts a zero after every sequence of five consecutive ones before the flags are attached and the signal unit is transmitted. At the receiving signalling link terminal, after flag detection and removal, each zero which directly follows a sequence of five consecutive ones is deleted.

4 Acceptance procedure

4.1 Acceptance of alignment

4.1.1 A flag which is not followed immediately by another flag is considered an opening flag. Whenever an opening flag is received the beginning of a signal unit is assumed. When the next flag (a closing flag) is received it is assumed to be the termination of the signal unit.

4.1.2 If seven or more consecutive ones are received the signal unit error rate monitor enters the "octet counting" mode (see Section 4.1.4) and the next valid flag searched for.

4.1.3 After deletion of the zeroes inserted for transparency the received signal unit length is checked to be a multiple of 8 bits and at least 6 octets. If it is not then the signal unit is discarded and the signal unit error rate monitor is incremented. If more than m + 7 octets are received before a closing flag the "octet counting" mode is entered [see Figure 9-2 (Q.703)] and the signal unit is discarded. m is the maximum length of the signalling information field (in octets) allowed on a particular signalling link. m takes the value 62 or 272 depending on the maximum message length restrictions of the signalling network concerned. 1) In the case of the basic error control method a negative acknowledgement may be sent according to the rules set out in Section 5.2.

4.1.4 When the "octet counting" mode is entered all the bits received after the last flag and before the next flag are discarded. The "octet counting" mode is left when the next correctly checking Signal Unit is received, this signal unit is accepted.

----

1) The value 272 may apply in national signalling networks (see Section 2.3.8) and it allows a single message signal unit to accommodate information blocks of up to 256 octets in length accompanied by a label and possible additional housekeeping information which may, for example, be used by level 4 to link such information blocks together. It remains for further study to determine if a unique value for the number of octets to be received before entering the "octet counting" mode is acceptable from an operational point of view.

4.2 Error detection

The error detection function is performed by means of 16 check bits provided at the end of each signal unit.

The check bits are generated by the transmitting signalling link terminal. They are the ones complement of the sum (Modulo 2) of:

i) the remainder of x^k (15 + x^{14} + x^{13} + x^{12}...... + x^2 + x + 1) divided (Modulo 2) by the generator polynomial $x^{16} + x^{12} + x^5 + 1$, where k is the number of bits in the signal unit existing between, but not including, the final bit of the opening flag and the first bit of the check bits, excluding bits inserted for transparency, and

ii) the remainder after multiplication by x^{16} and then division (Modulo 2) by the generator polynomial $x^{16} + x^{12} + x^5 + 1$ of the content of the signal unit, existing between but not including, the final bit of the opening flag and the first bit of the check bits, excluding bits inserted for transparency.

As a typical implementation, at the transmitting signalling link terminal, the initial remainder of the division is preset to all ones and is then modified by division by the generator polynomial (as described above) on all the fields of the signal unit; the ones complement of the resulting remainder is transmitted as the 16 check bits.

At the receiving signalling link terminal, the correspondence between the check bits and the remaining part of the signal unit is checked; if a complete correspondence is not found the signal unit is discarded.

As a typical implementation at the receiving signalling link terminal, the initial remainder is preset to all ones, and the serial incoming protected bits including the check bits (after the bits inserted for transparency are removed) when divided by the generator polynomial will result in a remainder of 0001110100001111 (x^{15} through x^0, respectively) in the absence of transmission errors.

5 Basic error correction method

5.1 General

The basic error correction method is a non-compelled method in which correction is performed by retransmission. In normal operation the method ensures correct transfer of message signal units over the signalling link, in sequence and with no double delivery. As a consequence, no resequencing or eliminating of the received information is required within the user parts.

Positive acknowledgements are used to indicate correct transfer of a message signal units. Negative acknowledgements are used as explicit requests for retransmission of signal units received in a corrupt form.

To minimize the number of retransmissions and the resulting message signal unit delay a request for retransmission is made only when a message signal unit (not another signal unit) has been lost because of, for example, transmission errors or disturbances.

The method requires that transmitted but not yet positively acknowledged message signal units remain available for retransmission. To maintain the correct message signal unit sequence when a retransmission is made, the message signal unit, the retransmission of which has been requested, and any subsequently transmitted message signal units are retransmitted in the order in which they were originally transmitted.

As part of the error correction method each signal unit carries a forward sequence number, a forward indicator bit, a backward sequence number and a backward indicator bit. The error correction procedure operates independently in the two transmission directions. The forward sequence number and forward indicator bit in one direction together with the backward sequence number and backward indicator bit in the other direction are associated with the message signal unit flow in the first direction. They function independently of the message signal unit flow in the other direction and its associated forward sequence number, forward indicator bit, backward sequence number and backward indicator bit.

The transmission of new message signal units is temporarily stopped during retransmissions or when no forward sequence number values are available to be assigned to new message signal units (due to a high momentary load or corruption of positive acknowledgements) (see Section 5.2.2).

Under normal conditions, when no message signal units are to be transmitted or retransmitted, fill in signal units are sent continuously. In some particular cases link status signal units, continuous fill-in signal units or flags may be sent as described in Sections 7, 8 and 10.

5.2 Acknowledgements (positive adknowledgement and negative acknowledgement)

5.2.1 Sequence numbering

For the purposes of acknowledgement and signal unit sequence control, each signal unit carries two sequence numbers. The signal unit sequence control is performed by means of the forward sequence number. The acknowledgement function is performed by means of the backward sequence number.

The value of the forward sequence number of a message signal unit is obtained by incrementing (Modulo 128, see Section 2.3.5) the last assigned value by 1.

This forward sequence number value uniquely identifies the message signal unit until its delivery is accepted without errors and in correct sequence, by the receiving terminal. The forward sequence number of a signal unit other than a message signal unit assumes the value of the forward sequence number of the last transmitted message signal unit.

5.2.2 Signal unit sequence control

Information regarding the service information octet, signalling information field and forward sequence number and the length of each message signal unit is retained at the transmitting signalling link terminal until an acknowledgement is received (see Section 5.2.3). In the meantime the same forward sequence number cannot be used for another message signal unit (see Section 5.2.3).

A forward sequence number value can be assigned to a new message signal until it is sent when a positive acknowledgement concerning that value incremented by at least one (Modulo 128) is received (see Section 5.2.3).

This means that not more than 127 signal units may be available for retransmission.

The action to be taken at the receiving signalling link terminal upon receipt of a correctly checking signal unit is determined by comparison of the received forward sequence number with the forward sequence number of the last previously accepted signal unit and on comparison of the received forward indicator bit with the latest sent backward indicator bit. In addition as the appropriate action differs for a message signal unit and another signal unit, the length indicator of the received signal unit mus be examined.

a) If the signal unit is a fill-in signa unit then:

   i) If the forward sequence umber value equals the forward sequence number value of the last accepted message signal unit then the signal unit is processed within the message transfer part.

   ii) If the forward sequence number value is different from the forward sequence number value of the last accepted message signal unit, then the signal unit is processed within the message transfer part. If the received forward indicator bit is in the same state as the last sent backward indicator bit, a negative acknowledgement is sent.

b) If the signal unit is a link status signal unit then it is processed within the message transfer part.

   i) If the forward sequence number value is the same as that of the last accepted signal unit then the signal unit is discarded, regardless of the state of the indicator bits.

   ii) If the forward sequence number value is one more (Modulo 128 see Section 2.3.6) than that of the last accepted signal unit and if the received forward indicator bit is in the same state as the last sent backward indicator bit, then the signal unit is accepted and delivered to level 3.

   Explicit positive acknowledgements to the accepted signal units are sent as specified in Section 5.2.3.

   If the forward sequence number is one more than that of the last accepted signal unit and if the received forward indicator bit is not in the same state as the last sent backward indicator bit then the signal unit is discarded.

iii) If the forward sequence number value is different from those values mentioned in (i) and (ii) above, then the signal unit is discarded. If the received forward indicator bit is in the same state as the last sent backward indicator bit a negative acknowledgement is sent.

Monitoring of the backward sequence number value and backward indicator bit value is performed even for those signal units that are discarded by the signal unit sequence control as described in Section 5.3.

5.2.3 Positive acknowledgement

The receiving signalling link terminal acknowledges the acceptance of one or more message signal units by assigning the forward sequence number value of the latest accepted message signal unit to the backward sequence number of the next signal unit sent in the opposite direction. The backward sequence numbers of subsequent signal units retain this value until a further message signal unit is acknowledged, which will cause a change of the backward sequence number sent.

The acknowledgement to an accepted message signal unit also represents an acknowledgement to all, if any, previously accepted, though not yet acknowledged, message signal units.

5.2.4 Negative acknowledgement

If a negative acknowledgement is to be sent (see Section 5.2.2) then the backward indicator bit value of the signal units transmitted is inverted. The new backward indicator bit value is maintained in subsequently sent signal units until a new negative acknowledgement is to be sent. The backward sequence numbers assume the value of the forward sequence number of the last accepted message signal unit.

5.3 Retransmission

5.3.1 Response to a positive acknowledgement

The transmitting signalling link terminal examines the backward sequence number value of the received message signal units and fill-in signal units that have satisfied the polynomial error check. The previously sent message signal unit, which has a forward sequence number value identical to the received backward sequence number value will no longer be available for transmission.

When an acknowledgement of a message signal unit having a given forward sequence number value is received, all other message signal units which preceded that message signal unit are considered to be acknowledged even though the corresponding backward sequence numbers have not been received.

In the case that the same acknowledgement is consecutively received a number of times no further action is taken.

In the case that a signal unit is received having a backward sequence number value which is not the same as the previous one or one of the forward sequence number values of the signal units available for retransmission, the signal unit is discarded. The following signal unit is discarded.

If any two backward sequence number values in three consecutively received signal units are not the same as the previous one or any of the forward sequence number values of the signal units in the retransmission buffer at the time that they are received, then level 3 is informed that the link is faulty.

In the case of excessive delay in the reception of a link failure indication is given to level 3.

5.3.2 Response to a negative acknowledgement

When the received backward indicator bit is not in the same state as the last sent forward indicator bit all the message signal units available for retransmission are transmitted in correct sequence starting with the signal unit which has a forward sequence number value of one more (Modulo 128, see Section 2.3.6) than the backward sequence number associated with the received backward indicator bit.

New message signal units can only be sent when the last message signal unit available for retransmission has been transmitted.

At the start of a retransmission the forward indicator bit is inverted, it thus becomes equal to the backward indicator bit value of the received signal units. The new forward indicator bit value is maintained in subsequently transmitted signal units until a new retransmission is started. Thus, under normal conditions the forward indicator bit included in the transmitted signal units is equal to the backward indicator bit value of the received signal units. If a retransmitted message signal unit is lost then this is detected by a check on the forward sequence number and forward indicator bit (see Section 5.2.2) and a new retransmission request is made.

In the case that a signal unit is received having a forward indicator bit value indicating the start of a retransmission when no negative acknowledgement has been sent then that signal unit is discarded.

If any two forward indicator bit values in three consecutively received signal units indicate the start of a retransmission when no negative acknowledgement has been sent at the time that they are received, then level 3 is informed that the link is faulty.

Note - Repetition of message signal units

The signal unit sequence control makes it possible to repeat a message signal unit which has not yet been acknowledged without affecting the basic error correction procedure. Thus a form of forward error correction by means of repetition of message signal units is possible as a national option (for example to reduce the effective signalling link speed in special national applications, and in long loop delay applications to lower the retransmission rate and thus reduce the average message delay). In the case of repetition each signal unit should be defined by its own opening and closing flags (i.e. there should be at least two flags between signal units) to ensure that the repeated signal unit is not lost by the corruption of only a single flag.

6 Error correction by preventive cyclic retransmission

6.1 General

The preventive cyclic retransmission method is essentially a non-compelled forward error correction method, whereby positive acknowledgements are needed to support the forward error correction.

Each message signal unit must be retained at the transmitting signalling link terminal until a positive acknowledgement arrives from the receiving signalling link terminal.

Error correction is effected by preventive cyclic retransmission of the message signal units already sent, though not yet acknowledged, preventive cyclic retransmission takes place whenever there are no new message signal units or link status signal units available to be sent.

To complement preventive cyclic retransmission, the message signal units available for retransmission are retransmitted with priority when a limit of the number of message signal units or a limit of the number of message signal unit octets available for retransmission has been reached.

Under normal conditions, when no message signal units are to be transmitted or cyclically retransmitted, fill-in signal units are sent. In some particular cases link status signal units, continuous fill-in signal units or flags may be sent as described in Sections 7, 8 and 10.

6.2 Acknowledgements

6.2.1 Sequence numbering

For the purposes of acknowledgement and signal unit sequence control, each signal unit carries 2 sequence numbers. The signal unit sequence control is performed by means of the forward sequence number. The acknowledgement function is performed by means of the backward sequence number.

The value of the forward sequence number of a message signal unit is obtained by incrementing (Modulo 128, see Section 2.3.6) the last assigned value by 1. This forward sequence number value uniquely identifies the message signal unit until its delivery is accepted without errors and in correct sequence, by the receiving signalling link terminal. The forward sequence number of a signal unit other than a message signal unit assumes the value of the forward sequence number of the last transmitted message signal unit.

6.2.2 Signal unit sequence control

Information regarding the service information octet, signalling information field and forward sequence number of each message signal unit is retained at the transmitting signalling link terminal until the related acknowledgement is received (see Section 6.2.3). In the meantime the same forward sequence number value cannot be used for another message signal unit (see Section 6.2.3).

A forward sequence number value can be assigned to a new message signal unit to be sent when an acknowledgement concerning that value incremented by at least one (Modulo 128) is received (see Section 6.2.3).

The action to be taken at the receiving signalling link terminal upon receipt of a correctly checking signal unit is determined by comparison of the received forward sequence number with the forward sequence number of the last previously accepted signal unit.

In addition, as the appropriate action differs for a message signal unit and another signal unit, the length indicator of the received signal unit must be examined. The forward indicator bit and the backward indicator bit are not used and are set to one.

a) If the signal unit is not a message signal unit then the signal unit is processed within the message transfer part.

b) If the signal unit is a message signal unit then:

   i) If the forward sequence number value is the same as that of the last accepted signal unit then the signal unit is discarded.

   ii) If the forward sequence number value is one more (Modulo 128, see Section 2.3.6) than that of the last accepted signal unit then the signal unit is accepted and delivered to level 3.

   Explicit positive acknowledgements for the accepted signal units are sent as specified in Section 5.2.3.

   iii) If the forward sequence number value is different from the values mentioned in i) and ii) above then the signal unit is discarded. Monitoring of the backward sequence number value is performed even for those signal units that are discarded by the signal unit sequence control, as described in Section 6.3.1.

6.2.3 Positive acknowledgement

The receiving signalling link terminal acknowledges the acceptance of one or more message signal units by assigning the forward sequence number value of the latest accepted message signal unit to the backward sequence number of the next signal unit sent. The backward sequence numbers of subsequent signal units retain this value until a further message signal unit is acknowledged, which will cause a change of the backward sequence number sent. The acknowledgement to an accepted message signal unit also represents an acknowledgement to all, if any, previously accepted though not yet acknowledged signal units.

6.3 Preventive cyclic retransmission

6.3.1 Response to a positive acknowledgement

All message signal units sent for the first time are retained until they have been positively acknowledged.

The transmitting signalling link terminal examines the backward sequence number value of the received message signal units and fill-in signal units that have satisfied the polynomial error check. The previously sent message signal unit, the forward sequence number value of which is the same as the backward sequence number value, will no longer be available for retransmission.

When an acknowledgement for a message signal unit having a given forward sequence number value is received all other message signal units, if any, having forward sequence number values preceding that value (Modulo 128) are considered to be acknowledged, even though the corresponding backward sequence number has not been received.

In the case that the same acknowledgement is consecutively received a number of times no further action is taken.

In the case that a signal unit is received having a backward sequence number value which is not the same as the previous one or one of the forward sequence number values of the signal units in the retransmission buffer the signal unit is discarded. The backward sequence number of the following signal unit is not used as an acknowledgement to signal units in the retransmission buffer.

If any two backward sequence number values in three consecutively received signal units are not the same as the previous one or any of the forward sequence number values of the signal units in the retransmission buffer at the time that they are received, then level 3 is informed that the link is faulty.

6.3.2 Preventive cyclic retransmission procedure

i) If no new signal units are available to be sent, the message signal units available for retransmission are retransmitted cyclically.

ii) If new signal units are available, the retransmission cycle, if any, must be interrupted and the signal units be sent with priority.

iii) Under normal conditions, when no message signal units are to be transmitted or cyclically retransmitted, fill-in signal units are sent continuously. In some particular cases link status signal units or flags may be sent as described in Sections 7 and 10.

6.4 Forced retransmission

To maintain the efficiency of error correction in those cases where automatic error correction by preventive cyclic retransmission alone is made impossible (by, for example, high signalling load) the preventive cyclic retransmission procedures must be complemented by the forced retransmission procedure.

6.4.1 Forced retransmission procedure

Both the number of message signal units available for retransmission (N_1) and the number of message signal unit octets available for retransmission (N_2) are monitored continuously.

If one of them reaches its set limit, no new message signal units or fill-in signal units are sent and all the message signal units available for retransmission are retransmitted once with priority, in the order in which they were originally transmitted. If all message signal units available for retransmission have been sent once and neither N_1 nor N_2 is at its limit value, the normal preventive cyclic retransmission procedure can be resumed. If not, all the message signal units available sent again with priority.

6.4.2 Limitation of the values N_1 and N_2

N_1 is limited by the maximum numbering capacity of the forward sequence number range which dictates that not more than 127 message signal units can be available for retransmission.

In the absence of errors N_2 is limited by the signalling link loop delay T_L. It must be ensured that not more than $T_L/T_{eb} + 1$ message signal unit octets are available for retransmission.

Where:

T_L is the signalling link loop delay, i.e. the time between the sending of a message signal unit and the reception of the acknowledgement for this message signal unit in undisturbed operation;

and

T_{eb} is the emission time of one octet.

7 Initial alignment procedure

7.1 General

The procedure is applicable to activation and to restoration of the link. The procedure provides a "normal" proving period for "normal" initial alignment and an "emergency" proving period for "emergency" initial alignment. The decision to apply either the "normal" or the "emergency" procedures is made unilaterally at level 3 (see Recommendation Q.704 [3]). Only the signalling link to be aligned is involved in the initial alignment procedure (i.e. no transfer of alignment information over other signalling links is required).

7.2 Initial alignment status indications

The initial alignment procedure employs four different alignment status indications:

- Status indication "O" (out of alignment)
- Status indication "N" ("normal" alignment status)
- Status indication "E" ("emergency" alignment status)
- Status indication "OS" (out of service)

These indications are carried in the status field of the link status signal units (see Section 2.2).

Status indication "O" is transmitted when initial alignment has been started and none of the status indications "O", "N", "E" or "OS" are received from the link. Status indication "N" is transmitted when, after having started initial alignment status indication "O", "N", "E" or "OS" is received and the terminal is in the "normal" alignment status. Status indication "E" is transmitted when, after having started initial alignment status indication "O", "N", "E" or "OS" is received and the terminal is in the "emergency" alignment status, i.e. it must employ the short "emergency" proving period.

Status indications "N" and "E" indicate the status of the transmitting signalling link terminal; this is not changed by reception of status indications indicating a different status at the remote signalling link terminal. Hence, if a signalling link terminal with a "normal" alignment status receives a status indication "E" it continues to send status indication "N" but initiates the short "emergency" proving period.

Status indication "OS" informs the remote signalling link terminal that for reasons other than processor outage (e.g. on link failure) the signalling link terminal can neither receive nor transmit message signal units.

7.3 Initial alignment procedure

The alignment procedure passes through a number of states during the initial alignment:

- State 00, the procedure is suspended.

- State 01, "not aligned"; the signalling link is not aligned and the terminal is sending status indication "O". Timeout T_2 is started on entry to State 01 and stopped when State 01 is left. 1).

- State 02, "aligned"; the signalling link is aligned and the terminal is sending status indication "N" or "E", status indications "N", "E" or "OS" are not received. Timeout T_3 is started on entry to State 02 and stopped when State 02 is left.

- State 03, "proving"; the signalling link terminal is sending status indication "N" or "E", status indication "O" or "OS" are not received, the backward indicator bit and the backward sequence number transmitted are set to the received forward indicator bit and forward sequence number, proving has been started.

The procedure itself is described in the overview diagram, Figure 7-1 (Q.703), and in state transition diagram, Figure 11-3 (Q.703).

7.4 Proving periods

The values of the proving periods are:

$P_n = 2^{16}$ octets $P_e = 2^{12}$ octets for both 64 kbit/s and lower bit rates. These values correspond to times of 8.2s and 0.5s respectively at 64 kbit/s, and 110s and 7s at 4.8 kbit/s.

8 Processor outage

The procedure for dealing with local and/or remote processor outage is described in Figure 1-4 (Q.703).

A processor outage situation occurs when, due to factors at a functional level higher than level 2, use of the link is precluded.

In this context, processor outage refers to a situation when signalling messages cannot be transferred to functional levels 3 and/or 4. This may be because of, for example, a central processor failure. It may also be due to a manually initiated blocking of an individual signalling link (see [4]). A processor outage condition may thus not necessarily affect all signalling links in a signalling point, nor does it exclude the possibility that level 3 is able to control the operation of the signalling link.

----

1) It must be ensured that the values of this timeout are different at each end of a signalling link (see Recommendation Q.704, Section 10 [3]).

When level 2 identifies a local processor outage condition, either by receiving an explicit indication from level 3, (i.e. local signalling link blocking, see Recommendation Q.704, Section 3.2.6 [4]), or by recognizing a failure of level 3, it transmits link status signal units indicating processor outage. Provided that the level 2 function at the far end of the signalling link is in its normal operating stage (i.e. transmitting message signal units or fill-in signal units), upon receiving link status signal units indicating processor outage it notifies level 3 and begins to continuously transmit fill-in signal units. As soon as it correctly receives a message signal unit or a fill-in signal unit it notifies level 3 and returns to normal operation.

When the local processor outage condition ceases, normal transmission of message signal units and fill-in signal units is resumed (provided that no local processor outage condition has arisen also at the remote end); as soon as the level 2 function at the remote end correctly receives a message signal unit or fill-in signal unit, it notifies level 3 and returns to normal operation. Format and code of link status signal units indicating processor outage (status indication 'PO') appear in Section 10.

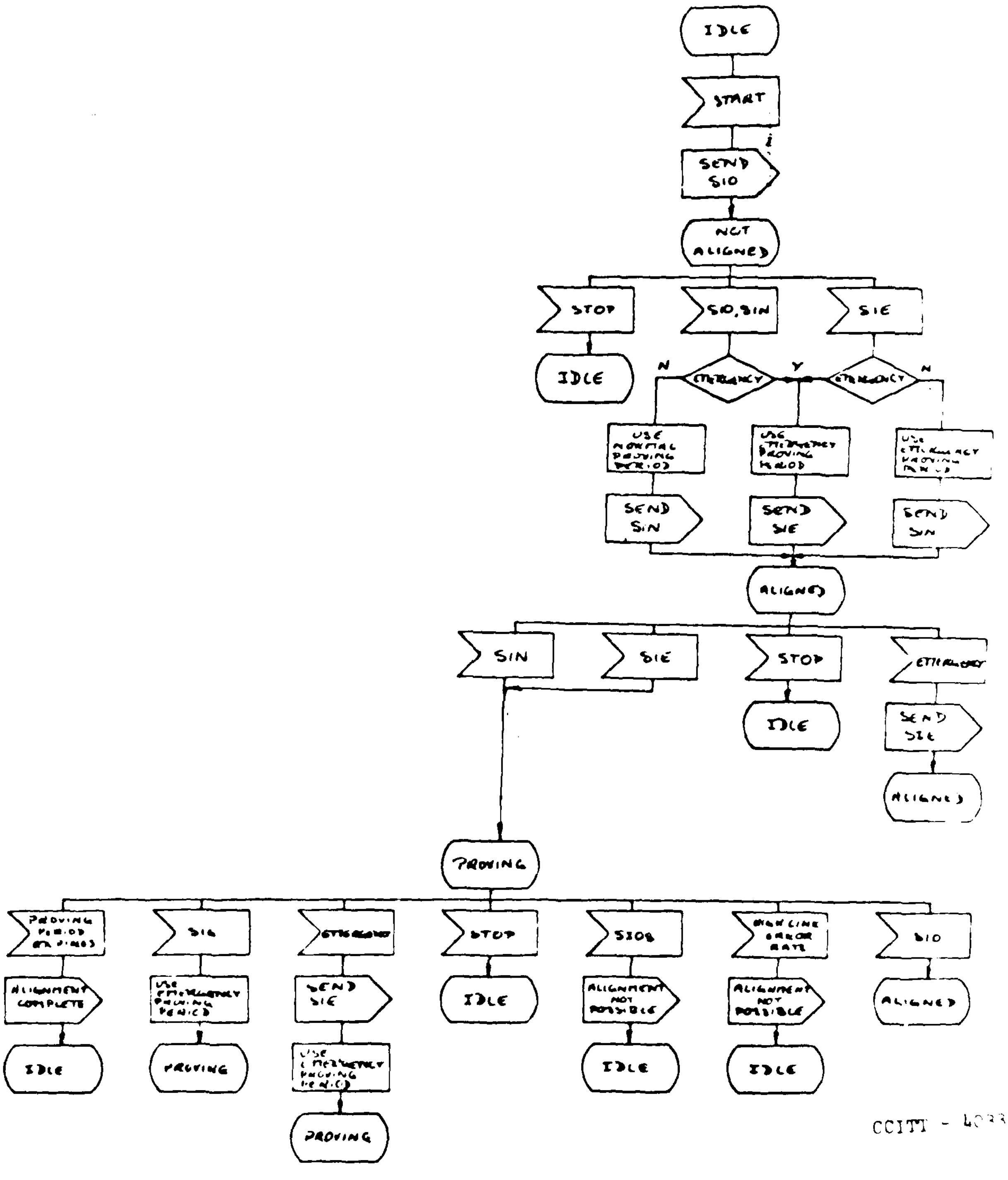


Figure 7-1 (Q.703) - Overview diagram of initial alignment contr...

9 Signalling link error monitoring

9.1 General

Two link error rate monitor functions are provided; one which is employed whilst a signalling link is in service and which provides one of the criteria for taking the link out of service, and one which is employed whilst a link is in the proving state of the initial alignment procedure (see Section 7.3). These are called the signal unit error rate monitor and the alignment error rate monitor respectively.

9.2 Signal unit error rate monitor

9.2.1 The characteristics of the signal unit error rate monitor are described by the curve of an orthogonal hyperbola which gives the time to cause a link failure indication to Level 3 (expressed in terms of messages) as a function of the signal unit error rate. The two parameters which determine the curve are; the number of consecutive Signal Units received in error that will cause an error rate high indication to Level 3, T (signal units), and the lowest signal unit error rate which will ultimately cause an error rate high indication to level 3, 1/D (signal unit errors/signal unit), [see Figure 9-1 (Q.703)].

9.2.2 The signal unit error rate monitor may be implemented in the form of an up/down counter decremented at a fixed rate (for every D received signal units or signal unit errors indicated by the acceptance procedure), but not below zero, and incremented every time a signal unit error is detected by the signal unit acceptance procedure (see Section 4), but not above the threshold [T (signal units)]. An excessive error rate will be indicated whenever the threshold [T (signal units)] is reached.

9.2.3 In the "octet counting" mode (see Section 4.1) the counter is incremented for every N octets received until a correctly checking signal unit is detected (causing the "octet counting" mode to be left).

9.2.4 When the link is brought into service the monitor count should start from zero.

9.2.5 The values of the three parameters are:

T = 64 signal units D = 256 signal units/signal unit error N = 16 octets	For 64 kbit/s
T = 16 signal units D = 256 signal units/signal unit error N = 16 octets	For lower bit rates

In the case of loss of alignment these figures will give times of approximately 128 ms and 854 ms to initiate changeover for 64 kbit/s and 4.8 kbit/s respectively.

9.3 Alignment error rate monitor

9.3.1 The alignment error rate monitor is a linear counter which is operated during normal and emergency proving periods.

9.3.2 The counter is started from zero whenever the proving state [State 03 of Figure 11-3 (Q.703)] of the alignment procedure is entered and is then incremented for every signal unit error detected. It is also incremented for every N octets received while in the octet counting mode, as described in Section 9.2.3.

9.3.3 When the counter reaches a threshold T_i, that particular proving period is aborted; on receipt of a correct signal unit or the expiry of the aborted proving period the proving state is re-entered. If proving is aborted M times then the link is returned to the out of service state. A threshold is defined for each of the two types of proving period (normal and emergency, see Section 7). These are T_{in} and T_{ie} and apply to the normal proving period and the emergency proving period respectively.

Proving is successfully completed when a proving period expires without an excessive error rate being detected and without the receipt of status indication "O" or "OS".

9.3.4 The values of the 4 parameters for both 64 kbit/s and lower bit rates are:

T_{in} = 4

T_{ie} = 1

M = 5

N = 16

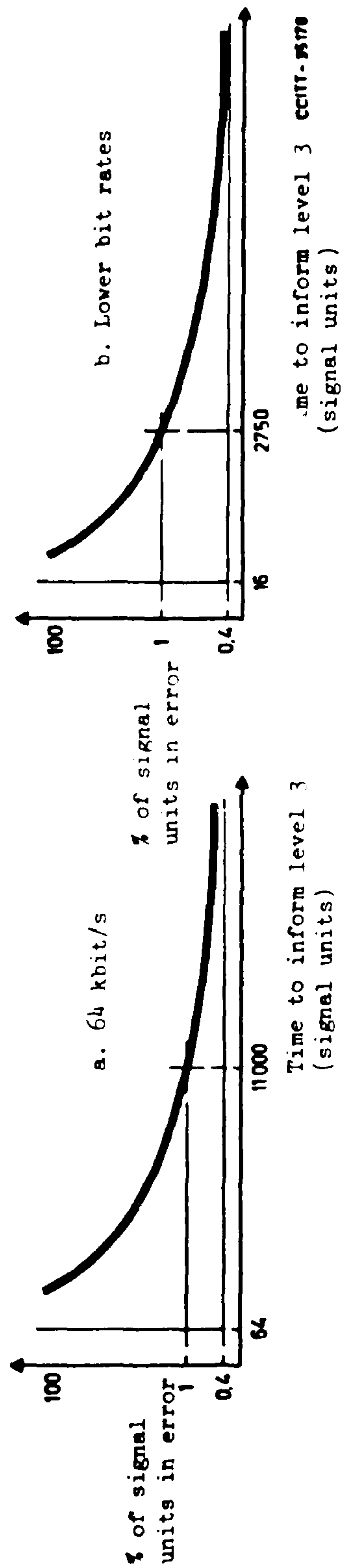


Figure 9-1 (Q.703) - Orthogonal hyperbola of the signal unit error rate monitor

10 Level 2 codes and priorities

10.1 Link status signal unit

10.1.1 The link status signal unit is identified by a length indicator value equal to 1 or 2. If the length indicator has a value of 1 then the status field consists of one octet, if the length indicator has a value of 2 then the status field consists of two octets.

10.1.2 The format of the one octet status field is as follows:

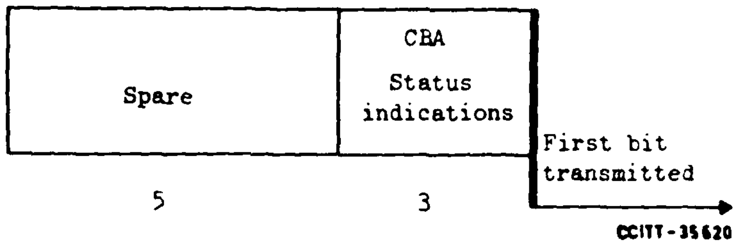


Figure 10-1 (Q.703) - Status field format

10.1.3 The use of the link status indications is described in Section 7; they are coded as follows:

CBA

000 - Status indication "O"

001 - Status indication "N"

010 - Status indication "E"

011 - Status indication "OS"

100 - Status indication "PO"

10.2 Transmission priorities within level 2

10.2.1 Five different items can be transmitted:

i) New message signal units.

ii) Message signal units which have not yet been acknowledged.

iii) Link status signal units.

iv) Fill-in signal units.

v) Flags.

In certain failure conditions it may only be possible to send flags or nothing at all.

10.2.2 For the basic error control method, two different priority situations may exist:

A: Transmission B: Retransmission

The priorities for each of these cases are shown in Figure 10-2 (Q.703).

PRIORITY CASE

	A	B
HIGHEST	iii	iii
	i	ii
	iv	iv
	v	v
LOWEST		

Figure 10-2 (Q.703) - Level 2 Priorities for the Basic Error Control Method

10.2.3 For the preventive cyclic retransmission methods two priority situations may exist:

A: Normal case. B: Forced retransmission case.

The priorities for each of these cases are shown in Figure 10-3 (Q.703).

PRIORITY CASE

	A	B
HIGHEST	iii	iii
	i	ii
	ii	i
	iv	iv
	v	v
LOWEST		

Figure 10-3 (Q.703) - Level 2 Priorities for the Preventive Cyclic Retransmission Method

<u>Note</u> - In the basic error control method, where the repetition of message signal units is employed as a national option, the repeated message signal unit will have a priority immediately below that of link status signal units.

11 State transition diagrams

This section contains the description of the signalling link control functions, described in this Recommendation, in the form of state transition diagrams according to the CCITT Specification and Description Language (SDL).

- Detailed functional block diagram: Figure 11-1 (Q.703).
- Link state control: Figure 11-2 (Q.703).
- Initial alignment control: Figure 11-3 (Q.703).
- Process or outage control: Figure 11-4 (Q.703).
- Delimitation, alignment and error control (receiving): Figure 11-5 (Q.703).
- Delimitation, alignment and error control (transmitting): Figure 11-6 (Q.703).
- Basic transmission control: Figure 11-7 (Q.703).
- Basic reception control: Figure 11-8 (Q.703).
- Preventive cyclic retransmission transmission control: Figure 11-9 (Q.703).
- Preventive cyclic retransmission reception control: Figure 11-10 (Q.703).
- Alignment error rate monitor: Figure 11-11 (Q.703).
- Signal unit error rate monitor: Figure 11-12 (Q.703).

The detailed functional breakdown shown in the following diagrams is intended to illustrate a reference model and to assist interpretation of the text in the earlier sections. The state transition diagrams are intended to show precisely the behaviour of the signalling system under normal and abnormal conditions as viewed from a remote location. It must be emphasized that the functional partitioning shown in the following diagrams is used only to facilitate understanding of the system behaviour and is not intended to specify the functional partioning to be adopted in a practical implementation of the signalling system.

In the following figures the term signal unit refers to units which do not contain all error control information.

ABBREVIATIONS USED IN FIGURE 11-1 (Q.703)

TB - Transmission buffer

RTB - Retransmission buffer

LSC - Link state control

AERM - Alignment error rate monitor

SU - Signal unit

FSNT - FSN of the last MSU transmitted

NACK - Negative acknowledgement

FSNX - FSN expected

BSNR - BSN received

BIBR - BIB received

BIBX - BIB expected

SIO - Status indication "O"

SIN - Status indication "N"

SIE - Status indication "E"

SIOS - Status indication "out of service"

SIPO - Status indication "processor outage"

FISU - Fill-in signal unit

MSU - Message signal unit

BIBT - BIB to be transmitted

BSNT - BSN to be transmitted

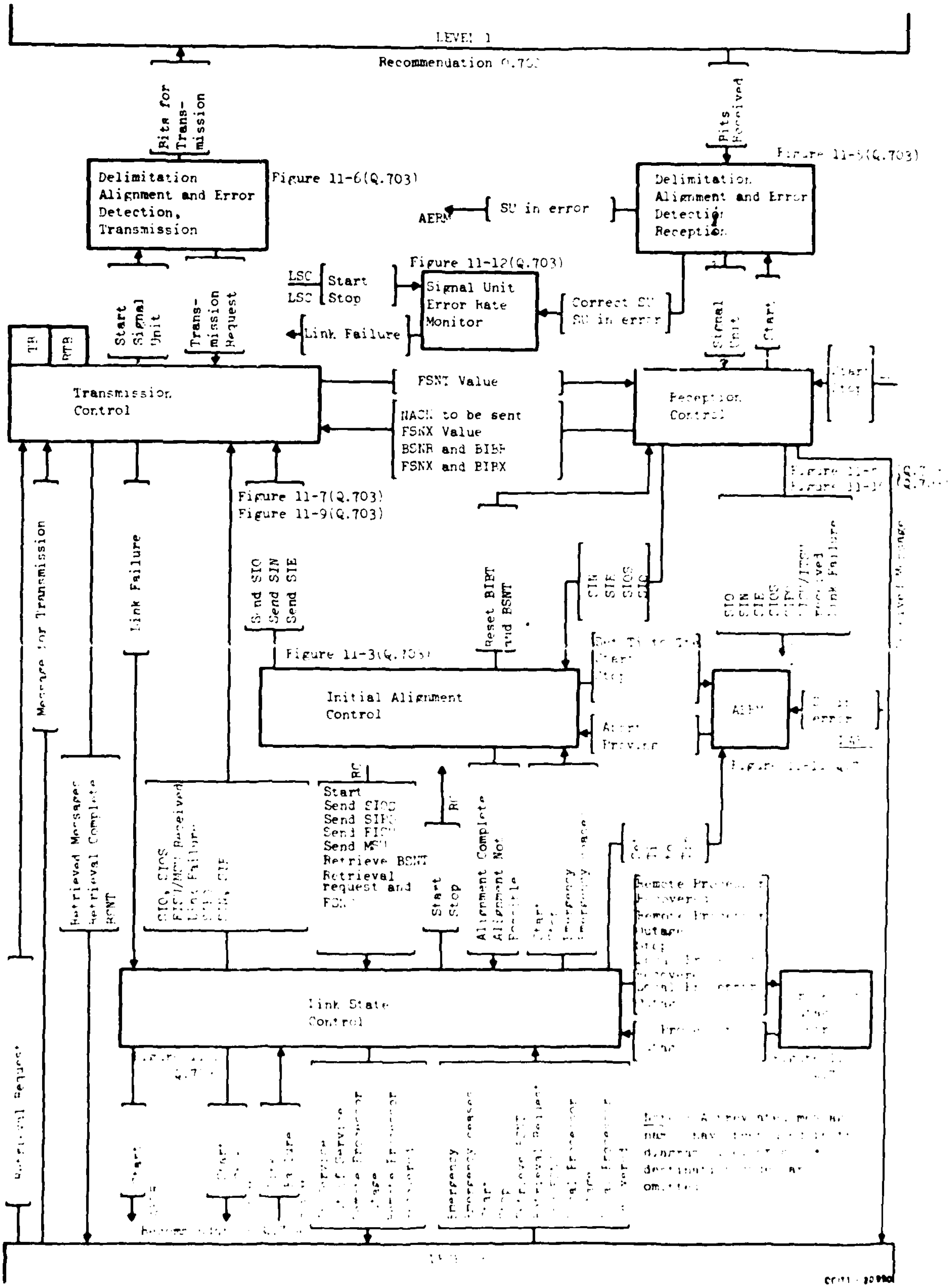
DAEDR - Delimination, alignment and error detection (receiving)

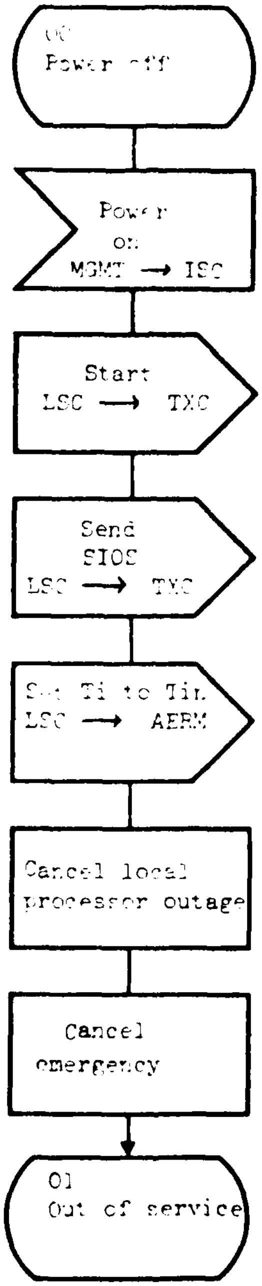
RC - Reception control

Ti - AERM threshold

Tin - Normal AERM threshold

SUERM - Signal unit error rate monitor


LEVEL 1
Bits for Trans-mission
Delimitation Alignment and Error Detection, Transmission
Figure 11-6(Q.703)
SU in error
AERM
Delimitation Alignment and Error Detection Reception
LSC
Start
Stop
Figure 11-12(Q.703)
Signal Unit Error Rate Monitor
Correct SU
Link Failure
TB
RTB
Start Signal Unit
Trans-mission Request
Transmission Control
FSNT Value
NACK to be sent
FSNX Value
BSNR and BIBR
FSNX and BIBX
Reception Control
Figure 11-7(Q.703)
Figure 11-9(Q.703)
Message for Transmission
Link Failure
Send SIO
Send SIN
Send SIE
Reset BIBT and BSNT
Figure 11-3(Q.703)
Initial Alignment Control
Retrieved Messages
Retrieval Complete
BSNT
Start
Send SIOS
Send SIPO
Send MSU
Retrieve BSNT
Retrieval request and
Start
Stop
Alignment Complete
Alignment Not Possible
Remote Processor
Link State Control
Retrieval Request
Start



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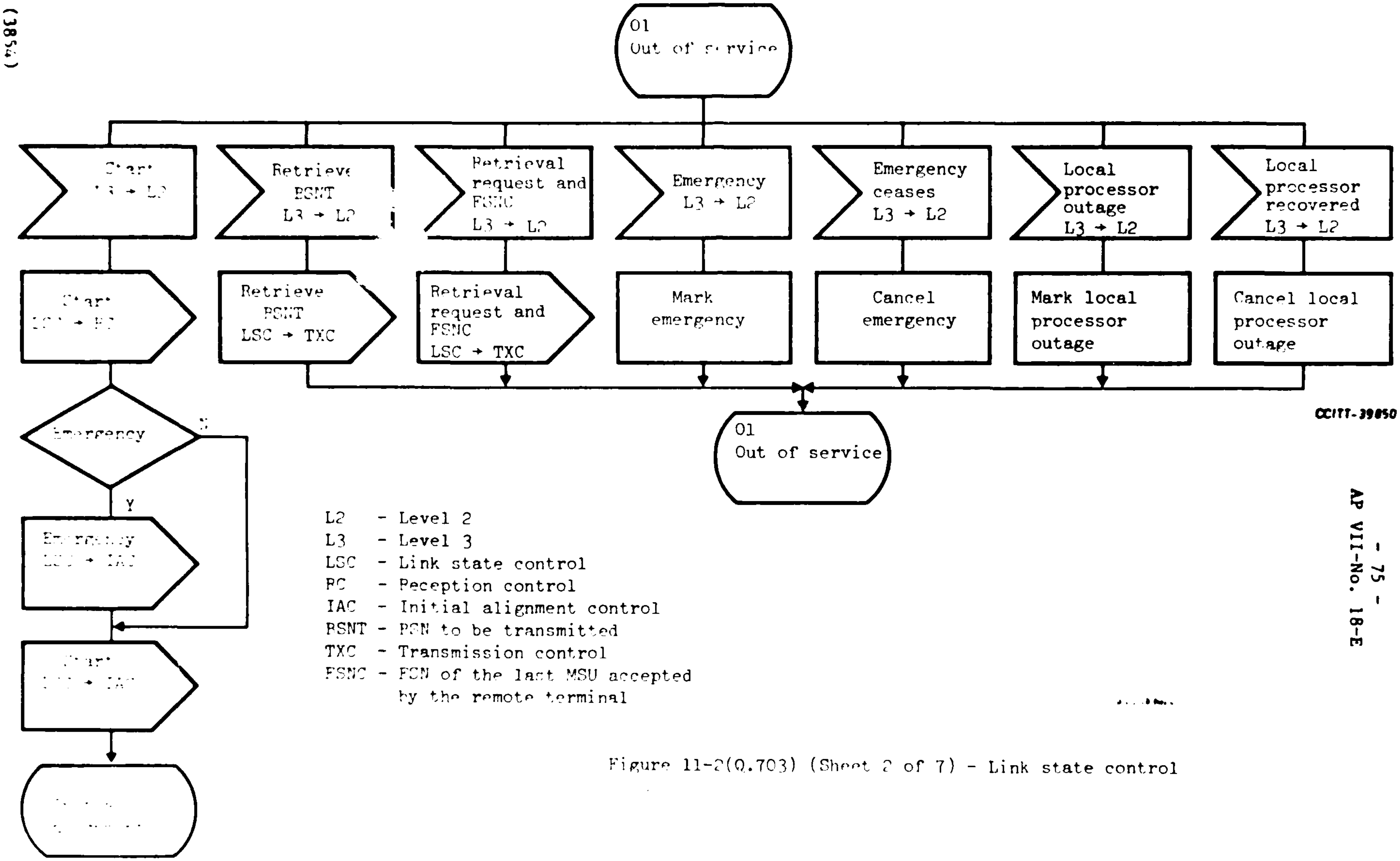
MGMT - Management system
LSC - Link state control
TXC - Transmission control
AERM - Alignment error rate monitor
Ti - Monitor threshold
Tin - Normal monitor threshold

Figure [illegible]-2(Q.703) (Sheet 1-7) - Link state control

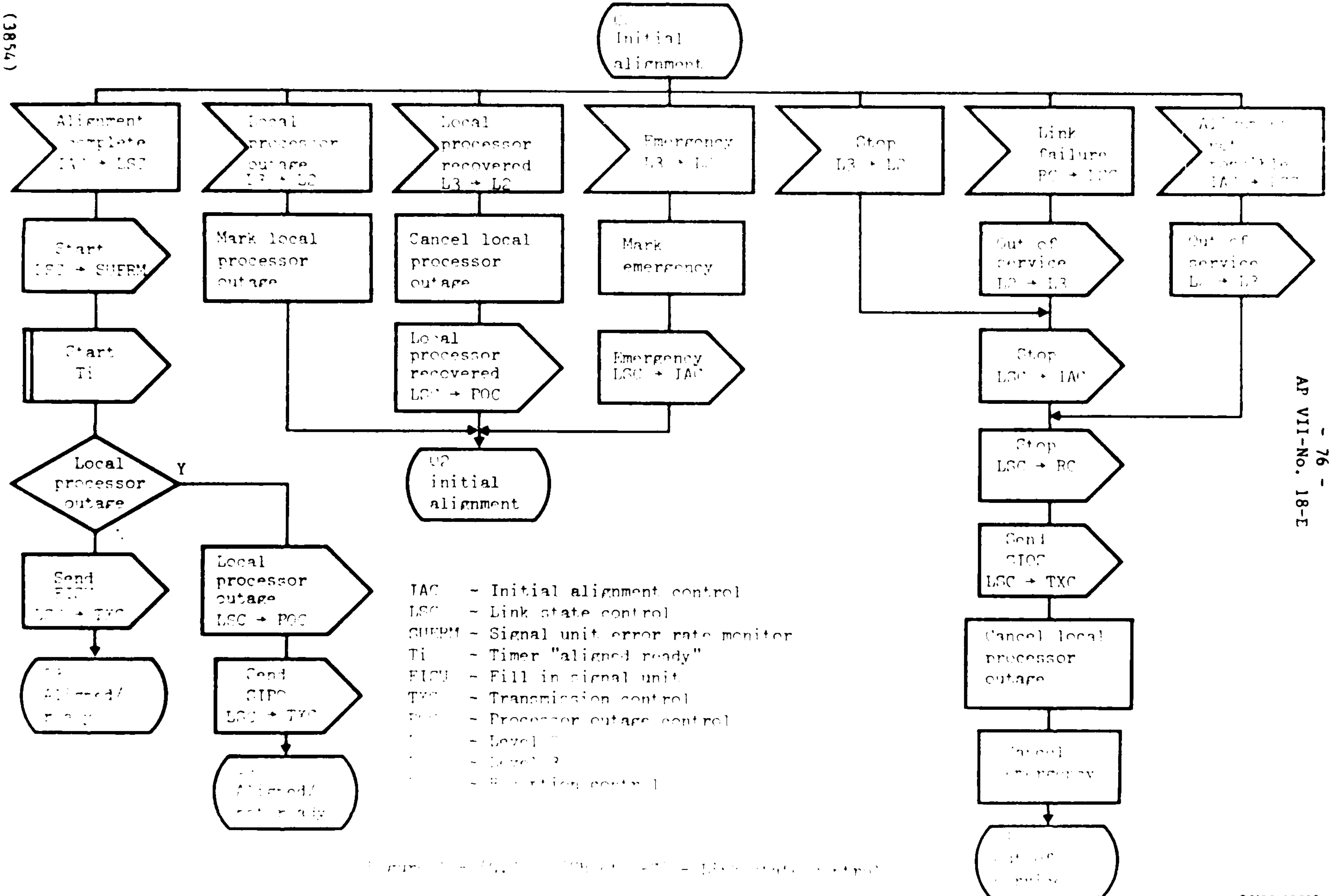
(3854)



L2 - Level 2
L3 - Level 3
LSC - Link state control
RC - Reception control
IAC - Initial alignment control
BSNT - BSN to be transmitted
TXC - Transmission control
FSNC - FSN of the last MSU accepted by the remote terminal

Figure 11-2(Q.703) (Sheet 2 of 7) - Link state control

(3854)


Initial alignment
Alignment complete
Local processor outage L3 → L2
Local processor recovered L3 → L2
Emergency
Stop L3 → L2
Link failure
Start
Start Ti
Mark local processor outage
Cancel local processor outage
Local processor recovered → POC
Mark emergency
Emergency LSC → IAC
Out of service
Stop
Stop LSC → BC
Local processor outage
Y
Send
Local processor outage LSC → POC
initial alignment
Send SIPO
Send LSC → TXC
Cancel local processor outage
IAC - Initial alignment control
LSC - Link state control
SUERM - Signal unit error rate monitor
Ti - Timer "aligned ready"
FISU - Fill in signal unit
TXC - Transmission control
POC - Processor outage control

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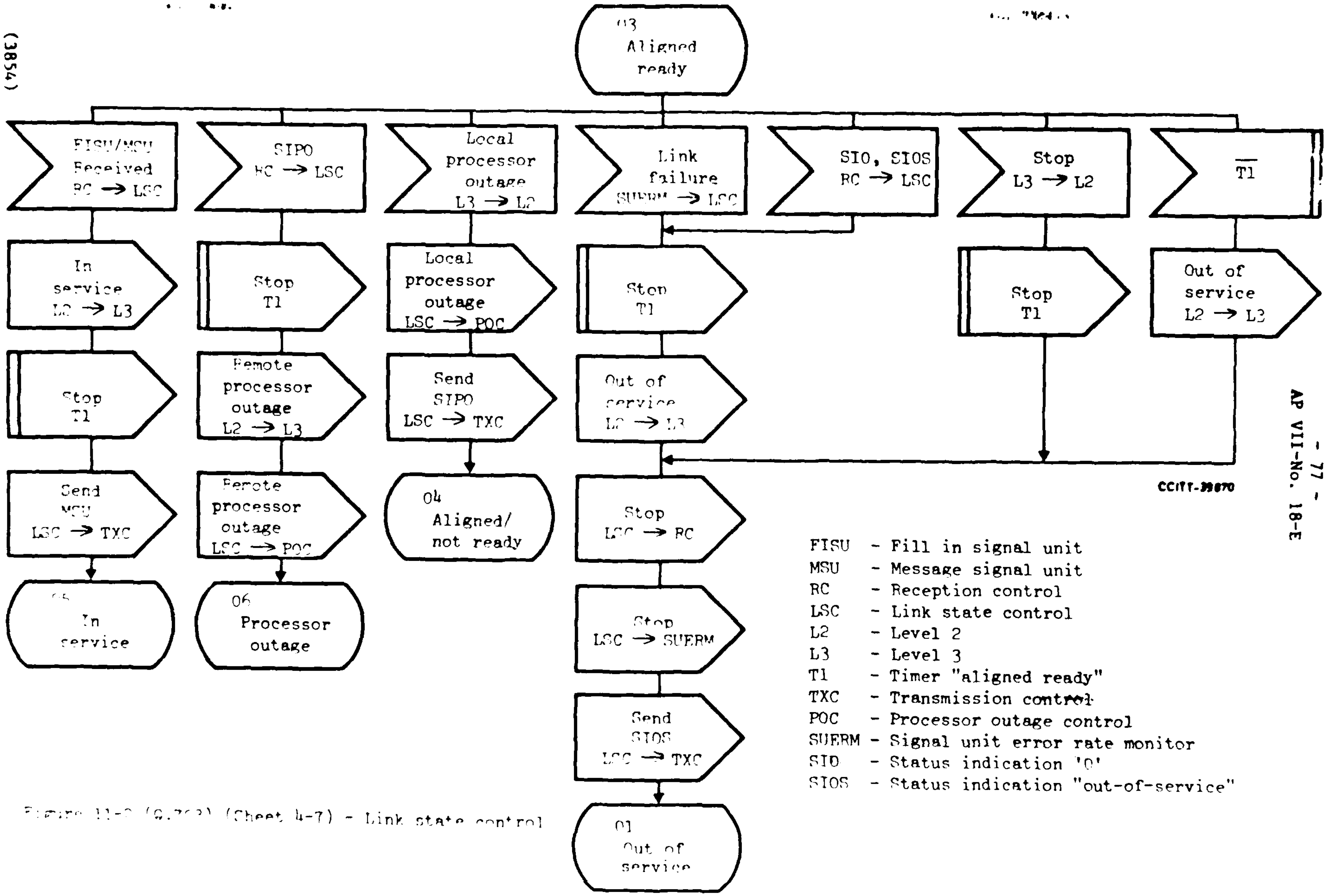
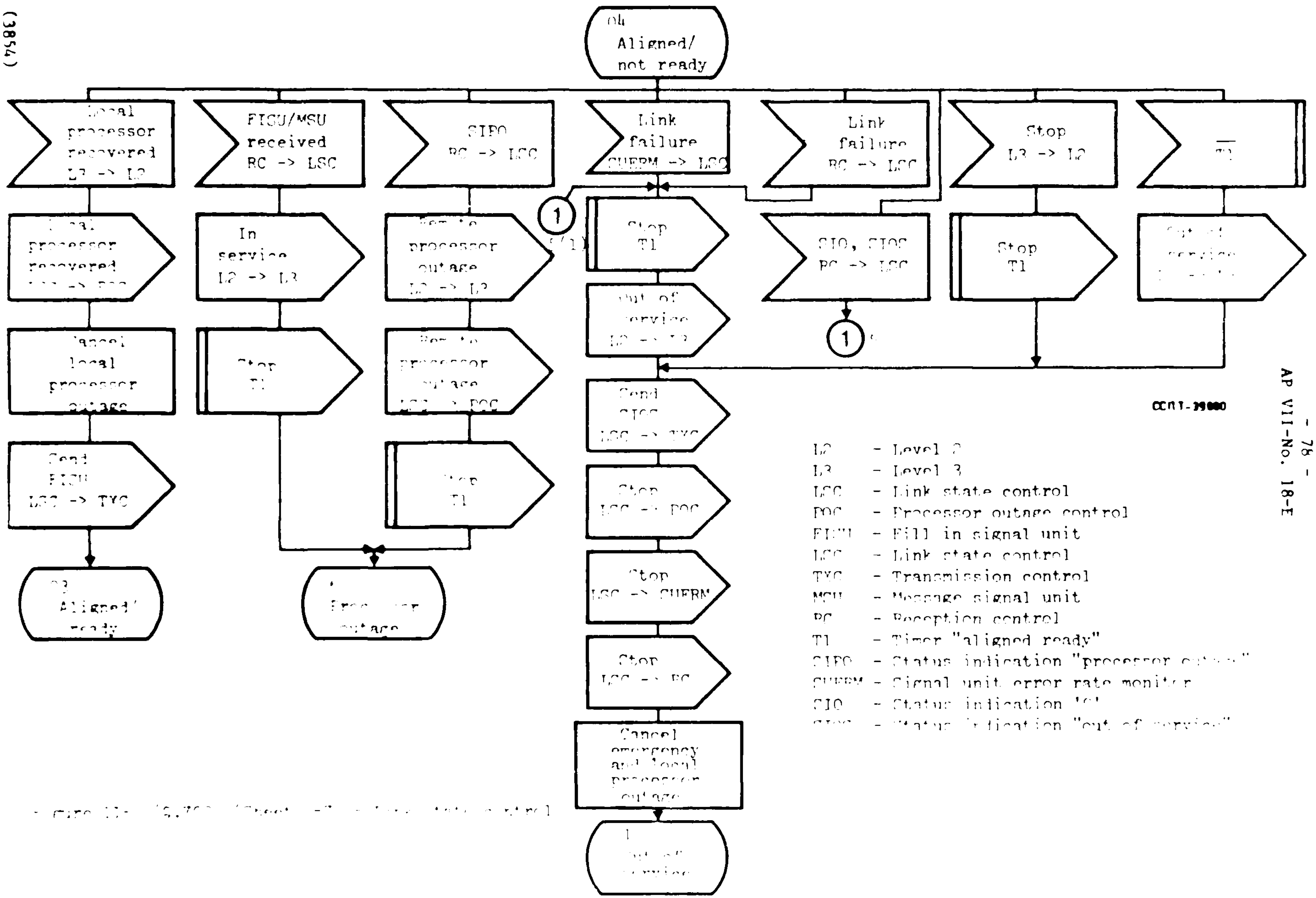
(3854)



FISU - Fill in signal unit
MSU - Message signal unit
RC - Reception control
LSC - Link state control
L2 - Level 2
L3 - Level 3
T1 - Timer "aligned ready"
TXC - Transmission control
POC - Processor outage control
SUERM - Signal unit error rate monitor
SIO - Status indication 'O'
SIOS - Status indication "out-of-service"

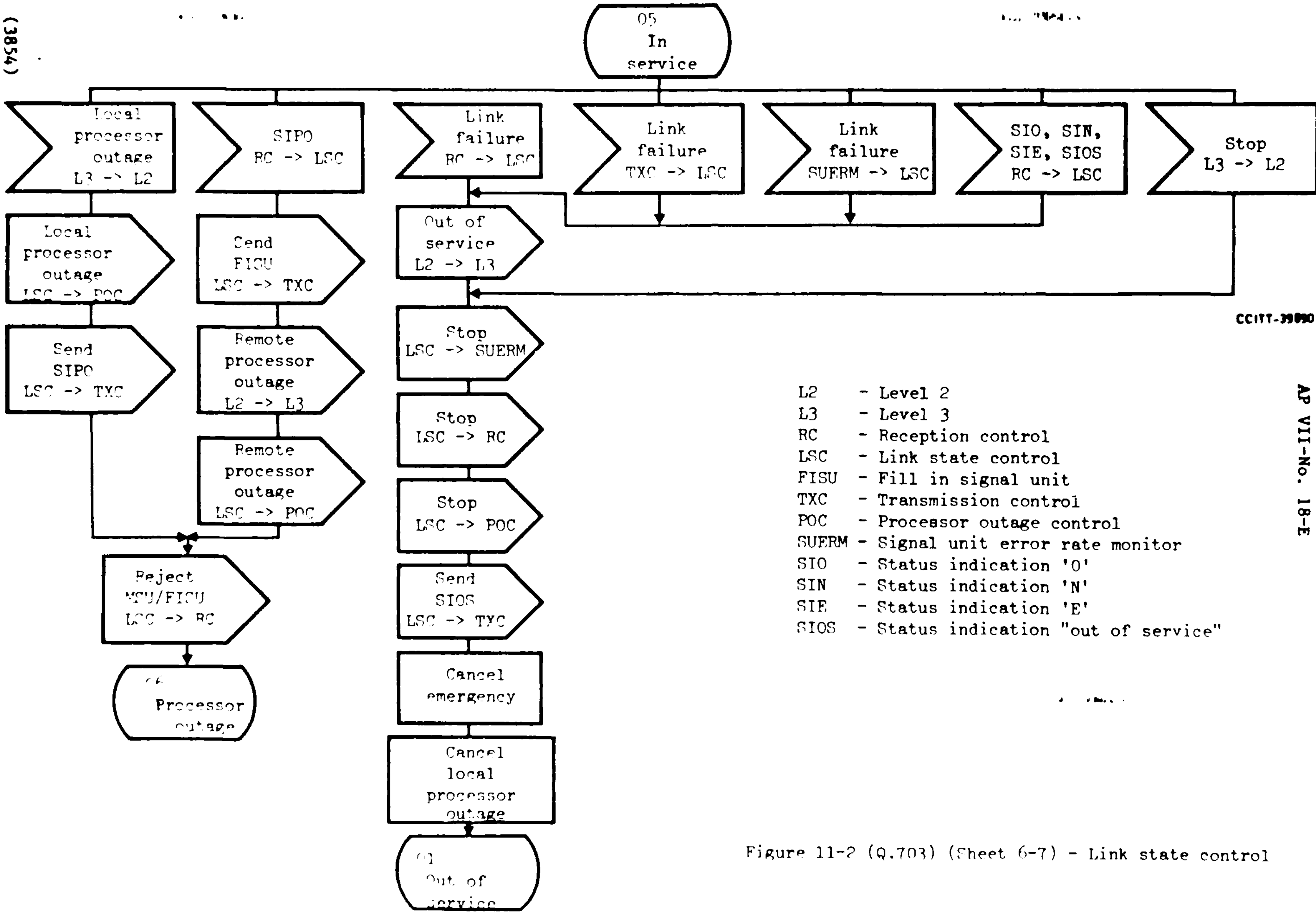
Figure 11-[illegible] (Q.703) (Sheet 4-7) - Link state control

(3854)



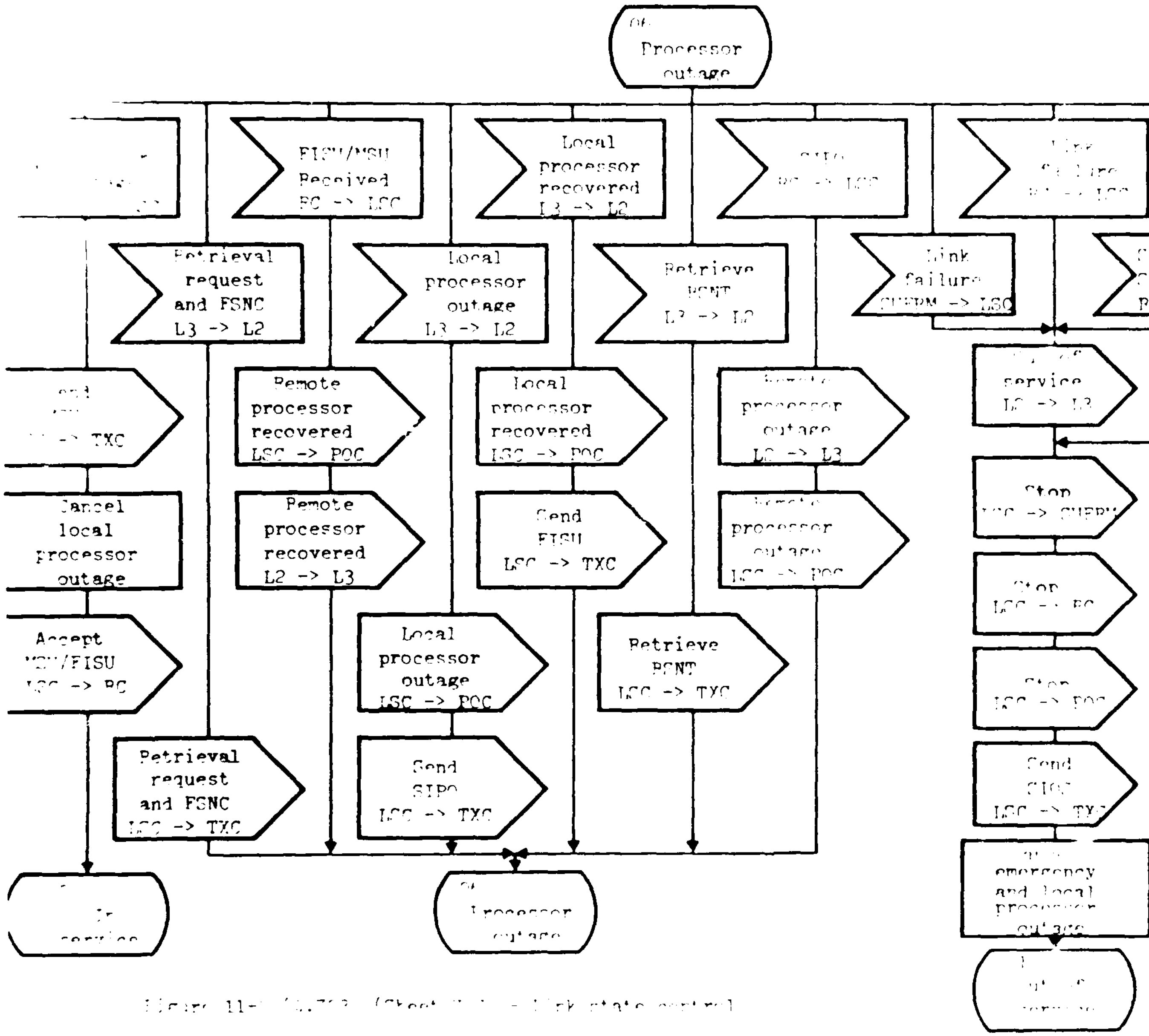
L2 - Level 2
L3 - Level 3
LSC - Link state control
POC - Processor outage control
FISU - Fill in signal unit
LSC - Link state control
TXC - Transmission control
MSU - Message signal unit
RC - Reception control
T1 - Timer "aligned ready"
SIPO - Status indication "processor outage"
SUERM - Signal unit error rate monitor
SIO - Status indication "O"
SIOS - Status indication "out of service"

Figure 11- (Q.703) (Sheet [illegible]) [illegible] state control



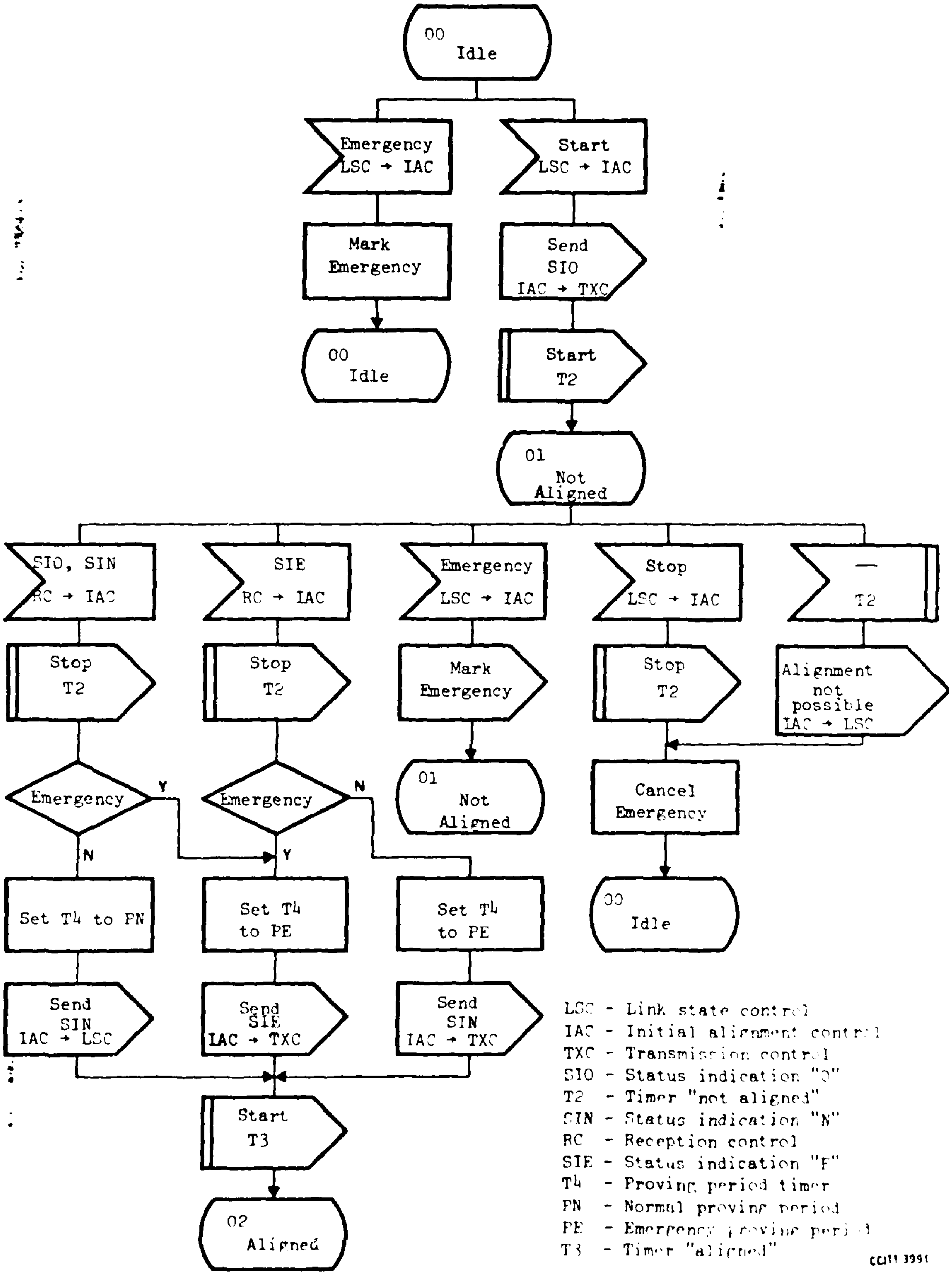
L2 - Level 2
L3 - Level 3
RC - Reception control
LSC - Link state control
FISU - Fill in signal unit
TXC - Transmission control
POC - Processor outage control
SUERM - Signal unit error rate monitor
SIO - Status indication 'O'
SIN - Status indication 'N'
SIE - Status indication 'E'
SIOS - Status indication "out of service"

Figure 11-2 (Q.703) (Sheet 6-7) - Link state control



L2 - Level 2
L3 - Level 3
MSU - Message signal unit
LSC - Link state control
TXC - Transmission control
RC - Reception control
FISU - Fill in signal unit
MSU - Message signal unit
POC - Processor outage control
BSNT - BSN to be transmitted
SIPO - Status indication "processor outage"
CIO - Status indication "
CIN - Status indication "N"
SIE - Status indication
SIOS - Status indication "out of service"
FSNC - FSN of the last message accepted by the

Figure 11- (Sheet) - Link state control



LSC - Link state control
IAC - Initial alignment control
TXC - Transmission control
SIO - Status indication "O"
T2 - Timer "not aligned"
SIN - Status indication "N"
RC - Reception control
SIE - Status indication "E"
T4 - Proving period timer
PN - Normal proving period
PE - Emergency proving period
T3 - Timer "aligned"

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Figure 11-3 (Q.703) (Sheet 1-3) - Initial Alignment Control

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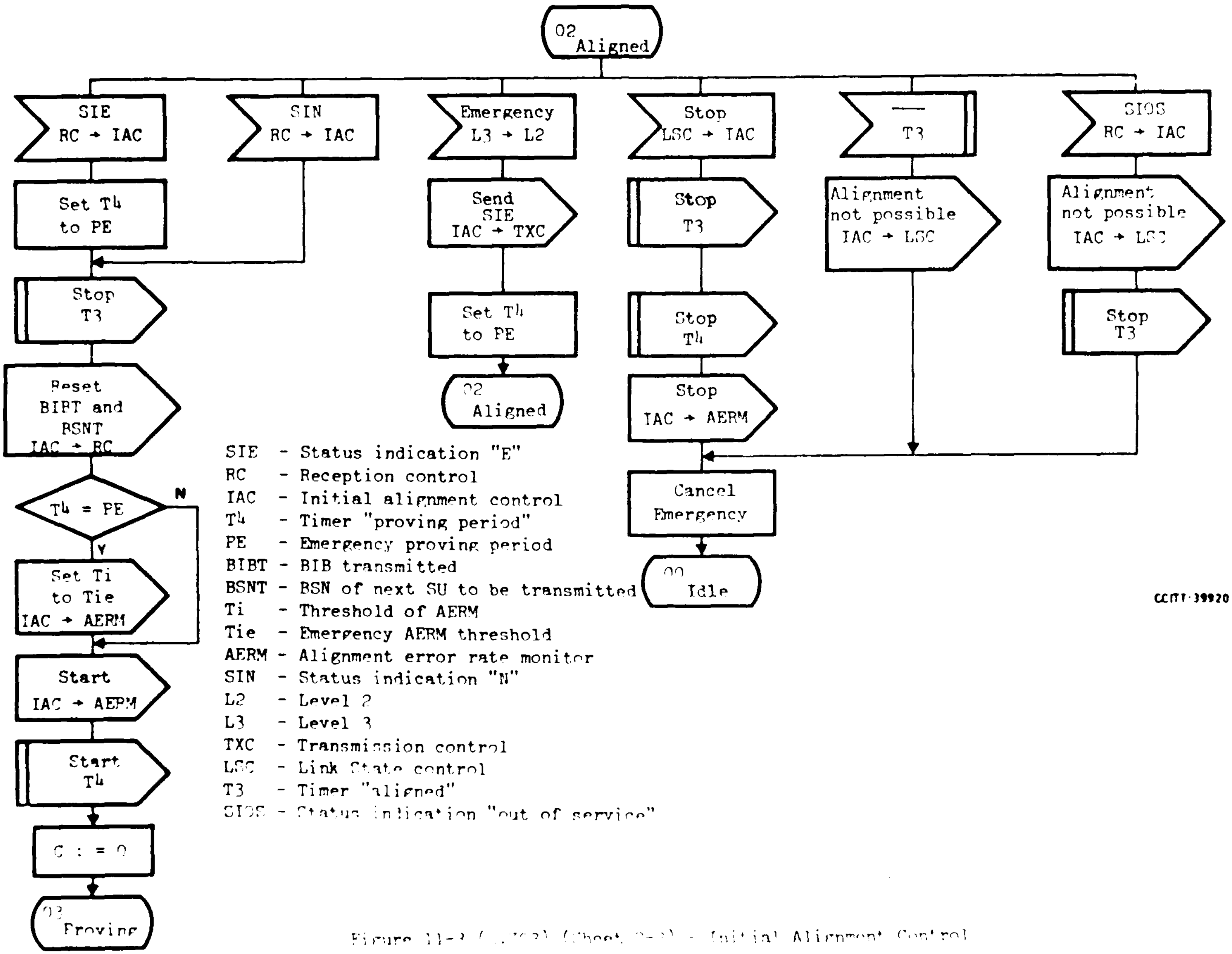

SIE - Status indication "E"
RC - Reception control
IAC - Initial alignment control
T4 - Timer "proving period"
PE - Emergency proving period
BIBT - BIB transmitted
BSNT - BSN of next SU to be transmitted
Ti - Threshold of AERM
Tie - Emergency AERM threshold
AERM - Alignment error rate monitor
SIN - Status indication "N"
L2 - Level 2
L3 - Level 3
TXC - Transmission control
LSC - Link State control
T3 - Timer "aligned"
SIOS - Status indication "out of service"

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Figure 11-[illegible] ([illegible]) (Sheet [illegible]) - Initial Alignment Control

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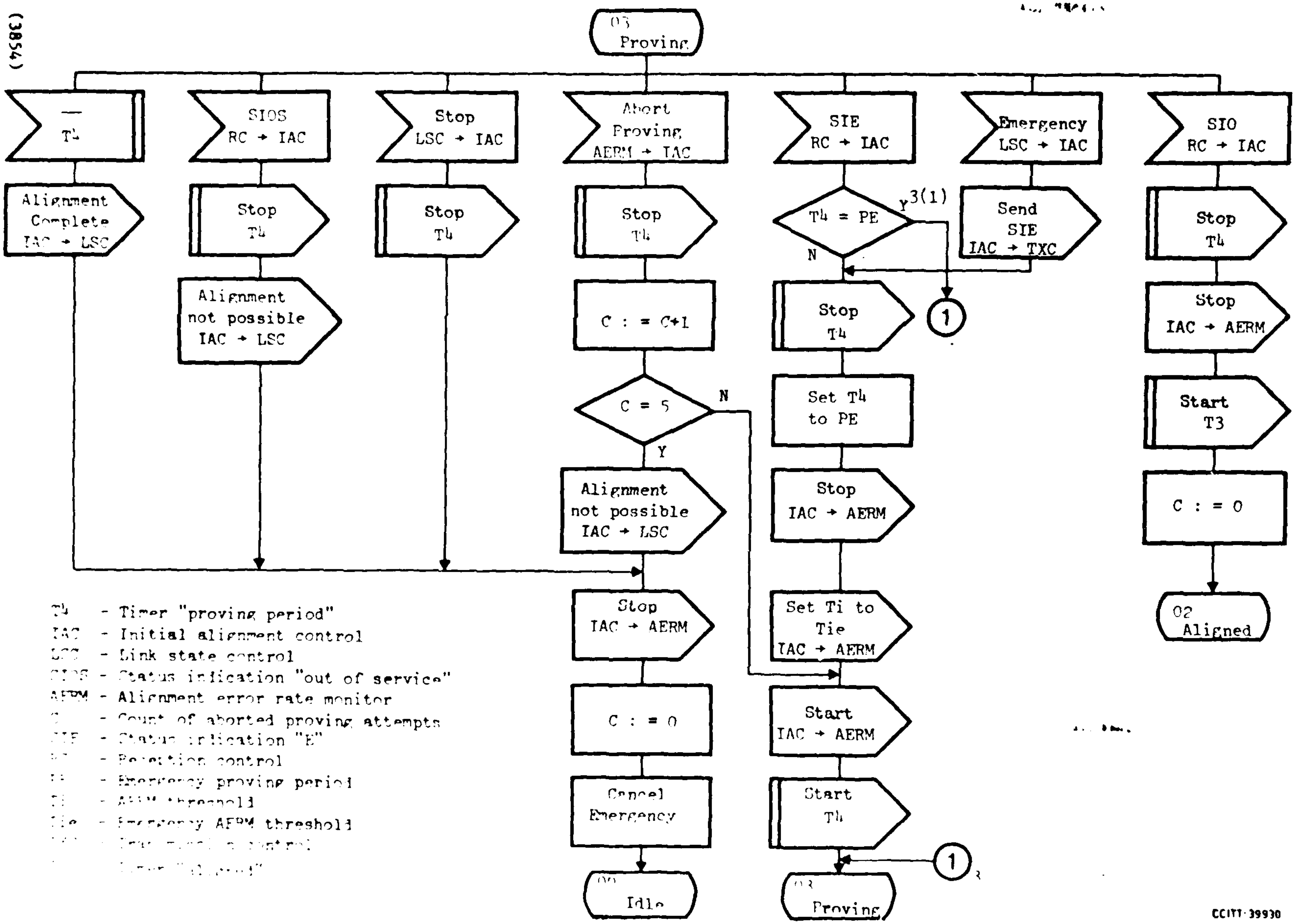

T4 - Timer "proving period"
IAC - Initial alignment control
LSC - Link state control
SIOS - Status indication "out of service"
AERM - Alignment error rate monitor
C - Count of aborted proving attempts
SIE - Status indication "E"
RC - Reception control
PE - Emergency proving period
Ti - AERM threshold
Tie - Emergency AERM threshold
[illegible] - [illegible] control
[illegible] - [illegible]

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Figure 11-[illegible] (sheet [illegible]) - Initial Alignment Control

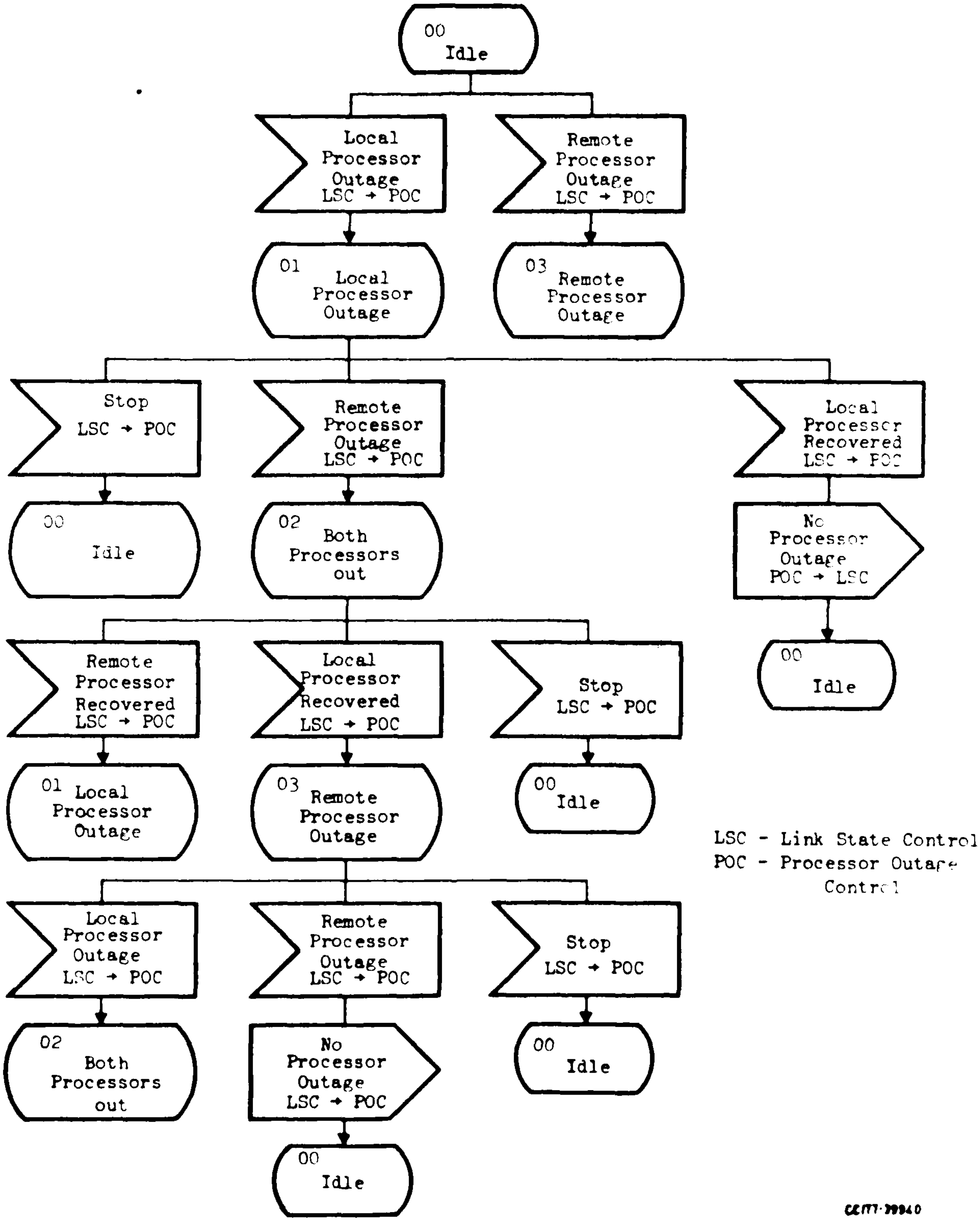

Figure 11-4 (Q.703) - Processor Outage Control

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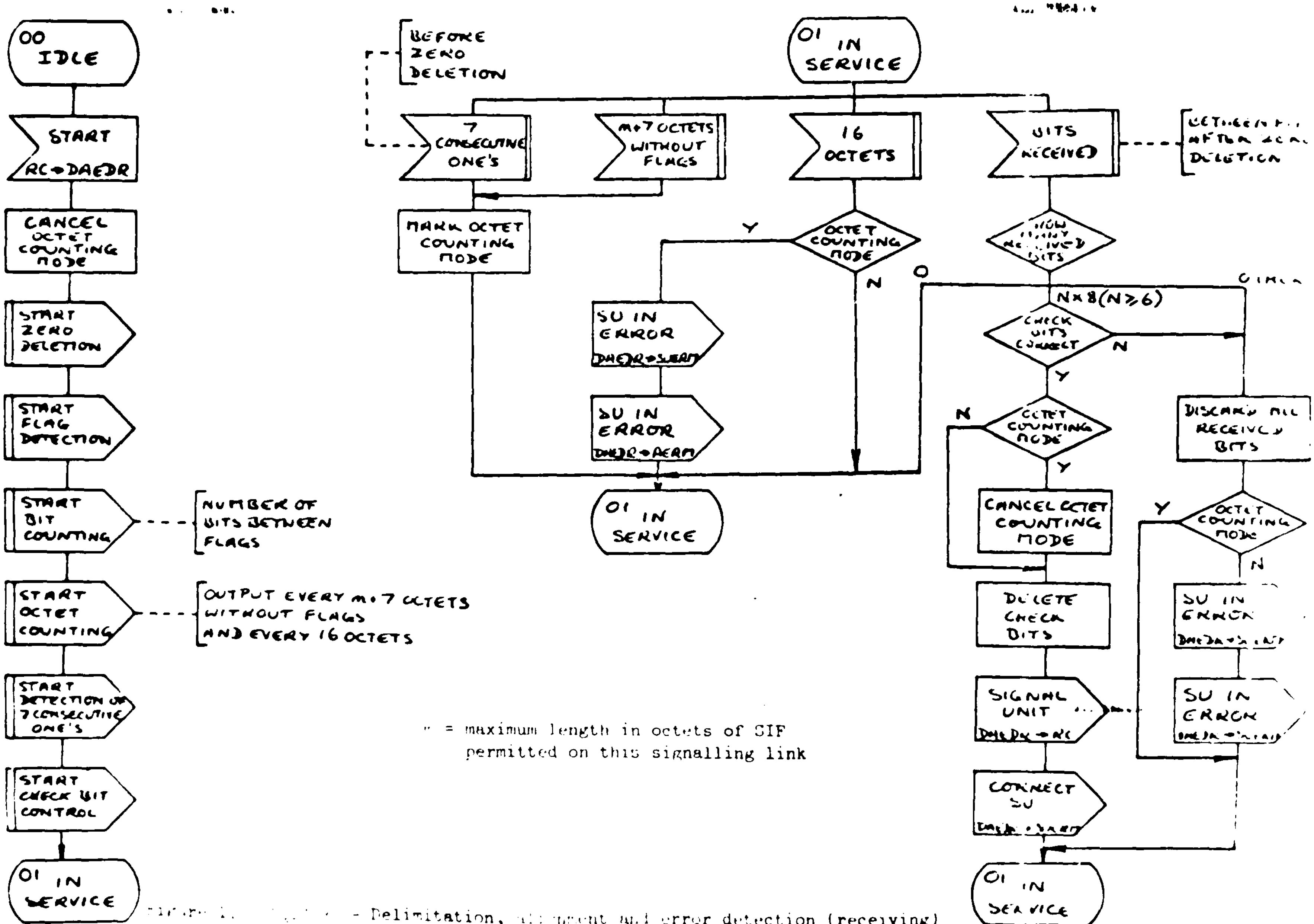

Figure ... - Delimitation, alignment and error detection (receiving)

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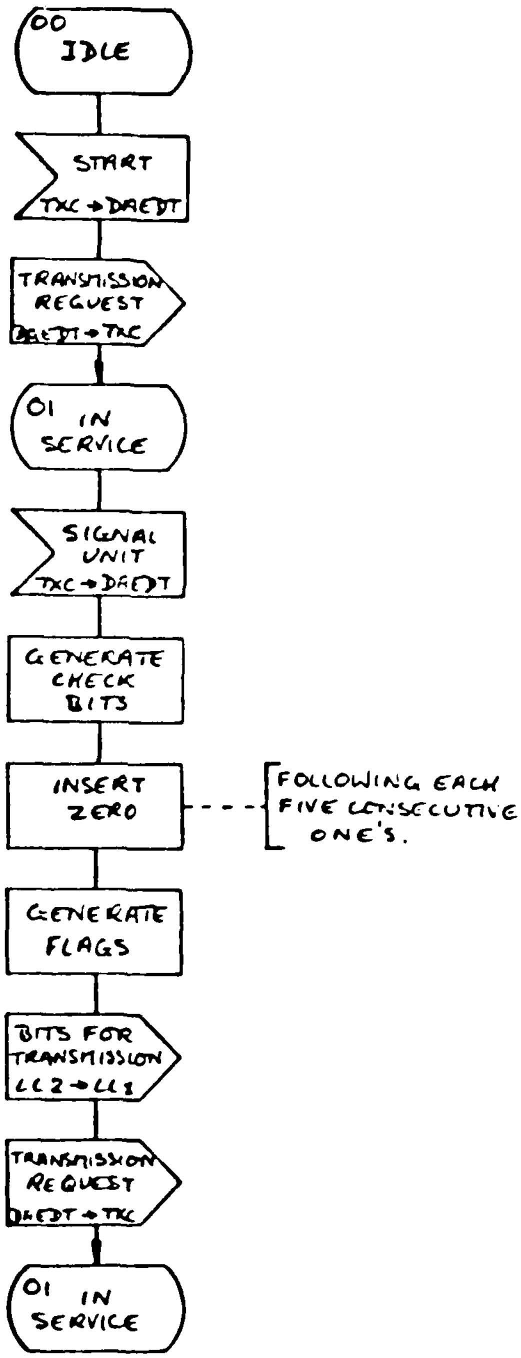

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Figure 11-[illegible] (Q.703) - Delimitation, alignment and error detection (transmitting)

TB - Transmission buffer
RTB - Retransmission buffer
FSNL - FSN of the last MSU entered into RTB
FSNX - FSN expected
FSNF - FSN of the oldest MSU in RTB
C - Counter of MSU in TB
FSNT - FSN to be transmitted
BIBT - BIB to be transmitted
BSNT - BSN to be transmitted
FIBT - FIB to be transmitted

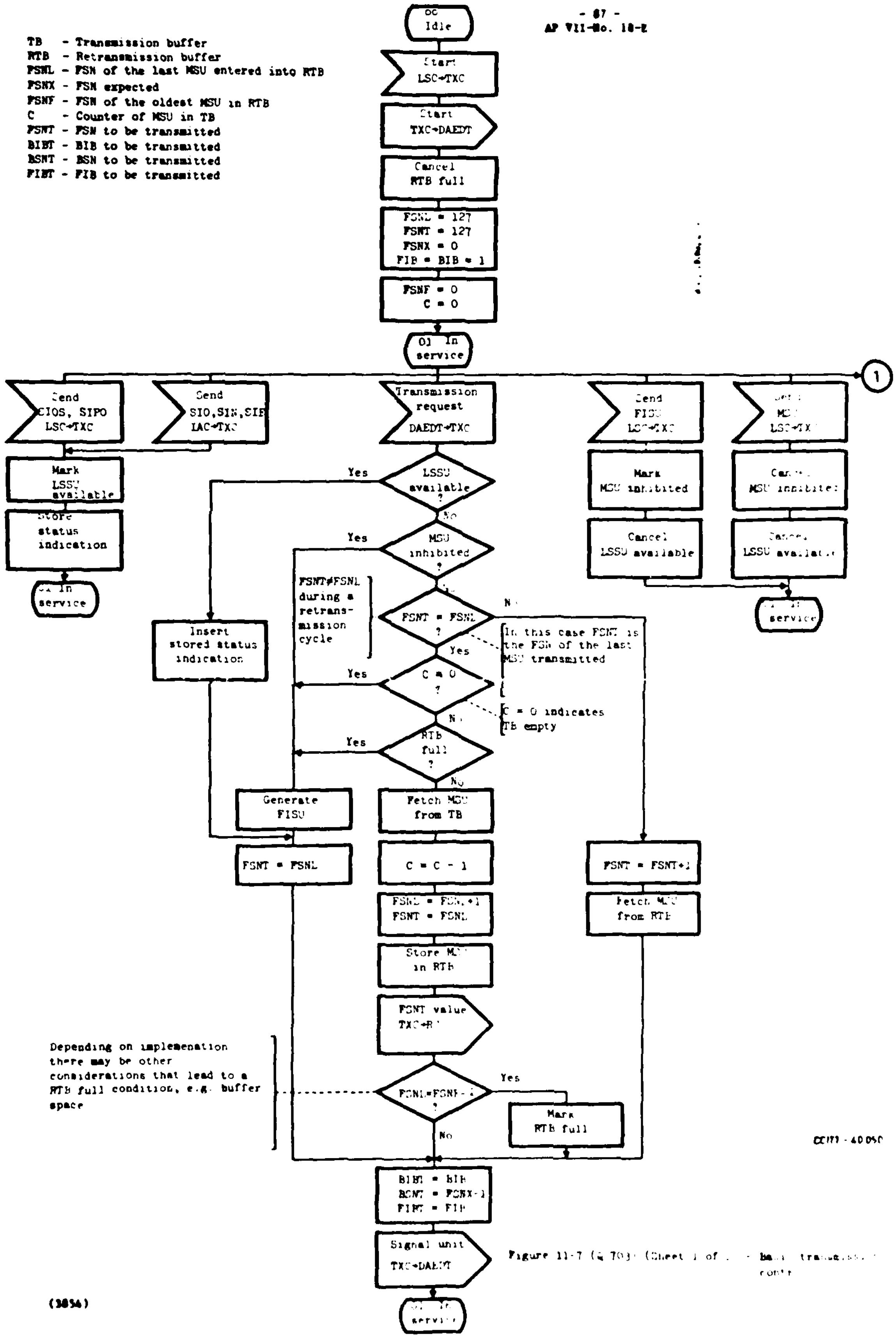

Figure 11-7 (Q.703) (Sheet 1 of ...) - Basic transmission control

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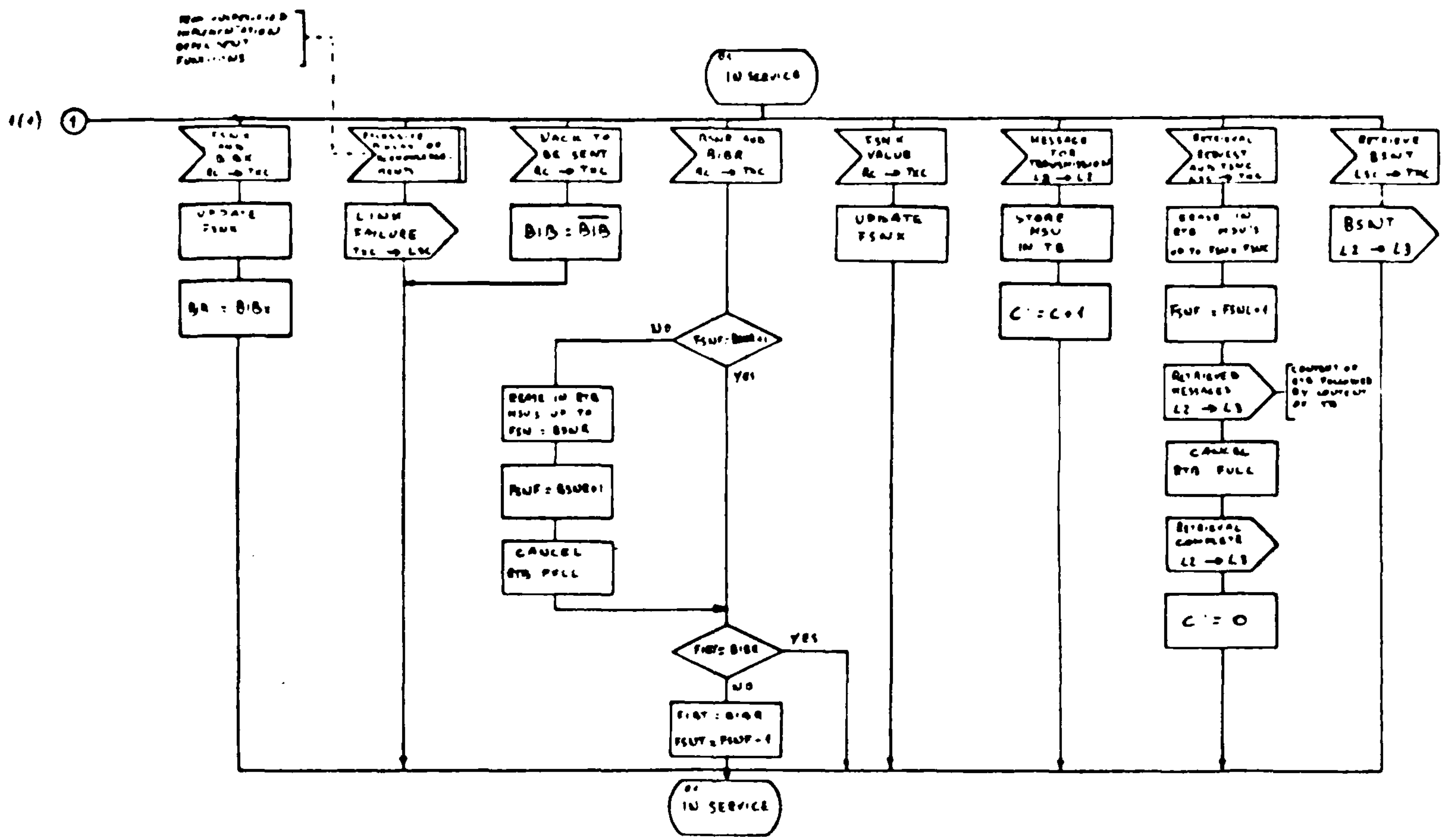

FIBR - FIB received
FSNR - FSN received
BSNR - BSN received
BIBR - BIB received

FSNC - FSN of the last MSU accepted
by the remote terminal ([illegible]
in the changeover message)

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Figure 11-7 (Q.703) (Sheet [illegible] of [illegible]) - Basic transmission control

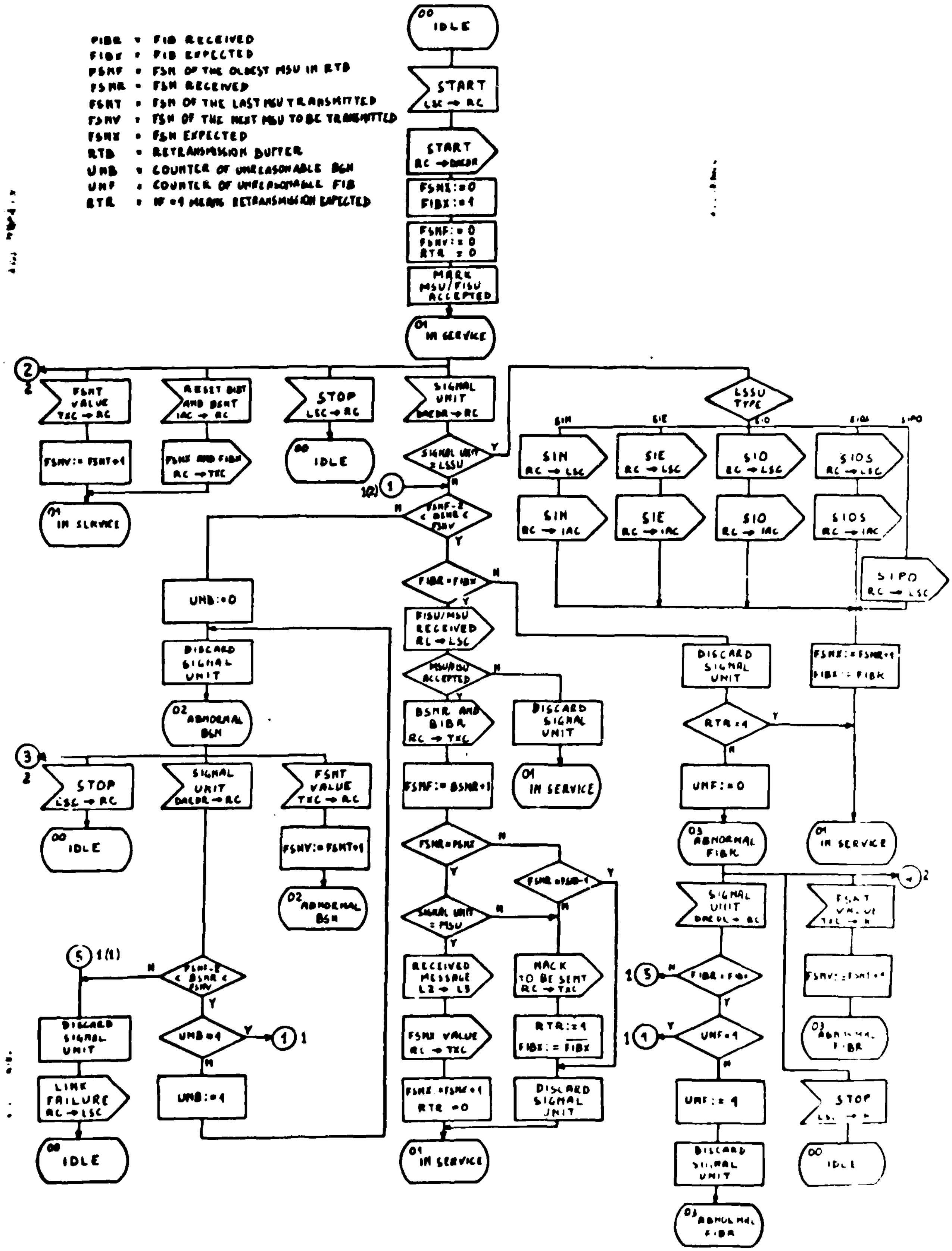

Figure 11-3 (Q.703) (Sheet 1-2) - Basic reception control

(3854)

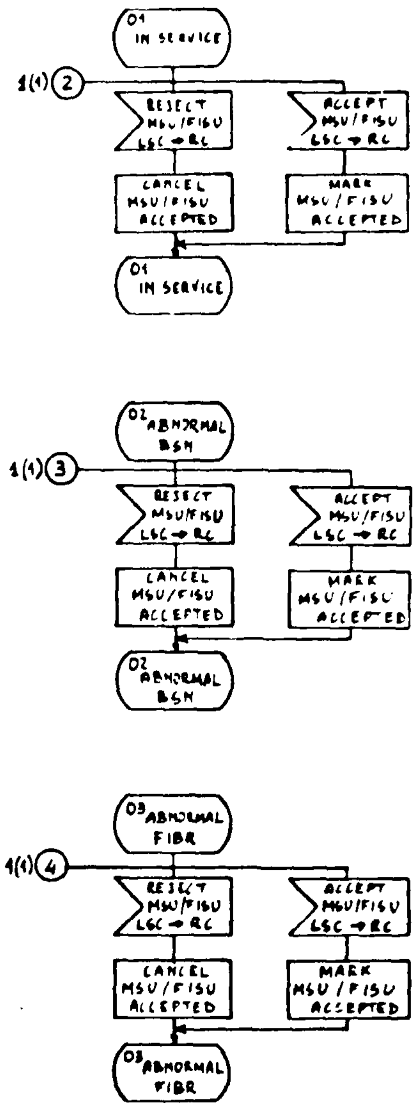

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Figure 11-8 (Q.703) (Sheet 2-2) - Basic reception control

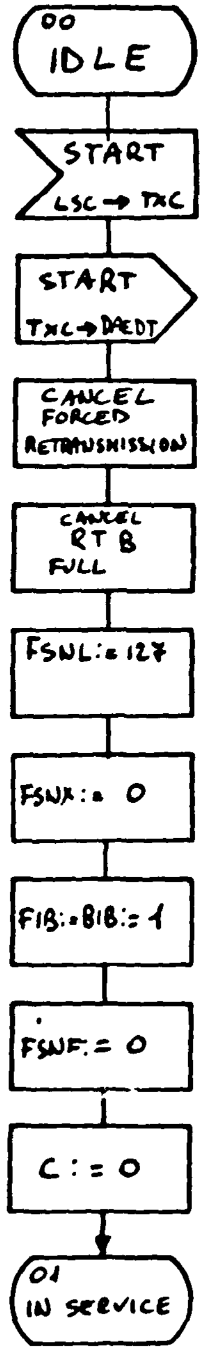

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Figure 11-9 (Q.703) (Sheet 1 of 3) - Preventive cyclic retransmission transmission control

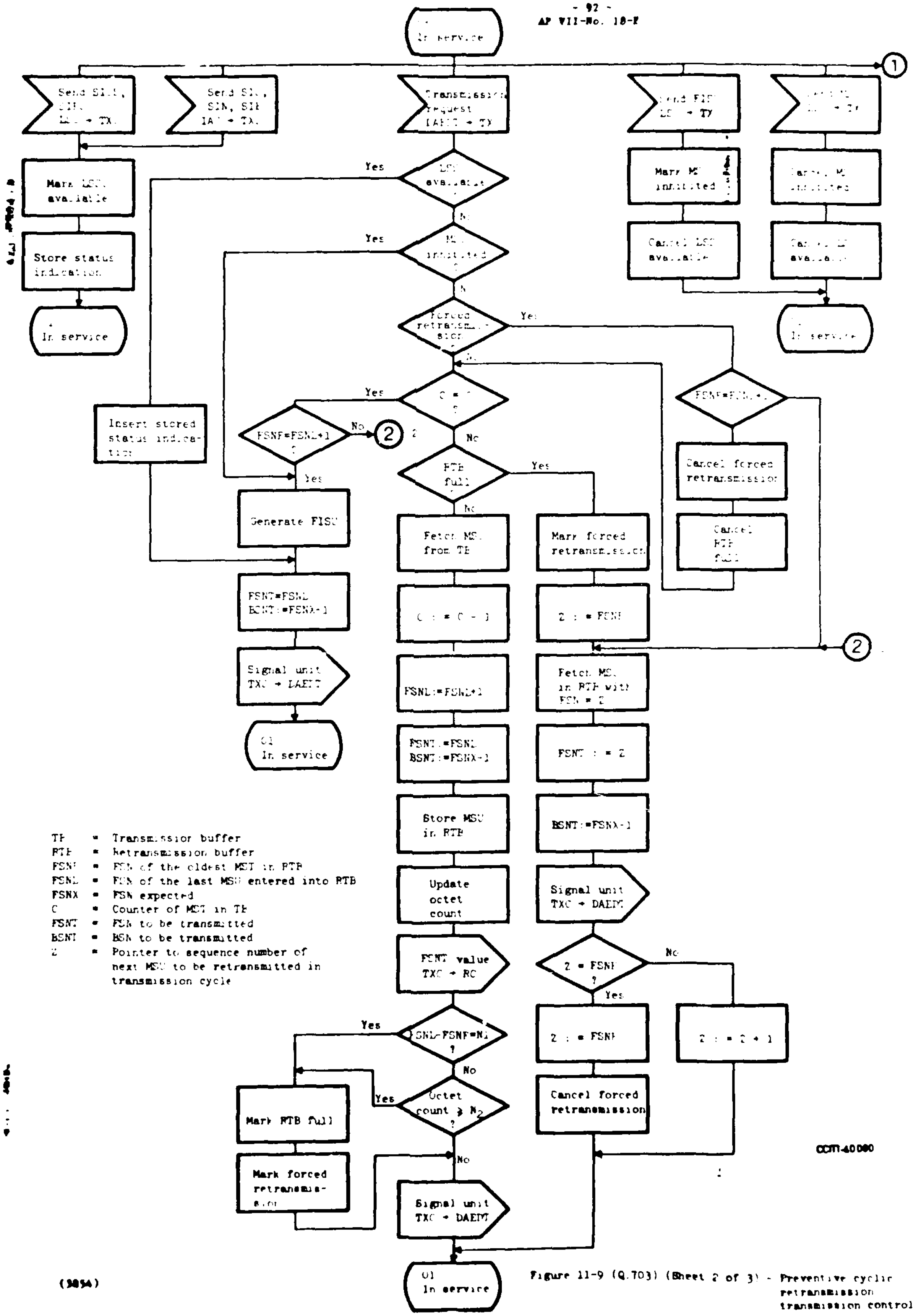
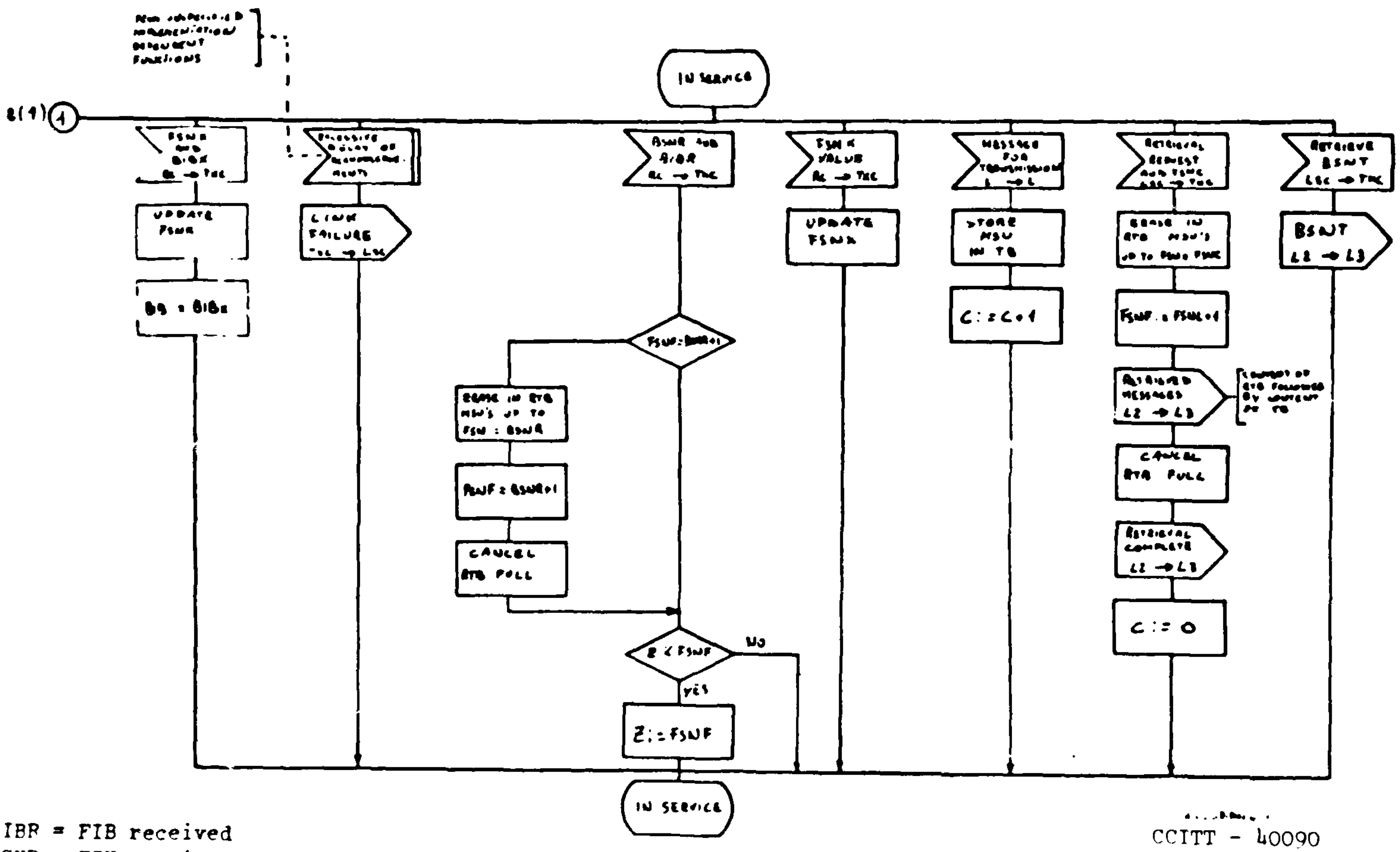


Figure 11-9 (Q.703) (Sheet 2 of 3) - Preventive cyclic retransmission transmission control



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FIBR = FIB received
FSNR = FSN received
BSNR = BSN received
BIBR = BIB received
FSNF = FSN of the last MSU accepted by the remote terminal (received in the changeover message)

Figure 11-9(Q.703) (sheet 3 of 3) - Preventive cyclic retransmission transmission control

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SPECIFICATIONS OF CCITT SIGNALLING SYSTEM NUMBER 7.(U)
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101055

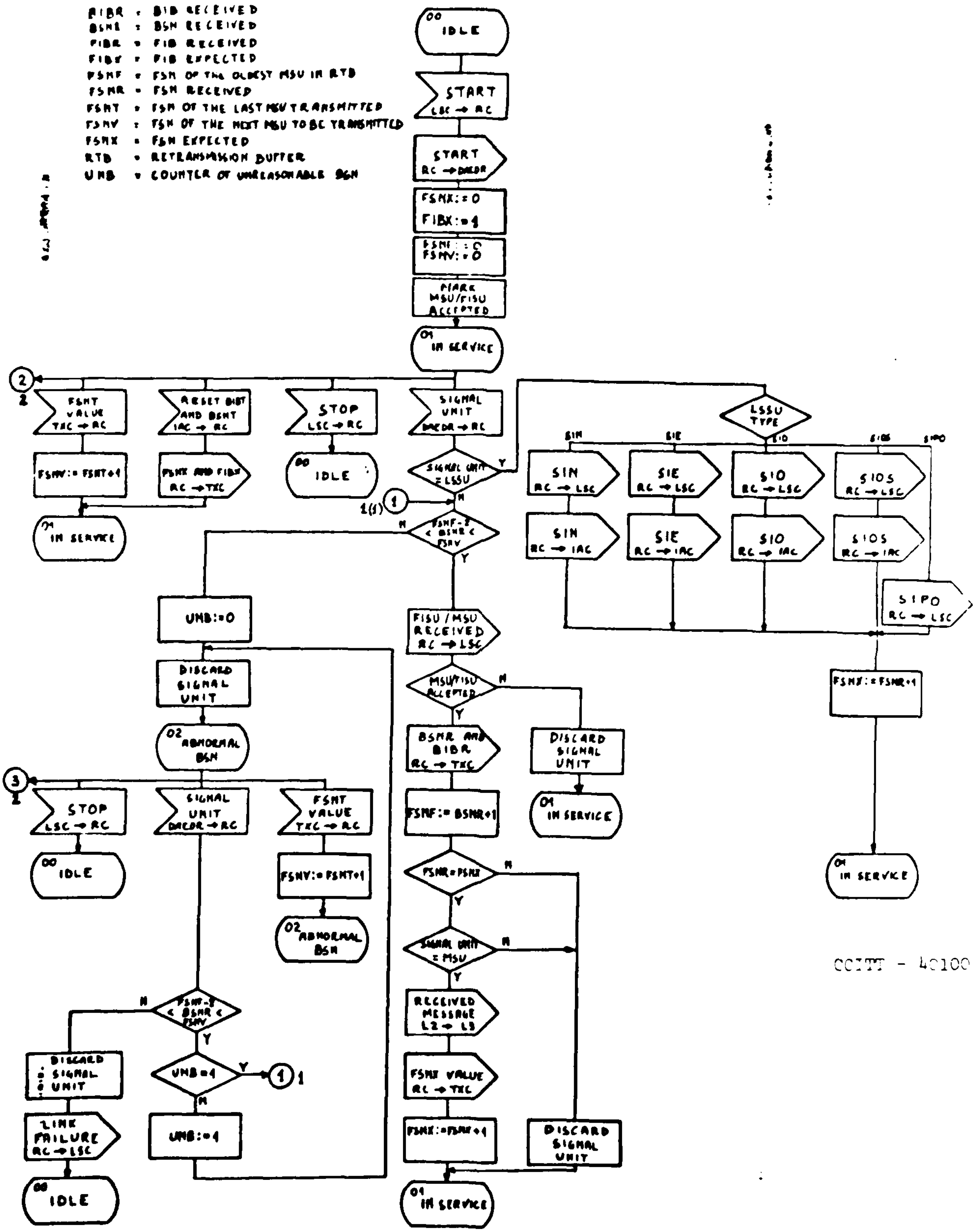

Figure 11-10(Q.703) (sheet 1-2) - Preventive cyclic retranmission reception control

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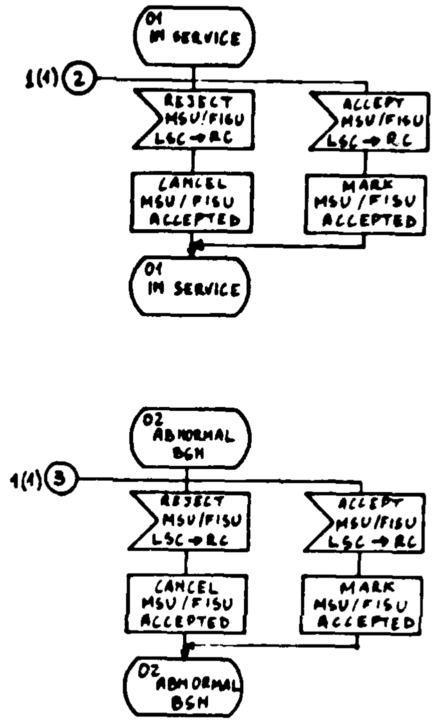

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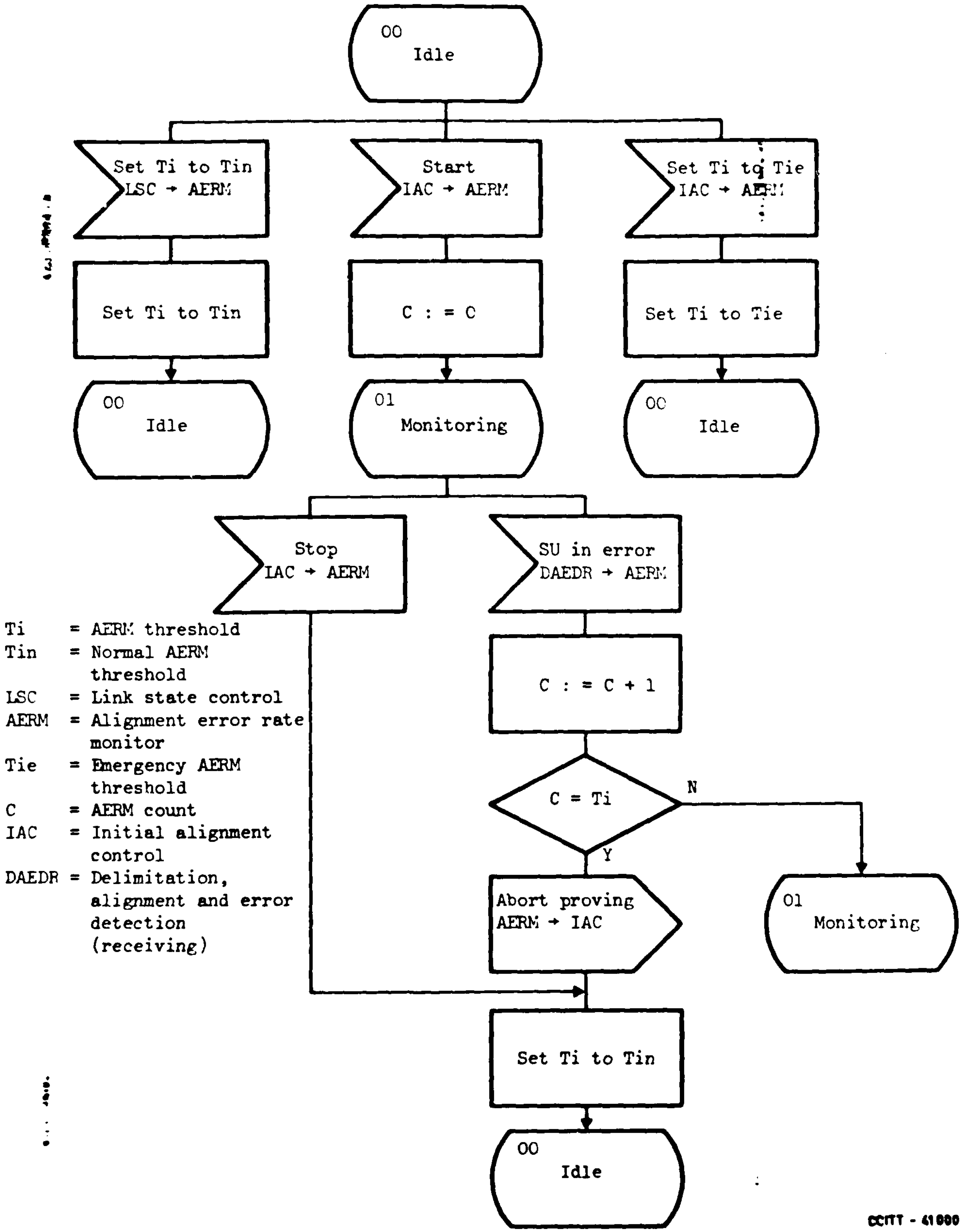
Figure 11-10(Q.703) (sheet 2-2) - Preventive cyclic retransmission reception control



(3854) Figure 11-11(Q.703) - Alignment error rate monitor

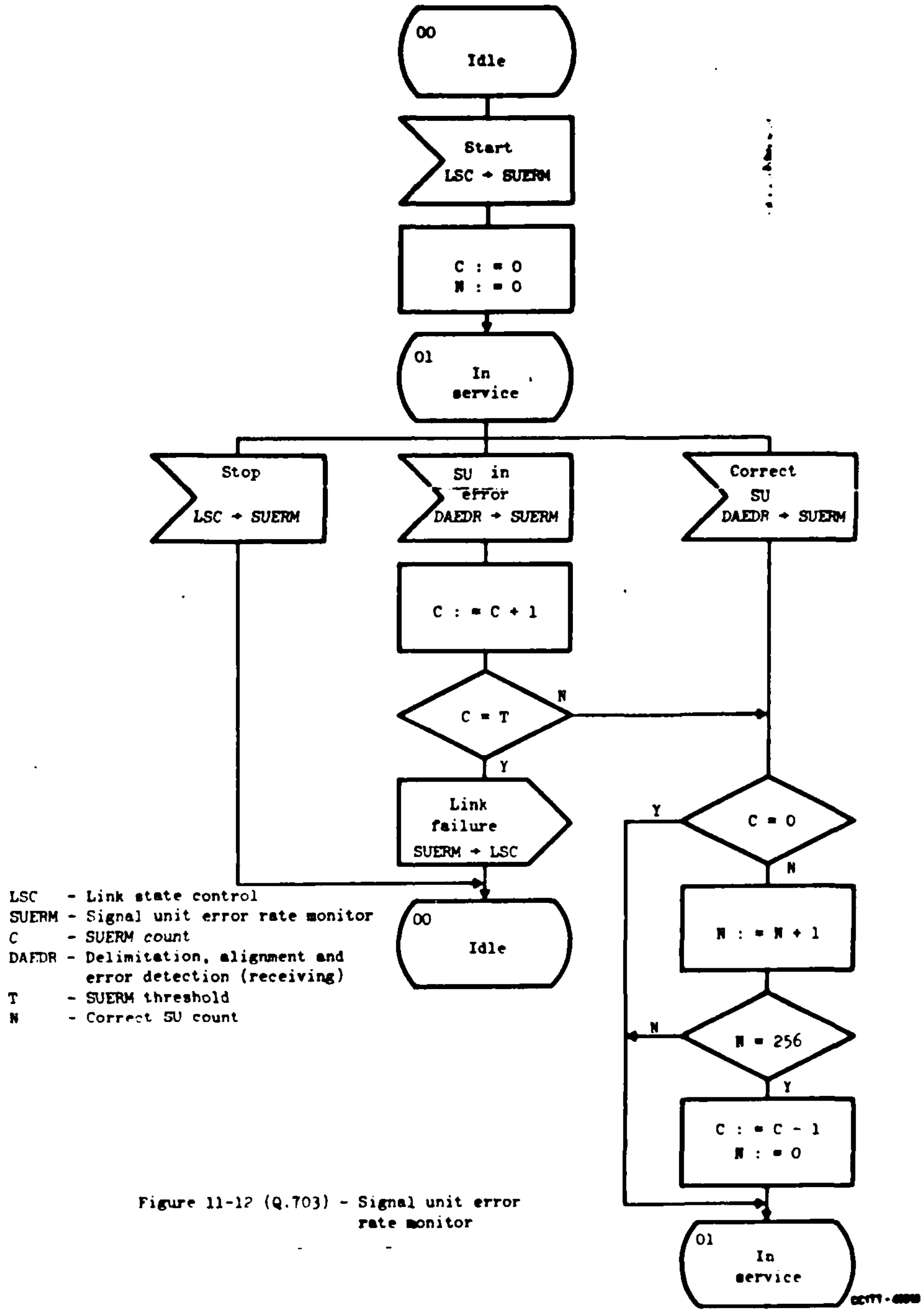


Figure 11-12 (Q.703) - Signal unit error rate monitor

References

[1] CCITT Recommendation Signalling Network Functions and Messages, Yellow Book, Vol. VI.7, Rec. (Q.704), Section 12.2.2.

[2] CCITT Recommendation Signalling Network Functions and Messages, Yellow Book, Vol. VI.7, Rec. (Q.704), Section 12.

[3] CCITT Recommendation Signalling Network Functions and Messages, Yellow Book, Vol. VI.7, Rec. (Q.704), Section 10.

[4] CCITT Recommendation Signalling Network Functions and Messages, Yellow Book, Vol. VI.7, Rec. (Q.704), Section 3.2.6.

Recommendation Q.704

SIGNALLING NETWORK FUNCTIONS AND MESSAGES

1 Introduction

1.1 General characteristics of the signalling network functions

1.1.1 This Recommendation describes the functions and procedures for and relating to the transfer of messages between the signalling points, which are the nodes of the signalling network. Such functions and procedures are performed by the Message Transfer Part at level 3, and therefore they assume that the signalling points are connected by signalling links, incorporating the functions described in Recommendations Q.702 [1] and Q.703 [2]. The signalling network functions must ensure a reliable transfer of the signalling messages, according to the requirements specified in Recommendation Q.706 [3] even in the case of the failure of signalling links and signalling transfer points; therefore they include the appropriate functions and procedures necessary both to inform the remote parts of the signalling network of the consequences of a fault, and to appropriately reconfigure the routing of messages through the signalling network.

1.1.2 According to these principles, the signalling network functions can be divided into two basic categories, namely:

- signalling message handling, and
- signalling network management.

The signalling message handling functions are briefly summarised in Section 1.2, the signalling network management functions in Section 1.3. The functional inter-relations between these functions are indicated in Figure 1-1 (Q.704).

1.2 Signalling message handling

1.2.1 The purpose of the signalling message handling functions is to ensure that the signalling messages originated by a particular User Part at a signalling point (originating point) are delivered to the same User Part at the destination point indicated by the sending User Part.

Depending on the particular circumstances, this delivery may be made through a signalling link directly interconnecting the originating and destination points, or via one or more intermediate signalling transfer points.

1.2.2 The signalling message handling functions are based on the label contained in the messages which explicitly identifies the destination and originating points.

The label part used for signalling message handling by the Message Transfer Part is called the routing label; its characteristics are described in Section 2.

1.2.3 As illustrated in Figure 1-1 (Q.704), the signalling message handling functions are divided into:

- the message routing function, used at each signalling point to determine the outgoing signalling link on which a message has to be sent towards its destination point;

- the message discrimination function, used at a signalling point to determine whether a received message is destined to the point itself or has to be transferred to the message routing function (i.e. when the concerned point acts as a signalling transfer point);

- the message distribution function, used at each signalling point to deliver the received messages (destined to the point itself) to the appropriate User Part.

The characteristics of the message routing, discrimination and distribution functions are described in Section 2.

1.3 Signalling network management

1.3.1 The purpose of the signalling network management functions is to provide reconfiguration of the signalling network in the case of failures. Such a reconfiguration is effected by use of appropriate procedures to change the routing of signalling traffic in order to by-pass the faulty links or signalling points; this requires communication between signalling points (and, in particular, the signalling transfer points) concerning the occurrence of the failures. Moreover, in some circumstances it is necessary to activate and align new signalling links, in order to restore the required signalling traffic capacity between two signalling points. When the faulty link or signalling point is restored the opposite actions and procedures take place, in order to re-establish the normal configuration of the signalling network.

1.3.2 As illustrated in Figure 1-1 (Q.704), the signalling network management functions are divided into:

- signalling traffic management,

- signalling link management, and

- signalling route management.

These functions are used whenever an event (such as the failure or restoration of a signalling link) occurs in the signalling network; the list of the possible events and the general criteria used in relation to each signalling network management function are specified in Section 3.

1.3.3 Sections 4 to 9 specify the procedures pertaining to signalling traffic management. In particular, the rules to be followed for the modification of signalling routing appear in Section 4. The diversion of traffic according to these rules is made, depending on the particular circumstances, by means of one of the following procedures: changeover, changeback, forced rerouting and controlled rerouting. They are specified in Section 5 to 8 respectively. Moreover in the case of congestion at signalling points the signalling traffic management may need to slow down signalling traffic on certain routes by using the signalling traffic flow control procedure specified in Section 9.

1.3.4 The different procedures pertaining to signalling link management are: restoration, activation and inactivation of a signalling link, link set activation and automatic allocation of signalling terminals and signalling data links. These procedures are specified in Section 10. An alternative to these procedures which may be used within national networks is described in Annex A.

1.3.5 The different procedures pertaining to signalling route management are: the transfer-prohibited, transfer-allowed and signalling-route-set test procedures specified in Section 11.

1.3.6 The format characteristics, common to all message signal units which are relevant to the Message Transfer Part, level 3, are specified in Section 12.

1.3.7 Labelling, formatting and coding of the signalling network management messages are specified in Section 13.

1.3.8 The description of signalling network functions in form of state transition diagrams according to the CCITT Specification and Description Language (SDL) is given in Section 14.

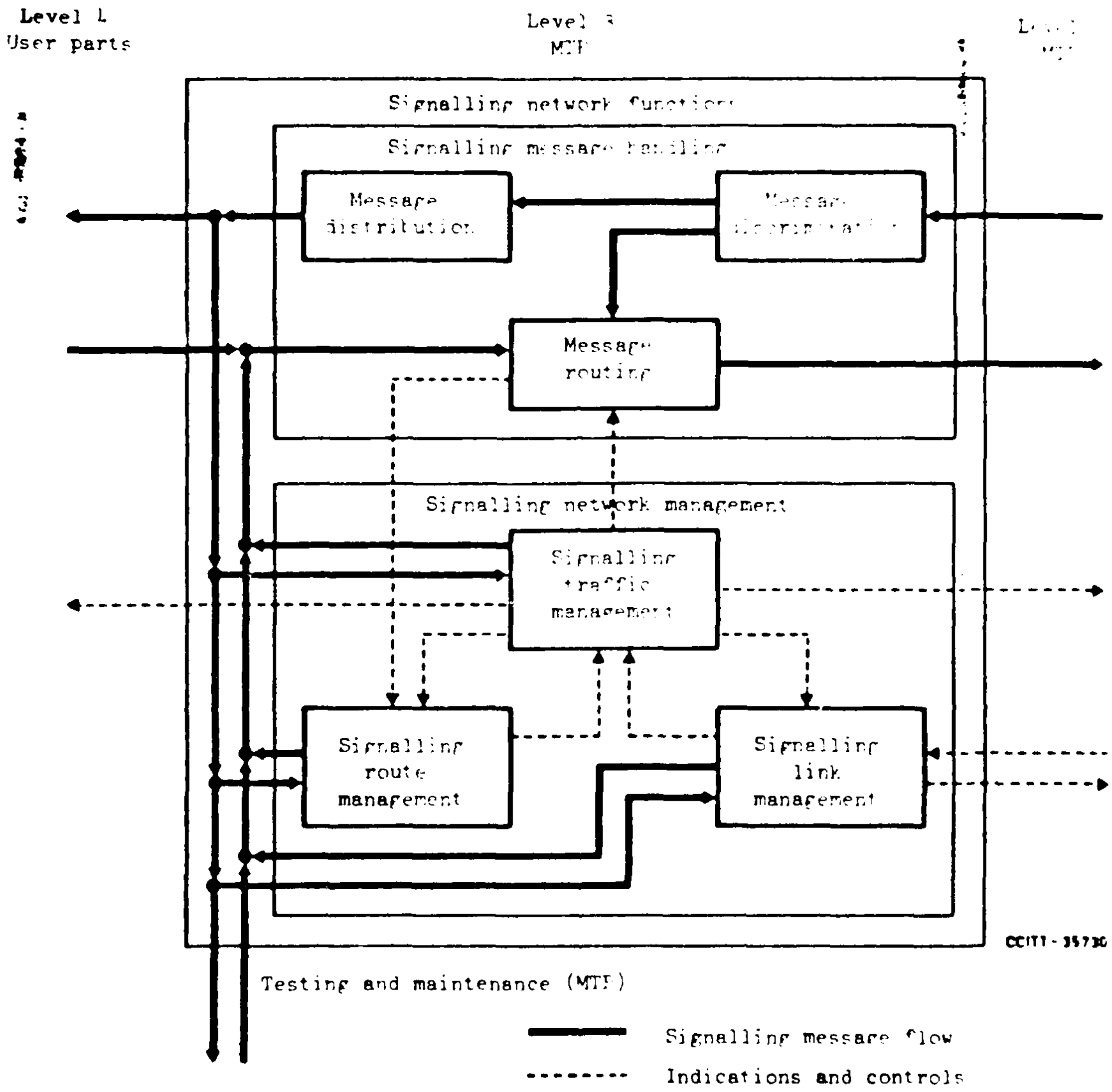


Figure 1-1 (Q.704) - Signalling network functions

2 Signalling message handling

2.1 General

2.1.1 Signalling message handling comprises message routing, discrimination and distribution functions which are performed at each signalling point in the signalling network.

Message routing is a function concerning the messages to be sent, while message distribution is a function concerning the received messages. The functional relations between message routing and distribution appear in Figure 2-1 (Q.704).

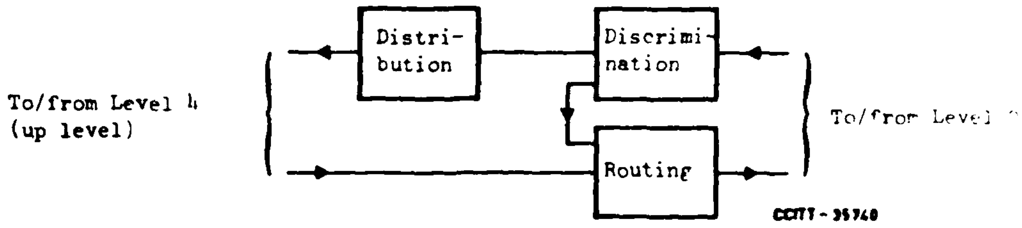


Figure 2-1 (Q.704) - Message routing, discrimination and distribution

2.1.2 When a message comes from level 4 (or is originated at level 3, in the case of Message Transfer Part-level 3 messages), the choice of the particular signalling link on which it has to be sent is made by the message routing function. When two or more links are used at the same time to carry traffic having a given destination, this traffic is distributed among them by the load sharing function, which is a part of the message routing function.

2.1.3 When a message comes from level 2, the discrimination function is activated, in order to determine whether it is destined to this signalling point (acting as a destination point), or it is destined to another signalling point in which case it has to be transmitted on an outgoing link according to the routing function (signalling point acting as a signalling transfer point).

2.1.4 In the case that the message is destined to the receiving signalling point, the message distribution function is activated in order to deliver it to the appropriate User Part (or to the local Message Transfer Part-level 3 functions).

2.1.5 Message routing, discrimination and distribution are based on the part of the label called the routing label, on the service indicator and, in national networks, also on the national indicator. They can also be influenced by different factors, such as a request (automatic or manual) obtained from a management system.

2.1.6 The position and coding of the service indicator and of the national indicator are described in Section 12.2. The characteristics of the label of the messages pertaining to the various User Parts are described in the specification of each separate User Part and in Section 13 for the signalling network management messages. The label used for signalling network management messages is also used for testing and maintenance messages [see Recommendation Q.707 (4)]. Moreover the general characteristics of the routing label are described in Section 2.2.

A description of the detailed characteristics of the message routing function, including load sharing, appears in Section 2.3; principles concerning the number of load shared links appear in Recommendation Q.705, Section 2.3 [5].

A description of the detailed characteristics of the message discrimination and distribution functions appears in Section 2.4.

2.2 Routing label

2.2.1 The label contained in a signal message, and used by the relevant User Part to identify the particular task to which the message refers (e.g. a telephone circuit), is also used by the Message Transfer Part to route the message towards its destination point.

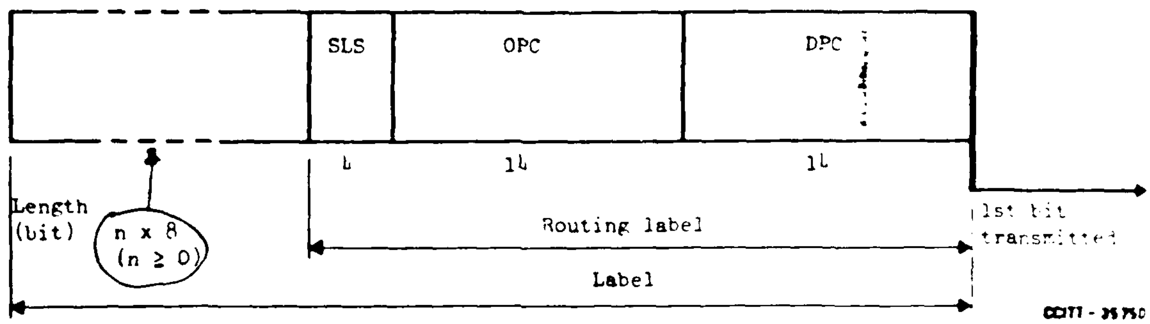
The part of the message label that is used for routing is called the routing label and it contains all the information necessary to deliver the message to its destination point.

Normally the routing label is common to all the services and applications in a given signalling network (national or international) (however, if this is not the case, the particular routing label of a message is determined by means of the service indicator).

The standard routing label is specified in the following. This label should be used in the international signalling network and is applicable also in national applications.

Note - There may be applications using a modified label having the same order and function, but possibly different sizes, of sub-fields as the standard routing label.

2.2.2 The standard routing label has a length of 32 bits and is placed at the beginning of the Signalling Information Field. Its structure appears in Figure 2-2 (Q.704).



DPC = Destination Point Code
OPC = Originating Point Code
SLS = Signalling Link Selection

Figure 2-2 (Q.704) - Routing label structure

2.2.3 The destination point code (DPC) indicates the destination point of the message. The originating point code (OPC) indicates the originating point of the message. The coding of these codes is pure binary. Within each field the least significant bit occupies the first position and is transmitted first.

A unique numbering scheme for the coding of the fields will be used for the signalling points of the international network, irrespective of the User Parts connected to each signalling point.

2.2.4 The signalling link selection (SLS) field is used, where appropriate, in performing load sharing, see Section 2.3. This field exists in all types of messages and always in the same position. The only exception to this rule is some Message Transfer Part-level 3 (e.g. the changeover order), for which the message routing function in the signalling point of origin of the message is not dependent on the field: in this particular case the field does not exist as such, but it is replaced by other information (e.g. in the case of the changeover order, the identity of the faulty link).

In the case of circuit related messages, the field contains the least significant bits of the circuit identification code (or bearer identification code, in the case of the Data User Part), these are not repeated elsewhere.

In the case of Message Transfer Part-level 3 messages, the signalling link selection field exactly corresponds to the signalling link code (SLC) which indicates the signalling link between the destination point and originating point to which the message refers.

2.2.5 From the rule stated in 2.2.4 above it follows that the signalling link selection of messages generated by any User Parts will be used in the load sharing mechanism. As a consequence, in the case of User Parts which are not specified (e.g. transfer of charging information) but for which there is the requirement to maintain the order of transmission of the messages, the field should be coded with the same value for all messages belonging to the same transaction, sent in a given direction.

2.2.6 The above principles should also apply to modified label structures that may be used nationally.

2.3 Message routing function

2.3.1 The message routing function is based on the information contained in the routing label; moreover in some circumstances the service indicator may also need to be used for routing purposes.

Note - A possible case for the use of the service indicator is that which would arise from the use of messages supporting the signalling route management function (i.e. transfer-prohibited, transfer-allowed and signalling-route-set-messages) referring to a destination more restrictive than a single signalling point (e.g. an individual User Part) (see Section 11). Another case may be in relation to signalling-route-test procedures which may be defined for testing and maintenance purposes [see (4)].

The number of such cases should be kept to a minimum in order to apply the same routing criteria to as many User Parts as possible.

Each signalling point will have routing information that allows it to determine the signalling link over which a message has to be sent on the basis of the destination point code and signalling link selection field and, in some cases, of the national indicator (see Section 2.4.3). Typically the destination point code is associated with more than one signalling link that may be used to carry the message; the selection of the particular signalling link is made by means of the signalling link selection field, thus effecting load sharing.

2.3.2 Two basic cases of load sharing are defined, namely:

a) load sharing between links belonging to the same link set,

b) load sharing between links not belonging to the same link set.

The capability to operate in load sharing according to both these cases is mandatory for any signalling point in the international network.

In case a) the traffic flow carried by a link set is shared (on the basis of the signalling link selection field) between different signalling links belonging to the link set. An example of such a case is given by a link set directly interconnecting the originating and destination points in the associated mode of operation, such as represented in Figure 2-3 (Q.704).

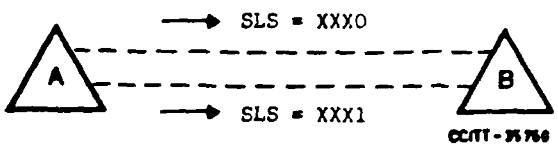


Figure 2-3 (Q.704) - Example of load sharing within a link set

In case b) traffic relating to a given destination is shared (on the basis of the signalling link selection field) between different signalling links not belonging to the same link set, such as represented in Figure 2-4 (Q.704). The load sharing rule used for a particular signalling relation may or may not apply to all the signalling relations which use one of the signalling links involved (in the example, traffic destined to B is shared between signalling links DE and DF with a given signalling link selection field assignment, while that destined to C is sent only on link DF, due to the failure of link EC).

As a result of the message routing function, in normal conditions all the messages having the same routing label (e.g. call set-up messages related to a given circuit) are routed via the same signalling links and signalling transfer points.

Principles relating to the number of load shared links appear in [5].

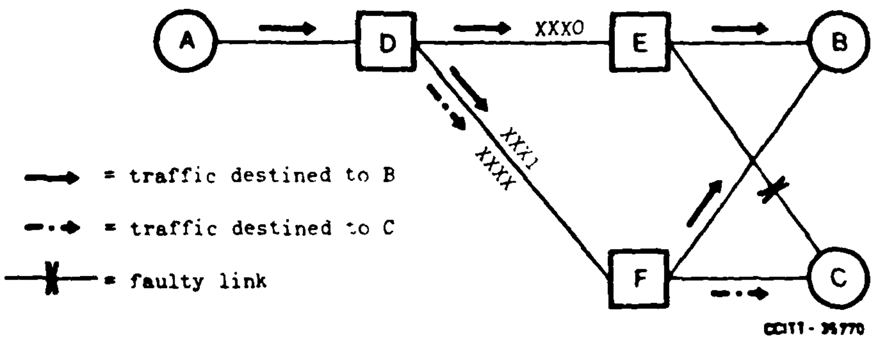


Figure 2-4 (Q.704) - Example of load sharing between link sets

2.3.3 The routing information mentioned in Section 2.3.1 should be appropriately updated when some event happens in the signalling network, which is relevant to the concerned signalling point (e.g. failure of a signalling link or unavailability of a signalling route). The updating of the routing information is made according to the particular event (see Section 3) and to the signalling routing modification rules specified in Section 4.

2.4 Message discrimination and distribution functions

2.4.1 The routing criteria and load sharing method described in the previous section imply that a signalling point, sending messages pertaining to a given signalling transaction on a given link, should be able to receive and process messages pertaining to that transaction, e.g. in response to the sent ones, coming from any (but only one) link.

The destination point code field of the received messages is examined by the discrimination function in order to determine if they are destined to the receiving signalling point or, in the case of a signalling point having the signalling transfer point capability, they are not; in the latter case they are directed to the routing function, as described in the previous sections, in order to be sent on the appropriate outgoing link towards the message destination point.

When a signalling point detects that a received message cannot be delivered to its destination point, it sends in response a transfer-prohibited message as specified in Section 11.2.

2.4.2 If the destination point code of the message identifies the receiving signalling point, the service indicator is examined by the message distribution function and the message is delivered to the corresponding User Part (or to the Message Transfer Part-level 3).

2.4.3 In the case of a signalling point handling both international and national signalling traffic (e.g. an international gateway exchange) the national indicator is also examined in order to determine the relevant numbering scheme (international or national) and possibly the label structure. Moreover within a national network the national indicator may be examined to discriminate between different label structures or between different signalling point numbering if dependent on the network levels, see Section 12.2.

3 Signalling network management

3.1 General

3.1.1 The signalling network management functions provide the actions and procedures required to maintain signalling service and to restore normal signalling conditions in the event of disruption in the signalling network, either in signalling links or at signalling points. For example, in the case of a link failure the traffic conveyed over the faulty link should be diverted to one or more alternative links. The link failure may also result in unavailable signalling routes and this, in turn, may cause diversion of traffic at other signalling points in the signalling network (i.e. signalling points to which no faulty links are connected).

3.1.2 The occurrence of or recovery from failures generally results in a change of the status of the affected signalling link(s) and route(s). A signalling link may be considered by level 3, either as "available" or "unavailable" to carry signalling traffic; in particular, an available signalling link becomes unavailable if it is recognised as "failed", "deactivated" or "blocked" 1) and it becomes once again available if it is recognized as "restored", "activated" or "unblocked" respectively. A signalling route may be considered by level 3 as "available" or "unavailable" too. The detailed criteria for the determination of the changes in the status of signalling links and routes are described in Sections 3.2 and 3.4 respectively.

3.1.3 Whenever a change in the status of a signalling link or route occurs, the three different signalling network management functions (i.e. signalling traffic management, link management and route management) are activated, when appropriate, as follows:

a) the signalling traffic management function is used to divert signalling traffic from a link or route to one or more different links or routes, or to temporarily slow down signalling traffic in the case of congestion at a signalling point; it comprises the following procedures:

- changeover (see Section 5),
- changeback (see Section 6),
- forced rerouting (see Section 7),
- controlled rerouting (see Section 8),
- signalling traffic flow control (see Section 9).

b) The signalling link management function is used to restore failed signalling links, to activate idle (not yet aligned) links and to de-activate aligned signalling links; it comprises the following procedures (see Section 10):

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

----

1) The "blocked" condition arises when the unavailability of a signalling link does not depend on a failure in the link itself, but on other causes, such as a "processor outage" condition in a signalling point.

c) The signalling route management function is used to distribute information about the signalling network status, in order to block or unblock signalling routes; it comprises the following procedures:

- transfer-prohibited procedure (see Section 11.2),
- transfer-allowed procedure (see Section 11.3),
- signalling-route-set-test procedure (see Section 11.4).

3.1.4 An overview of the use of the procedures relating to the different management functions on occurrence of the link and route status changes is given in Section 3.3 and 3.5 respectively.

3.2 Status of signalling links

3.2.1 A signalling link is always considered by level 3 in one of two possible major states: available and unavailable. Depending on the cause of unavailability, the unavailable state can be subdivided into three possible cases as follows [see also Figure 3-1 (Q.704)]:

- unavailable, failed or inactive,
- unavailable, blocked,
- unavailable, failed or inactive and blocked.

The concerned link can be used to carry signalling traffic only if it is available. Six possible events can change the status of a link: signalling link failure, restoration, deactivation, activation, blocking and unblocking; they are described in Sections 3.2.2 to 3.2.7.

3.2.2 Signalling link failure

A signalling link (in service or blocked, see 3.2.6) is recognised by level 3 as failed when:

a) A link failure indication is obtained from level 2. The indication may be caused by:

- intolerably high signal unit error rate, see Recommendation Q.703, Section 9 [6];
- excessive length of the realignment period, see Recommendation Q.703, Section 4.1 [7] and 9 [10];
- excessive delay of acknowledgements, see Recommendation Q.703, Section 5.3 [8] and 6.3 [9];
- failure of signalling terminal equipment;
- two out of three unreasonable backward sequence numbers or forward indicator bits (see Recommendation Q.703, Sections 5.3 [8] and 6.3 [9]);

- reception of consecutive link status signal units indicating out of alignment, out of service, normal or emergency terminal status (see Recommendation Q.703, Section 1.7 [10]).

The first two conditions are detected by the signal unit error rate monitor (see Recommendation Q.703, Section 8 [11]).

b) A request (automatic or manual) is obtained from a management or maintenance system.

Moreover a signalling link which is available (not blocked) is recognized by level 3 as failed when a changeover order is received.

3.2.3 Signalling link restoration

A signalling link previously failed is restored when both ends of the signalling link have successfully completed an initial alignment procedure (see [10]).

3.2.4 Signalling link deactivation

A signalling link (in service, failed or blocked) is recognized by level 3 as deactivated (i.e. removed from operation) when:

a) A request is obtained from the signalling link management function (see Section 10).

b) A request (automatic or manual) is obtained from an external management or maintenance system.

3.2.5 Signalling link activation

A signalling link previously inactive is recognized by level 3 as activated when both ends of the signalling link have successfully completed an initial alignment procedure (see [10]).

3.2.6 Signalling link blocking

A signalling link (which is not failed or inactive) is recognized as blocked when:

a) An indication is obtained from the signalling terminal that a processor outage condition exists at the remote terminal (i.e. link status signal units with processor outage indication are received, see Recommendation Q.703, Section 8 [11].

b) A request (automatic or manual) is obtained from a management system.

Note - A link becomes unavailable when it is failed or deactivated and/or blocked, see Figure 3-1 (Q.704).

3.2.7 Signalling link unblocking

A signalling link previously blocked is unblocked when:

a) An indication is obtained from the signalling terminal that the processor outage condition has ceased at the remote terminal. (Applies in the case when the processor outage condition was initiated by the remote terminal.)

b) A request from a management system is obtained. (Applies in the case when the blocking was initiated by the management system).

Note - A link becomes available when it is restored or activated and/or unblocked see Figure 3-1 (Q.704).

3.3 Procedures used in connection with link status changes

In this section the procedures relating to each signalling management function, which are applied in connection with link status changes are listed. [See also Figures 3-1, 3-2 and 3-3 (Q.704)]. Typical examples of the application of the procedures to the particular network cases appear in Recommendation Q.705 [12].

3.3.1 Signalling link failed

a) Signalling traffic management: the changeover procedure (see Section 5) is applied, if required, to divert signalling traffic from the unavailable link to one or more alternative links with the objective of avoiding message loss, repetition or mis-sequencing, it includes determination of the alternative link or links where the affected traffic can be transferred and procedures to retrieve messages sent over the failed link but not received by the far end.

b) Signalling link management: the procedures described in Section 10 are used to restore a signalling link and to make it available for signalling. Moreover, depending on the link set status the procedures can also be used to activate another signalling link in the same link set to which the unavailable link belongs and to make it available for signalling.

c) Signalling route management: in the case when the failure of a signalling link causes a signalling route set to become unavailable the signalling transfer point which can no longer route the concerned signalling traffic applies the transfer-prohibited procedures described in Section 11.

3.3.2 Signalling link restored

a) Signalling traffic management: the changeback procedure (see Section 6) is applied, if required, to divert signalling traffic from one or more links to a link which has become available; it includes determination of the traffic to be diverted and procedures for maintaining the correct message sequence.

b) Signalling link management: the signalling link de-activation procedure (see Section 10) is used if during the signalling link failure, another signalling link of the same link set was activated, it is used to assure that the link set status is returned to the same state as before the failure. This requires that the active link activated during the link failure, is deactivated and considered no longer available for signalling.

c) Signalling route management: in the case when the restoration of a signalling link causes a signalling route set to become available, the signalling transfer point which can once again route the concerned signalling traffic applies the transfer-allowed procedures described in Section 11.

3.3.3 Signalling link deactivated

a) Signalling traffic management: as specified in Section 3.3.1 (a).

Note - The signalling traffic has normally already been removed when signalling link deactivation is initiated.

b) Signalling link management: if the number of active signalling links in the link set to which the deactivated signalling link belongs has become less than the normal number of active signalling links in that link set, the procedures described in Section 10 may be used to activate another signalling link in the link set.

c) Signalling route management: as specified in Section 3.3.1 (c).

3.3.4 Signalling link activated

a) Signalling traffic management: as specified in Section 3.3.2 (a).

b) Signalling link management: if the number of active signalling links in the link set to which the activated signalling link belongs has become greater than the normal number of active signalling links in that link set, the procedures described in Section 10 may be used to deactivate another signalling link in the link set.

c) Signalling route management: as specified in Section 3.3.2 (c).

3.3.5 Signalling link blocked

a) Signalling traffic management: will be the same as in Section 3.3.1 (a).

b) Signalling route management: if the blocking of the link causes a signalling route set to become unavailable the signalling transfer point which can no longer route the concerned signalling traffic applies the transfer-prohibited procedures described in Section 11.

Note - In the case when the blocking is initiated by a management system, an indication should be given to the signalling terminal in order to stop transmission of Message Signal Units and start contiguous transmission of link status signal units indicating processor outage (see [8]). In the case when the blocking was initiated by the receipt of a changeover order, an indication should be given to the terminal in order to start contiguous transmission of fill in signal units (see [10]).

3.3.6 Signalling link unblocked

a) Signalling traffic management: the actions will be the same as in Section 3.3.2 (a).

b) Signalling route management: if the link unblocked causes a signalling route set to become available the signalling transfer point which can once again route the signalling traffic in that route set applies the transfer-allowed procedures described in Section 11.

Note - In the case when the blocking and thus the unblocking was initiated by a management system, an indication should be given to the signalling terminal in order to stop any transmission of link status signal units indicating processor outage.

3.4 Status of signalling routes

A signalling route can be either available or unavailable, for signalling traffic having the concerned destination [see also Figure 3-1 (Q.704)].

3.4.1 Signalling route unavailability

A signalling route becomes unavailable when a transfer-prohibited message, indicating that signalling traffic towards a particular destination cannot be transferred via the signalling transfer point sending the concerned message, is received, see Section 11.

3.4.2 Signalling route availability

A signalling route becomes available when a transfer-allowed message, indicating that signalling traffic towards a particular destination can be transferred via the signalling transfer point sending the concerned message, is received, see Section 11.

3.5 Procedures used in connection with route status changes

In this section the procedures relating to each signalling management function which in general are applied in connection with route status changes are listed. [See also Figures 3-1 and 3-3 (Q.704).] Typical examples of the application of the procedures to particular network cases appear in [12].

3.5.1 Signalling route unavailable

a) Signalling traffic management: the forced rerouting procedure (see Section 7) is applied; it is used to transfer signalling traffic to the concerned destination from the link set, belonging to the unavailable route, to an alternative link set which terminates in another signalling transfer point. It includes actions to determine the alternative route.

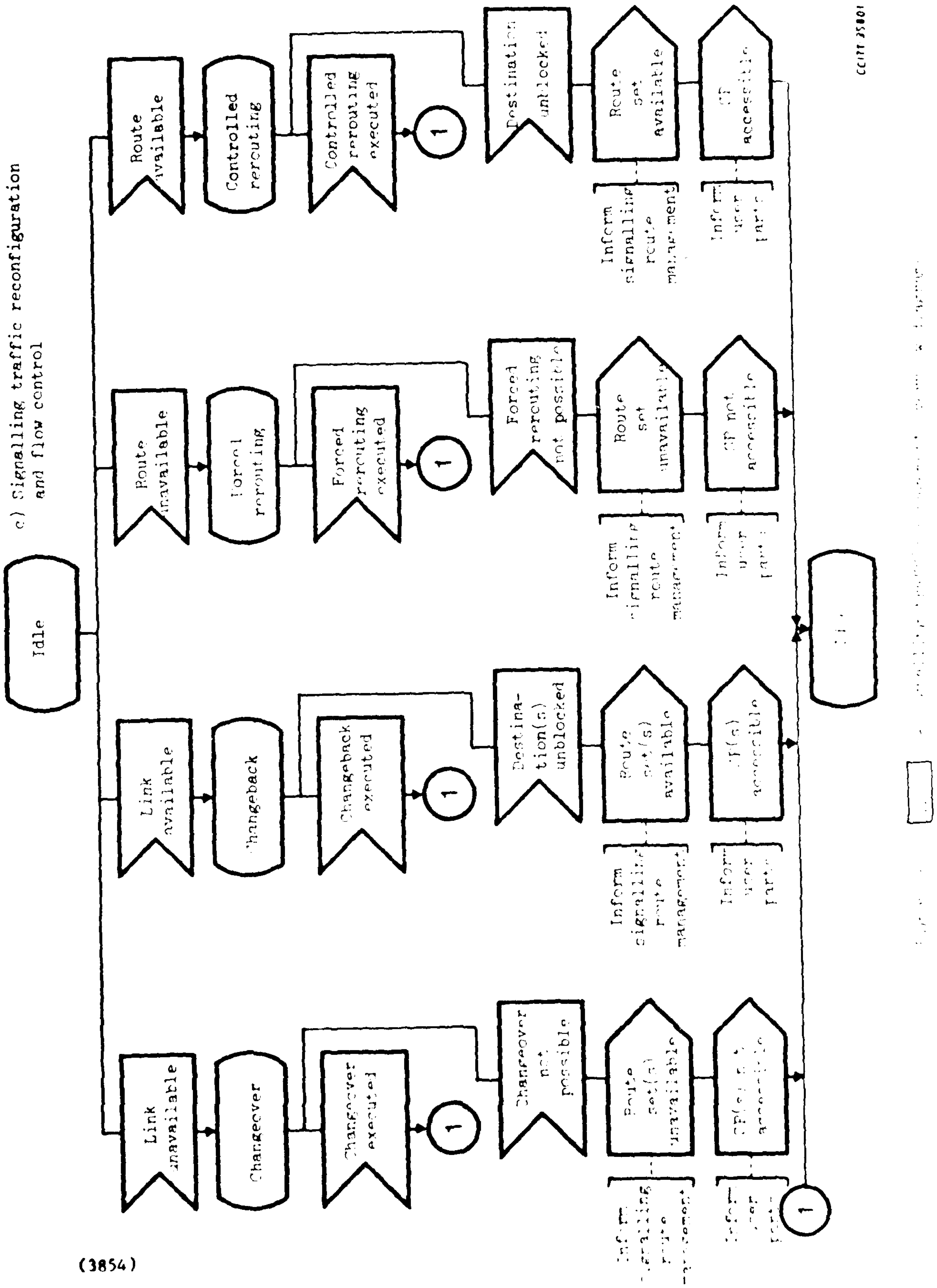
b) Signalling route management: because of the unavailability of the signalling route the network is reconfigured; in the case that a signalling transfer point can no longer route the concerned signalling traffic, it applies the procedures described in Section 11.

3.5.2 Signalling route available

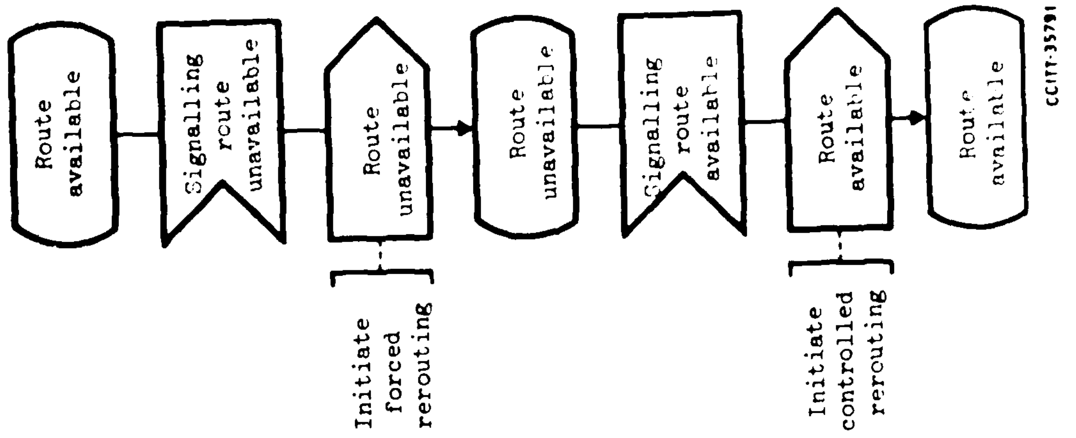
a) Signalling traffic management: the controlled rerouting procedure (see Section 8) is applied; it is used to transfer signalling traffic to the concerned destination from a signalling link or link set belonging to an available route, to another link set which terminates in another signalling transfer point. It includes the determination of which traffic should be diverted and procedures for maintaining the correct message sequence.

b) Signalling route management: because of the restored availability of the signalling route the network is reconfigured; in the case that a signalling transfer point can once again route the concerned signalling traffic, it applies the procedures described in Section 11.

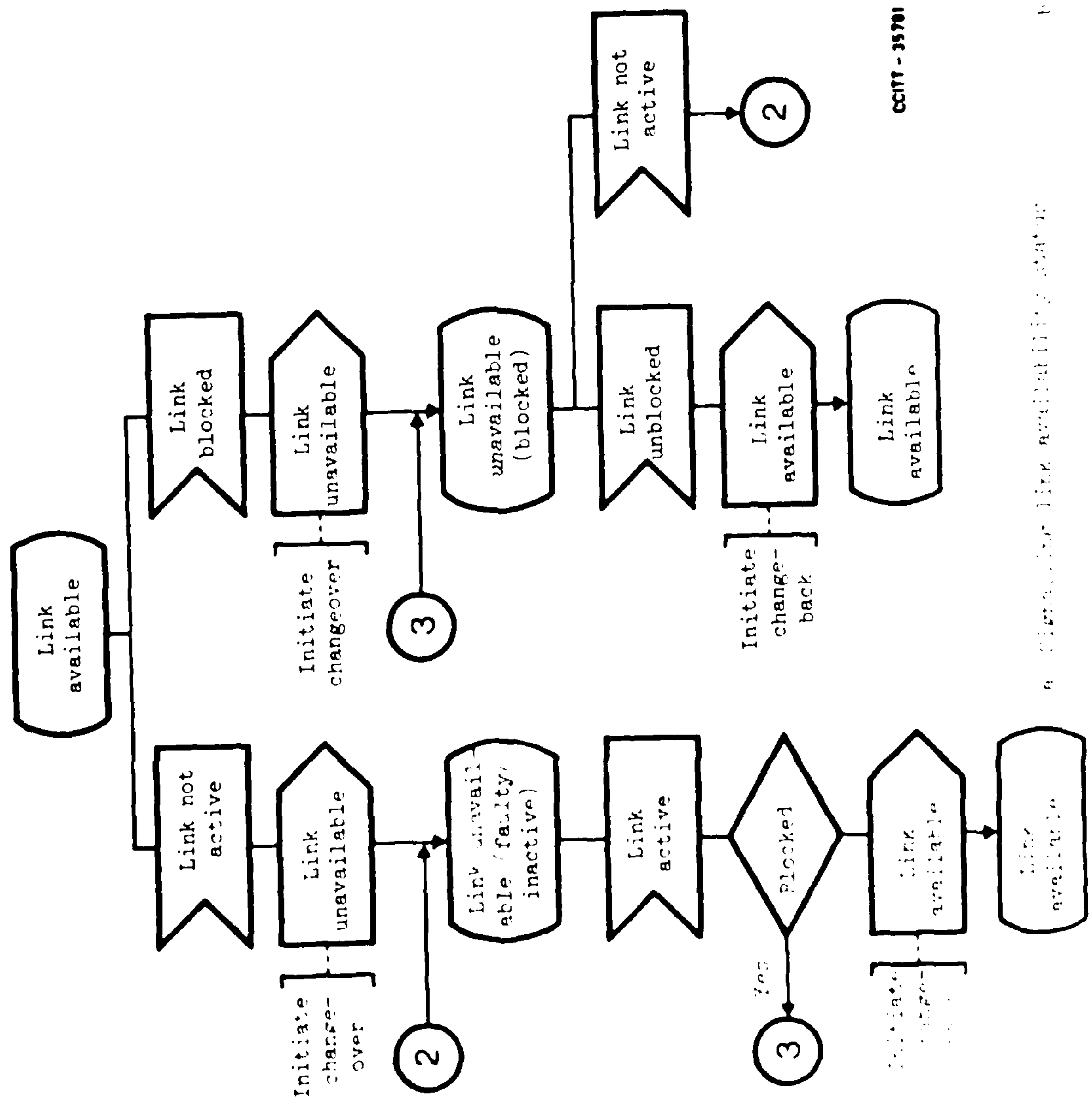
c) Signalling traffic reconfiguration and flow control



(3854)



b) Signalling route availability status



a) Signalling link availability status

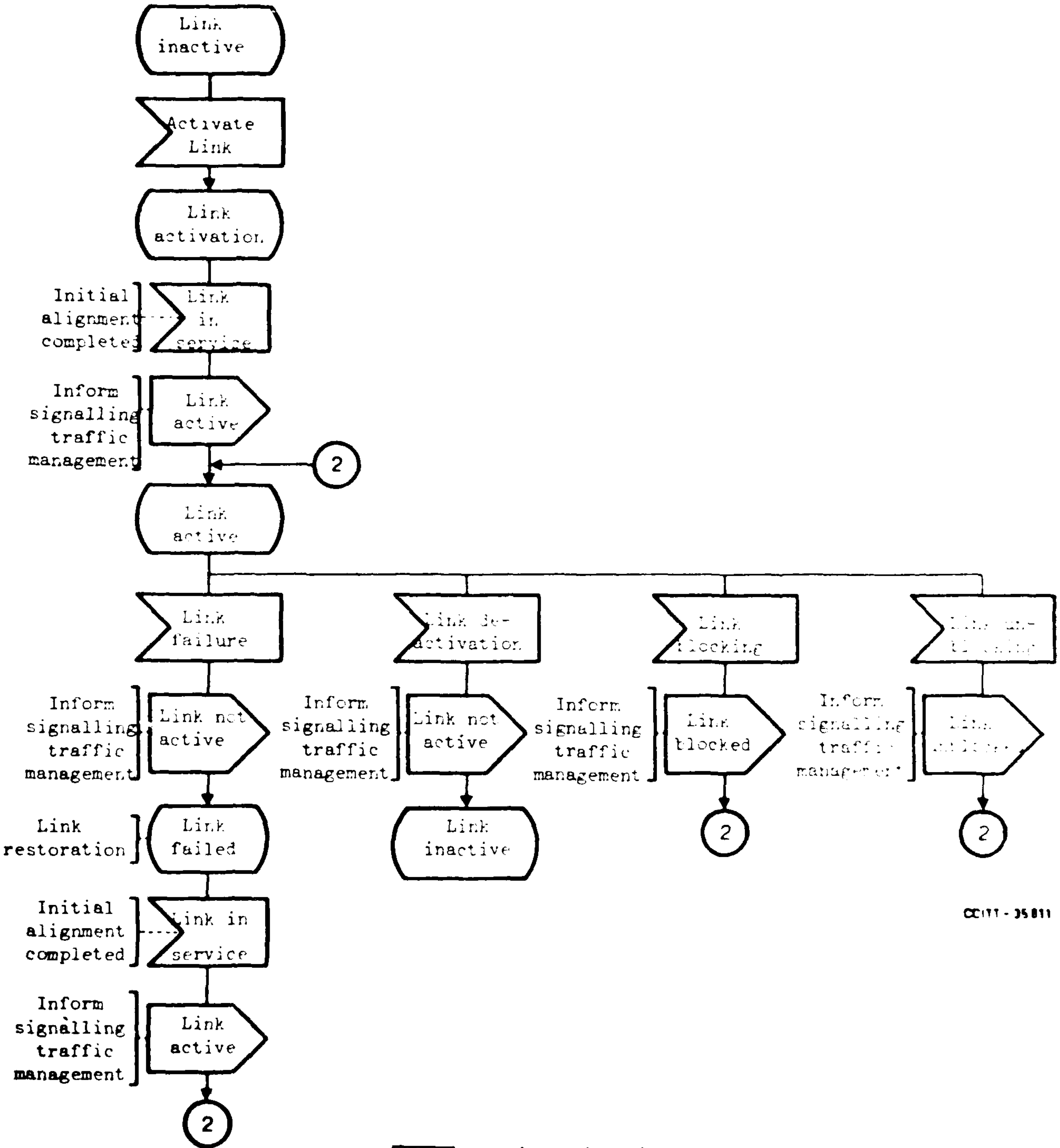


Figure 3-2 (Q.704) - Signalling link management overview diagram

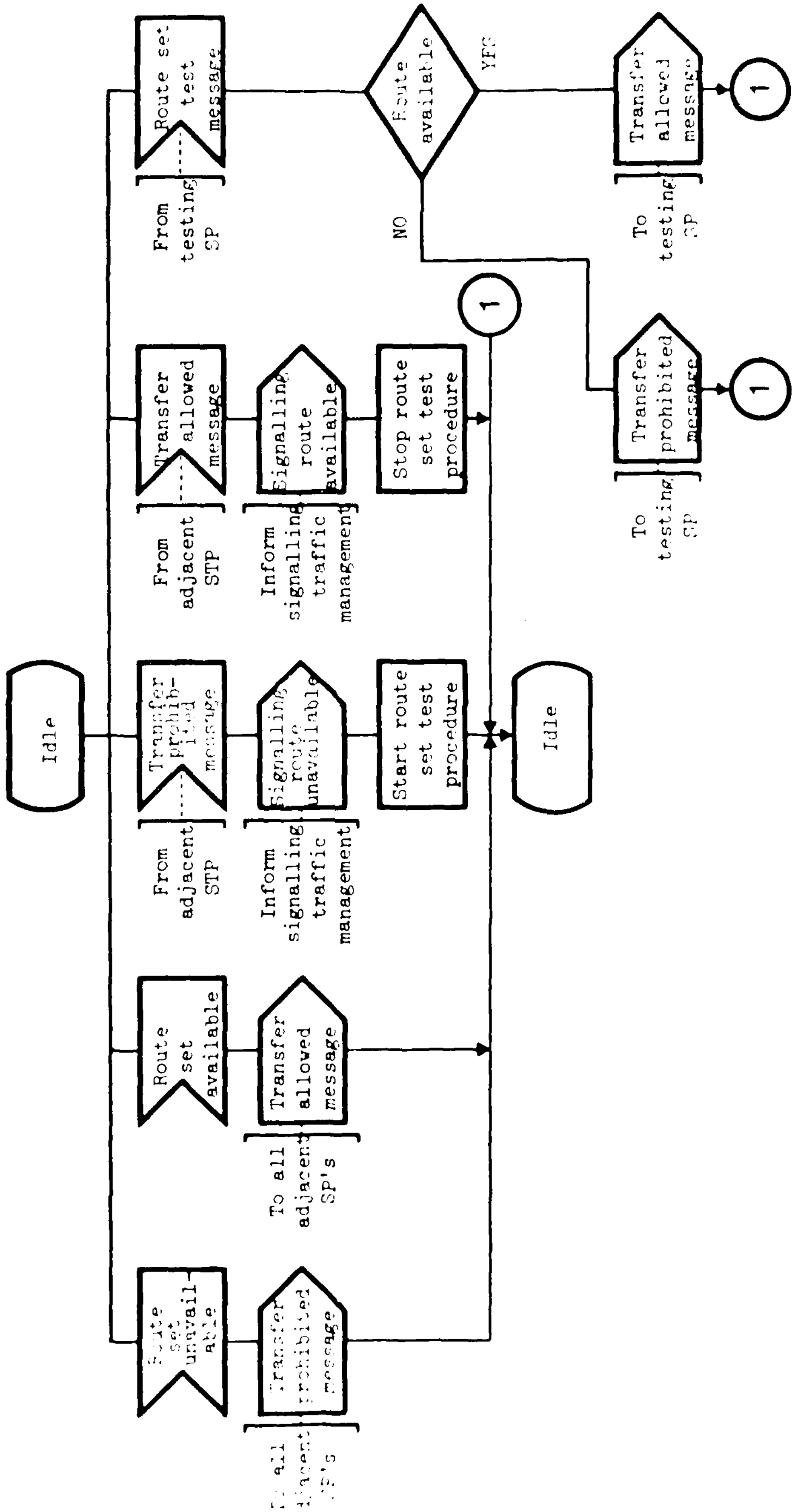


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Figure 3-? ( ) - Signalling route management overview diagram

4 Signalling traffic management

4.1 General

4.1.1 The signalling traffic management function is used, as indicated in Section 3, to divert signalling traffic from signalling links or routes, or to temporarily reduce it in quantity in the case of congestion.

4.1.2 The diversion of traffic in the cases of unavailability or availability of signalling links and routes is typically made by means of the following basic procedures, included in the signalling traffic management function:

- signalling link unavailability (failure, deactivation or blocking): the changeover procedure (see Section 5) is used to divert signalling traffic to one or more alternative links (if any);

- signalling link availability (restoration, activation or unblocking): the changeback procedure (see Section 6) is used to divert signalling traffic to the link made available;

- signalling route unavailability: the forced rerouting procedure (see Section 7) is used to divert signalling traffic to an alternative route (if any);

- signalling route availability: the controlled rerouting procedure (see Section 8) is used to divert signalling traffic to the route made available.

Each procedure includes different elements of procedure, the application of one or more of which depends on the particular circumstances, as indicated in the relevant Sections. Moreover these procedures include a modification of the signalling routing, which is made in a systematic way, as described in Sections 4.2 to 4.6.

4.1.3 The signalling traffic flow control procedures are used in the case of signalling traffic congestion in a signalling point, in order to request a temporary interruption of the signalling traffic sent to it by one or more adjacent signalling points. These procedures are specified in Section 9.

4.2 Normal routing situation

4.2.1 Signalling traffic to be sent to a particular signalling point in the network, is normally routed to one or, in the case of load sharing between link sets, two links sets. Within a link set, a further routing may be performed in order to load share the traffic over the available signalling links, see Section 2.

To cater for the situations when signalling links or routes become unavailable, alternative routing data is defined.

For each destination which may be reached from a signalling point, one or more alternative link sets are allocated. The possible link sets appear in a certain priority order. The link set having the highest priority is used whenever it is available. It is defined as the normal link set for traffic to the concerned destination. In case of load sharing between link sets, a normal link set exists for each portion of the divided signalling traffic.

For each signalling link, the remaining signalling links in the link set are alternative links. The signalling links of a link set are arranged in a certain priority order. Under normal conditions the signalling link (or links) having the highest priority is used to carry the signalling traffic. These signalling links are defined as normal signalling links, and each portion of load shared traffic has its own normal signalling link. Signalling links other than normal may be active stand-by or inactive signalling links, see Section 10.

4.2.2 Message routing (normal as well as alternative) is in principle independently defined at each signalling point. Thus, signalling traffic between two signalling points may be routed over different signalling links or paths in the two directions.

4.3 Signalling link unavailability

4.3.1 When a signalling link becomes unavailable (see Section 3.2) signalling traffic carried by the link is transferred to one or more alternative links by means of a changeover procedure. The alternative link or links are determined in accordance with the following criteria.

4.3.2 In the case when there is one or more alternative signalling links available in the link set to which the unavailable link belongs, the signalling traffic is transferred within the link set to:

a) an aligned and unblocked signalling link, currently not carrying any traffic. If no such signalling link exists, the signalling traffic is transferred to

b) one or possibly more than one signalling link currently carrying traffic. In the case of transfer to one signalling link, the alternative signalling link is that having the highest priority of the signalling links in service.

4.3.3 In the case when there is no alternative signalling link within the link set to which the unavailable signalling link belongs, the signalling traffic is transferred to one or more alternative link sets in accordance with the alternative routing defined for each destination. For a particular destination, the alternative link set is the link set in service having the highest priority.

Within a new link set, signalling traffic is distributed over the signalling links in accordance with the routing currently applicable for that link set; i.e. the transferred traffic is routed in the same way as the traffic already using the link set.

4.4 Signalling link availability

4.4.1 When a previously unavailable signalling link becomes available again (see Section 3.2), signalling traffic may be transferred to the available signalling link by means of the changeback procedure. The traffic to be transferred is determined in accordance with the following criteria.

4.4.2 In the case when the link set, to which the available signalling link belongs, already carries signalling traffic on other signalling links in the link set, the traffic to be transferred is the traffic for which the available signalling link is the normal one.

The traffic is transferred from one or more signalling links, depending on the criteria applied when the signalling link became unavailable (see Section 4.3.2).

4.4.3 In the case when the link set, to which the available signalling link belongs, does not carry any signalling traffic (i.e. a link set has become available), the traffic to be transferred is the traffic for which the available link set has higher priority than the link set currently used. However, in the case of load sharing between link sets, traffic is not transferred from a normal link set.

The traffic is transferred from one or more link sets and from one or more signalling links within each link set.

4.5 Signalling route unavailability

When a signalling route becomes unavailable (see Section 3.4) signalling traffic carried by the unavailable route is transferred to an alternative route by means of forced rerouting procedure. The alternative route (i.e. the alternative link set) is determined in accordance with the alternative routing defined for the concerned destination, see Section 4.3.3.

4.6 Signalling route availability

When a previously unavailable signalling route becomes available again (see Section 3.4) signalling traffic may be transferred to the available route by means of a controlled rerouting procedure. This is applicable in the case when the available route (link set) has higher priority than the route (link set) currently used for traffic to the concerned destination (see Section 4.4.3).

The transferred traffic is distributed over the links of the new link set in accordance with the routing currently applicable for that link set.

5 Changeover

5.1 General

5.1.1 The objective of the changeover procedure is to ensure that signalling traffic carried by the unavailable signalling link is diverted to the alternative signalling link(s) as quickly as possible while avoiding message loss, duplication or mis-sequencing. For this purpose, in the normal case the changeover procedure includes buffer up-dating and retrieval, which are performed before reopening the alternative signalling link(s) to the diverted traffic. Buffer updating consists of identifying all those messages in the retransmission buffer of the unavailable signalling link which have not been received by the far end. This is done by means of a hand-shake procedure, based on, changeover messages performed between the two ends of the unavailable signalling link. Retrieval consists of transferring the concerned messages to the transmission buffer(s) of the alternative link(s).

5.1.2 Changeover includes the procedures to be used in the case of unavailability (due to failure or blocking) of a signalling link, in order to divert the traffic pertaining to that signalling link to one or more alternative signalling links. These signalling links can be carrying their own signalling traffic and this is not interrupted by the changeover procedure.

The different network configurations to which the changeover procedure may be applied are described in Section 5.2.

The criteria for initiation of changeover, as well as the basic actions to be performed, are described in Section 5.3.

Procedures necessary to cater for equipment failure or other abnormal conditions are also provided.

5.2 Network configurations for changeover

5.2.1 Signalling traffic diverted from an unavailable signalling link is routed by the concerned signalling point according to the rules specified in Section 4. In summary, two alternative situations may arise (either for the whole diverted traffic or for traffic relating to each particular destination):

i) traffic is diverted to one or more signalling links of the same link set,

or

ii) traffic is diverted to one or more different link sets.

5.2.2 As a result of these arrangements, and of the message routing function described in Section 2, three different relationships between the new signalling link and the unavailable one can be identified, for each particular traffic flow. These three basic cases may be summarized as follows:

a) the new signalling link is parallel to the unavailable one [see Figure 5-1 (Q.704)];

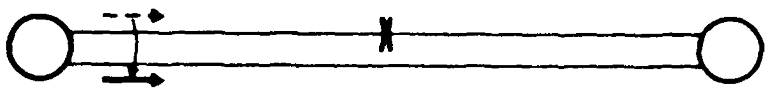

Figure 5-1 (Q.704) - Example of changeover to a parallel link

b) the new signalling link belongs to a signalling route other than that to which the unavailable signalling link belongs, but this signalling route still passes through the signalling point at the far end of the unavailable signalling link [see Figure 5-2 (Q.704)];

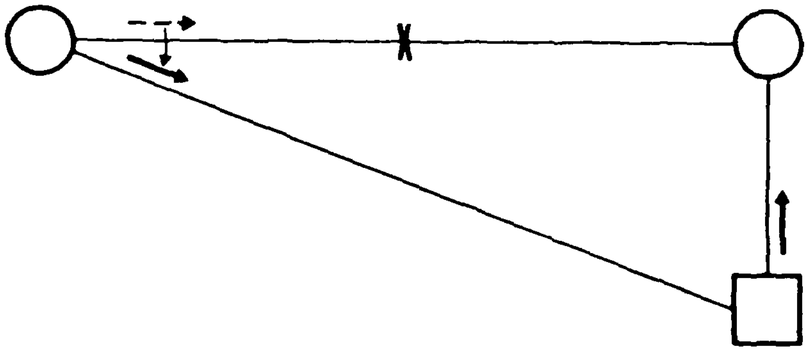

Figure 5-2 (Q.704) - Example of changeover to a signalling route passing through the remote signalling point

c) the new signalling link belongs to a signalling route other than that to which the unavailable signalling link belongs, and this signalling route does not pass through the signalling point acting as signalling transfer point, at the far end of the unavailable signalling link [see Figure 5-3 (Q.704)].

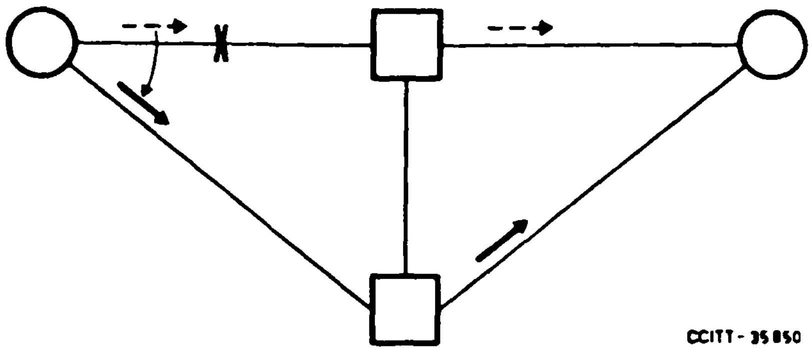

Figure 5-3 (Q.704) - Example of changeover to a signalling route not passing through the remote signalling point

Only in the case of (c) does a possibility of message mis-sequencing exist: therefore its use should take into account the overall service dependability requirements described in [3].

5.3 Changeover initiation and actions

5.3.1 Changeover is initiated at a signalling point when a signalling link is recognized as unavailable according to the criteria listed in Sections 3.2.2 and 3.2.6.

The following actions are then performed:

a) transmission and acceptance of message signal units on the concerned signalling link is terminated;

b) transmission of link status signal units or fill in signal units, as described in [8], takes place;

c) the alternative signalling link(s) are determined according to the rules specified in Section 4;

d) a procedure to update the content of the retransmission buffer of the unavailable signalling link is performed as specified in 5.4 below;

e) signalling traffic is diverted to the alternative signalling link(s) as specified in 5.5 below.

In addition, if traffic toward a given destination is diverted to an alternative signalling link terminating in a signalling transfer point not currently used to carry traffic toward that destination, a transfer-prohibited procedure is performed as specified in Section 11.2.

5.3.2 In the case when there is no traffic to transfer from the unavailable signalling link action (b) only is required.

5.3.3 If no alternative signalling link exists for signalling traffic towards one or more destinations; the concerned destination(s) are declared inaccessible and the following actions apply:

i) the routing of the concerned signalling traffic is blocked and the concerned messages already stored in the transmission and retransmission buffers of the unavailable signalling link, as well as those received subsequently, are discarded; 1)

ii) a command is sent to the User Part(s) (if any) in order to stop generating the concerned signalling traffic;

iii) the transfer-prohibited procedure is performed, as specified in Section 11.2;

iv) the appropriate signalling link management procedures are performed, as specified in Section 10.

5.3.4 In some cases of failures or in some network configurations, the normal buffer updating and retrieval procedures described in 5.4 and 5.5 cannot be accomplished. In such cases, the emergency changeover procedures described in Section 5.6 apply.

Other procedures to cover possible abnormal cases appear in Section 5.7.

5.4 Buffer updating procedure

5.4.1 When a decision to changeover is made a changeover order is sent to the remote signalling point. In the case that the changeover was initiated by the reception of a changeover order (see 5.2) a changeover acknowledgement is sent instead.

A changeover order is always acknowledged by a changeover acknowledgement, even when changeover has already been initiated in accordance with another criterion.

No priority is given to the changeover order or changeover acknowledgement in relation to the normal traffic of the signalling link on which the message is sent.

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1) The adequacy of this procedure to meet the acceptable dependability objective in terms of loss of messages requires further study.

5.4.2 The changeover order and changeover acknowledgement are signalling network management messages and contain the following information:

- the label, indicating the destination and originating signalling points and the identity of the unavailable signalling link,

- the changeover-order (or changeover-acknowledgement) signal, and

- the forward sequence number of the last message signal unit accepted from the unavailable signalling link.

Formats and codes of the changeover order and the changeover acknowledgement appear in Section 13.

5.4.3 Upon reception of a changeover order or changeover acknowledgement, the retransmission buffer of the unavailable signalling link is updated (except as noted in Section 5.6), according to the information contained in the message. The message signal units successive to that indicated by the message are those which have to be retransmitted on the alternative signalling link(s), according to the retrieval and diversion procedure.

5.5 Retrieval and diversion of traffic

When the procedure to update the retransmission buffer content is completed the following actions are performed:

- the routing of the signal traffic to be diverted is changed;

- the signal traffic already stored in the transmission buffers and retransmission buffer of the unavailable signalling link is sent directly towards the new signalling link(s), according to the modified routing.

The diverted signalling traffic will be sent towards the new signalling link(s) in such a way that the correct message sequence is maintained. The diverted traffic has no priority in relation to normal traffic already conveyed on the signalling link(s).

5.6 Emergency changeover procedures

5.6.1 Due to the failure in a signalling terminal it may be impossible for the corresponding end of the faulty signalling link to determine the forward sequence number of the last message signal unit accepted over the unavailable link. In this case, the concerned end accomplishes, if possible, the buffer updating procedure described in Section 5.4 but it makes use of an emergency changeover order or an emergency changeover acknowledgement instead of the corresponding normal message; these emergency messages, the format of which appears in Section 13, do not contain the forward sequence number of the last accepted message signal unit. Furthermore the signalling link is taken out of service, i.e. the concerned end initiates, if possible, the sending of out-of-service link status signal units on the unavailable link (see [8]).

When the other end of the unavailable signalling link receives the emergency changeover order or acknowledgement, it accomplishes the changeover procedures described in Sections 5.4 and 5.5, the only difference being that it does not perform either buffer updating or retrieval. Instead it directly starts sending the signalling traffic not yet transmitted on the unavailable link on the alternative signalling link(s).

The use of normal or emergency changeover messages depends on the local conditions of the sending signalling point only; in particular:

- an emergency changeover order is acknowledged by a changeover acknowledgement if the local conditions are normal, and

- a changeover order is acknowledged by an emergency changeover acknowledgement if there are local fault conditions.

5.6.2 It may happen that no signalling path exists between the two ends of the unavailable link, so that the exchange of changeover messages is impossible.

When the concerned signalling point decides to initiate changeover in such circumstances, after the expiry of a time T1 = 1s (provisional value) it starts signalling traffic not yet transmitted on the unavailable signalling link on the alternative link(s); the purpose of withholding traffic for the time T1 is to reduce the probability of message mis-sequencing.

An example of such a case appears in Recommendation Q.705, Annex A [13].

In the abnormal case when the concerned signalling point is not aware of the situation, it will start the normal changeover procedure and send a changeover order; in this case it will receive no changeover message in response and the procedure will be completed as indicated in Section 5.7.2. Possible reception of a transfer-prohibited message (sent by an involved signalling transfer point on reception of the changeover order, see Section 11.2) will not affect changeover procedures.

5.6.3 Due to failures, it may be impossible for an signalling point to perform retrieval even if it has received the retrieval information from the far end of the unavailable signalling link. In this case, it starts sending new traffic on reception of the changeover message (or on time-out expiry, see Sections 5.6.2 and 5.7.2); no further actions in addition to the other normal changeover procedures are performed.

5.7 Procedures in abnormal conditions

5.7.1 The procedures described in this section allow the completion of the changeover procedures in abnormal cases other than those described in Section 5.6.

5.7.2 If no changeover message in response to a changeover order is received within a time-out T2 = 1 s (provisional value), new traffic is started on the alternative signalling link(s).

5.7.3 If a changeover order or acknowledgement containing an unreasonable value of the forward sequence number is received, no buffer updating or retrieval is performed, and new traffic is started on the alternative signalling link(s).

5.7.4 If a changeover acknowledgement is received without having previously sent a changeover order, no action is taken.

5.7.5 If a changeover order is received relating to a particular signalling link after the completion of changeover from that signalling link, an emergency changeover acknowledgement is sent in response, without any further action.

6 Changeback

6.1 General

6.1.1 The objective of the changeback procedure is to ensure that signalling is diverted from the alternative signalling link(s) to the signalling link made available as quickly as possible, while avoiding message loss, duplication or mis-sequencing. For this purpose, (in the normal case) changeback includes a procedure to control the message sequence.

6.1.2 Changeback includes the basic procedures to be used to perform the opposite action to changeover, i.e. to divert traffic from the alternative signalling link(s) to a signalling link which has become available (i.e. it was restored or unblocked). The characteristics of the alternative signalling link(s) from which changeback can be made are described in Section 5.2. In all the cases mentioned in Section 5.2 the alternative signalling links can be carrying their own signalling traffic and this is not interrupted by the changeback procedures.

Procedures necessary to cater for particular network configuration or other abnormal conditions are also provided.

6.2 Changeback initiation and actions

6.2.1 Changeback is initiated at a signalling point when a signalling link is restored or unblocked and therefore it becomes once again available, according to the criteria listed in Sections 3.2.3 and 3.2.7. The following actions are then performed:

a) the alternative signalling link(s) are determined, to which traffic normally carried by the signalling link made available was previously diverted (e.g. on occurrence of a changeover);

b) signalling traffic is diverted (if appropriate, according to the criteria specified in Section 4) to the concerned signalling link by means of the sequence control procedure specified in Section 6.3; traffic diversion can be performed at the discretion of the signalling point initiating changeback, as follows:

   i) individually for each traffic flow (i.e. on destination basis);

   ii) individually for each alternative signalling link (i.e. for all the destinations previously diverted on that alternative signalling link);

iii) at the same time for a number of or for all the alternative signalling links.

On occurrence of changeback, it may happen that traffic towards a given destination is no longer routed via a given adjacent signalling transfer point, towards which a transfer-prohibited procedure was previously performed on occurrence of changeover (see Section 5.3.1); in this case a transfer-allowed procedure is performed, as specified in Section 11.3.

In addition, if traffic towards a given destination is diverted to an alternative signalling link terminating in a signalling transfer point not currently used to carry traffic toward that destination, a transfer-prohibited procedure is performed as specified in Section 11.2.

6.2.2 In the case when there is no traffic to transfer to the signalling link made available none of the previous actions are performed.

6.2.3 In the case that the signalling link made available can be used to carry signalling traffic toward a destination which was previously declared inaccessible, the following actions apply:

i) the routing of the concerned signalling traffic is unblocked and transmission of the concerned messages (if any) is immediately started on the link made available;

ii) a command is sent to the User Part(s) (if any) in order to restart generating the concerned signalling traffic;

iii) the transfer-allowed procedure is performed, as specified in Section 11.3.

6.2.4 If the signalling point at the far end of the link made available currently results inaccessible at the signalling point initiating changeback, the sequence control procedure specified in Section 6.3 (which requires communication between the two concerned signalling points) does not apply; instead, the time-controlled diversion specified in Section 6.4 is performed. This is made also when the concerned signalling points is accessible, but there is no signalling route to it using the same outgoing signalling link(s) (or one of the same signalling links) from which traffic will be diverted.

6.3 Sequence control procedure

6.3.1 When a decision is made at a given signalling point to divert a given traffic flow (towards one or more destinations) from an alternative signalling link to the signalling link made available, the following actions are performed if possible (see Section 6.4):

i) transmission of the concerned traffic on the alternative signalling link is stopped; such traffic is stored in a changeback buffer;

ii) a changeback declaration is sent to the remote signalling point of the signalling link made available via the concerned alternative signalling link; this message indicates that no more message signal units relating to the traffic being diverted to the link made available will be sent on the alternative signalling link.

6.3.2 The concerned signalling point will restart diverted traffic over the signalling link made available when it receives a changeback acknowledgement from the far signalling point of the link made available; this message indicates that all signal messages relating to the concerned traffic flow and routed to the remote signalling point via the alternative signalling link have been received. The remote signalling point will send the changeback acknowledgement to the signalling point initiating changeback in response to the changeback declaration; any available signalling route between the two signalling points can be used to carry the changeback acknowledgement.

6.3.3 The changeback declaration and changeback acknowledgement are signalling network management messages and contain:

- the label, indicating the destination and originating signalling points, and the identity of the signalling link to which traffic will be diverted;

- the changeback-declaration (or changeback-acknowledgement) signal, and

- the changeback code.

Formats and codes of the changeback declaration and changeback acknowledgement appear in Section 13.

6.3.4 A particular configuration of the changeback code is autonomously assigned to the changeback declaration by the signalling point initiating changeback; the same configuration is included in the changeback acknowledgement by the acknowledging signalling point. This allows discrimination between different changeback declarations and acknowledgements when more than one sequence control procedures are initiated in parallel, as follows.

6.3.5 In the case that a signalling point intends to initiate changeback in parallel from more than one alternative signalling links, a sequence control procedure is accomplished for each involved signalling link, and a changeback declaration is sent on each of them; each changeback declaration is assigned a different configuration of the changeback code. Stopped traffic is stored in one or more changeback buffers (in the latter case, a changeback buffer is provided for each alternative signalling link). When the changeback acknowledgement relating to that alternative signalling link is received, traffic being diverted from a given alternative signalling link can be restarted on the signalling link made available, starting with the content of the changeback buffer; discrimination between the different changeback acknowledgement is made by the changeback code configuration, which is the same as that sent in the changeback declaration.

This procedure allows either reopening the recovered signalling link to traffic in a selective manner (provided that different changeback buffers are used) as soon as each changeback acknowledgement is received, or only when all the changeback acknowledgements have been received.

6.4 Time-controlled diversion procedure

6.4.1 The time-controlled diversion procedure is used in the case when the remote signalling point is inaccessible at the signalling point initiating changeback, i.e. communication between the two ends of the signalling link made available is not possible via a signalling route other than that signalling link; the sending of changeback declaration is therefore impossible. An example of such a case appears in Figure 6-1 (Q.704).

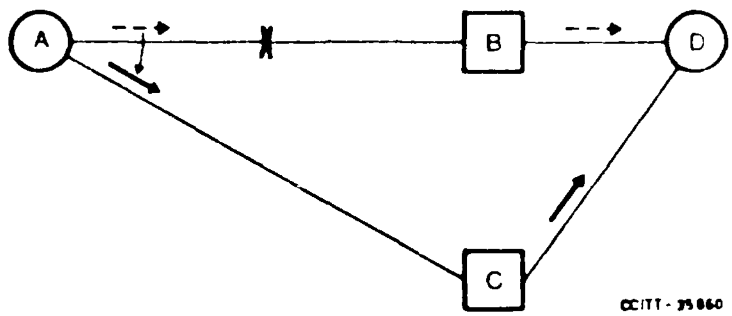

Figure 6-1 ($\boxed{\text{Q.704}}$) - Example of time-controlled diversion procedure

In this example, on failure of signalling link AB, traffic towards the destination was diverted to signalling link AC. When signalling link AB is made available, sending of changeback declaration from A to B is impossible, since no signalling link exists between C and B.

6.4.2 When changeback is initiated, a signalling point unable to send a changeback declaration stops traffic to be diverted from the alternative signalling link for a time T3 = 1 s (provisional value) after which it reopens traffic on the signalling link made available. The time delay minimizes the probability of out of sequence delivery to the destination point(s).

6.4.3 In the abnormal case when the concerned signalling point is not aware of the situation it will start a normal changeback procedure and send a changeback declaration; in this case it will receive no changeback acknowledgement in response and the procedure will be completed as indicated in Section 6.5.3. Reception of a transfer prohibited message (sent by C, in the figure, on reception of the changeback declaration from A, see Section 11.2) will not affect the above procedures.

6.5 Procedures in abnormal conditions

6.5.1 If a changeback acknowledgement is received by a signalling point which has not previously sent a changeback declaration, no action is taken.

6.5.2 If a changeback declaration is received after the completion of the changeback procedure, a changeback acknowledgement is sent in response, without taking any further action. This corresponds to the normal action described in 6.3.2 above.

6.5.3 If no changeback acknowledgement is received in response to a changeback declaration within a time T4 = 1 s (provisional value), the changeback declaration is repeated and a new time-out T5 = 1 s (provisional value) is started. If no changeback acknowledgement is received before the expiry of T5, the maintenance functions are alerted and traffic on the link made available is started. The changeback code contained in the changeback acknowledgement message makes it possible to determine in the case of parallel changebacks from more than one reserve paths, which changeback declaration is unacknowledged and has therefore to be repeated.

7 Forced rerouting

7.1 General

7.1.1 The objective of the forced rerouting procedure is to restore, as quickly as possible, the signalling capability between two signalling points towards a particular destination, in such a way as minimize the consequences of a failure. However, since the unavailability of a signalling route is in general caused by the fact that the concerned destination has become inaccessible to a signalling transfer point a probability of message loss exists (see Section 5.3.3). Therefore the structure of the signalling network should be such as to reduce the probability of signalling route unavailability to limits compatible with the overall dependability requirements (see [3]).

7.1.2 Forced rerouting is the basic procedure to be used in case that a signalling route towards a given destination becomes unavailable (due to for example remote failures in the signalling network) to divert signalling traffic towards that destination to an alternative signalling route outgoing from the concerned signalling point. Signalling links pertaining to the alternative signalling route can be carrying their own signalling traffic (relating to different signalling routes) and this is not interrupted by the forced rerouting procedure.

7.2 Forced rerouting initiation and actions

7.2.1 Forced rerouting is initiated at a signalling point when a transfer-prohibited message, indicating a signalling route unavailability, is received.

The following actions are then performed:

a) transmission of signalling traffic towards the concerned destination on the link set(s) pertaining to the unavailable route is immediately stopped; such traffic is stored in a forced rerouting buffer;

b) the alternative route is determined according to the rules specified in Section 4;

c) as soon as action b) is completed, the concerned signalling traffic is restarted on a link set pertaining to the alternative route, starting with the content of the forced rerouting buffer;

d) if appropriate, a transfer-prohibited procedure is performed (see Section 11.2.2).

7.2.2 In the case when there is no signalling traffic to be diverted from the unavailable route, action b) and d) only apply.

7.2.3 If no alternative route exists for signalling traffic towards the concerned destination, that destination is declared inaccessible and the actions specified in Section 5.3.3 apply.

8 Controlled rerouting

8.1 General

8.1.1 The objective of the controlled rerouting procedure is to restore the optimal signalling routing and to minimize mis-sequencing of messages. Therefore controlled re-routing includes a time-controlled traffic diversion procedure, which is the same as that used in some cases of changeback (see Section 6.4).

8.1.2 Controlled rerouting is the basic procedure to be used in the case that a signalling route towards a given destination becomes available (due to for example recovery of previous remote failures in the signalling network), to divert back signalling traffic towards that destination from the alternative to the normal signalling route outgoing from the concerned signalling point. Signalling links pertaining to the alternative signalling route can be carrying their own signalling traffic (relating to different signalling routes) and this is not interrupted by the normal rerouting procedure.

8.2 Controlled rerouting initiation and actions

8.2.1 Controlled rerouting is initiated at a signalling point when a transfer-allowed message, indicating that the signalling route has become available, is received. The following actions are then performed:

a) transmission of signalling traffic towards the concerned destination on the link set pertaining to the alternative route is stopped; such traffic is stored in a controlled rerouting buffer; a time out T6 = 1 s (provisional value) is started;

b) a transfer-prohibited message is sent on the route made available and a transfer-allowed message on the alternative one (see Sections 11.2.2 and 11.3.2 respectively);

c) at the expiry of T6, the concerned signalling traffic is restarted on an outgoing link set pertaining to the signalling route made available, starting with the content of the controlled rerouting buffer; the aim of the time delay is to minimize the probability of out of sequence delivery to the destination point(s).

8.2.2 When there is no signalling traffic to be diverted back to the route made available, the above actions are not performed and the signalling point notes the availability of the route, which therefore may be used if necessary.

8.2.3 If, the destination was inaccessible, when the route is made available, then the destination is declared accessible and the actions specified in Section 6.2.3 apply.

9 Signalling traffic flow control

9.1 General

The purpose of the signalling traffic flow control functions is to limit signalling traffic at its source in the case when the signalling network is not capable of transferring all signalling traffic offered by the User Parts because of network failures or overload situations.

Flow control actions may be taken as a consequence of a number of events; the following cases have been identified:

- Failures in the signalling network (signalling links or signalling points) have resulted in route set unavailability.

- Overload of a signalling link or signalling point has resulted in a situation wheh reconfiguration of traffic is not possible or appropriate.

- Failure or overload of a User Part has made it impossible for the User Part to handle all messages delivered by the Message Transfer Part.

When the normal transfer capability is restored, the flow control functions initiate resumption of the normal traffic flow.

9.2 Flow control indications

The need for the following indications has been identified, however other indications are likely to be required (e.g. for User Part overload or User Part failure).

9.2.1 Signalling route set unavailability

In the case when no signalling route is available for traffic towards a particular destination (see Sections 5.3.3 and 7.2.3), an indication is given from the Message Transfer Part to all User Parts, informing them that signalling messages destined to the particular signalling point cannot be transferred via the signalling network. Each User Part then takes appropriate actions in order to stop generation of signalling information destined for the inaccessible signalling point.

9.2.2 Signalling route set availability

In the case when a signalling route becomes available for traffic to a previously blocked destination (see Sections 6.2.3 and 8.2.3), an indication is given from the Message Transfer Part to the User Parts, informing them that signalling messages destined to the particular Signalling Points can be transferred via the signalling network. Each User Part then takes appropriate actions in order to start generation of signalling information destined for the now accessible signalling point.

10 Signalling link management

10.1 General

10.1.1 The signalling link management function is used to control the locally connected signalling links. The function provides means for establishing and maintaining a certain predetermined capability of a link set. Thus, in the event of signalling link failures the signalling link management function controls actions aimed at restoring the capability of the link set.

Three sets of signalling link management procedures are specified in the following sections. Each set corresponds to a certain level of automation as regards allocation and reconfiguration of signalling equipment. The basic set of signalling link management procedures (see Section 10.2) provides no automatic means for allocation and reconfiguration of signalling equipment. The basic set includes the minimum number of functions which must be provided for international application of the signalling system.

The two alternative sets of signalling link management procedures are provided as options and include functions allowing for a more efficient use of signalling equipment in the case when signalling terminal devices have switched access to signalling data links.

Note - In Annex A to Recommendation Q.704, a modified set of signalling link management functions are defined, being an alternative for national applications to those functions specified in Section 10.4.

10.1.2 A signalling link set consists of one or more signalling links having a certain order of priority as regards the signalling traffic conveyed by the link set (see Section 4). Each signalling link in operation is assigned a signalling data link and a signalling terminal at each end of the signalling data link.

The signalling link identity is independent on the identities of the signalling data link and signalling terminals which it comprises. Thus, the identity referred to by the Signalling Link Code (SLC) included in the label of messages originated at Message Transfer Part level 3 is the signalling link identity and not the signalling data link identity or the signalling terminal identity.

Depending on the level of automation in an application of the signalling system, allocation of signalling data link and signalling terminals to a signalling link may be made manually or automatically.

In the first case, applicable for the basic signalling link management procedures, a signalling link includes predetermined signalling terminals and a predetermined signalling data link. To replace a signalling terminal or signalling data link, a manual intervention is required. The signalling data link to be included in a particular signalling link is determined by bilateral agreement (see also [1]).

In the second case for a given signalling point, a signalling link includes any of the signalling terminals and any of the signalling data links applicable to a link group. As a result of, for example, signalling link failure, the signalling terminal and signalling data link included in a signalling link, may be replaced automatically. The criteria and procedures for automatic allocation of signalling terminals and signalling data links are specified in Sections 10.5 and 10.6 respectively. The implementation of these functions requires that for a given link group any signalling terminal can be connected to any signalling data link.

Note - A link group is a group of identical signalling links directly connecting two signalling points. A link set may include one or more link groups.

10.1.3 When a link set is to be brought into service, actions are taken to establish a predetermined number of signalling links. This is made by connecting signalling terminals to signalling data links and for each signalling link performing an initial alignment procedure (see [8]). The process of making a signalling link ready to carry signalling traffic is defined as signalling link activation.

Activation of a signalling link may also be applicable for example when a link set is to be extended or when a persisting failure makes another signalling link in the link set unavailable for signalling traffic.

In the case of signalling link failure, actions should be taken to restore the faulty signalling link, i.e. to make it available for signalling again. The restoration process may include replacement of a faulty signalling data link or signalling terminal.

A link set or a single signalling link is taken out of service by means of a procedure defined as signalling link deactivation.

The procedures for activation, restoration and deactivation are initiated and performed in different ways depending on the level of automation applicable for a particular implementation of the signalling system. In the following, procedures are specified for the cases when:

a) no automatic functions are provided for allocation of signalling terminals and signalling data links (see Section 10.2);

b) an automatic function is provided for allocation of signalling terminals (see Section 10.3);

c) automatic functions are provided for allocation of signalling terminals and signalling data links (see Section 10.4).

10.2 Basic signalling link management procedures

10.2.1 Signalling link activation

a) In the absence of failures, a link set contains a certain predetermined number of active (i.e. aligned) signalling links. In addition, the link set may contain a number of inactive signalling links, that is signalling links which have not been put into operation. Predetermined signalling terminals and a signalling data link are associated with each inactive signalling link.

The number of active and inactive signalling links in the absence of failures and the priority order for the signalling links in a link set, should be identical at both ends of the link set.

Note - In the typical case, all signalling links in a link set are active in the absence of failures.

b) When a decision is taken to activate an inactive signalling link, initial alignment starts. If the initial alignment procedure is successful, the signalling link is active and ready to convey signalling traffic. In the case when initial alignment is not possible, as determined at Message Transfer Part level 2 (see [10]), new initial alignment procedures are started on the same signalling link until the signalling link is activated or a manual intervention is made.

10.2.2 Signalling link restoration

After a signalling link failure is detected, signalling link initial alignment will take place. In the case when the initial alignment procedure is successful, the signalling link is regarded as restored and thus available for signalling.

If initial alignment is not possible, as determined at Message Transfer Part level 2 (see [10]), new initial alignment procedures may be started on the same signalling link until the signalling link is restored or a manual intervention is made, for example to replace the signalling data link or the signalling terminal.

10.2.3 Signalling link deactivation

An active signalling link may be made inactive by means of a deactivation procedure, provided that no signalling traffic is carried on that signalling link. When a decision has been taken to deactivate a signalling link the signalling terminal of the signalling link is taken out of service.

10.2.4 Link set activation

A signalling link set not having any signalling links in service is started by means of a link set activation procedure.

Two alternative link set activation procedures are defined:

- link set normal activation,
- link set emergency restart.

a) Link set normal activation

Link set normal activation is applicable when a link set is to be put into service for the first time (link set initial activation) or when a link set is to be restarted (link set normal restart); the latter is applicable for example in the case when:

- all signalling links in a link set are faulty,
- a processor restart in a signalling point makes it necessary to re-establish a link set,
- a signalling point recognizes other irregularities concerning the interworking between the two signalling points,

provided that none of the above events create an emergency situation.

When link set normal activation is initiated, signalling link activation starts on as many signalling links as possible. (All signalling links in the link set are regarded as being inactive at the start of the procedure.)

The signalling link activation procedures are performed on each signalling link in parallel as specified in Section 10.2.1 until the signalling links are made active.

Signalling traffic may however commence when one signalling link is successfully activated.

b) Link set emergency restart

Link set emergency restart is applicable when an immediate re-establishment of the signalling capability of a link set is required, (i.e., in a situation when the link set normal restart procedure is not fast enough). The precise criteria for initiating link set emergency restart instead of normal restart, may vary between different applications of the signalling system. Possible situations for emergency restart are for example:

- when signalling traffic that may be conveyed over the link set to be restarted is blocked,
- when it is not possible to communicate with the signalling point at the remote end of the link set.

When link set emergency restart is initiated, signalling link activation starts on as many signalling links as possible, in accordance with the principles specified for normal link set activation. In this case, the signalling terminals will have emergency status (see [10]) resulting in the sending of status indications of type "E" when applicable. Furthermore the signalling terminals employ the emergency proving procedure and short time-outs values in order to accelerate the procedure.

When the emergency situation ceases, a transition from emergency to normal signalling terminal status takes place resulting in the employment of normal proving procedure and normal time-out values.

c) Time-out values

The initial alignment procedure (specified in [14]) includes time-outs the expiry of which indicates the failure of an activation or restoration attempt. The values of the time-outs are for further study.

10.3 Signalling link management procedures based on automatic allocation of signalling terminals

10.3.1 Signalling link activation

a) In the absence of failures a link set contains a certain predetermined number of active (i.e. aligned) signalling links. The link set may also contains a number of inactive signalling links.

An inactive signalling link is a signalling link not in operation. A predetermined signalling data link is associated with each inactive signalling link, however, signalling terminals may not yet be allocated.

The number of active and inactive signalling links in the absence of failures and the priority order for the signalling links in a link set, should be identical at both ends of the link set.

b) Whenever the number of active signalling links is below the value specified for the link set, actions to activate new inactive signalling links should be taken automatically. This is applicable, for example, when a link set is to be brought into service for the first time (see Section 10.3.4) or when a link failure occurs. In the latter case, activation starts when the restoration attempts on the faulty link are considered unsuccessful (see Section 10.3.2).

The signalling link(s) to activate is the inactive link(s) having the highest priority in the link set.

Generally, if it is not possible to activate a signalling link, an attempt to activate the next inactive signalling link (in priority order) is made. In the case when an activation attempt performed on the last signalling link in the link set is unsuccessful, the "next" signalling link is the first inactive signalling link in the link set (i.e. there is a cyclic assignment).

Activation of a signalling link may also be initiated manually.

Activation shall not be initiated automatically for a signalling link previously deactivated by means of a manual intervention.

c) When a decision is taken to activate a signalling link, the signalling terminal to be employed has to be allocated at each end.

The signalling terminal is allocated automatically by means of the function defined in Section 10.5.

In the case when the automatic allocation function cannot provide a signalling terminal the activation attempt is aborted.

The predetermined signalling data link which may be utilized for other purposes when not connected to a signalling terminal must be removed from its alternative use (e.g. as a speech circuit) before signalling link activation can start.

d) The chosen signalling terminal is then connected to the signalling data link and initial alignment starts (see [10]).

If the initial alignment procedure is successful, the signalling link is active and ready to convey signalling traffic.

If initial alignment is not possible, as determined at Message Transfer Part level 2 (see [10]), the activation is unsuccessful and activation of the next inactive signalling link (if any) is initiated. Successive initial alignment attempts may however continue on the previous signalling link until it is activated or its signalling terminal is disconnected (see Section 10.5).

In the case when activation attempts take place at both ends of a link set, it may be that the two ends attempt to activate different signalling links, thus making initial alignment impossible. By initiating activation of the next signalling link when an activation attempt fails, and by having different lengths of the initial alignment time-outs at the two ends of the link set (see Section 10.3.4, point [c]) it is ensured that eventually a signalling data link will be provided with signalling terminals at both ends at the same time.

10.3.2 Signalling link restoration

a) After a signalling link failure is recognized, signalling link initial alignment will take place (see [10]). In the case when the initial alignment is successful, the signalling link is regarded as restored and thus available for signalling. If the initial alignment is unsuccessful, the signalling terminals and signalling link may be faulty and require replacement.

b) The signalling terminal may be automatically replaced in accordance with the principles defined for automatic allocation of signalling terminals (see Section 10.5). After the new signalling terminal has been connected to the signalling data link, signalling link initial alignment starts. If successful, the signalling link is restored.

If initial alignment is not possible or if no alternative signalling terminal is available for the faulty signalling link, activation of the next signalling link in the link set (if any) starts. In the case when it is not appropriate to replace the signalling terminal of the faulty signalling link (e.g. because it is assumed that the signalling data link is faulty) activation of the next inactive signalling link (if any) is also initiated. In both cases successive initial alignment attempts may continue on the faulty signalling link until a manual intervention is made or the signalling terminal is disconnected (see Section 10.5).

Note - In the case when a signalling terminal cannot be replaced, activation of the next signalling link is only initiated if the link set includes an alternative link group having access to other signalling terminals than the signalling link for which restoration is not possible.

10.3.3 Signalling link deactivation

In the absence of failures a link set contains a specified number of active (i.e. aligned) signalling links. Whenever that number is exceeded (e.g. as a result of signalling link restoration) the active signalling link having the lowest priority in the link set is to be made inactive automatically provided that no signalling traffic is carried on that signalling link.

Deactivation of a particular signalling link may also be initiated manually, for example in conjunction with manual maintenance activities.

When a decision has been taken to deactivate a signalling link, the signalling terminal and signalling data link may be disconnected.

After deactivation, the idle signalling terminal may become part of other signalling links (see Section 10.5).

10.3.4 Link set activation

A signalling link set not having any signalling links in service is started by means of a link set activation procedure. The objective of the procedure is to activate a specified number of signalling links for the link set. The activated signalling links should, if possible, be the signalling links having the highest priority in the link set.

Two alternative link set activation procedures are defined:

- link set normal activation,
- link set emergency restart.

a) Link set normal activation

Link set normal activation is applicable when a link set is to be put into service for the first time (link set initial activation) or when a link set is to be restarted (link set normal restart); the latter is applicable for example in the case when:

- all signalling links in a link set are faulty,
- a processor restart in a signalling point makes it necessary to re-establish a link set,
- a signalling point recognizes other irregularities concerning the interworking between the two signalling points, for example that a certain signalling data link is associated with different signalling links at the two ends of the link set,

provided that none of the above events create an emergency situation.

When link set normal activation is initiated, signalling link activation starts on as many signalling links as possible. (All signalling links in the link set are regarded as being inactive at the start of the procedure.) If activation cannot take place on all signalling links in the link set (for example, because a sufficient number of signalling terminals is not available), then the signalling links to activate are determined in accordance with the link priority order.

Note - All idle signalling terminals may not necessarily be made available for link set activation. Thus making possible, for example, restoration of faulty signalling links in other link sets at the same time.

The signalling link activation procedures are performed as specified in Section 10.3.1.

If the activation attempt for a signalling link is unsuccessful, (i.e. initial alignment is not possible) activation of the next inactive signalling link, if any, in the priority order is initiated 1). According to the principles for automatic allocation of signalling terminals defined in Section 10.5 the signalling terminal connected to the unsuccessfully activated signalling link, will typically be connected to the signalling data link of that signalling link for which the new activation attempt is to be made.

When a signalling link is successfully activated, signalling traffic may commence.

After the successful activation of one signalling link, the activation attempts on the remaining signalling links continue in accordance with the principles defined in Section 10.3.1, in such a way that the signalling links having the highest priorities are made active. This is done in order to obtain, if possible, the normal configuration within the link set. Signalling link activation continues until the predetermined number of active signalling links is obtained.

b) Link set emergency restart

Link set emergency restart is applicable in the case when the link set normal restart procedure is not fast enough. Emergency restart is performed in the same way as link set normal activation except that in the case of emergency restart, the emergency proving procedure and the short emergency time-out values (cf [10]) are employed in order to accelerate the procedure, see further Section 10.2.4, point b.

c) Time-out values

The values of the time-outs included in the initial alignment procedure (see [15]) should be different at the two ends of the link set. These values are for further study.

10.4 Signalling link management procedures based on automatic allocation of signalling data links and signalling terminals

10.4.1 Signalling link activation

a) In the absence of failures a link set contains a certain predetermined number of active (i.e. aligned) signalling links. The link set may also contain a number of inactive signalling links.

An inactive signalling link is a signalling link currently not in operation. It is not associated with any signalling terminal or signalling data link, (i.e. the signalling link is only identified by its position in the link set).

The number of active and inactive signalling links (in the absence of failures) and the priority order for the signalling links in a link set, should be identical at both ends of the link set.

----

1) Inactive links exist in the case when the number of signalling terminals available is less than the number of signalling links defined for the link set.

b) Whenever the number of active signalling links is below the value specified for the link set, actions to activate new inactive signalling links should be taken automatically. This is for example applicable when a link set is to be brought into service for the first time (see Section 10.4.4) or when a link failure occurs. In the latter case, activation starts when the the restoration attempts on the faulty link are considered unsuccessful (see Section 10.4.2).

The signalling link(s) to activate is the inactive link(s) having the highest priority in the link set.

If it is not possible to activate a signalling link an attempt to activate the next inactive signalling link (in priority order) is made. In the case when an activation attempt performed on the last signalling link in the link set is unsuccessful, the "next" signalling link is the first inactive link in the link set (i.e. a cyclic assignment).

Note - Activation of the next signalling link is only initiated if the link set includes an alternative link group, having access to other signalling terminals and/or other signalling data links than the signalling link for which activation is not possible.

Activation of a particular signalling link may also be initiated upon receiving a request from the remote signalling point, or by a manual request.

Activation shall not be initiated automatically for a signalling link previously inactivated by means of a manual intervention.

c) When a decision is taken to activate a signalling link, the signalling terminals and signalling data link to be employed have to be allocated.

A signalling terminal is allocated automatically by means of the function defined in Section 10.5.

The signalling data link is allocated automatically by means of the function defined in Section 10.6. However, in conjunction with link set activation the identity of the signalling data link to use may be predetermined (see further Section 10.4.4). A signalling data link which is not connected to a signalling terminal may be utilized for other purposes, for example, as a speech circuit. When the data link is to be employed for signalling, it must be removed from its alternative use.

In the case when the automatic allocation functions cannot provide a signalling terminal or a signalling data link, the activation attempt is aborted.

d) When the signalling data link and signalling terminal to be used for a particular signalling link are determined, the signalling terminal is connected to the signalling data link and signalling link initial alignment starts (see [10]). If the initial alignment procedure is successful, the signalling link is active and ready to convey signalling traffic.

If initial alignment is not possible, as determined at Message Transfer Part level 2 (see [10]), alternative signalling data links are automatically connected to the signalling terminal, until an initial alignment procedure is successfully completed. In the case when the function for automatic allocation of signalling data links cannot provide an alternative signalling data link, the activation is regarded as unsuccessful and activation of the next inactive signalling link (if any) is initiated [see however the note to point b) above]. Successive initial alignment attempts may continue on the previous signalling link until it is activated or its signalling terminal is disconnected (see Section 10.5).

10.4.2 Signalling link restoration

a) After a signalling link failure is recognized, signalling link initial alignment will take place (see [10]). In the case when the initial alignment is successful, the signalling link is regarded as restored and thus available for signalling.

If the initial alignment is unsuccessful, the signalling terminal and signalling data link may be faulty and require replacement.

b) The signalling data link may be automatically replaced by an alternative, in accordance with the principles defined in Section 10.6. After the new signalling data link has been connected to the signalling terminal signalling link initial alignment starts. If successful, the signalling link is restored. If not, alternative data links are connected to the signalling terminal, until an initial alignment procedure is successfully completed.

If the automatic allocation function cannot provide a new signalling data link, activation of the next inactive signalling link (if any) is initiated [see however the note to point b) of Section 10.4.1]. Successive initial alignment attempts may however continue on the faulty signalling link until it is restored or its signalling terminal is disconnected.

c) The signalling terminal may be automatically replaced in accordance with the principles defined in Section 10.5. After the new signalling terminal has been connected to the signalling data link, signalling link initial alignment starts. If successful, the signalling link is restored. If not, activation of the next signalling link in the link set (if any) starts [see however the note to point b) of Section 10.4.1].

Successive initial alignment attempts may, however, continue on the faulty signalling link until it is restored or, for example, the signalling terminal or signalling data link is disconnected.

Note - Activation of the next signalling link in the link set should not be initiated as long as one of the activities described in points b) and c) above is taking place.

10.4.3 Signalling link deactivation

In the absence of failures, a link set contains a specified number of active (i.e. aligned) signalling links. Whenever that number is exceeded (e.g. as a result of signalling link restoration) the active signalling link having the lowest priority in the link set is to be made inactive automatically, provided that no signalling traffic is carried on that signalling link.

Deactivation of a particular signalling link may also be initiated manually, for example in conjunction with manual maintenance activities.

When a decision has been taken to deactivate a signalling link, the signalling terminal and signalling data link may be disconnected. After deactivation, the idle signalling terminal and signalling data link may become parts of other signalling links (see Sections 10.5 and 10.6).

10.4.4 Link set activation

Link set activation is applicable in the case when a link set not having any signalling links in service is to be started for the first time or after a failure (see Section 10.3.4). The link set activation procedure is performed as specified in Section 10.3.4, also as regards the allocation of signalling data links, that is, signalling data links are allocated in accordance with a predetermined list assigning a signalling data link to some or all of the signalling links in the link set. This is made in order to cater for the situation when it is not possible to communicate with the remote end of the link set (c.f. Section 10.6). However, when a signalling link has become active, signalling data link allocation may again be performed automatically (i.e. activation of a signalling link takes place as specified in Section 10.4.1).

10.5 Automatic allocation of signalling terminals

In conjunction with the signalling link activation and restoration procedures specified in Sections 10.3 and 10.4, signalling terminals may be allocated automatically to a signalling link. A signalling terminal applicable to the link group is allocated in accordance with the following principles:

a) an idle signalling terminal (i.e. a signalling terminal not connected to a signalling data link) is chosen if possible;

b) if no idle signalling terminal is available, a signalling terminal is chosen which is connected to an unsuccessfully restored or activated signalling link.

Note - Activation and restoration is regarded as unsuccessful when it is not possible to complete the initial alignment procedure successfully (see Sections 10.3 and 10.4).

Measures should be employed to ensure that signalling terminals to be allocated to signalling links are able to function correctly (see Recommendation Q.707 [4]).

A link set may be assigned a certain number of signalling terminals. A signalling terminal may be transferred from a signalling link in one link set to a signalling link in another link set (in accordance with b) above) only when the remaining number of signalling terminals in the link set is not below the specified value.

Note - From a link set with a minimum number of signalling terminals, only one signalling terminal and signalling data link may be removed at a time (e.g. for testing, see [4]).

10.6 Automatic allocation of signalling data links

10.6.1 In conjunction with the signalling link activation and restoration procedures specified in Section 10.4, signalling data links may be allocated automatically. Any signalling data link applicable to a link group may be chosen for a signalling link within that link group.

The signalling data links applicable to a link group are determined by bilateral agreement and may, for example, include all speech circuits between two exchanges. A signalling data link may also be established as a semi-permanent connection via one or more intermediate exchanges.

When a potential signalling data link is not employed for signalling, it is normally used for other purposes (e.g. as a speech circuit).

The identity of the signalling data link to be used for a particular signalling link is determined at one of the two involved signalling points and reported to the remote end by a signalling data link connection order message. The signalling point controlling the choice of signalling data link is the signalling point initiating the activation or restoration procedure or, in the case when both ends initiate the procedure at the same point in time, the signalling point having the highest signalling point code (included in the label of the message).

10.6.2 When a signalling data link has been chosen at a signalling point, the data link is made unavailable for other uses (e.g. as a speech circuit) and an order to connect the appointed signalling data link to a signalling terminal is sent to the signalling point at the remote end of the signalling link.

The signalling-data-link-connection-order contains:

- the label, indicating the destination and originating signalling points and the identity of the signalling link to activate or restore;

- the signalling-data-link-connection-order;

- the identity of the signalling data link.

Formats and codes for the signalling-data-link-connection-order message appear in Section 13.

10.6.3 Upon reception of the signalling-data-link-connection-order, the following applies:

a) In the case when the signalling link to which a received signalling-data-link-connection-order refers is inactive as seen from the receiving signalling point, the message is regarded as an order to activate the concerned signalling link, resulting in, for example, allocation of a signalling terminal. The signalling data link indicated in the signalling-data-link-connection-order is then connected to the associated signalling terminal and signalling link initial alignment starts. An acknowledgement is sent to the remote signalling point.

In the case when it is not possible to connect the appointed signalling data link to a signalling terminal (e.g. because there is no working signalling terminal available), the acknowledgement contains an indication informing the remote signalling point whether or not an alternative signalling data link should be allocated to the concerned signalling link.

b) In the case when the signalling point receives a signalling data link connection order when waiting for an acknowledgement, the order is disregarded in the case when the signalling point code of the receiving signalling point is higher than the signalling point code of the remote signalling point. If the remote signalling point has the highest signalling point code, the message is acknowledged and the signalling data link referred to in the received message is connected.

c) In the case when a signalling-data-link-connection-order is received in other situations, (e.g. in the case of an error in procedure) no actions are taken.

The signalling-data-link-connection-acknowledgement contains the label, indicating the destination and originating signalling points and the identity of the signalling link to activate or restore, and one of the following signals:

- connection-successful signal, indicating that the signalling data link has been connected to a signalling terminal;

- connection-not-successful signal, indicating that it was not possible to connect the signalling data link to a signalling terminal, and that an alternative signalling data link should be allocated;

- connection-not-possible signal, indicating that it was not possible to connect the signalling data link to a signalling terminal, and that no alternative signalling data link should be allocated.

Formats and codes for the signalling-data-link-connection-acknowledgement message appear in Section 13.

10.6.4 When the signalling point initiating the procedure receives a message indicating that signalling data link and signalling terminal have been connected at the remote end, the signalling data link is connected to the associated signalling terminal and initial alignment starts (see Section 10.4).

In the case when the acknowledgement indicates that it was not possible to connect the signalling data link to a signalling terminal at the remote end, an alternative signalling data link is allocated and a new signalling data link connection order is sent (as specified above). However, if the acknowledgement indicates that no alternative signalling data link should be allocated, the activation or restoration procedure is terminated for the concerned signalling link.

If no signalling-data-link-connection-acknowledgement or -order is received from the remote signalling point within a time-out T7 = 2 s (provisional value), the signalling-data-link-connection-order is repeated.

10.6.5 When a signalling data link is disconnected in conjunction with signalling link restoration or deactivation, the signalling data link is made idle (and available, e.g. as speech circuit).

11 Signalling route management

11.1 General

The purpose of the signalling route management function is to ensure a reliable exchange of information between the signalling points about the availability of the signalling routes.

The unavailability and availability of a signalling route is communicated by means of the transfer-prohibited and transfer-allowed procedure respectively, specified in Sections 11.2 and 11.3.

Recovery of signalling route status information is made by means of the signalling-route-set-test procedure specified in Section 11.4.

11.2 Transfer-prohibited

11.2.1 The transfer-prohibited procedure is performed at a signalling point acting as a signalling transfer point for messages relating to a given destination, when it has to notify one or more adjacent signalling points that they must no longer route the concerned messages via that signalling transfer point.

The transfer-prohibited procedure makes use of the transfer-prohibited message and of the transfer-prohibited-acknowledgement message which contain:

- the label, indicating the destination and originating points;

- the transfer-prohibited (or transfer-prohibited-acknowledgement) signal;

  and

- the destination for which traffic transfer is no longer possible. 1)

Formats and codes of these messages appear in Section 13.

11.2.2 A transfer-prohibited message relating to a given destination "X" is sent from a signalling transfer point "Y" in the following cases:

i) When signalling transfer point "Y" starts to route (at changeover, changeback, forced or normal rerouting) signalling traffic destined to signalling point "X" via a signalling transfer point "Z" not currently used by signalling transfer point "Y" for this traffic. In this case the transfer-prohibited message is sent to signalling transfer point "Z".

ii) When signalling transfer point "Y" recognizes that it is unable to transfer signalling traffic destined to signalling point "X" (see Sections 5.3.3 and 7.2.3). In this case a transfer-prohibited message is sent to all accessible adjacent signalling points.

iii) When a message destined to signalling point "X" is received at signalling transfer point "Y" and signalling transfer point "Y" is unable to transfer the message. In this case the transfer-prohibited message is sent to the adjacent signalling point from which the concerned message was received.

If no transfer-prohibited-acknowledgement is received in response to a transfer-prohibited message within T8 = 1 s (provisional value) the transfer-prohibited message is repeated. During this time, the transfer-prohibited message will not be sent according to criterion iii) above.

Examples of the above situation appear in [12].

11.2.3 When a signalling point receives a transfer-prohibited message from signalling transfer point "Y" it sends in response to Signalling Transfer Point "Y" a transfer-prohibited-acknowledgement; moreover it performs the actions specified in Section 7 (since reception of transfer-prohibited message indicates the unavailability of the concerned signalling route, see Section 3.4.1).

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1) The possibility to refer to a more general destination than a single signalling point (e.g. a signalling region), or more restrictive than a single signalling point (e.g. an individual User Part) is for further study.

11.2.4 In some circumstances it may happen that a signalling point receives either a repeated transfer-prohibited message or a transfer-prohibited message relating to a non existent route (i.e. there is no route from that signalling point to the concerned destination via signalling transfer point "Y", according to signalling network configuration) or to a destination which is already inaccessible, due to previous failures; in this case a transfer-prohibited-acknowledgement is sent, without further actions.

11.3 Transfer-allowed

11.3.1 The transfer-allowed procedure is performed at a signalling point, acting as signalling transfer point for messages relating to a given destination, when it has to notify one or more adjacent signalling points that they may start to route to it, if appropriate, the concerned messages.

The transfer-allowed procedure makes use of the transfer-allowed message and of the transfer-allowed-acknowledgement which contain:

- the label, indicating the destination and originating points;
- the transfer-allowed (or transfer-allowed-acknowledgement) signal;

  and
- the destination for which tranfer is now possible. 1)

Formats and codes of these messages appear in Section 13.

11.3.2 A transfer-allowed message relating to a given destination "X" is sent from signalling transfer point "Y" in the following cases:

i) When signalling transfer point "Y" stops routing (at changeback or normal rerouting) signalling traffic destined to signalling point "X" via a signalling transfer point "Z" (to which the concerned traffic was previously diverted as a consequence of changeover or forced rerouting). In this case the transfer-allowed message is sent to signalling transfer point "Z".

ii) When signalling transfer point "Y" recognizes that it is again able to transfer signalling traffic destined to signalling point "X" (see Sections 6.2.3 and 8.2.3). In this case a transfer-allowed message is sent to all accessible adjacent signalling points.

If no transfer-allowed-acknowledgement is received in response to a transfer-allowed message within T9 = 1 s (provisional value), the transfer-allowed message is repeated.

Examples of the above situations appear in [12].

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1) The possibility to refer to more general destination than a single signalling point (e.g. a signalling region), or more restrictive than a single signalling point (e.g. an individual User Part) is for further study.

11.3.3 When a signalling point receives a transfer-allowed message from signalling transfer point "Y", it sends in response a transfer-allowed-acknowledgement to signalling transfer point; moreover it performs the actions specified in Section 8 (since reception of a transfer-allowed message indicates the availability of the concerned signalling route, see Section 3.4.2).

11.3.4 In some circumstances it may happen that signalling point receives either a repeated transfer-allowed message or a transfer-allowed message relating to an existing signalling route (i.e. there is no route from that signalling point to the concerned destination via signalling transfer point "Y" according to the signalling network configuration); in this case a transfer-allowed-acknowledgement is sent, without further actions.

11.4 Signalling-route-set-test

11.4.1 The signalling-route-set-test procedure is used at a signalling point to test whether or not signalling traffic towards a certain destination may be routed via an adjacent signalling transfer point.

The procedure make use of the signalling-route-set-test message, and the transfer-allowed and the transfer-prohibited procedures.

The signalling-route-set-test message contains:

- the label, indicating the destination and originating points;
- the signalling-route-set-test signal, and
- the destination the accessibility of which is to be tested. 1)

Format and coding of this message appear in Section 13.

11.4.2 A signalling-route-set-test message is sent from a signalling point in the following cases:

a) When a transfer-prohibited message is received from an adjacent signalling transfer point. In this case a signalling-route-set-test message is sent to that signalling transfer point referring to the destination declared inaccessible by the transfer-prohibited message every 30 seconds (provisional value) until a transfer-allowed message, indicating that the destination has become accessible, is received.

b) When a previously unavailable link set, directly connecting the signalling point with a signalling transfer point, becomes available. In this case signalling-route-set-test messages sent to the signalling transfer point refer to all destinations which in the absence of failures are accessible via the signalling transfer point.

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1) The possibility to refer to more general destination than a single signalling point (e.g. a signalling region), or more restrictive than a single signalling point (e.g. an individual User Part) is for further study.

c) When the route status information at a signalling point is to be updated for example in conjunction with processor restart. In this case signalling-route-set-test messages, referring to all destinations which in the absence of failures are accessible from the signalling point are sent. For a certain destination a signalling-route-set-test message is sent to each adjacent signalling transfer point which under normal conditions is capable of routing signalling traffic to the destination.

In case a) above, the procedure is used in order to recover the signalling route availability information that may not have been received because of some signalling network failure.

In cases b) and c) above, the positive or negative responses to the test messages (i.e. the reception of transfer-allowed messages or transfer-prohibited messages) are used to update route status information in the signalling point.

11.4.3 A signalling-route-set-test message is sent to the adjacent signalling transfer point as an ordinary signalling network management message.

11.4.4 At the reception of a signalling-route-set-test message, a signalling transfer point will send in response:

- a transfer-allowed message, referring to the destination the accessibility of which is tested, if the signalling transfer point can reach the indicated destination via a signalling link not connected to the signalling point from which the signalling-route-set-test message was originated;

- a transfer-prohibited message in all other cases (including the inaccessibility of that destination).

11.4.5 At the reception of the transfer-allowed or transfer-prohibited message, the signalling point will perform the procedures specified in Sections 11.2.3 and 11.3.3 respectively.

12 Common characteristics of message signal unit formats

12.1 General

The basic signal unit format which is common to all message signal units is described in [15]. From the point of view of the Message Transfer Part level 3 functions, common characteristics of the message signal units are the presence of:

- the service information octet;
- the label, contained in the signalling information field, and, in particular, the routing label.

12.2 Service information octet

The service information octet of message signal units contains the service indicator and the sub-service field. The structure of the service information octet is shown in Figure 12-1 (Q.704).

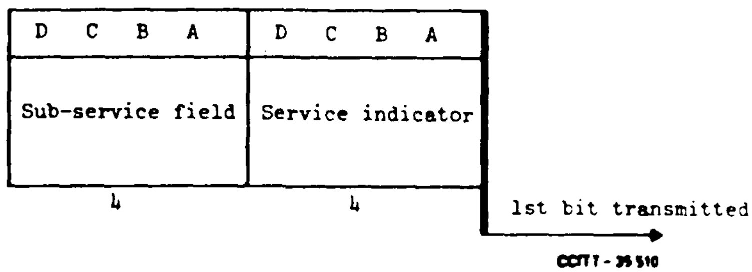

Figure 12-1 ($\boxed{\text{Q.704}}$) - Service information octet

12.1.1 Service indicator

The service indicator is used by signalling handling functions to perform message distribution (see Section 2.4) and, in some special applications, to perform message routing (see Section 2.3).

The service indicator codes are allocated as follows:

bits D C B A	
0 0 0 0	Signalling network management messages
0 0 0 1	Signalling network testing and maintenance messages
0 0 1 0 0 0 1 1	Spare for international allocation
0 1 0 0	Telephone User Part
0 1 0 1	Spare for international allocation
0 1 1 0	Data User Part (call and circuit related messages)

0 1 1 1	Data User Part (facility registration and cancellation messages)
1 0 0 0 1 0 0 1 1 0 1 0 1 0 1 1	Spare for international allocation
1 1 0 0 1 1 0 1 1 1 1 0 1 1 1 1	For national use

12.2.2 Sub-service field

The sub-service field contains the national indicator (bits C and D) and two spare bits (bits A and B). The national indicator is used by signalling message handling functions (e.g. in order to determine the relevant signalling point numbering scheme), see Sections 2.3 and 2.4.

The two spare bits, coded 00, are available for possible future needs that may require a common solution for all international User Parts.

The national indicator provides for discrimination between international and national messages. In the case of national messages it can be used, for example, for discrimination between different label structures. The national indicator codes are allocated as follows:

bits D C

0 0 International message

0 1 Spare (for international use only)

1 0 National message

1 1 Reserved for national use

The international spare code (01) should not be used for implementing features which are to be provided both internationally and nationally.

In national applications when the discrimination provided by the national indicator is not used, the whole sub-service field can be used independently for different User Parts.

12.3 Label

The structure and content of the label is defined for each User Part and is defined in the relevant specification. The common part of the label used for signalling message handling, the routing label, is specified in Section 2.2.

13 Formats and codes of signalling network management messages

13.1 General

13.1.1 The signalling network management messages are carried on the signalling channel in message signal units, the format of which is described in Recommendation Q.703, Section 2 [15], and Section 12 of this Recommendation. In particular, as indicated in Section 12.2 these messages are distinguished by the configuration 0000 of the service indicator (SI). The sub-service field (SSF) of the messages is used according with the rules indicated in Section 12.2.2.

13.1.2 The signalling information field consists of an integral number of octets and contains the label, the heading code and one or more signals and indications. The structure and function of the label, and of the heading code, are described in Sections 13.2 and 13.3 respectively; the detailed message formats are described in the following sections. For each message the sequence of fields is shown in the corresponding figure, including fields that may or may not be present.

In the figures, the fields are shown starting from the right to the left (i.e. the first field to be transmitted is at the right).

13.2 Label

For signalling network management messages the label coincides with the routing label and indicates the destination and originating signalling points of the message; moreover, in the case of messages related to a particular signalling link, it also indicates the identity of the signalling link among those interconnecting the destination and originating points. The standard label structure of Message Transfer Part level 3 messages appears in Figure 13-1 (Q.704); the total length is 32 bits.

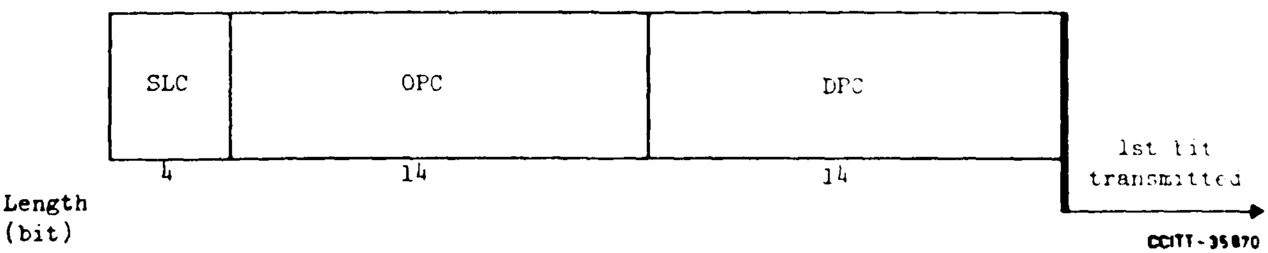

Figure 13-1 (Q.704) - Standard label structure

The meaning and use of the destination point code (DPC) and of the originating point code (OPC) fields are described in Section 2. The signalling link code (SLC) indicates the signalling link, connecting the destination and originating points, to which the message is related. If the message is not related to a signalling link, or another particular code is not specified, it is coded 0000.

13.3 Heading code (Ho)

The heading code (Ho) is the 4 bit field following the label and identifies the message group.

The different heading codes are allocated as follows:

0 0 0 0	Spare
0 0 0 1	Changeover and changeback messages
0 0 1 0	Emergency changeover message
0 0 1 1	Spare (reserved for signalling-traffic-flow-control-messages
0 1 0 0	Transfer-prohibited and -allowed messages
0 1 0 1	Signalling-route-set-test message
0 1 1 0	Spare
0 1 1 1	Spare
1 0 0 0	Signalling-data-link-connection messages

The remaining codings are spare.

The synopsis of signalling network management messages is given in Table 13-1 (Q.704).

13.4 Changeover message

13.4.1 The format of the changeover message is shown in Figure 13-2 (Q.704).

0		D C B A	0 0 0 1	
	FSN of last accepted MSU	Heading code H_1	Heading code H_0	Label
1	7	4	4	32

1st bit transmitted

Figure 13-2 (Q.704) - Changeover message

CCITT - 358

13.4.2 The changeover message is made up of the following fields:

- Label (32 bits): see Section 13.2.
- Heading code (Ho) (4 bits): see Section 13.3.
- Heading code H1 (4 bits): see Section 13.4.3.
- Forward sequence number of last accepted message signal unit (7 bits).
- A filler bit coded 0.

13.4.3 The Heading code H1 contains signal codes as follows:

bit D C B A

0 0 0 1	Changeover order signal
0 0 1 0	Changeover acknowledgement signal

13.5 <u>Changeback message</u>

13.5.1 The format of the changeback message is shown in Figure 13-3 (Q.704).

	D C B A	0 0 0 1	
Changeback code	Heading code H_1	Heading code H_0	Label
8	4	4	32

1st bit transmitted

CCITT - 35580

Figure 13-3 (Q.704) - Changeback message

13.5.2 The changeback message is made up of the following fields:

- Label (32 bits): see Section 13.2.
- Heading code Ho (4 bits): see Section 13.3.
- Heading code H1 (4 bits): see Section 13.5.3.
- Changeback code (8 bits): see Section 13.5.4.

13.5.3 The Header code H1 contains signal codes as follows:

bit C D B A

0 1 0 1	Changeback declaration signal
0 1 1 0	Changeback acknowledgement signal

13.5.4 The changeback code is an 8 bit code assigned by the signalling point which sends the message according to the criteria described in Section 6.

13.6 Emergency changeover message

13.6.1 The format of the emergency changeover message is shown in Figure 13.4 (Q.704).

D C B A	0 0 1 0	
Heading code H_1	Heading code H_0	Label
4	4	32

1st bit transmitted

CCITT - 35570

Figure 13-4 (Q.704) - Emergency changeover message

13.6.2 The emergency changeover message is made up of the following fields:

- Label (32 bits): see Section 13.2.
- Heading code Ho (4 bits): see Section 13.3.
- Heading code Hl (4 bits): see Section 13.4.3.

13.7 Transfer-prohibited message

13.7.1 The format of the transfer-prohibited message is shown in Figure 13-5 (Q.704) 1).

0 0		D C B A	0 1 0 0	
	Destination	Heading code H_1	Heading code H_0	Label
2	14	4	4	32

1st bit transmitted

CCITT - 35890

Figure 13-5 (Q.704) - Transfer-prohibited message

13.7.2 The transfer-prohibited message is made up of the following fields:

- Label (32 bits): see Section 13.2.
- Heading code Ho (4 bits): see Section 13.3.
- Heading code Hl (4 bits): see Section 13.7.3.
- Destination (14 bits): see Section 13.7.4.
- Spare bits (2 bits) code 00.

13.7.3 The heading code H1 contains signal codes as follows:

bit D C B A

0 0 0 1 Transfer-prohibited signal

0 0 1 0 Transfer-prohibited-acknowledgement signal

13.7.4 The destination field contains the identity of the signalling point to which the message refers.

13.8 <u>Transfer-allowed message</u>

13.8.1 The format of the transfer-allowed message is shown in Figure 13-6 (Q.704). 1)

0 0		D C B A	0 1 0 0	
	Destination	Heading code H_1	Heading code H_0	Label
2	14	4	4	32

1st bit transmitted

CCITT - 35890

Figure 13-6 (Q.704) - Transfer allowed message

13.8.2 The transfer-allowed message is made up of the following fields:

- Label (32 bits): see Section 13.2.
- Heading code Ho (4 bits): see Section 13.3.
- Heading code H1 (4 bits): see Section 13.8.3.
- Destination (14 bits): see Section 13.7.3.
- Spare bits (2 bits) coded 00.

13.8.3 The heading code H1 contains signal codes as follows:

bit D C B A

0 1 0 1 Transfer-allowed signal

0 1 1 0 Transfer-allowed-acknowledgement signal

----

1) The possibility to refer to more general destination than a single signalling point (e.g. a signalling region), or more restrictive than a single signalling point (e.g. an individual User Part) is for further study.

13.9 Signalling-route-set-test message

13.9.1 The format of the signalling-route-set-test message is shown in Figure 13-7 (Q.704). 1)

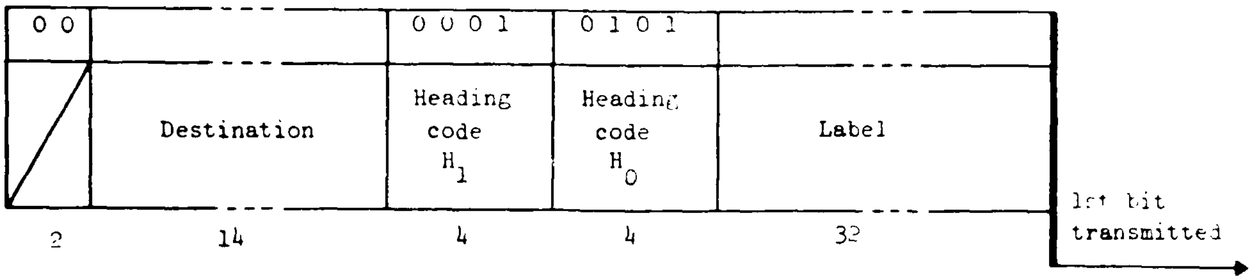

Figure 13-7 (Q.704) - Signalling-route-set-test message

CCITT-35890

13.9.2 This message is made up of the following fields:

- Label (32 bits): see Section 13.2.
- Heading code Ho (4 bits): see Section 13.3.
- Heading code H1 (4 bits): is coded 0001.
- Destination (14 bits): see Section 13.7.3.
- Spare bits (2 bits), *coded* 00.

13.10 Signalling data link connection order message

13.10.1 The format of the signalling data link connection order message is shown in Figure 13-8 (Q.704).

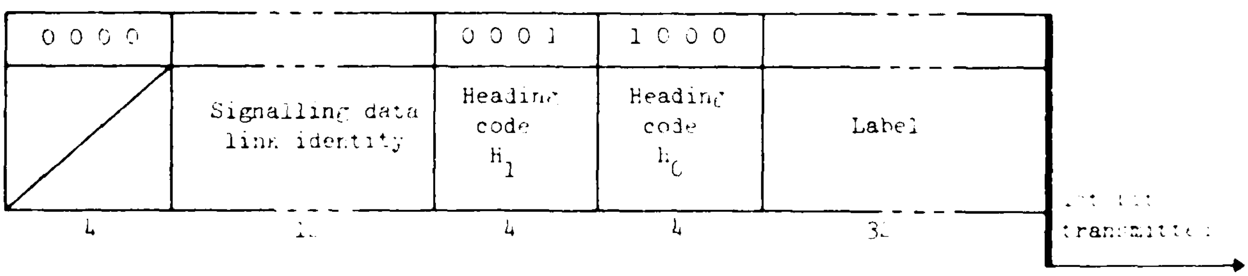

Figure 13-8 (Q.704) - Signalling-data-link-connection-order message

CCITT-35900

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1) The possibility to refer to more general destination than a single signalling point (e.g. a signalling region), or more restrictive than a single signalling point (e.g. an individual User Part) is for further study.

13.10.2 The signalling-data-link-connection-order message is made up of the following fields:

- Label (32 bits): see Section 13.2.
- Heading code Ho (4 bits): see Section 13.3.
- Heading code H1 (4 bits): is coded 0001.
- Signalling data link identity (12 bits): see Section 13.10.3.
- Spare bits (4 bits) coded 0000.

13.10.3 The signalling data link identity field contains the circuit identification code (CIC), or the bearer identification code in case of a 64 kbit/s channel used to carry submultiplexed data streams (BIC), of the transmission link corresponding to the signalling data link.

13.11 Signalling-data-link-connection-acknowledgement message

13.11.1 The format of the signalling data link connection acknowledgement message is shown in Figure 13-9(Q.704).

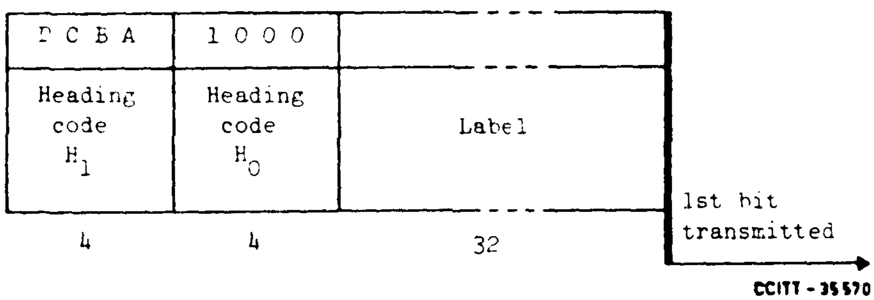


Figure 13-9 ($\boxed{Q.704}$) - Signalling-data-link-connection-acknowledgement-message

13.11.2 The signalling data link connection acknowledgement message is made up of the following fields:

- Label (32 bits): see Section 13.2.
- Heading code Ho (4 bits): see Section 13.3.
- Heading code H1 (4 bits): see Section 13.11.3.

13.11.3 The heading code H1 contains signal codes as follows:

bit HO D C B A

0 0 1 0 Connection-successful signal

0 0 1 1 Connection-not-successful signal

0 1 0 0 Connection-not-possible signal

TABLE 13.1 (Q.704)

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																
TFM	0100		TFP	TFA			TFA	TAA									
RSM	0101		RST														
	0110																
	0111																
DLM	1000		DLC	CSS	CNS	CNP											
	1001																
	1010																
	1011																
	1100																
	1101																
	1110																
	1111																

ABBREVIATIONS USED IN Q.704 TABLE 13.1

CBA - Changeback-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 messages

RSM - Signalling-route-set-test message

RST - Signalling-route-set-test signal

TAA - Transfer-allowed-acknowledgement signal

TFA - Transfer-allowed signal

TFM - Transfer-prohibited and transfer-allowed messages

TFP - Transfer-prohibited signal

TPA - Transfer-prohibited-acknowledgement signal

14 State transition diagrams

14.1 General

This Section contains the description of the signalling network functions described in Sections 2 to 11 in the form of state transition diagrams according to the CCITT Specification and Description Language (SDL).

A set of diagrams is provided for each of the following major functions:

a) signalling message handling (SMH), described in Section 2;

b) signalling traffic management (STM), described in Sections 4 to 9;

c) signalling route management (SRM), described in Section 10;

d) signalling link management (SLM), described in Section 11.

For each major function a figure illustrates a subdivision functional specification blocks, showing their functional interactions as well as the interactions with the other major functions. In each case this is followed by Figures showing state transition diagrams for each of the functional specification blocks.

The detailed functional breakdown shown in the following diagrams is intended to illustrate a reference model and to assist interpretation of the text in the earlier sections. The state transition diagrams are intended to show precisely the behaviour of the signalling system under normal and abnormal conditions as viewed from a remote location. It must be emphasized that the functional partitioning shown in the following diagrams is used only to facilitate understanding of the system behaviour and is not intended to specify the functional partioning to be adopted in a practical implementation of the signalling system.

14.2 Draughting conventions

a) Each major function is designated by its acronym (e.g. SMH = signalling message handling).

b) Each functional block is designated by an acronym which identifies it and also identifies the major function to which it belongs, (e.g. HMRT = signalling message handling-message routing); TLAC = signalling traffic management-link availability control).

c) External inputs and outputs are used for interactions between different functional blocks. Included within each input and output symbol in the state transition diagrams are acronyms which identify the functions which are the source and destination of the message, e.g.

L2 → L3 indicates that the message is sent between functional levels
from: functional level 2
to: functional level 3

RTPC → TSRC indicates that the message is sent within a functional level (3 in this case)
from: signalling route management-transfer prohibited control
to: signalling traffic management-signalling routing control

d) Internal inputs and outputs are only used to indicate control of time-outs.

14.3 Signalling message handling

Figure 14-1 (Q.704) shows a subdivision of the signalling message handling (SMH) function into smaller functional specification blocks and also shows the functional interactions between them. Each of these functional specification blocks is described in detail in a state transition diagram as follows:

a) message discrimination (HMDC) is shown in Figure 14-2 (Q.704);

b) message distribution (HMDT) is shown in Figure 14-3 (Q.704);

c) message routing (HMRT) is shown in Figure 14-4 (Q.704).

14.4 Signalling traffic management

Figure 14-5 (Q.704) shows a subdivision of the signalling traffic management (STM) function into smaller functional specification blocks and also shows functional interactions between them. Each of these functional specification blocks is described in detail in a state transition diagram as follows:

a) link availability control (TLAC) is shown in Figure 14-6 (Q.704);

b) signalling routing control (TSRC) is shown in Figure 14-7 (Q.704);

c) changeover control (TCOC) is shown in Figure 14-8 (Q.704);

d) changeback control (TCBC) is shown in Figure 14-9 (Q.704);

e) forced rerouting control (TFRC) is shown in Figure 14-10 (Q.704);

f) controlled rerouting control (TCRC) is shown in Figure 14-11 (Q.704);

g) signalling traffic flow control (TSFC) is shown in Figure 14-12 (Q.704).

14.5 Signalling link management

Figure 14-13 (Q.704) shows a subdivision of the signalling link management function (SLM) into smaller functional specification blocks and also shows functional interactions between them. Each of these functional specification blocks is described in detail in a state transition diagram as follows:

a) link set control (LLSC) is shown in Figure 14-14 (Q.704);

b) signalling link activity control (LSAC) is shown in Figure 14-15 (Q.704);

c) signalling link activation (LSLA) is shown in Figure 14-16 (Q.704);

d) signalling link restoration (LSLR) is shown in Figure 14-17 (Q.704);

e) signalling link deactivation (LSLD) is shown in Figure 14-18 (Q.704);

f) signalling terminal allocation (LSTA) is shown in Figure 14-19 (Q.704);

g) signalling data link allocation (LSDA) is shown in Figure 14-20 (Q.704).

14.6 Signalling route management

Figure 14-21 (Q.704) shows a subdivision of the signalling route management (SRM) function into smaller functional specification blocks and also shows functional interactions between them. Each of these functional specification blocks is described in detail in a state transition diagram as follows:

a) transfer prohibited control (RTPC) is shown in Figure 14-22 (Q.704);

b) transfer allowed control (RTAC) is shown in Figure 14-23 (Q.704);

c) signalling route set test control (RSRT) is shown in Figure 14-24 (Q.704).

ABBREVIATIONS USED IN FIGURES 14-1 to 14.24 (Q.704)

BSNT - Backward sequence number of next signal unit to be transmitted

DPC - Destination point code

FSNC - Forward sequence number of last message signal unit accepted by remote level 2

HMDC - Message discrimination

HMDT - Message distribution

HMRT - Message routing

L1 - Level 1

L2 - Level 2

L3 - Level 3

L4 - Level 4

LLSC - Link set control

LSAC - Signalling link activity control

LSDA - Signalling data link allocation

LSLA - Signalling link activation

LSLD - Signalling link deactivation

LSLR - Signalling link restoration

LSTA - Signalling terminal allocation

MGMT - Management system

RSRT - Signalling route set test control

RTAC - Transfer allowed control

RTPC - Transfer prohibited control

SLM - Signalling link management

SLS - Signalling link selection

SMH - Signalling message handling

SRM - Signalling route management

STM - Signalling traffic management

TCBC - Changeback control

TCOC - Changeover control

TCRC - Controlled rerouting control

TFRC - Forced rerouting control

TLAC - Link availability control

TSFC - Signalling traffic flow control

TSRC - Signalling routing control

<u>TIMERS</u> :

T1 - Delay to avoid message mis-sequencing on changeover

T2 - Waiting for changeover acknowledgement

T3 - Time controlled diversion - delay to avoid mis-sequencing on changeback

T4 - Waiting for changeback acknowledgement (first attempt)

T5 - Waiting [illegible] changeback acknowledgement (second attempt)

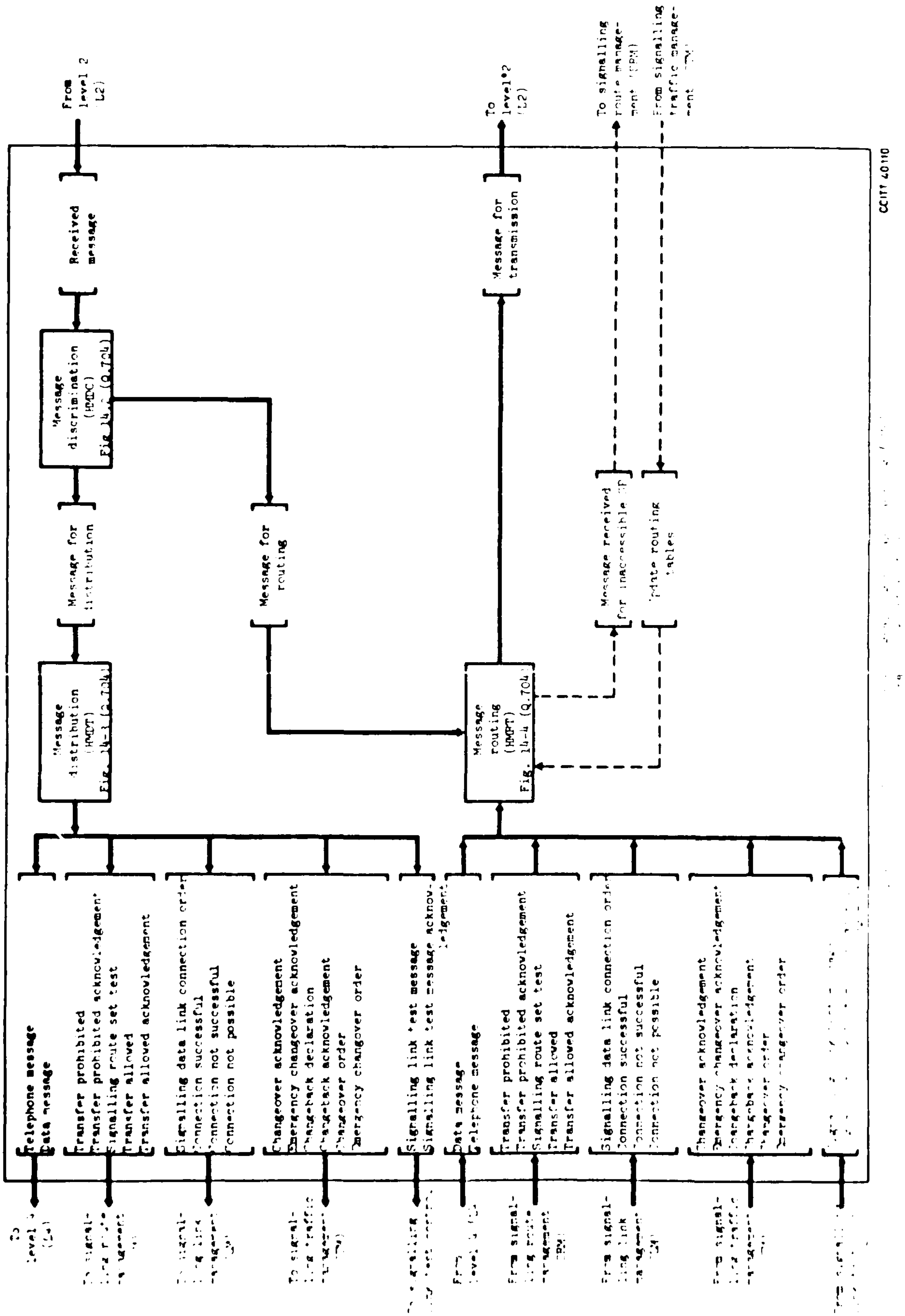
T6 - Delay to avoid message mis-sequencing on controlled rerouting

T7 - Waiting for signalling data link connection acknowledgement

T8 - Waiting for transfer prohibited acknowledgement

T9 - Waiting for transfer allowed acknowledgement

T10 - Waiting to repeat signalling route set test message


From level 2 (L2)
Received message
Message discrimination (HMDC) Fig. 14-2 (Q.704)
Message for distribution
Message for routing
Message distribution (HMDT) Fig. 14-3 (Q.704)
To level 2 (L2)
Message for transmission
Message routing (HMRT) Fig. 14-4 (Q.704)
Message received for inaccessible SP
Update routing tables
Telephone message
Data message
Transfer prohibited
Transfer prohibited acknowledgement
Signalling route set test
Transfer allowed
Transfer allowed acknowledgement
Signalling data link connection order
Connection successful
Connection not successful
Connection not possible
Changeover acknowledgement
Emergency changeover acknowledgement
Changeback declaration
Changeback acknowledgement
Changeover order
Emergency changeover order
Signalling link test message
Signalling link test message acknowledgement
CCITT 40110

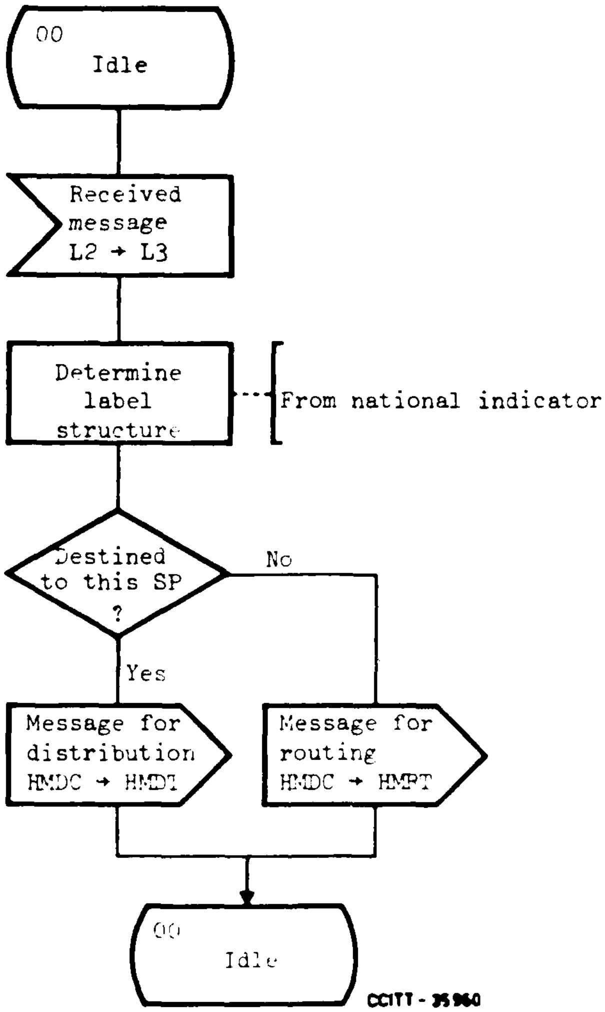
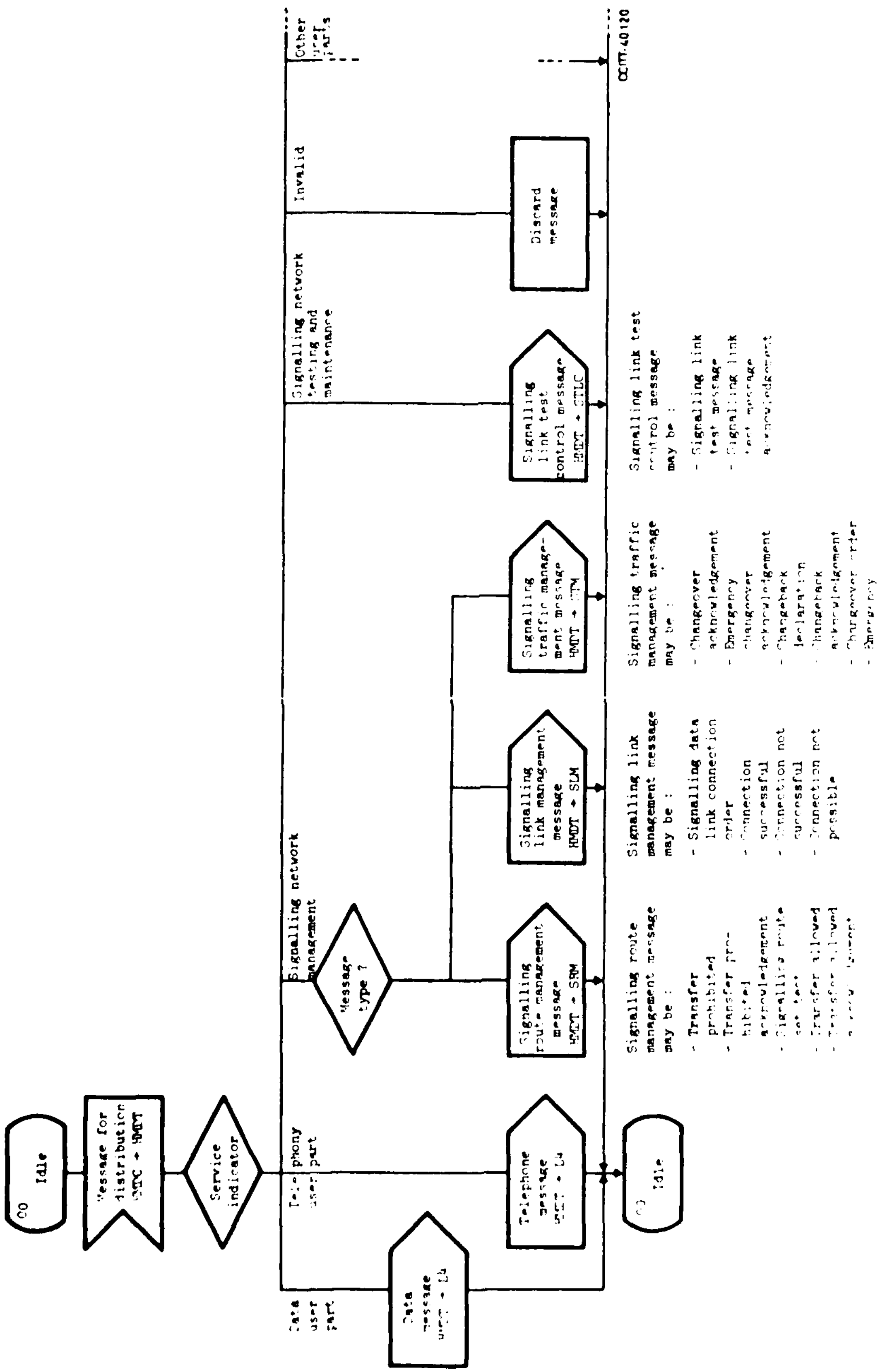
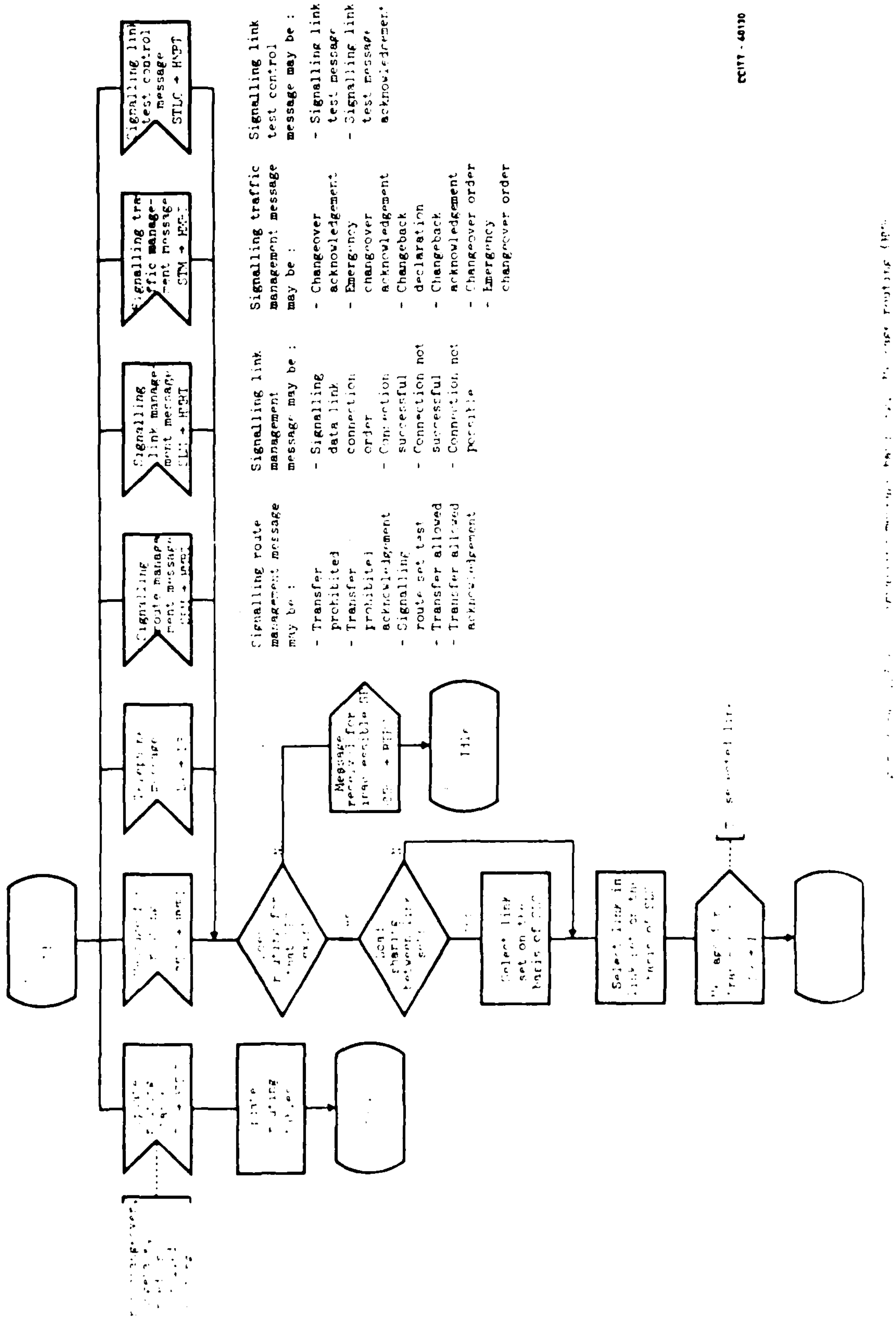
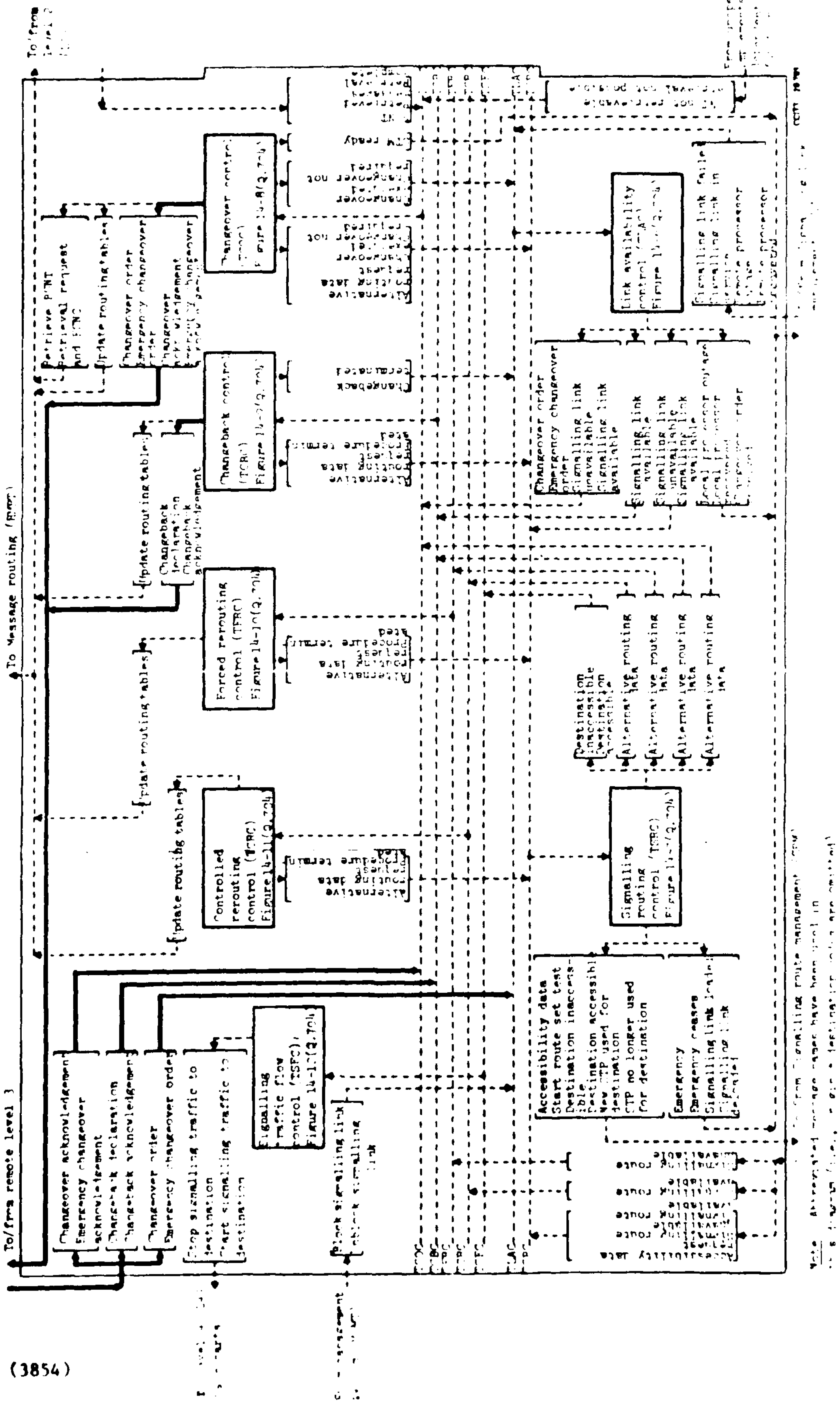


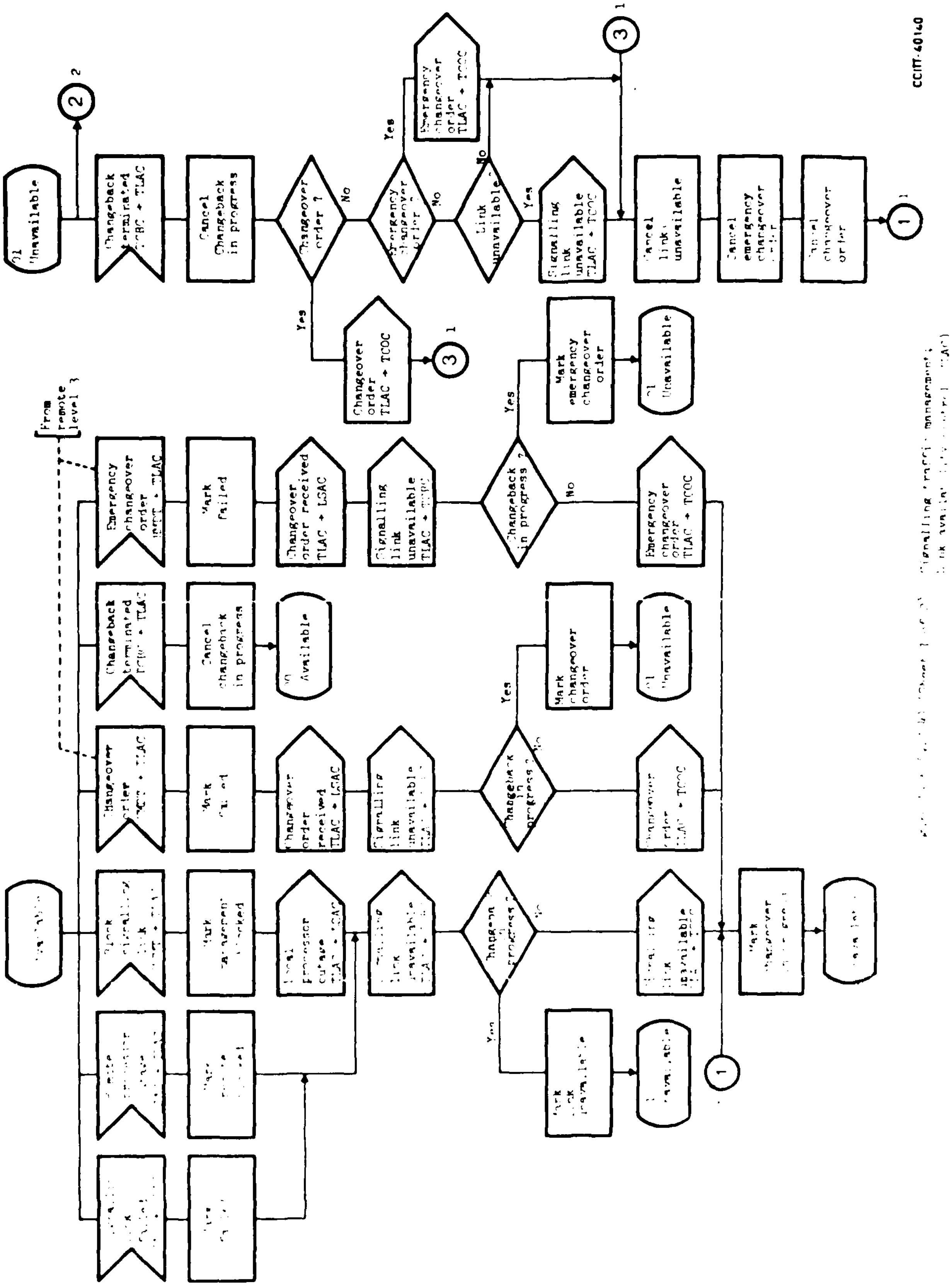
Figure 14-? (Q.704) - Signalling message handling;
Message discrimination (HMDC)


00
Idle
Message for
distribution
HMDC → HMDT
Service
indicator
Data
user
part
Telephony
user part
Signalling network
management
Message
type ?
Signalling network
testing and
maintenance
Invalid
Other
user
parts
Data
message
HMDT → L4
Telephone
message
HMDT → L4
Signalling
route management
message
HMDT → SRM
Signalling
link management
message
HMDT → SLM
Signalling
traffic manage-
ment message
HMDT → STM
Signalling
link test
control message
HMDT → STLC
Discard
message
00
Idle
CCITT-40120
Signalling route
management message
may be :
- Transfer
prohibited
- Transfer pro-
hibited
acknowledgement
- Signalling route
set test
- Transfer allowed
Signalling link
management message
may be :
- Signalling data
link connection
order
- Connection
successful
- Connection not
successful
- Connection not
possible
Signalling traffic
management message
may be :
- Changeover
acknowledgement
- Emergency
changeover
acknowledgement
- Changeback
declaration
- Changeback
acknowledgement
- Changeover order
- Emergency
changeover order
Signalling link test
control message
may be :
- Signalling link
test message
- Signalling link
test message
acknowledgement

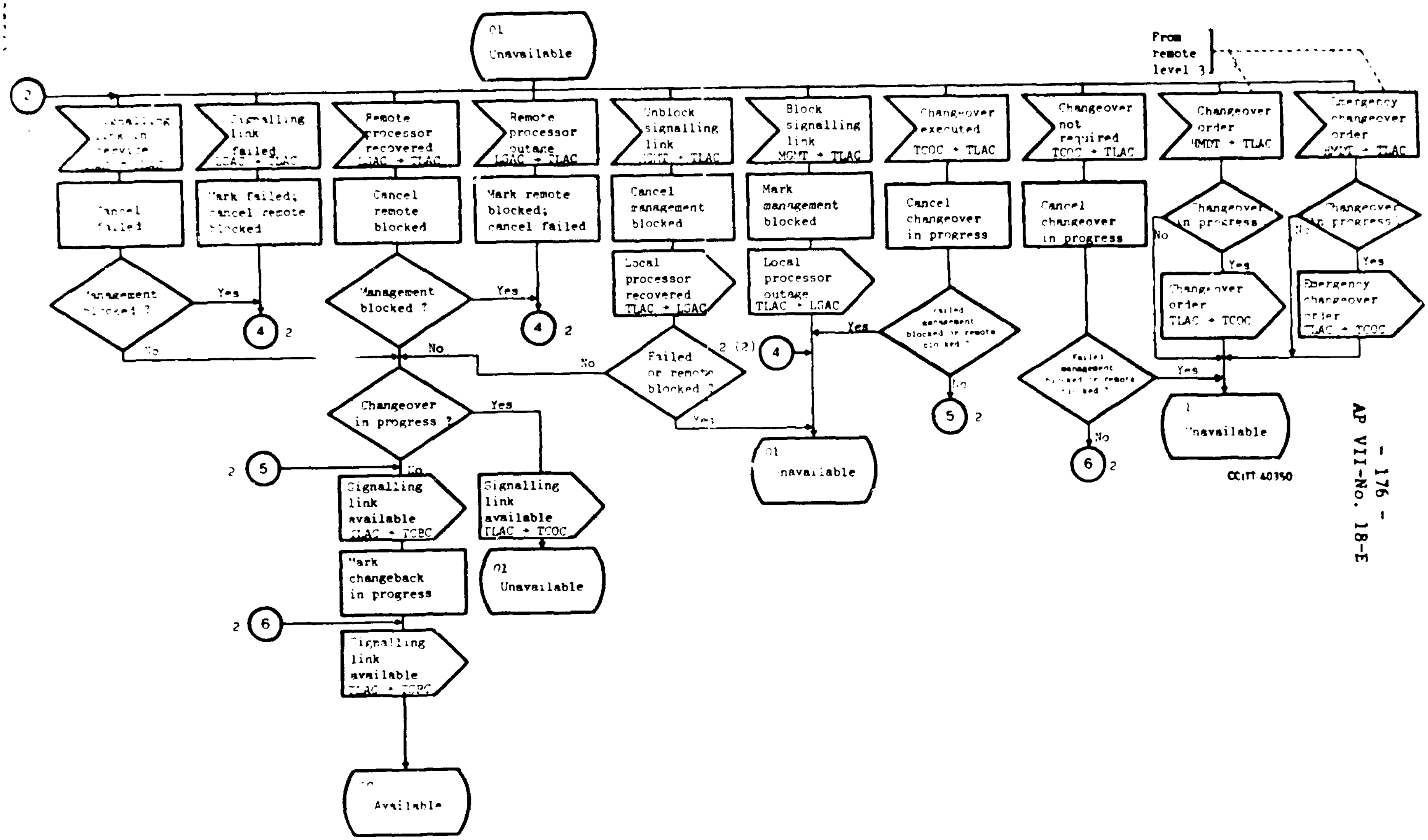
(3854)

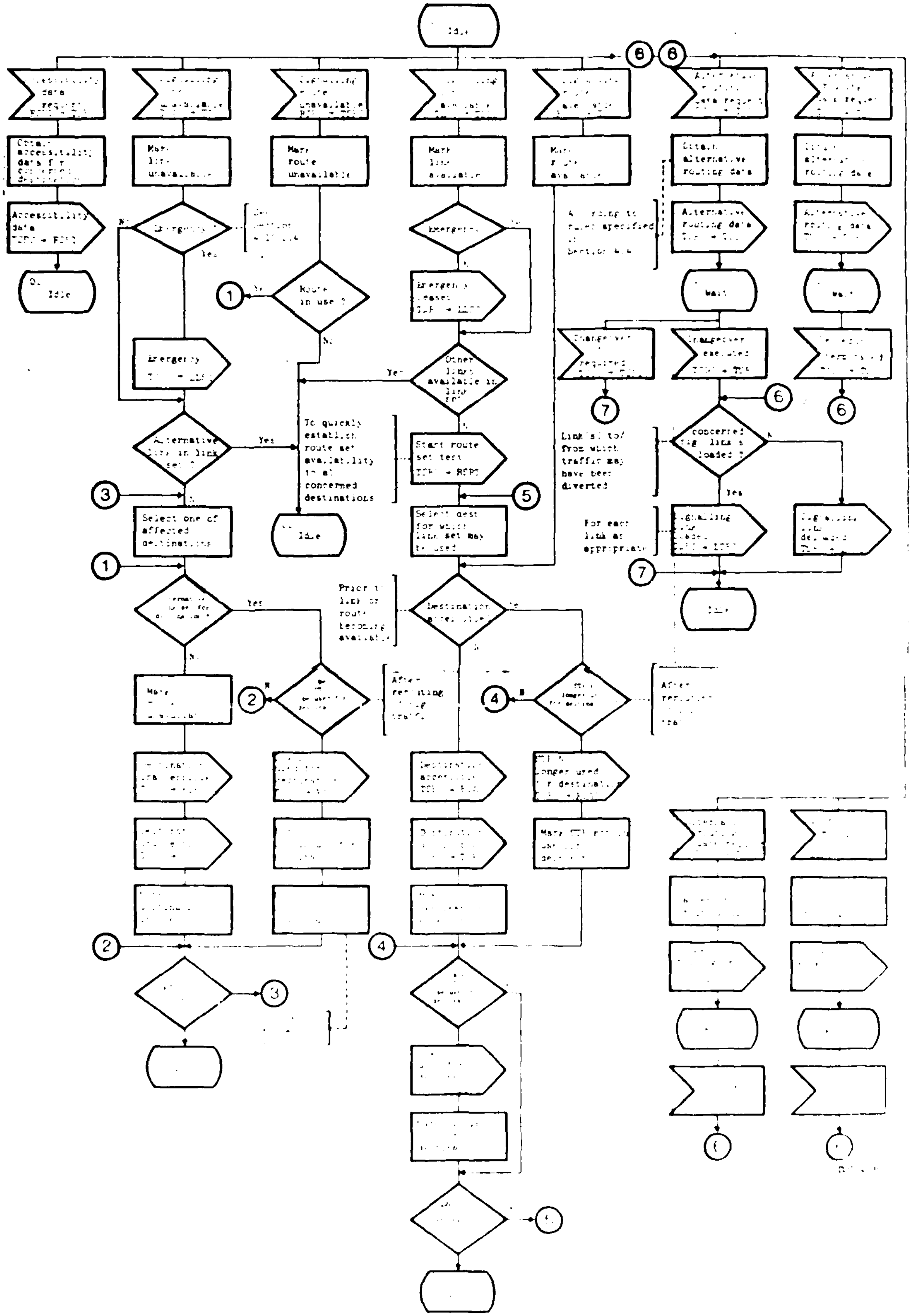

Signalling link test control message STLC → HMRT
Signalling route management message may be :
- Transfer prohibited
- Transfer prohibited acknowledgement
- Signalling route set test
- Transfer allowed
- Transfer allowed acknowledgement
Signalling link management message may be :
- Signalling data link connection order
- Connection successful
- Connection not successful
- Connection not possible
Signalling traffic management message may be :
- Changeover acknowledgement
- Emergency changeover acknowledgement
- Changeback declaration
- Changeback acknowledgement
- Changeover order
- Emergency changeover order
Signalling link test control message may be :
- Signalling link test message
- Signalling link test message acknowledgement
Message received for inaccessible SP
Idle
Select link set on the basis of
CCITT - 40130


To/from remote level 3
To Message routing (MRT)
Changeover control (TCOC) Figure 14-8(Q.704)
Changeback control (TCBC) Figure 14-9(Q.704)
Forced rerouting control (TFRC) Figure 14-10(Q.704)
Controlled rerouting control (TCRC) Figure 14-11(Q.704)
Signalling traffic flow control (TSFC) Figure 14-13(Q.704)
Signalling routing control (TSRC)
Link availability control (TLAC)
Update routing tables
Changeover order
Emergency changeover order
Changeback declaration
Changeback acknowledgement
Alternative routing data
Accessibility data
Start route set test
Block signalling link
Unblock signalling link


01 Unavailable
Changeback terminated TLAC
Cancel Changeback in progress
Changeover order ?
Yes
No
Changeover order TLAC + TCOC
Emergency changeover order ?
Emergency changeover order TLAC + TCOC
Link unavailable ?
Signalling link unavailable TLAC + TCOC
Cancel link unavailable
Cancel emergency changeover order
Cancel changeover order
From remote level 3
Emergency changeover order
Mark failed
Changeover order received TLAC + LSAC
Signalling link unavailable
Changeback in progress ?
Mark emergency changeover order
Emergency changeover order TLAC + TCOC
Changeback terminated
Cancel changeback in progress
Available
Mark changeover order
Changeover order
Mark failed
Changeover order received TLAC + LSAC
Signalling link unavailable
Changeback in progress ?
Changeover order TLAC + TCOC
Mark management blocked
Local processor outage
Mark changeover order
Mark link unavailable
CCITT-40140

(3854)


01
Unavailable
From
remote
level 3
Signalling
link
failed
Mark failed;
cancel remote
blocked
Remote
processor
recovered
Cancel
remote
blocked
Management
blocked ?
Yes
No
Remote
processor
outage
LSAC + TLAC
Mark remote
blocked;
cancel failed
Unblock
signalling
link
Cancel
management
blocked
Local
processor
recovered
TLAC + LSAC
Failed
or remote
blocked ?
Block
signalling
link
MGMT + TLAC
Mark
management
blocked
Local
processor
outage
TLAC + LSAC
01
navailable
Changeover
executed
TCOC + TLAC
Cancel
changeover
in progress
Changeover
not
required
TCOC + TLAC
Changeover
order
MGMT + TLAC
Changeover
in progress
Changeover
order
TLAC + TCOC
Emergency
changeover
order
TLAC + TCOC
Unavailable
CCITT-40350
Changeover
in progress ?
Signalling
link
available
TLAC + TCOC
01
Unavailable
Mark
changeback
in progress
Signalling
link
available
Available


Idle
Mark link unavailable
Mark route unavailable
Mark link available
Obtain alternative routing data
Alternative routing data
Emergency ?
Route in use ?
Emergency
Emergency
Other links available in link set ?
Alternative link in link set ?
Yes
To quickly establish route set availability to all concerned destinations
Start route set test
Link(s) to/from which traffic may have been diverted
concerned sig links loaded ?
Select one of affected destinations
Idle
Select dest for which link set may be used
For each link as appropriate
Prior to link or route becoming available
Destination accessible ?
After rerouting traffic
After
Changeover executed
Changeover required
Wait
No longer used for destination
Mark ... used
Destination accessible

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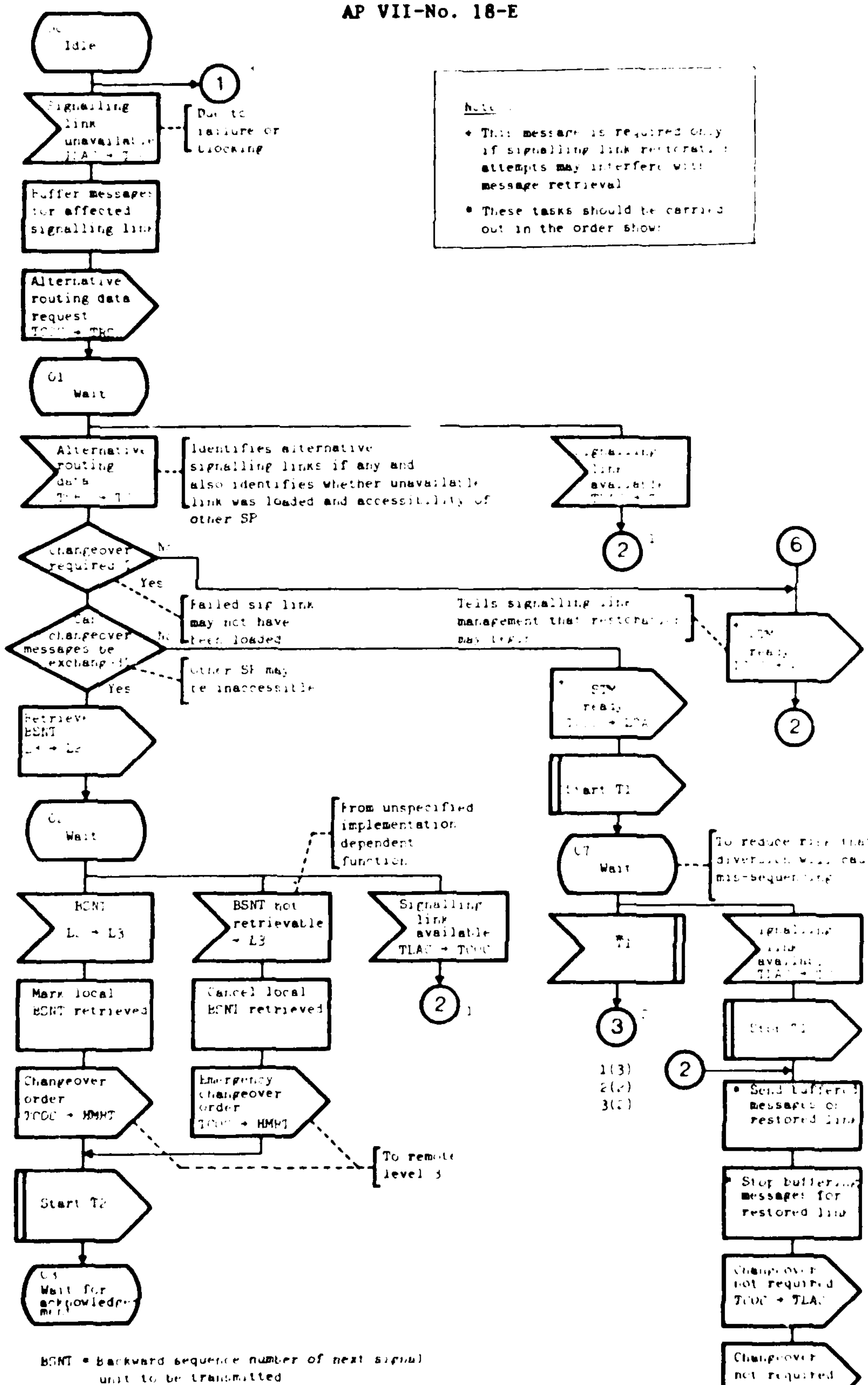

Figure ... (Sheet 1 of 3) - Signalling traffic management ... changeover control (TCOC)

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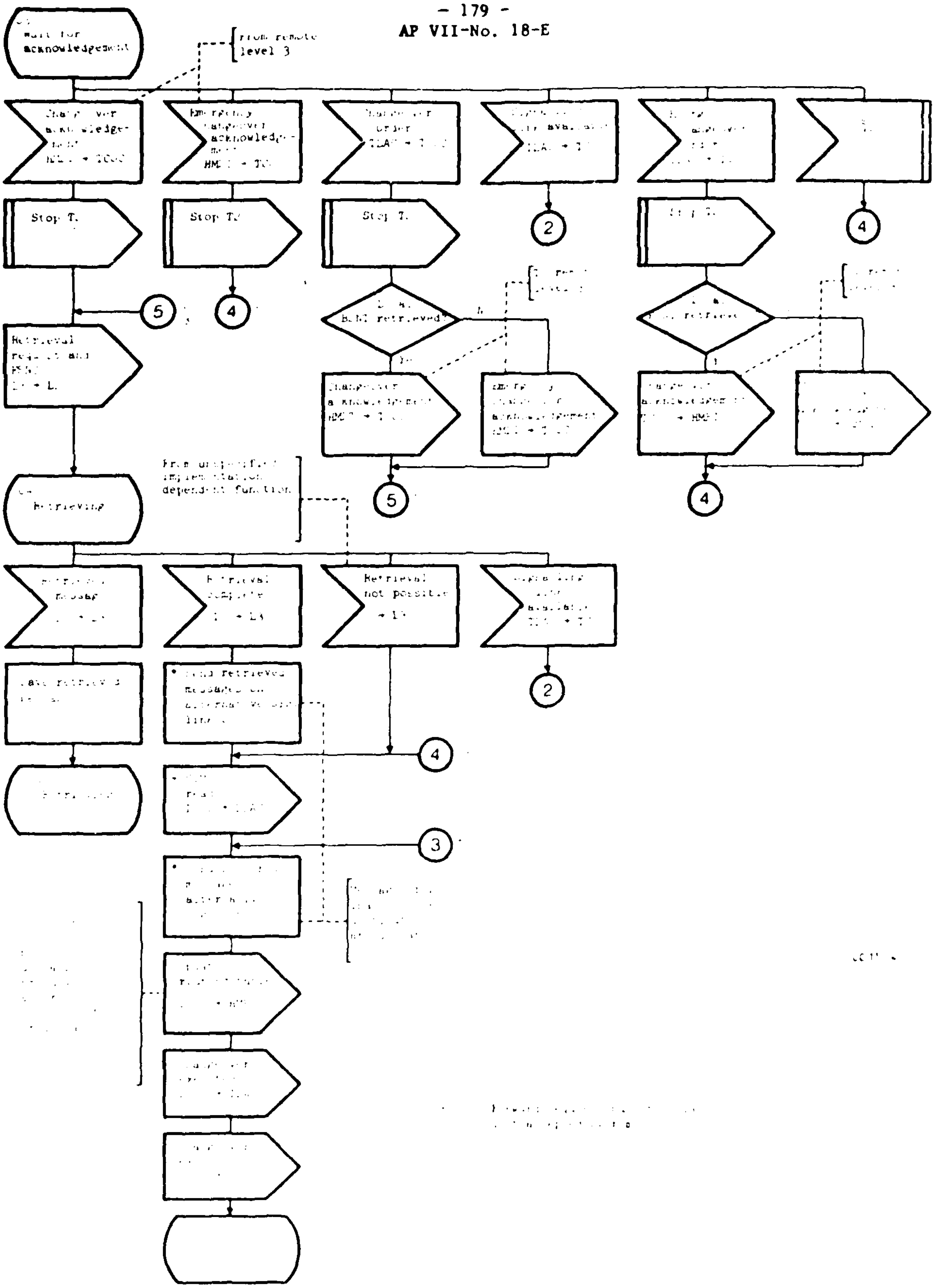

wait for acknowledgement
from remote level 3
Stop T.
Retrieval request and
Retrieving
From unspecified implementation dependent function
Retrieval not possible
Save retrieved
Send retrieved messages on alternative link

(3854)

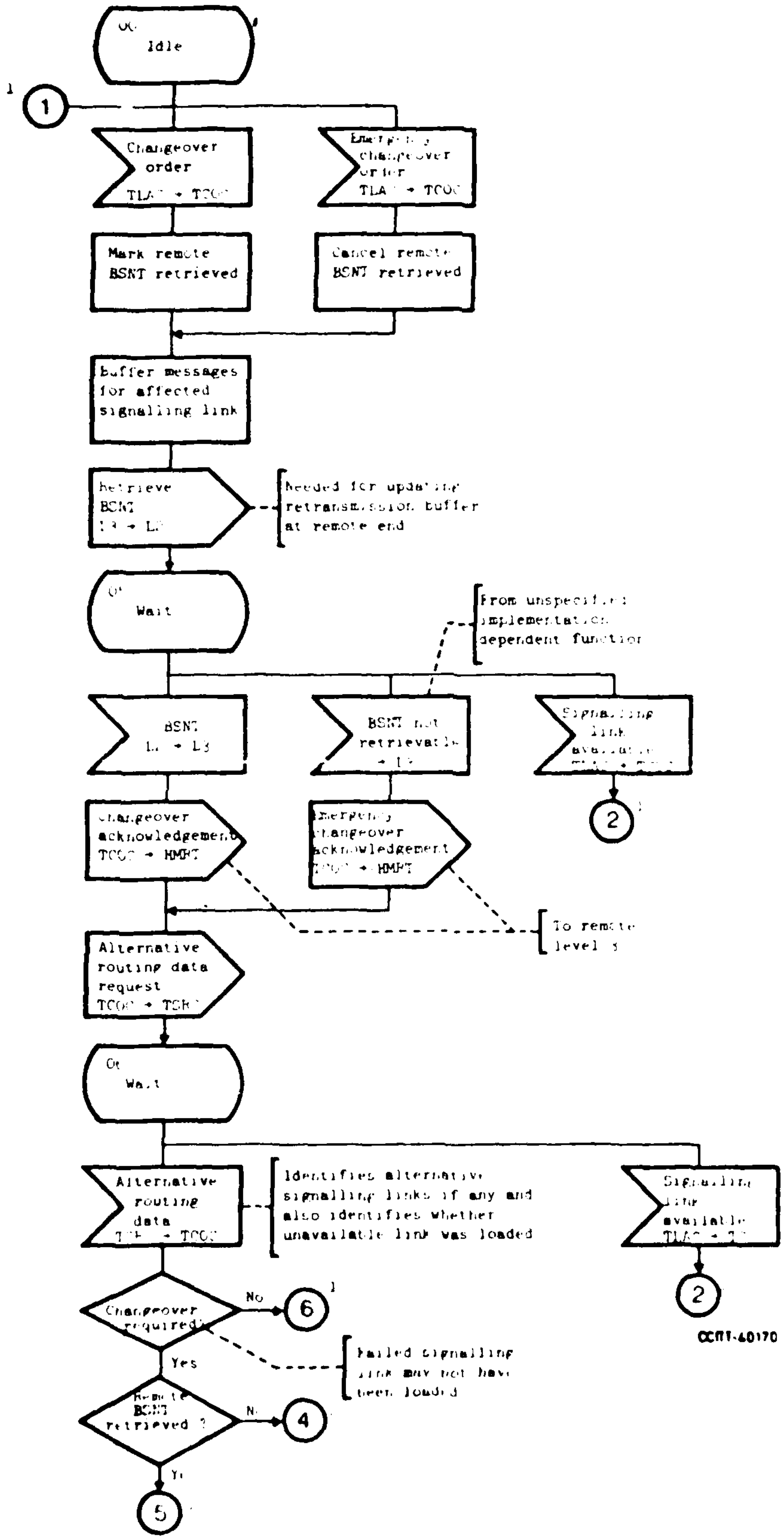
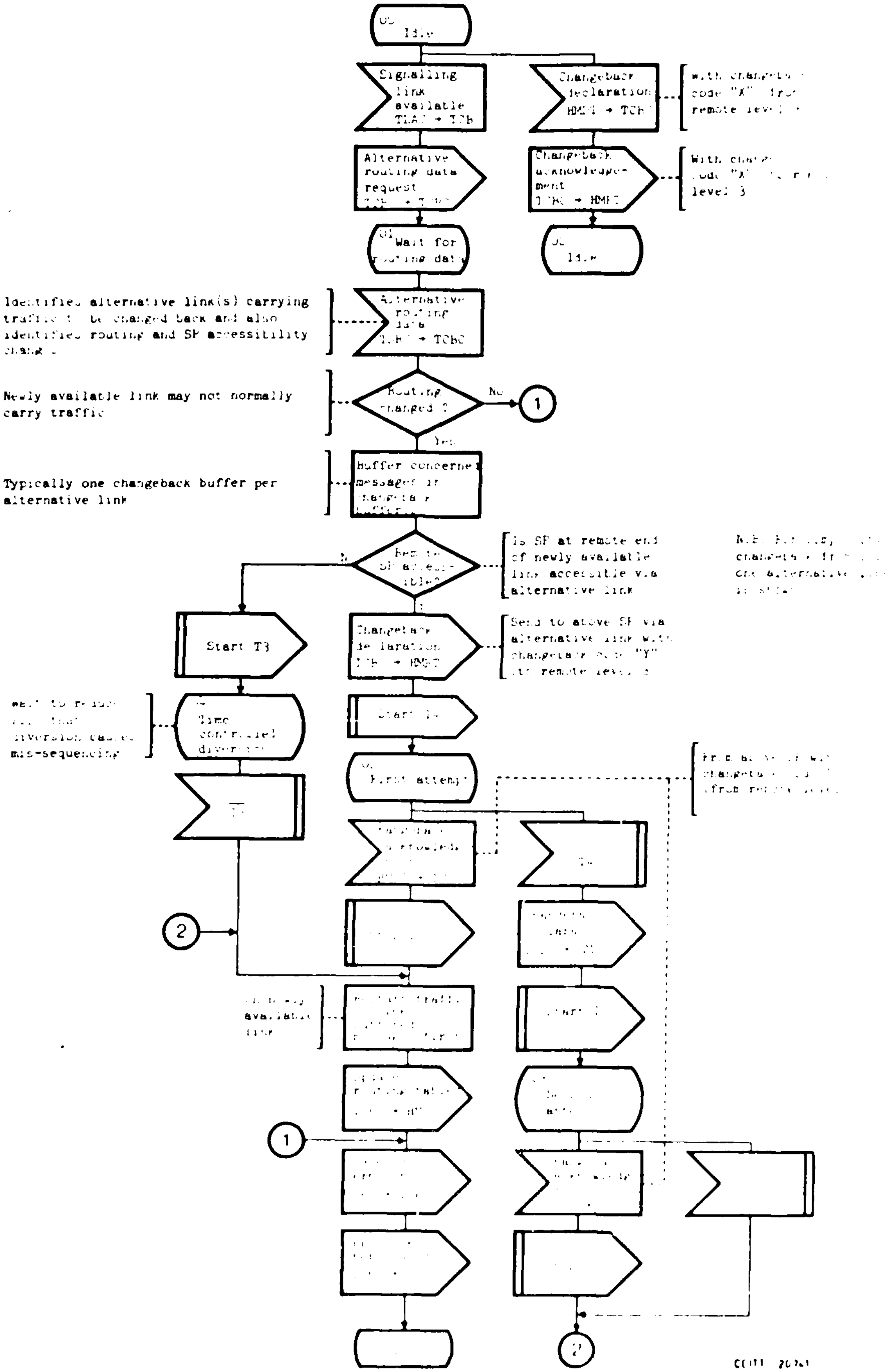


Figure [illegible] Signalling traffic management, changeover control [illegible]


Idle
Signalling link available
Changeback declaration
with changeback code "X" from remote level 3
Alternative routing data request
Changeback acknowledgement
With changeback code "X" to level 3
Idle
Wait for routing data
Identified alternative link(s) carrying traffic to be changed back and also identifies routing and SP accessibility change
Alternative routing data
Newly available link may not normally carry traffic
Routing changed ?
No
Yes
1
Typically one changeback buffer per alternative link
Buffer concerned messages in changeback buffer
Is SP at remote end of newly available link accessible via alternative link
Start T3
Changeback declaration
Send to above SP via alternative link with changeback code "Y" to remote level 3
Time controlled diversion
mis-sequencing
First attempt
2
1
2

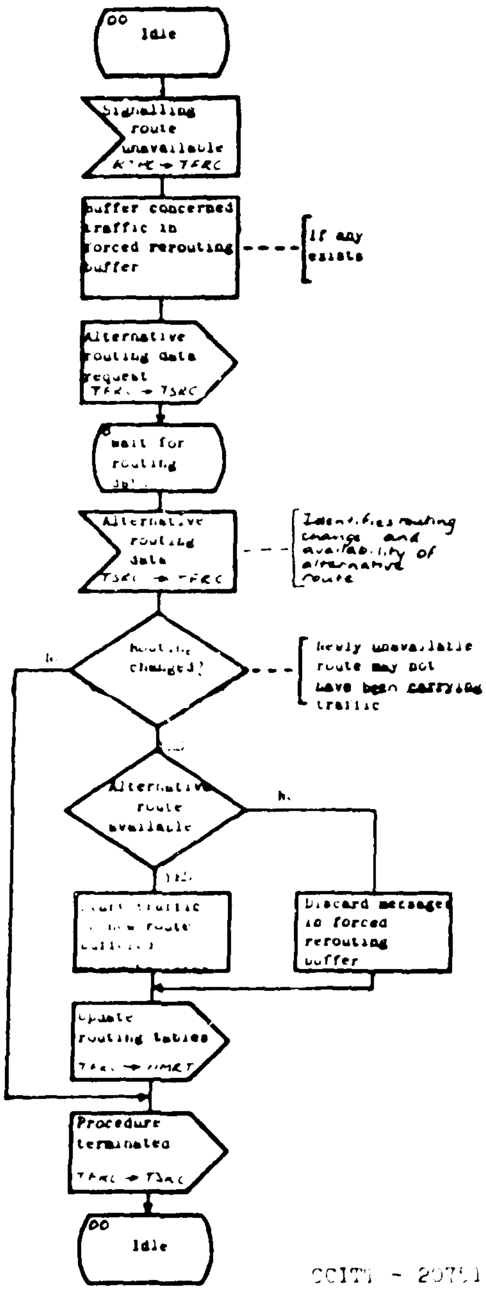


Figure 14-10 (Q.704) - Signalling traffic management; Forced rerouting control (TFRC)

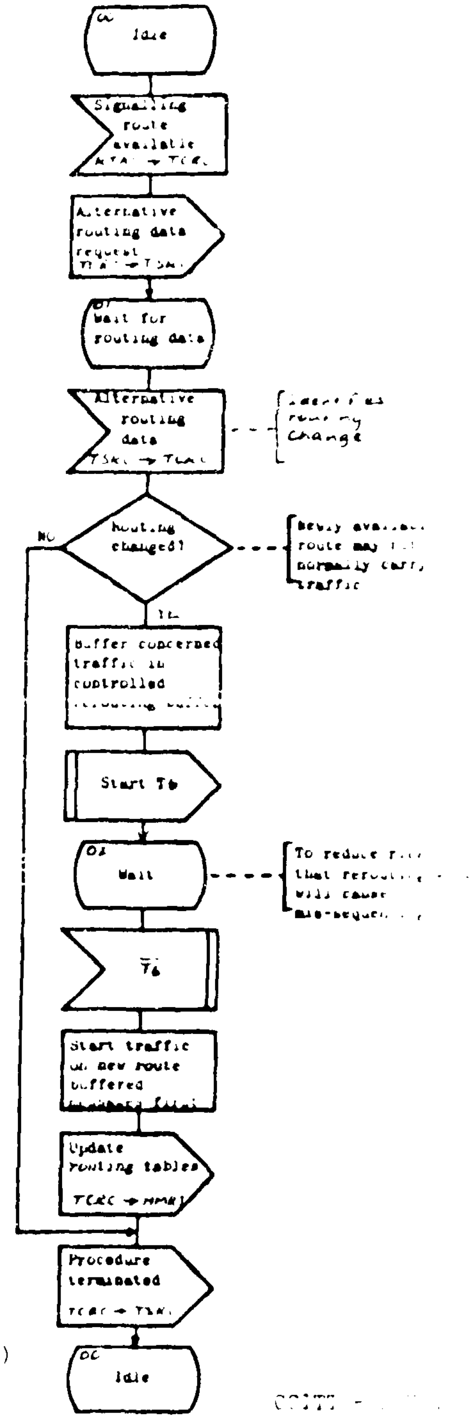


Figure 14-11 (Q.704) - Signalling traffic manag... Controlled rerouting ...

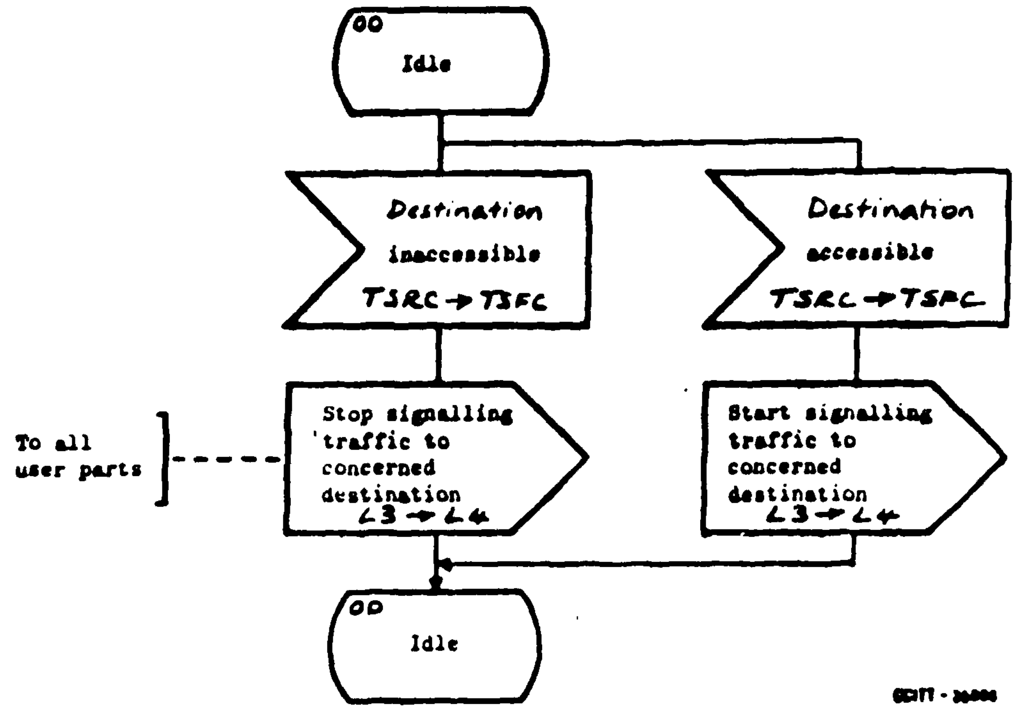


Figure 14-12 (Q.704) - Signalling traffic management; Signalling traffic flow control (TSFC)

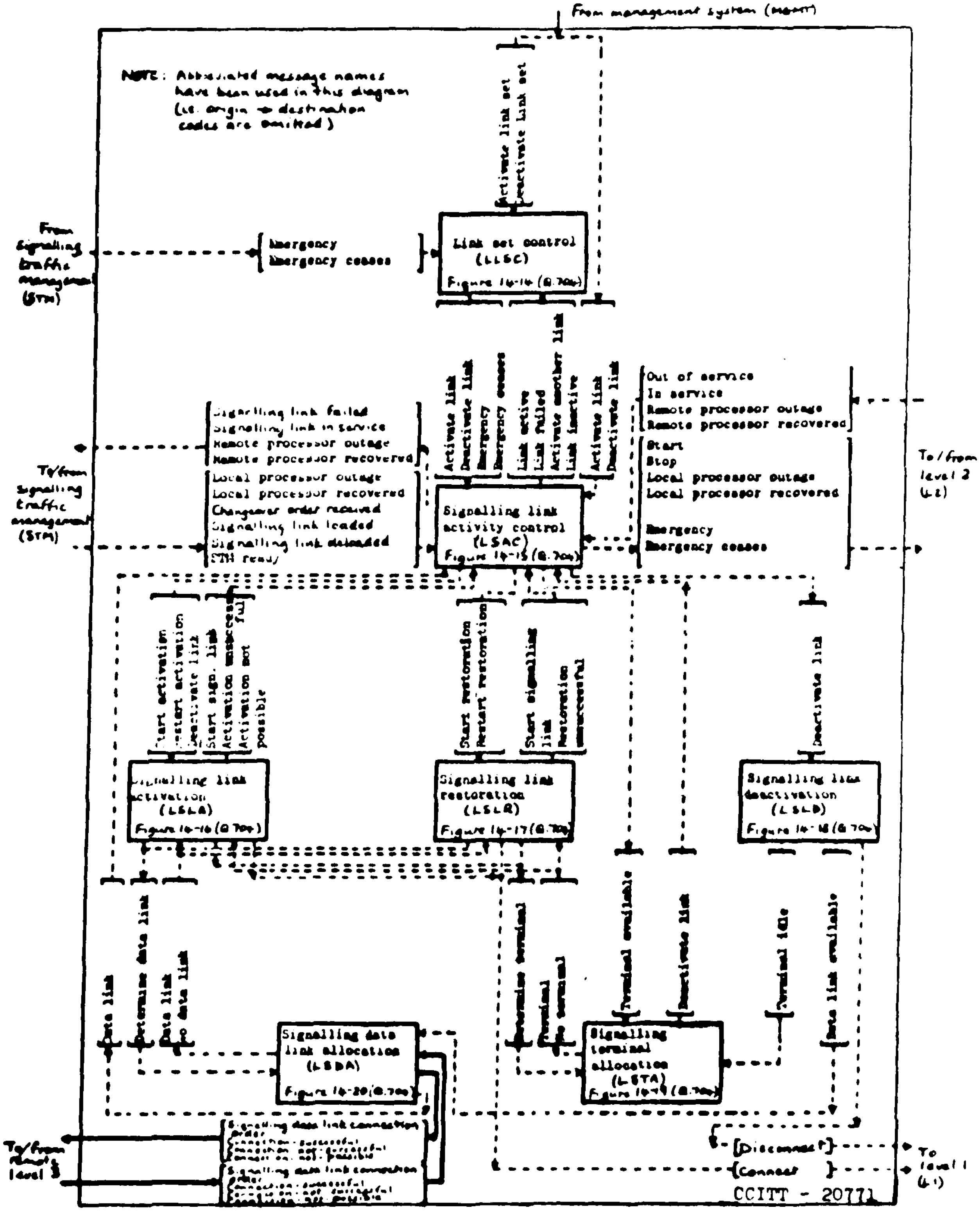


Figure 14-13 (Q. 704) - Level 3 - Signalling link management (SLM)
Functional block interactions

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(3854)

Note: 1. It is assumed that this function has access to information regarding the number of links in a link set

2. It should be ensured that signalling link activation and deactivation attempts are not made simultaneously for the same signalling link.

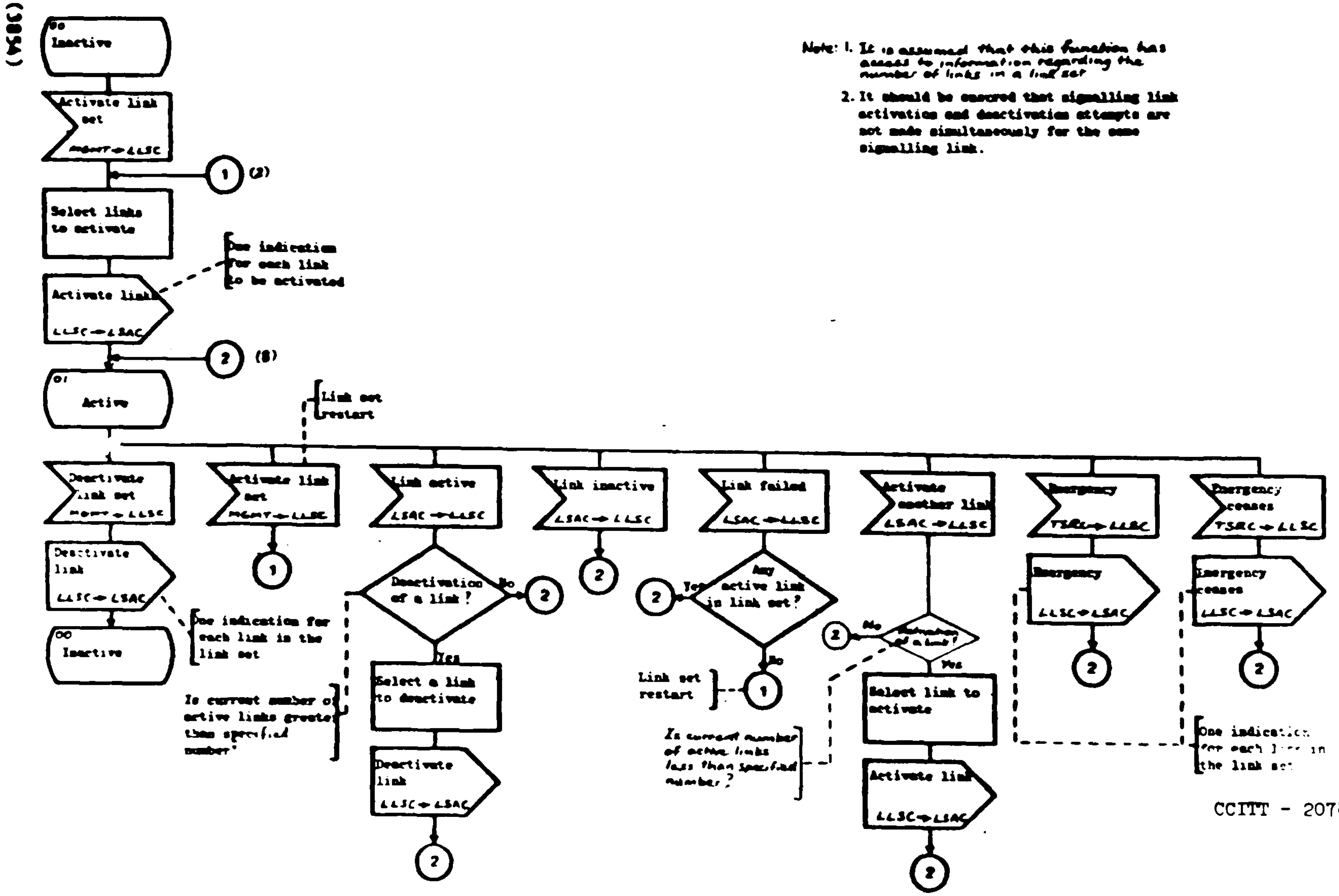

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Figure 14-14 (Q. 704) - Signalling link management; Link set control (LLSC)

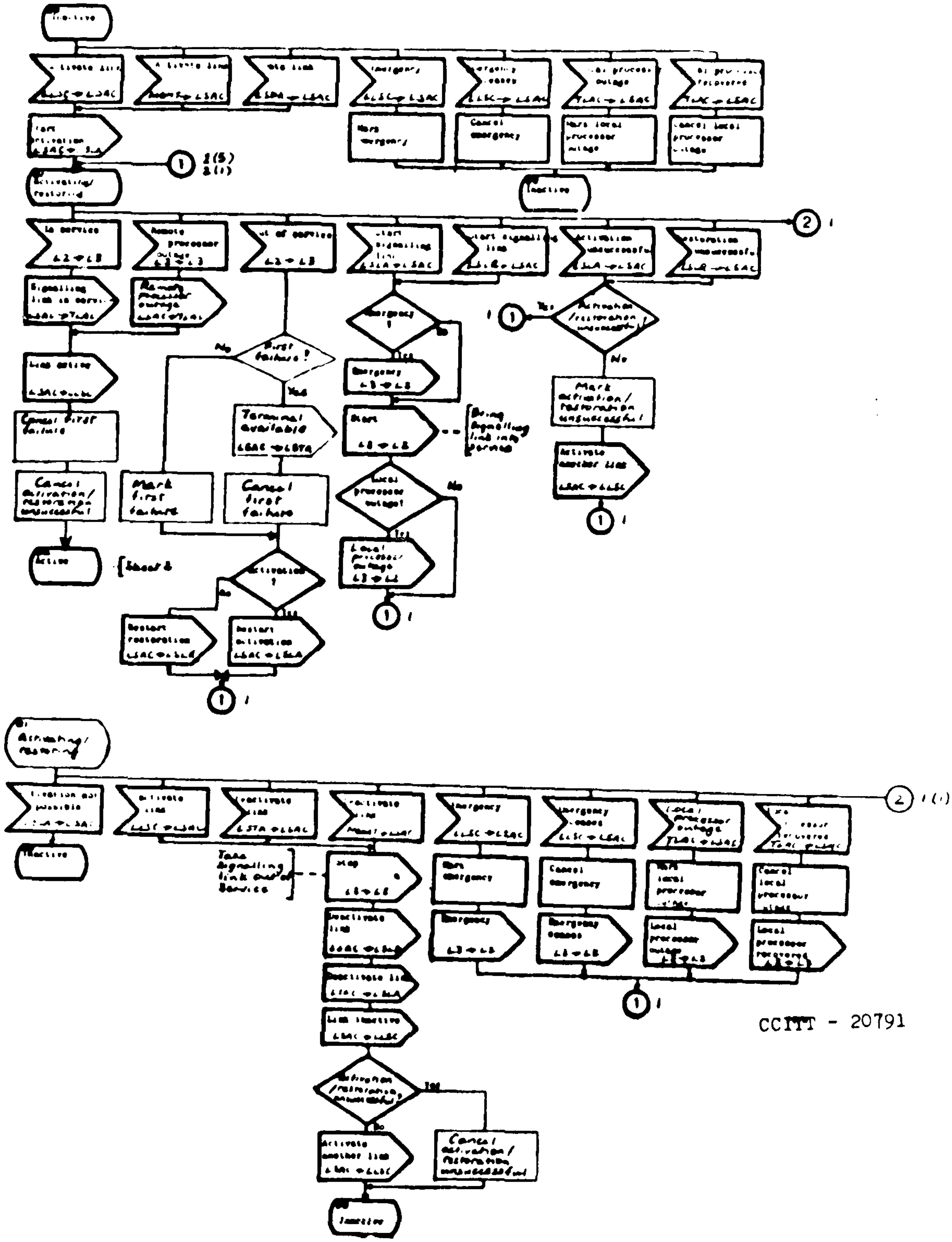

Figure 14-15 (Q.704) (Sheet 1 of 2) - Signalling link management;
Signalling link activity control (LSAC)

(3034)

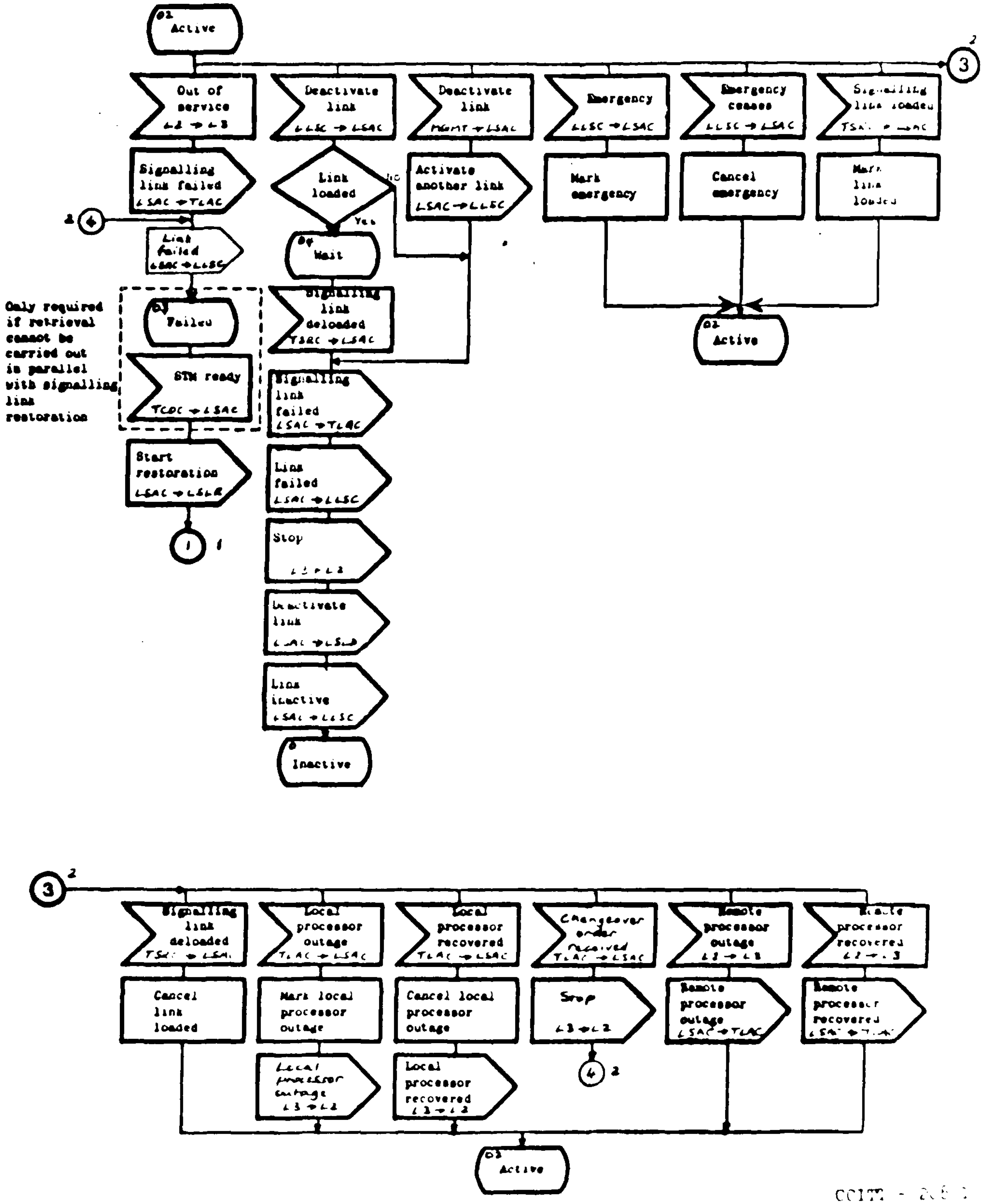

Figure 14-15 (Q.704) (Sheet 2 of 2) - Signalling link management;
Signalling link activity control (LSAC)

(3854)

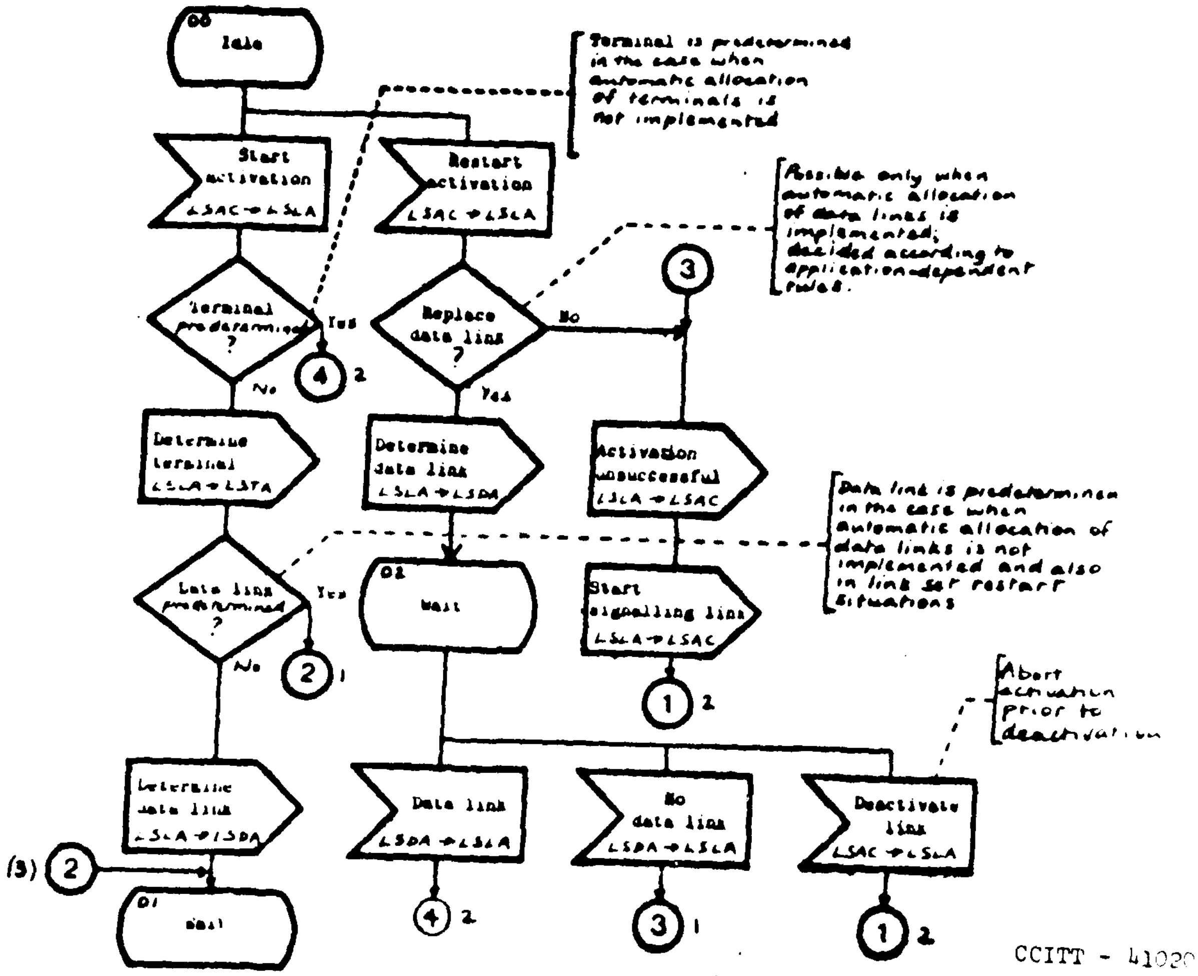

Figure 14-16 (Q.704) (Sheet 1 of 2) - Signalling link management;
Signalling link activation (LSLA)

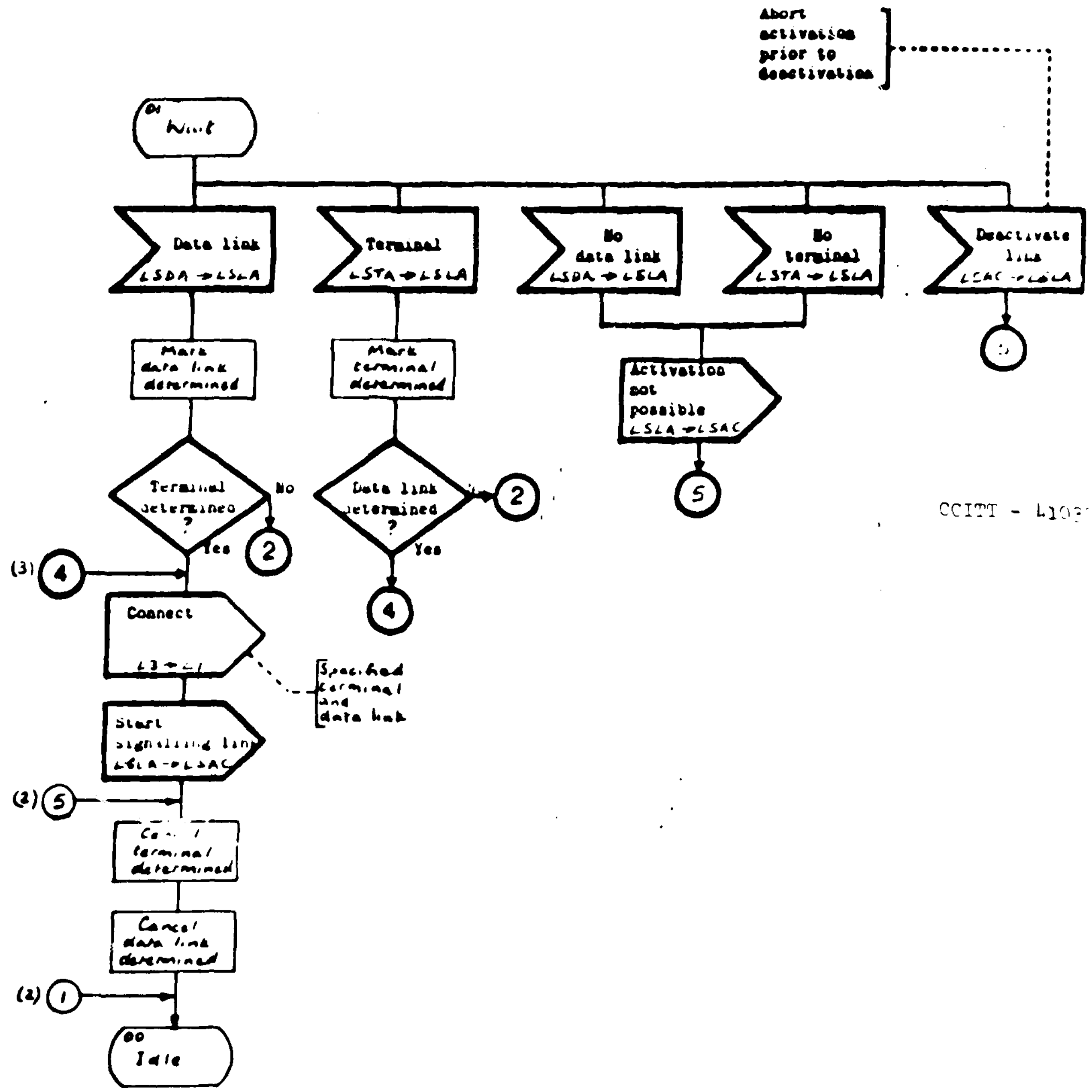

Figure 14-16 (Q.704) (Sheet 2 of 2) - Signalling link management;
Signalling link activation (LSLA)

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SPECIFICATIONS OF CCITT SIGNALLING SYSTEM NUMBER 7.(U)
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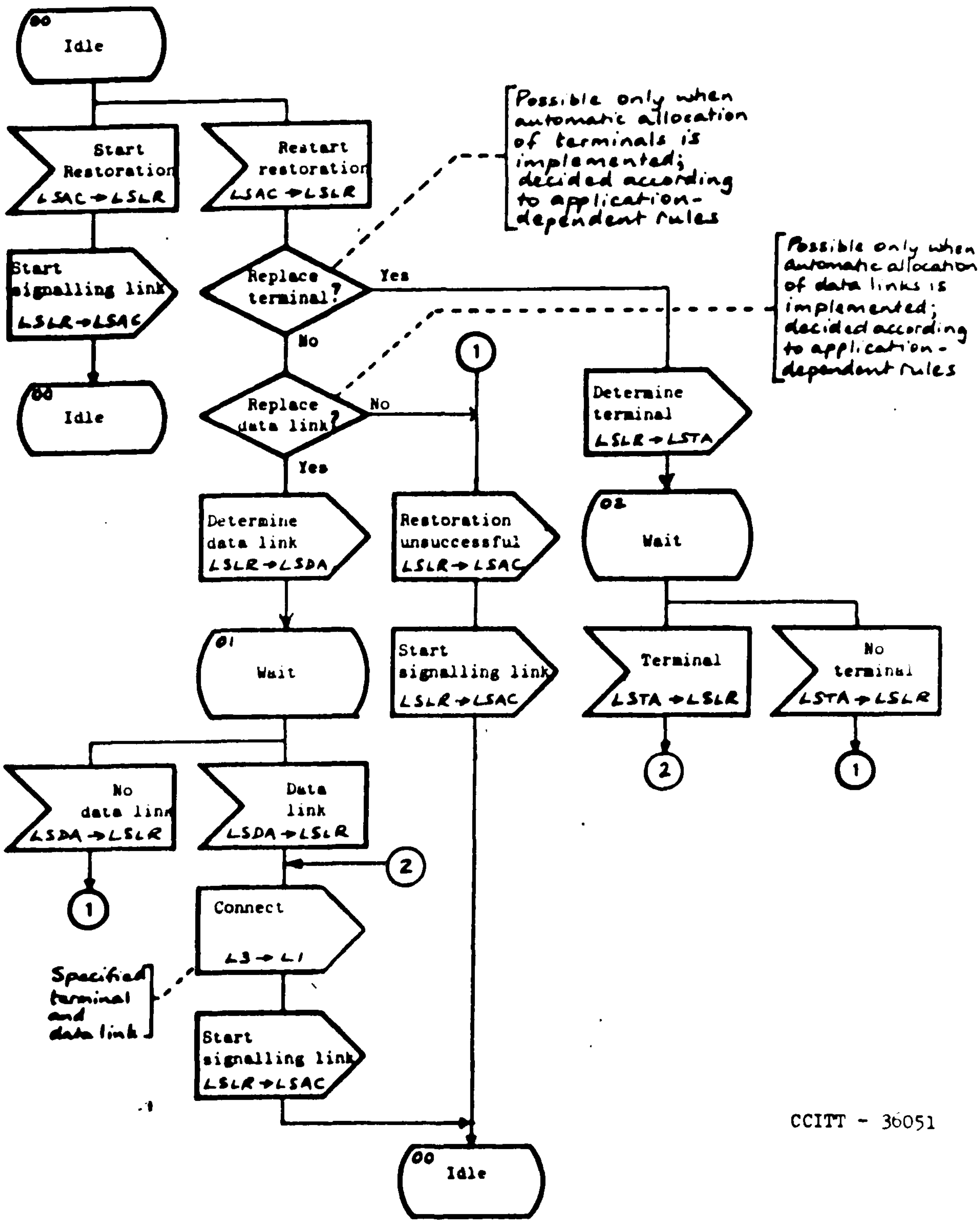

Figure 14-17 (Q.704) - Signalling link management; Signalling link restoration (LSLR)
(3854)

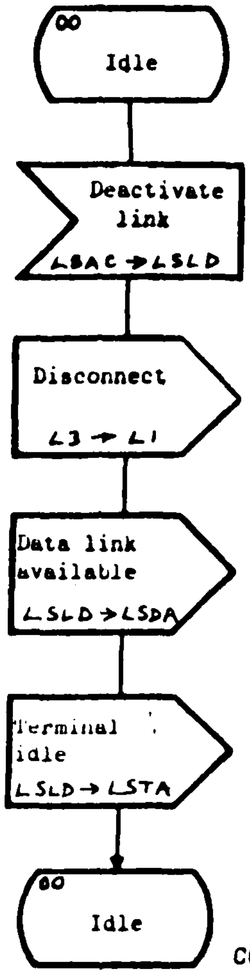

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Figure 14-18 (Q.704) - Signalling link management; Signalling link deactivation (LSLD)

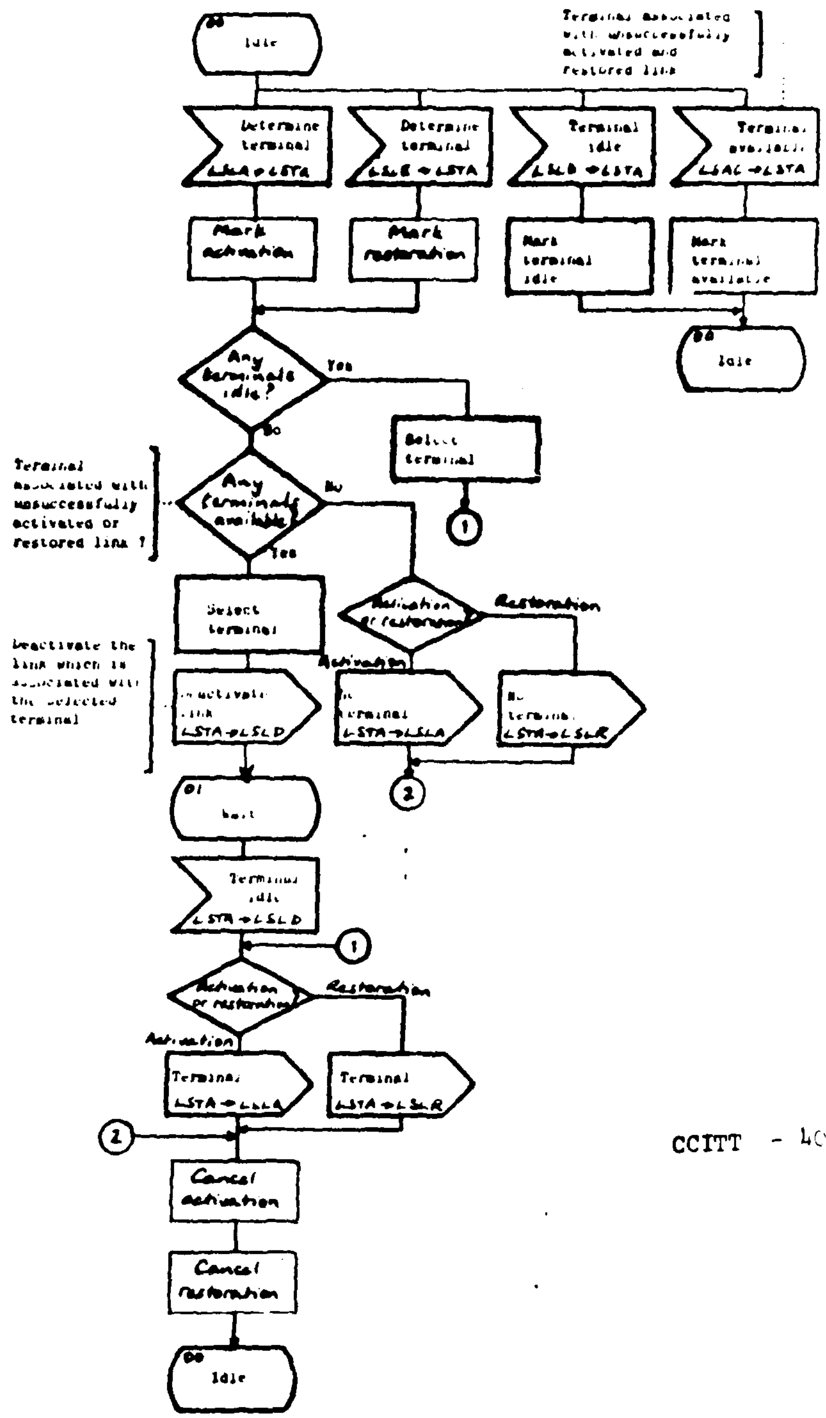

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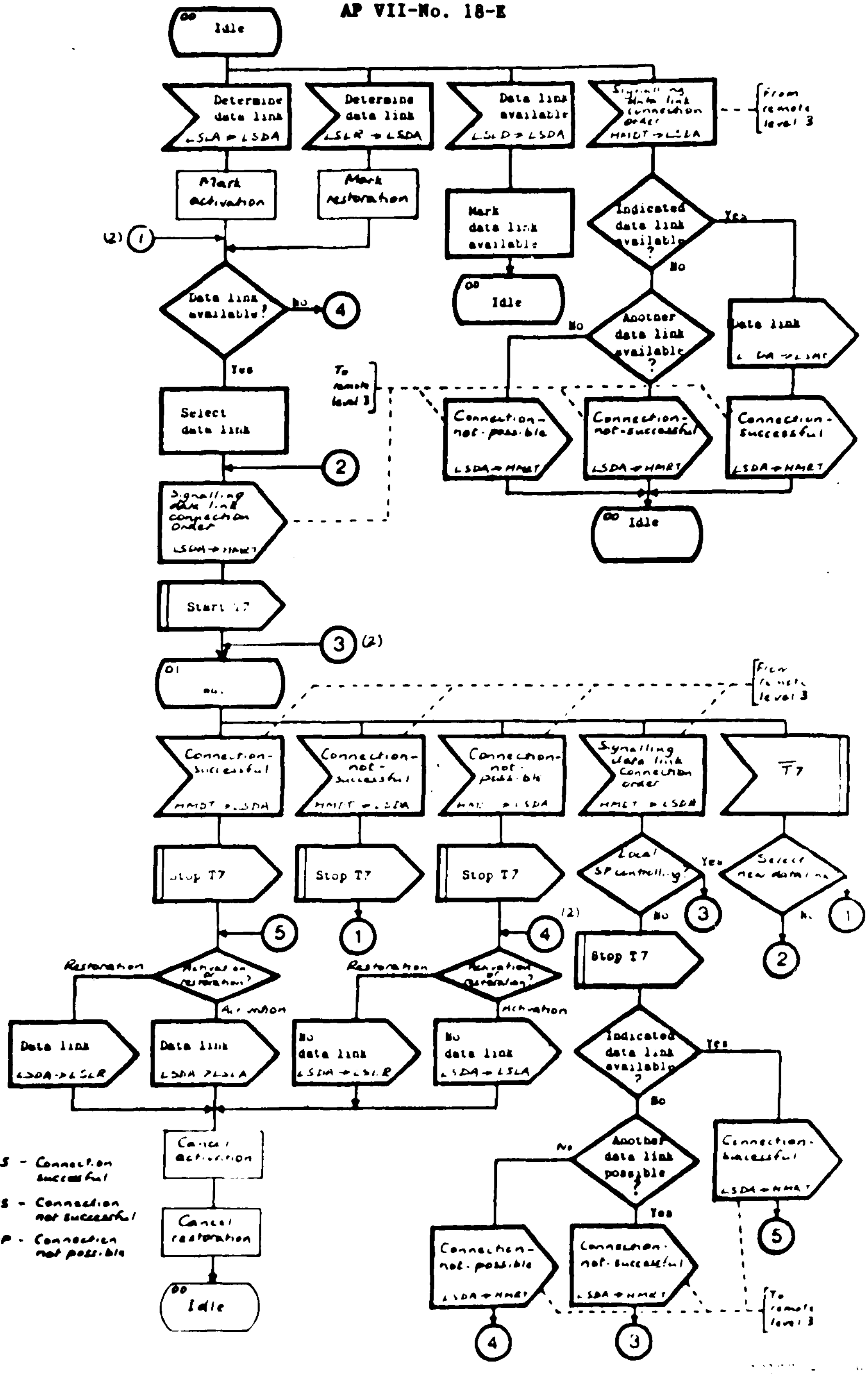
Figure 14-19 (Q.704) - Signalling link management;
Signalling terminal allocation (LSTA)

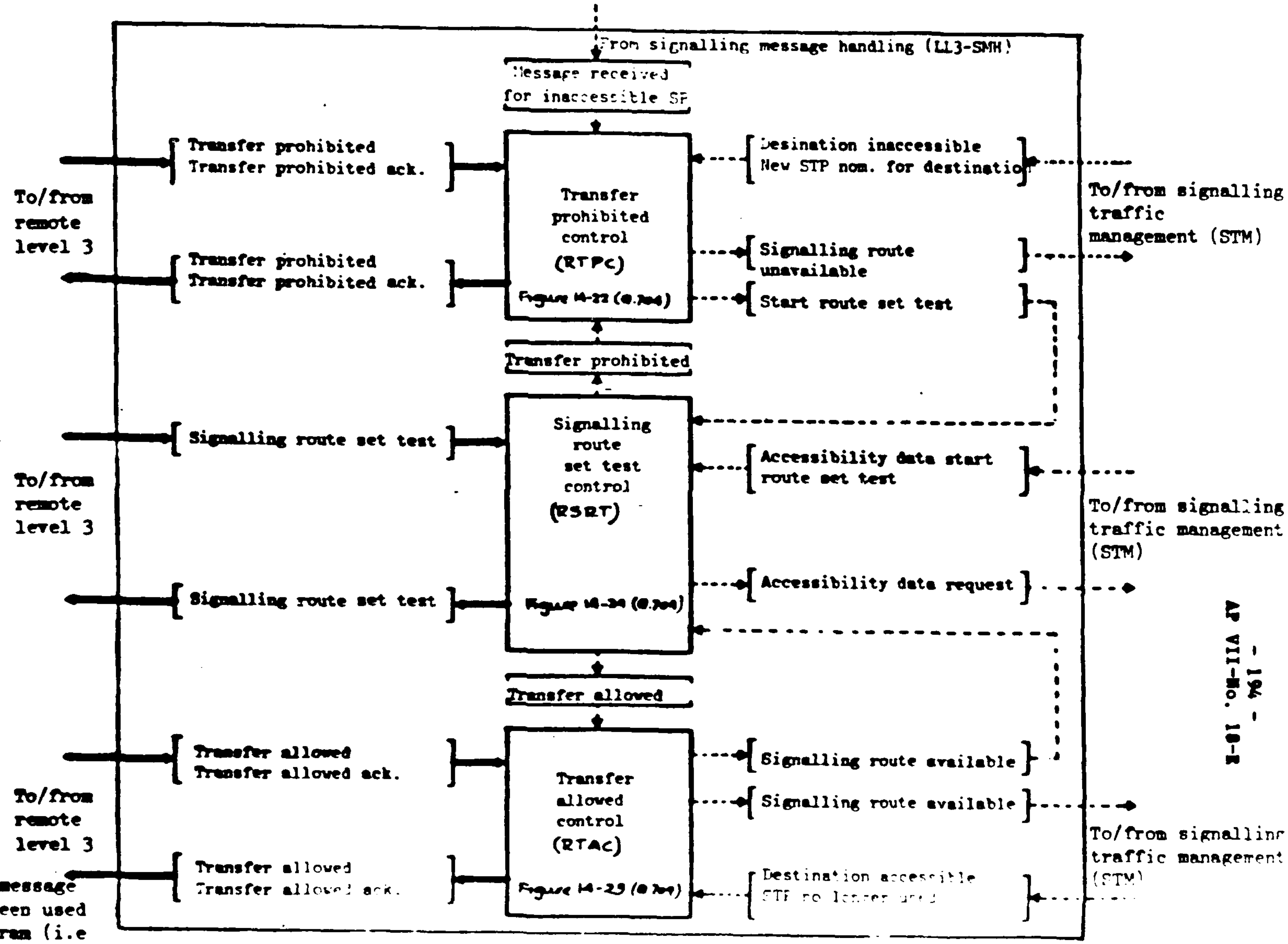


CSS - Connection successful

CNS - Connection not successful

CNP - Connection not possible

(3854) Figure 14-20 (Q.704) - Signalling link management; Signalling data link allocation (LSDA)



Note : Abbreviated message names have been used in this diagram (i.e origin + destination codes have been omitted)

Figure 14-21 (Q.704) - Level 3 - Signalling route management (SRM)
Functional block interactions

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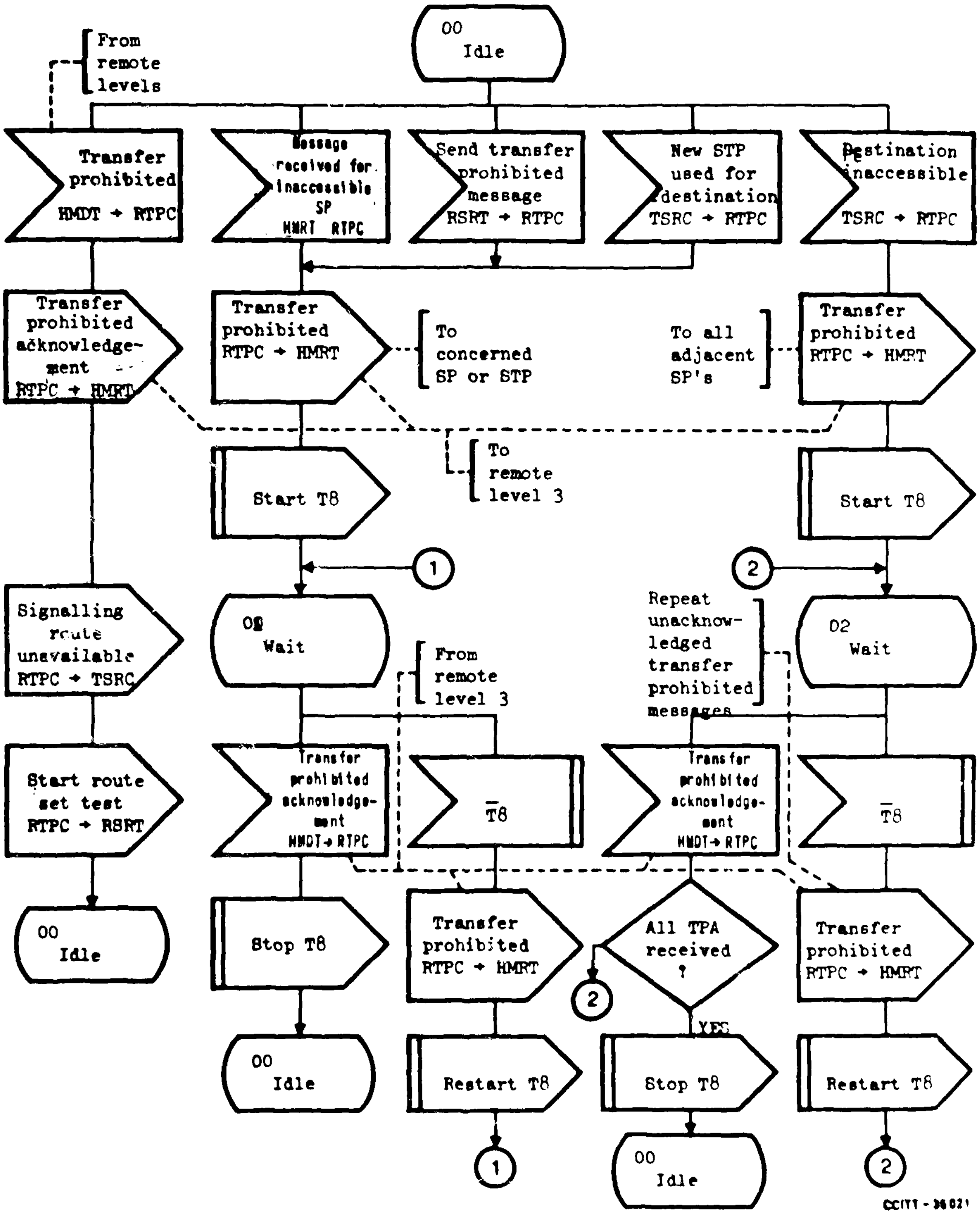


Figure 14-22 (Q.704) - Signalling route management; Transfer prohibited control (RTPC)

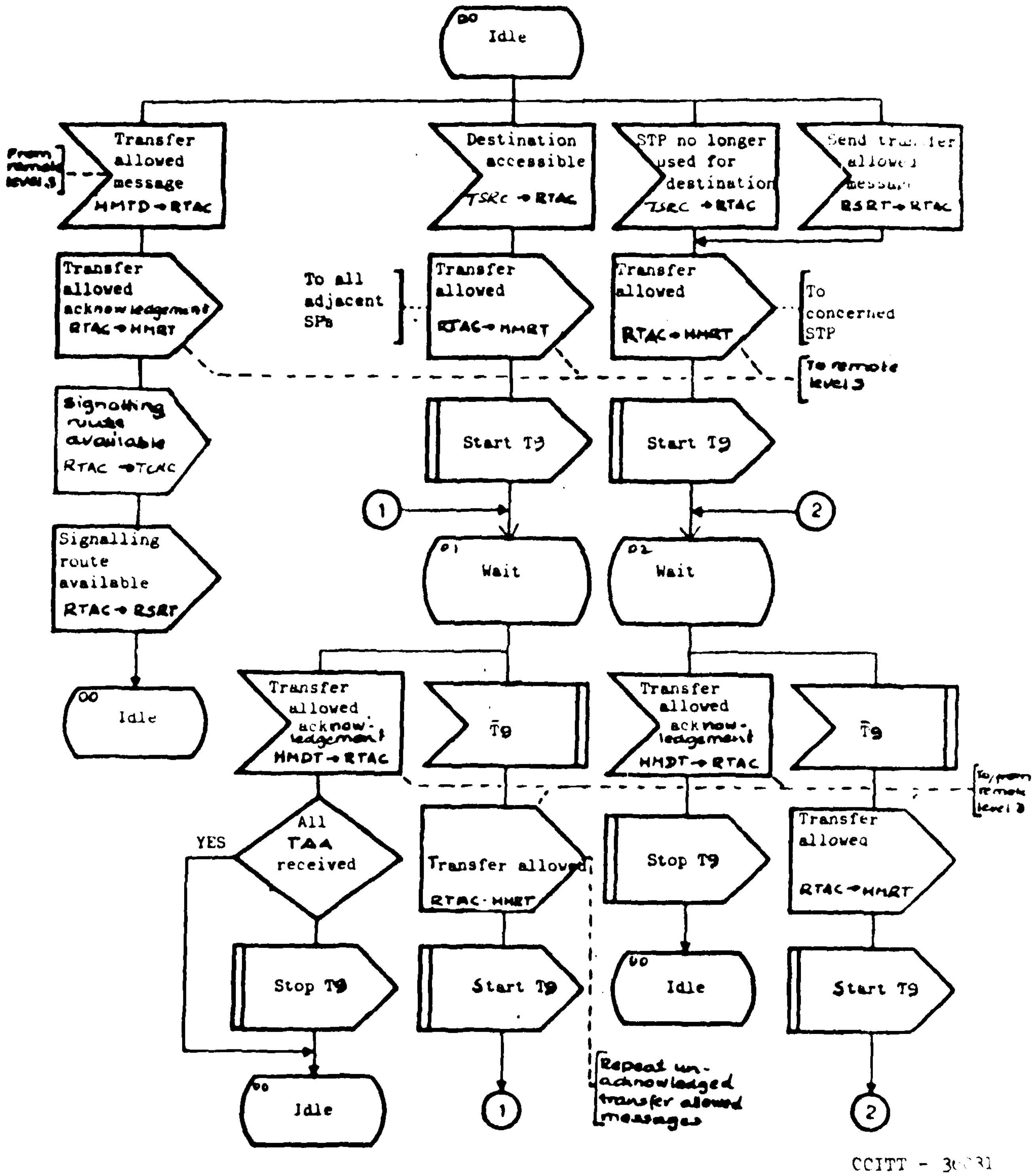


Figure 14-23 (Q.704) - Signalling route management; Transfer allowed control (RTAC)

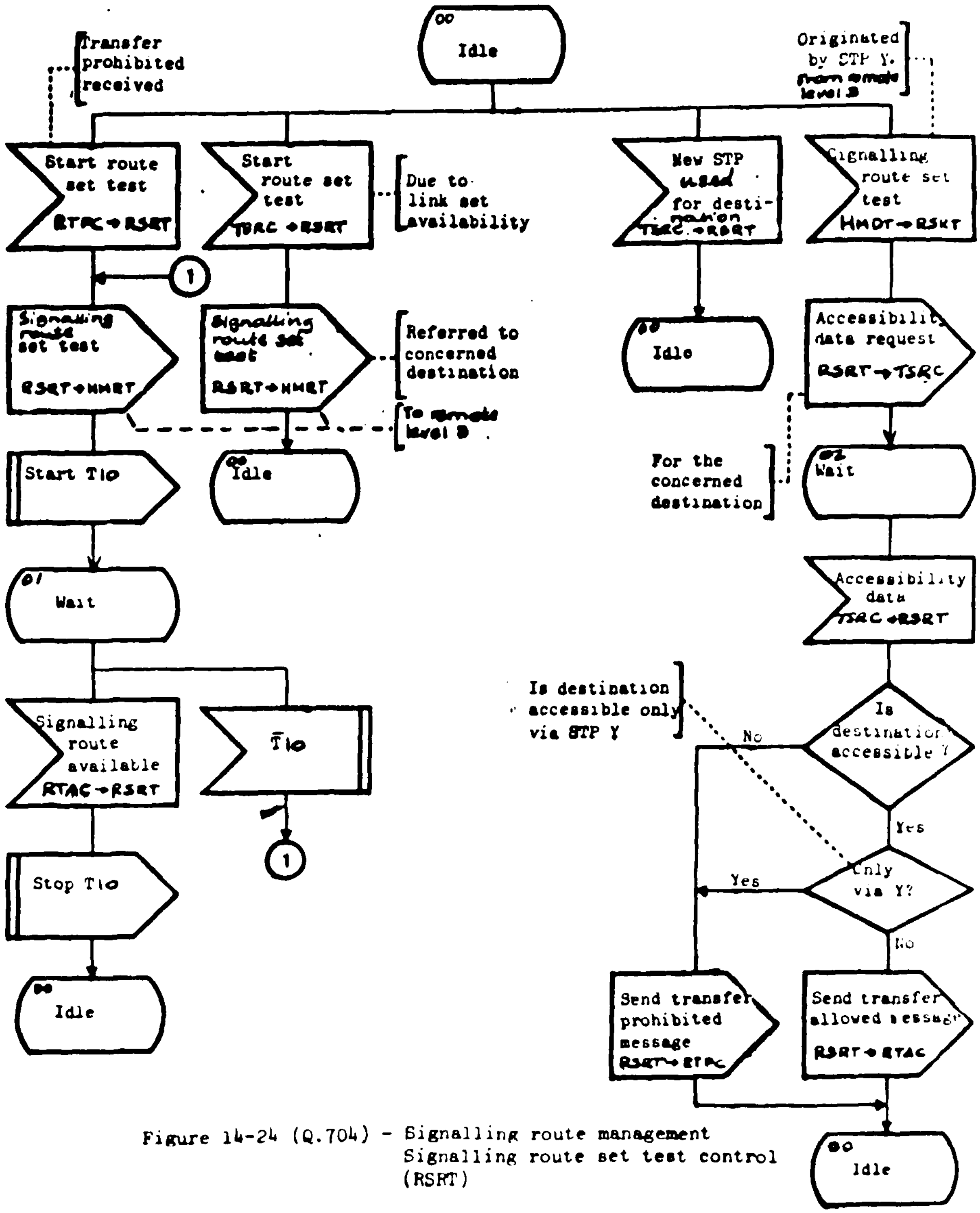


Figure 14-24 (Q.704) - Signalling route management
Signalling route set test control
(RSRT)

ANNEX A

Signalling Link Management and Signalling Traffic Management by the Switchover Method

A.1 General

A.1.1 This Annex describes a set of actions and procedures for signalling link management which is an alternative to some of the procedures specified in Section 10, and which is intended for use within national integrated digital networks, in particular for local exchange networks. Alternative signalling traffic management actions to those specified in Section 5 are also described.

A.1.2 The switchover method is characterised by its response to signalling link failure in that before changeover of signalling traffic is initiated, an attempt is made to restore the failed signalling link using the switchover procedure to rapidly connect a new signalling data link between the signalling terminals of the failed signalling link. Changeover of the affected signalling traffic takes place only if the signalling link has not been restored within a specified time interval. Since the latter case is expected to be encountered in only a small proportion of failure situations, and since the introduction of a delay before diversion of signalling traffic reduces the probability of message sequence errors, a subset of the emergency changeover procedures is employed in conjunction with the method.

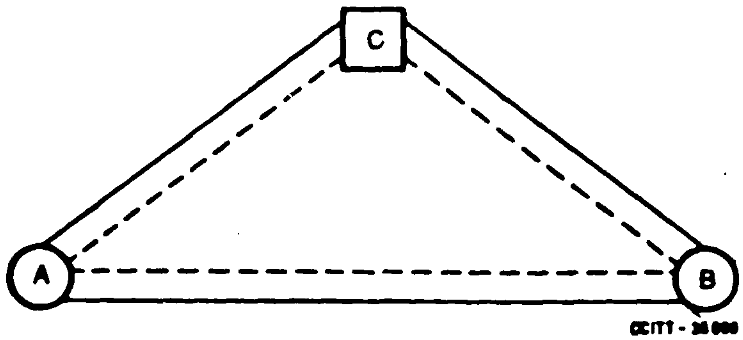
A.1.3 The functions described in this Annex are consistent with and are accommodated within the functional organization shown in Figure 1-1 (Q.704).

A.1.4 Apart from additions and modifications to signalling link management itself, no further modifications are necessary in level 3 procedures. It should be noted, however, that within signalling traffic management, only a subset of the changeover procedure is needed by the switchover method (see Section A.6).

A.1.5 In addition to the above, the switchover method requires that some additions be made to the level 2 procedures and that provision be made for monitoring the error performance of standby signalling data links which are not connected to signalling terminals (see Section A.6).

A.2 Principles of the switchover method

The switchover method is intended for application within signalling network configurations in which all, or some large fraction, of the signalling points are interconnected by non-duplicated signalling links. The basic principles of the switchover method may be described with reference to the simple configuration shown in Figure A.2-1 (Q.704).



Active signalling link

Standby signalling data link

Figure A.2-1 (Q.704) - Simple network configuration to illustrate the switchover method

A.2.1 Actions on detection of a failure

Failure of the signalling data link between signalling points A and B will normally be detected by level 2 functions at each end of the signalling link and level 3 will be notified before each level 2 function automatically goes out of service. As soon as it is notified of the failure, signalling traffic management at each end initiates buffering of messages destined for the failed link. At this point, instead of performing the normal changeover procedure with exchange of changeover messages and retrieval of unacknowledged messages from level 2, it begins a time-out which is inherent in the emergency changeover procedures described in Section 5.6.2. At the same time, signalling link management initiates replacement of the failed signalling data link by a predetermined standby signalling data link, using the switchover procedure in an attempt to rapidly restore the failed signalling link. Having been connected to the new signalling data link, the signalling terminals resume normal operation starting at the points in the transmission (or retransmission) procedure at which they were interrupted at the time of failure. Provided that this signalling link restoration attempt is successful, no messages are lost, duplicated or sent out of sequence. The switchover procedure is described in more detail in Section A.3.

No initial alignment of the signalling link is initiated, instead signalling traffic management is notified of the recovery of the failed signalling link, and provided that recovery is completed within the above mentioned time-out interval, the buffered signalling traffic is released onto the recovered signalling link followed by subsequent signalling messages. If, however, signalling traffic management completes the time-out without being notified of recovery of the failed signalling link, signalling traffic is diverted onto one or more alternative signalling routes (e.g. ACB in Figure A.2-1 (Q.704)) without exchange of changeover signals or retrieval of messages from level 2 of the failed signalling link, the latter messages being discarded.

Once the signalling link has been satisfactorily restored to service, signalling link management initiates a standby data link selection procedure to automatically select a new standby signalling data link. This procedure is described in more detail in Section A.4.

In order to allow the signalling terminals to resume normal operation at the point where they were interrupted by signalling data link failure, it is necessary to avoid performing the initial alignment procedure on the signalling link prior to restarting signalling traffic on it. Therefore a means has to be provided to continuously monitor the error performance of a standby signalling data link prior to its connection to a level 2 function. The details of such an error monitor require further study (see Section A.6).

Note - The above description outlines only the normal flow of signalling traffic and signalling link management actions which would follow a typical signalling link failure caused by failure of the signalling data link. Signalling link management actions taken in the event of more complex failure situations (e.g. signalling terminal failure) are identical to those described in Section 10.4.

A.2.2 Actions resulting from management blocking of a signalling link

Consider the events following the blocking of the signalling link between signalling link points A and B in Figure A.2.1 (Q.704) as a result of management system action (automatic or manual) at signalling point A. Such an action may, for example, precede the removal of the affected signalling link from service for maintenance or other purposes.

As already stated above, the switchover method employs a subset of the emergency changeover procedures in which no retrieval of message signal units from the concerned signalling link is attempted. In order to avoid message signal units being lost when changeover results from management system blocking, it is necessary to ensure that the transmission and reception of message signal units, by the level 2 functions over the concerned signalling link, continues for some time after the emergency changeover procedure (described in Section 5.6.2) has been initiated by level 3. This allows all of the message signal units contained in the level 2 transmission and retransmission buffers, at signalling points A and B, to be transmitted and acknowledged before the signalling link is taken out of service, The above capability is made possible by introducing a time-out procedure within Level 2. This is described in detail in Section A.5.

A.3 Switchover procedure

A.3.1 General

The objective of the switchover procedure is to recover a failed signalling link as quickly as possible without introducing message loss, duplication or sequence errors.

Higher level recovery measures employed when the switchover procedure is unable to recover the failed signalling link, are described in Section 10.4.

A.3.2 Criteria for initiation of the switchover procedure

Switchover is the first measure employed by the signalling link restoration procedure following the detection of signalling link failure. The criteria which initiate switchover (as part of signalling link restoration) are identical to those which are described in Section 3.2.2 and which would normally cause signalling link initial alignment to be initiated (see Section 10.4.2) in parallel with the normal changeover procedure.

A.3.3 Actions following signalling link failure

A.3.3.1 Following signalling link failure, signalling link restoration is initiated and its first signalling link restoration attempt is based upon the use of the switchover procedure, to switch the standby signalling data link to the signalling terminal of the failed signalling link. Following the above action, level 2 begins to continuously transmit fill-in signal units. Level 2 then proceeds to the aligned/ready state as soon as it correctly receives one fill-in signal unit.

A.3.3.2 If level 3 receives an in service or remote processor outage indication from level 2, the signalling link restoration attempt is considered successful, the signalling link is once more considered to be active and signalling traffic management is informed. Finally the standby data link selection procedure is initiated. This procedure will select a new error monitored standby signalling data link for the recovered signalling link.

A.3.4 Procedures for abnormal conditions

A.3.4.1 If the initial signalling link restoration attempt cannot be completed (because no standby data link is allocated) or is unsuccessful (because level 2 indicates out of service or a level 2 failure is suspected), further signalling link restoration and/or activation measures are performed. These measures are exactly as specified in Section 10.4.2 for the case when the initial signalling link restoration attempt (based on attempted initial alignment of the failed signalling link) is not successful.

A.3.4.2 When a failed signalling link is restored (or an alternative signalling link is activated) signalling traffic management is informed and the standby data link selection procedure is initiated in order to select a standby signalling data link for the restored (or activated) signalling link.

A.4 Standby data link selection procedure

A.4.1 General

The standby data link selection procedure is used by signalling link management to determine a new standby data link which can be used for switchover purposes (see Section A.3.3.2) and which is dedicated to a particular signalling link.

The procedure is dependant on at least one other signalling data link being available between two signalling points in addition to the active signalling data link (i.e., the signalling data link which is in use as part of the working signalling link for which the standby data link will be selected). The signalling data link chosen to become a standby should be selected in such a way as to take advantage of transmission facility diversity with respect to the active signalling data link, in order to minimize the chances of the same fault disabling both the active and standby signalling data link. The procedure makes use of the automatic signalling data link allocation procedure described in Section 10.6.

A.4.2 Criteria for initiation of standby data link selection

The following events result in the initiation of the standby data link selection procedure:

a) An intolerable error rate is recognized on the standby signalling data link (by a standby data link error monitor, see Section A.6) while the signalling link, to which it is assigned, is still active.

b) Restoration or activation of a signalling link (see Section 10.4) is completed.

A.4.3 Standby data link selection

A.4.3.1 If standby data link selection is initiated at the local end of thesignalling link, as a result of either of the criteria identified in Section A.4.2, the automatic signalling data link allocation procedure described in Section 10.6 is used to allocate a signalling data link for the signalling link concerned. Provided that the signalling data link is allocated successfully, the data link is identified as being the new standby data link for the concerned signalling link and error monitoring of the new standby link is initiated.

A.4.3.2 If standby data link selection is initiated at the remote end of the concerned signalling link, a signalling data link is allocated using the procedure above. Provided the concerned signalling link is active (i.e. not out of service or in the process of initial alignment), the allocated signalling data link is recognized as being a new standby data link (as distinct from a signalling data link to be used in a restoration or activation attempt currently in progress) and error monitoring of the new standby data link is initiated.

A.4.4 Procedures for abnormal conditions

A.4.4.1 If standby data link selection is initiated at the local end of the concerned signalling link but no signalling data link is available, further attempts to select a signalling data link are repeated at intervals of TA2 (value for further study) until either an attempt is successful or the signalling link ceases to be active (as the result of signalling link failure or signalling link deactivation).

A.5 Procedure for management blocking of a signalling link

As noted in Section A.2.2, when blocking of a signalling link is initiated by a management system action, it is necessary to ensure that transmission and reception of message signal units by the level 2 function on the concerned link continues for some time after emergency changeover has been initiated. This is achieved by level 2, which, while it is in the in service state, responds to indications of local or remote processor outage (received from level 3 or remote level 2 respectively) as described below.

In Figure A.2-1 (Q.704), at signalling point A, i.e., at the signalling point where blocking of the signalling link AB is initiated, level 3 sends a local processor outage indication to level 2 which starts a time-out TA4 = 100 ms(provisional value) but remains in service, sending and receiving message signal units normally. At the expiry of the time-out interval, if the level 2 transmission and retransmission buffers are empty, level 2 begins to continuously transmit link status signal units indicating processor outage as specified in Section 3.3.3. If, however, the level 2 buffers are not empty, the time-out is restarted.

At signalling point B, upon receiving a link status signal unit indicating processor outage on the signalling link AB, level 2 immediately notifies level 3 of the remote processor outage condition and starts a time-out TA4 as above, meanwhile remaining in service. At the expiry of the time-out interval, if the level 2 transmission and retransmission buffers are empty, level 2 begins to continuously transmit fill-in signal units. If however, the level 2 buffers are not empty, the notification of remote processor outage to level 3 is repeated and the time-out is restarted.

Note - In the above procedure it is an implicit assumption that level 2 at signalling point A continues to accept and acknowledge message signal units received over the concerned signalling link from signalling point B while simultaneously sending link status signal units indicating processor outage.

A.6 Impact on MTP functions

The impact of the switchover method on Message Transfer Part functions is summarized in Table A.6-1 (Q.704).

A.6.1 Level 3 - signalling link management

A.6.1.1 In order to accommodate the switchover and standby data link selection procedures, the following changes are required to the standby set of signalling link management functions. No standard functions are replaced, one new function (standby data link selection) is added, additional logic is inserted into one standard function (signalling link activity control) and additional logic replaces one portion of another standard function (signalling link restoration). The overall impact of the switchover method on the functional structure of signalling link management is illustrated in Figure A.6-1 (Q.704).

A.6.1.2 The switchover procedure is incorporated into the signalling link restoration procedure defined in Section 10.4.2. It replaces the first signalling link initial alignment attempt in the normal signalling link restoration procedure as described in Section A.3. The impact on the signalling link restoration function is illustrated in Figure A.6-2 (Q.704).

A.6.1.3 Standby data link selection is a new procedure which is defined in addition to the standard signalling link management procedures. The operation of the procedure is described in Section A.4 while the logic of the procedure is illustrated in Figure A.6-3 (Q.704) in the form of a new functional element, standby data link selection, which is activated by signalling link activity control.

A.6.1.4 In order to accommodate the standby data link selection procedure some additions are necessary to the signalling link activity control function as illustrated in Figure A.6-4 (Q.704).

A.6.2 Level 3 - signalling traffic management

A.6.2.1 The only impact of the switchover method on signalling traffic management is within the changeover control function and the link availability control function. Since changeover messages are never exchanged in the switchover method, the changeover control function reduces to a subset of the standard changeover control function as illustrated in Figure A.6-5 (Q.704). Similarly some simplification of the link availability control function is possible as illustrated in Figure A.6-6 (Q.704). No other changes are necessary within signalling traffic management.

A.6.3 Level 2 - signalling link control

Modifications required to functional level 2 are restricted to the link state control function (see [2]). The modifications relate to the addition of 2 new states to the link state control function.

The first new state is one in which level 2 emits and receives fill-in signal units only. This forms part of a logical path via which level 2 can pass from the out of service state to the in service state without performing initial alignment (as described in Section A.2.1).

The second new state is a wait state in which level 2 awaits the expiry of a time-out interval TA4 before proceeding to the processor outage state (as described in Section A.5 above).

The required additions are illustrated in Figure A.6-7 (Q.704).

A.6.4 Level 1 - signalling data link

In order to provide for error monitoring of a standby signalling data link, some additions may be required to functional level 1. An error monitor is required which would give an early indication of standby data link failure, thus enabling a new standby data link to be rapidly assigned if necessary. The means by which such error monitoring should be performed requires further study.

Note - As an alternative to monitoring the error rate on each individual standby signalling data link (e.g., by using a signal unit error rate monitor similar to that employed by functional level 2), it may be possible to monitor the error performance of a primary digital PCM multiplex system using the synchronisation channel (i.e., time slot 0 in the case of G.732 based systems or the framing bit in the case of G.733 based systems).

TABLE A.6-1 (Q.704)

Impact of the switchover method on Message Transfer Part functions - summary

Functional level	Function	Impact	
		Type	Figure in Q.704
3	Signalling link management	see below	A.6-1
	- signalling link activity control	additional logic	A.6-4
	- signalling link restoration	additional logic	A.6-2
	- standby data link selection	new function	A.6-3
	Signalling traffic management	see below	
	- link availability control	slightly simplified	A.6-6
	- changeover control	considerably simplified	A.6-5
2	Link state control	additional logic	A.6-7
1	Signalling data link	error monitor required	-

ABBREVIATIONS USED IN FIGURES A.6-1 to A.6-7 (Q.704)

BSNT - Backward sequence number of next signal unit to be transmitted

FISU - Fill-in signal unit

FSNC - Forward sequence number of last message signal unit accepted by remote level 2

HMDT - Message distribution

HMRT - Message routing

IAC - Initial alignment control

L1 - Level 1

L2 - Level 2

L3 - Level 3

LLSC - Link set control

LSAC - Signalling link activity control

LSC - Link state control

LSDA - Signalling data link allocation

LSDS - Standby data link selection

LSLA - Signalling link activation

LSLD - Signalling link deactivation

LSLR - Signalling link restoration

LSTA - Signalling terminal allocation

MGMT - Management system

MSU - Message signal unit

POC - Processor outage control

RC - Reception control

SIE - Status indication "emergency"

SIN - Status indication "normal"

SIO - Status indication "out of alignment"

SIOS - Status indication "out of service"

SIPO - Status indication "processor outage"

SLM - Signalling link management

STM - Signalling traffic management

SUERM - Signal unit error rate monitor

TCBC - Changeback control

TCOC - Changeover control

TLAC - Link availability control

TSRC - Signalling routing control

TXC - Transmission control

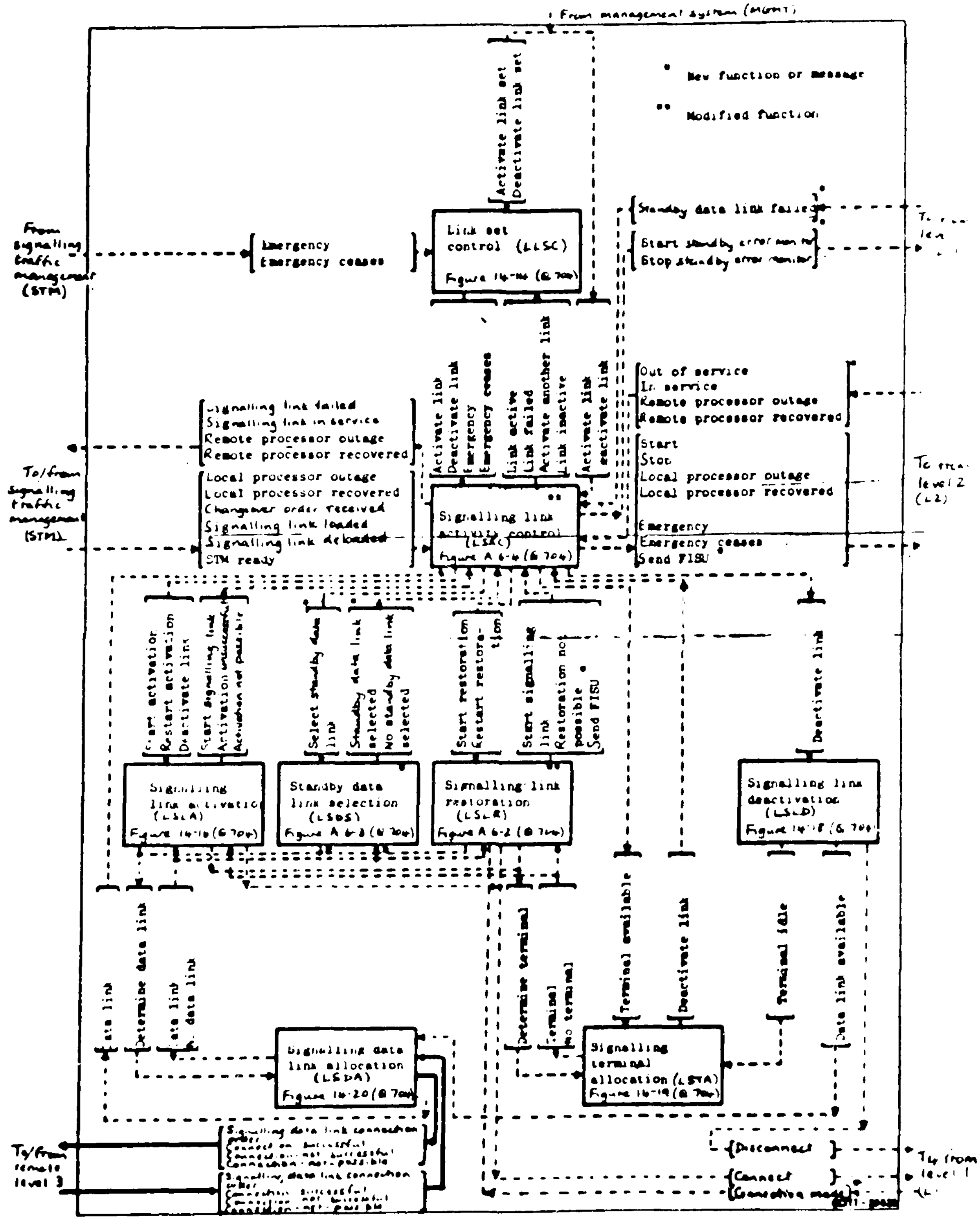


Figure A.6-1 (Q.704) - Level 3 - Signalling link management (SLM); Functional block interactions (Impact of switchover method)
(c.f. Figure 14-13 (Q.704))

(3854)

ABBREVIATIONS USED IN FIGURES A.6-1 to A.6-7 (Q.704) (cont.)

Timers

TA1 - Waiting for connection of new signalling data link (during switchover)

TA2 - Delay to limit frequency of standby data link selection attempts

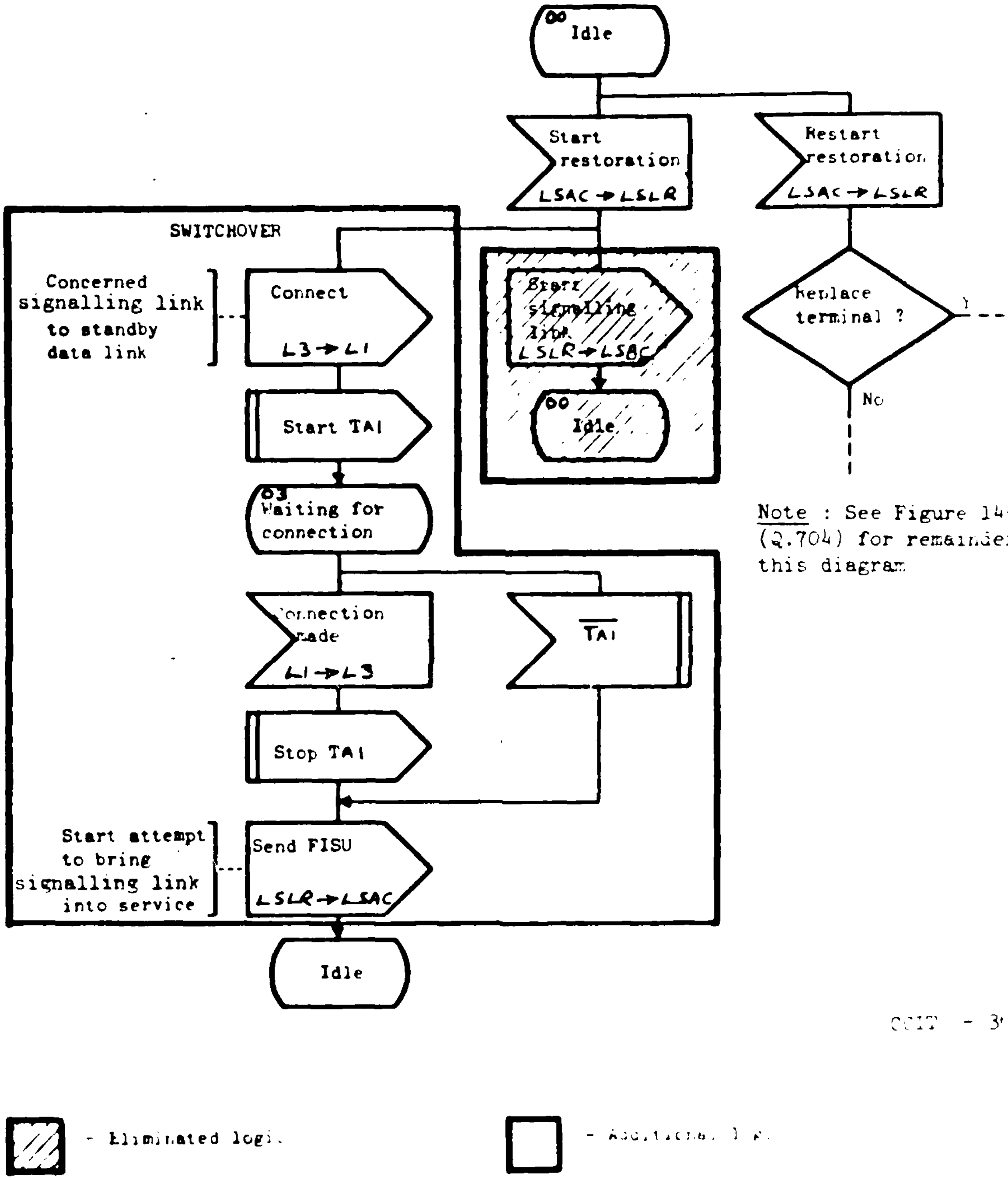
TA3 - Waiting for indication of FISU reception (confirming successful switchover)

TA4 - Delay to allow transmission and retransmission buffers (level 2) to empty before initiating processor outage action

T1 - (level 3) Delay to avoid message mis-sequencing on changeover

- (level 2) Waiting for indication of FISU/MSU reception

T2 - (level 3) Waiting for changeover acknowledgement



Note : See Figure 14-17 (Q.704) for remainder of this diagram

Figure A.6-2 (Q.704) - Level 3 - Signalling link management; Signalling link restoration (LSLR) (Impact of switchover method) (c.f. Figure 14-17 (Q.704))

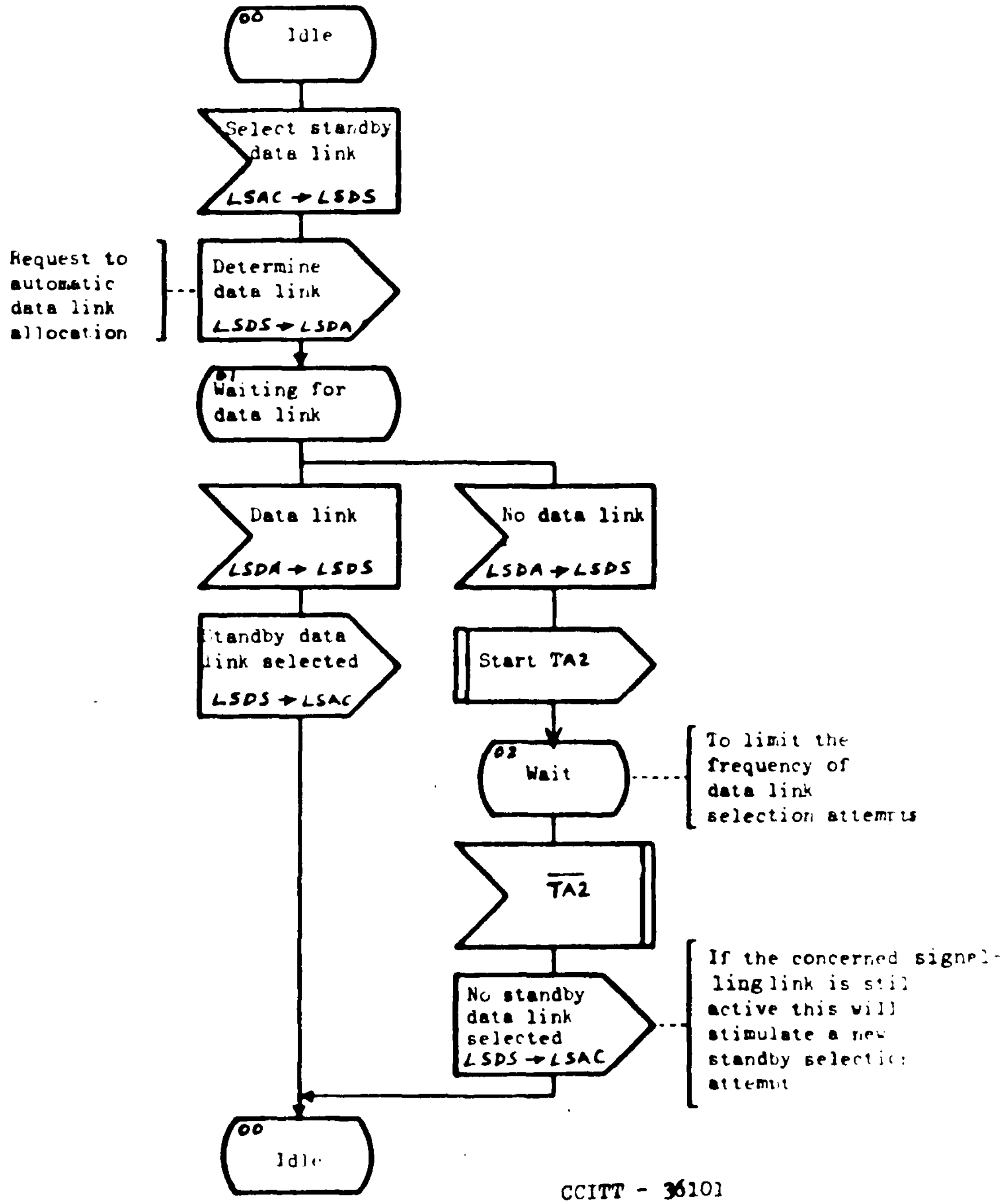


Figure A.6-3 (Q.704) - Level 3 - Signalling link management; Standby data link selection (LSDS) (new function required for the switchover method)

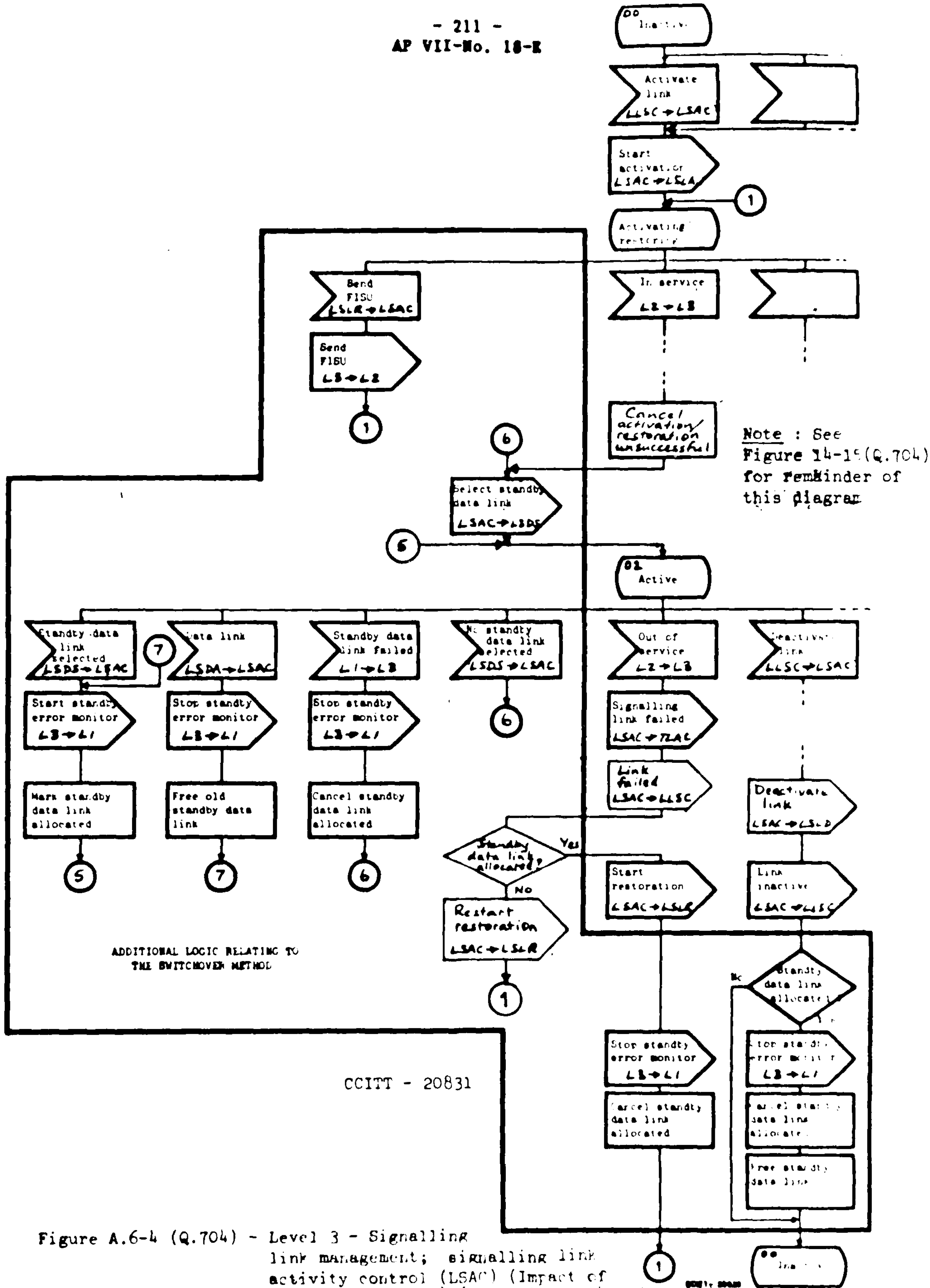
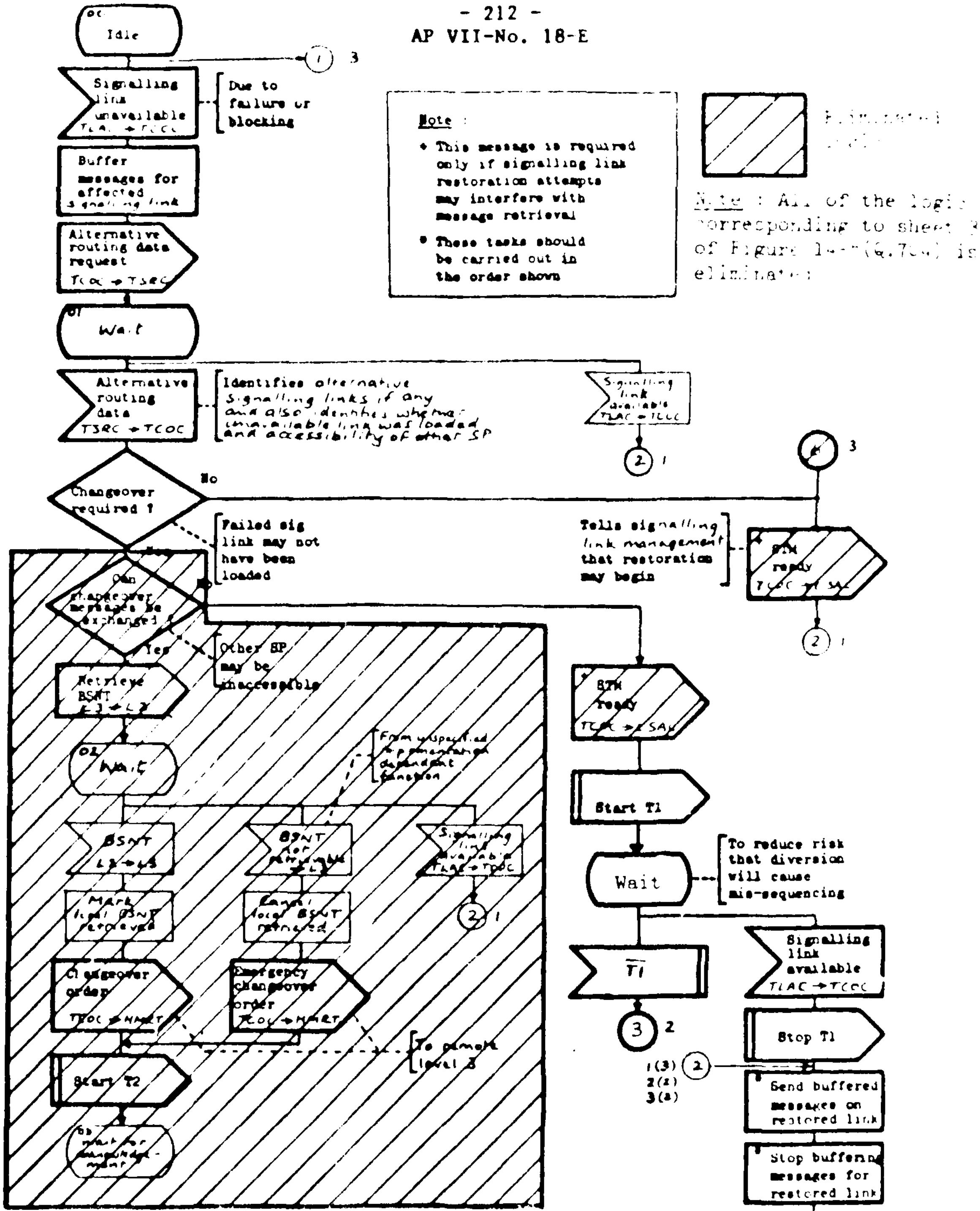


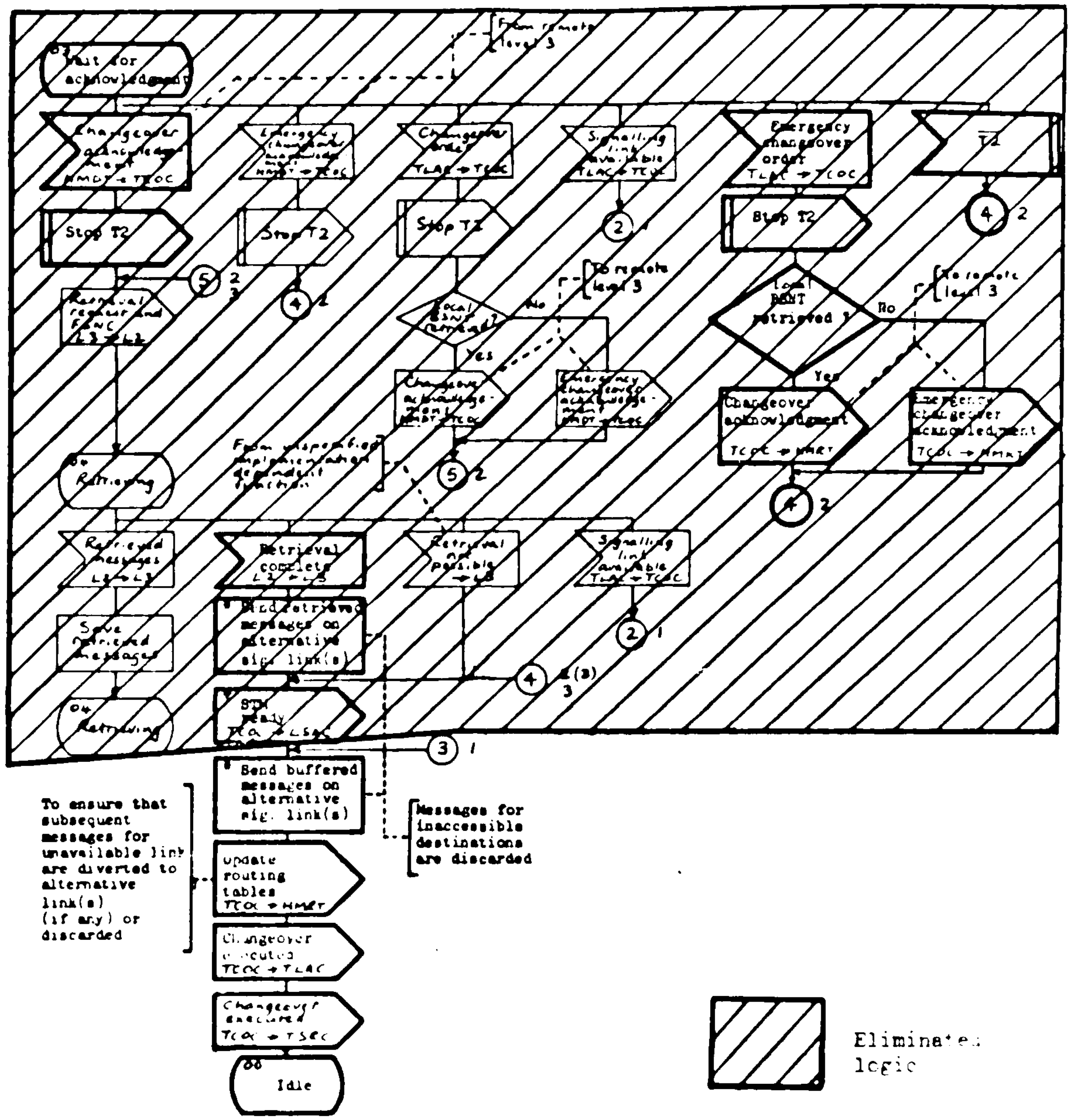
Figure A.6-4 (Q.704) - Level 3 - Signalling link management; signalling link activity control (LSAC) (Impact of switchover method) (c.f. Figure 14-15(Q.704)



BSNT = Backward sequence number of next signal unit to be transmitted

Figure A.6-5(Q.704) (Sheet 1 of 2) - Level 3 - Signalling traffic management; Changeover control (TCOC) (Impact of switchover method) (c.f. Figure 14-8(Q.704))

(3854)



FSNC = Forward sequence number of last message signal unit accepted by remote level 2

Figure A.6-5(Q.704) (Sheet 2 of 2) - Level 3 Signalling traffic management; Changeover control (TCOC) (Impact of switchover method) (c.f. Figure 18-8(Q.704))

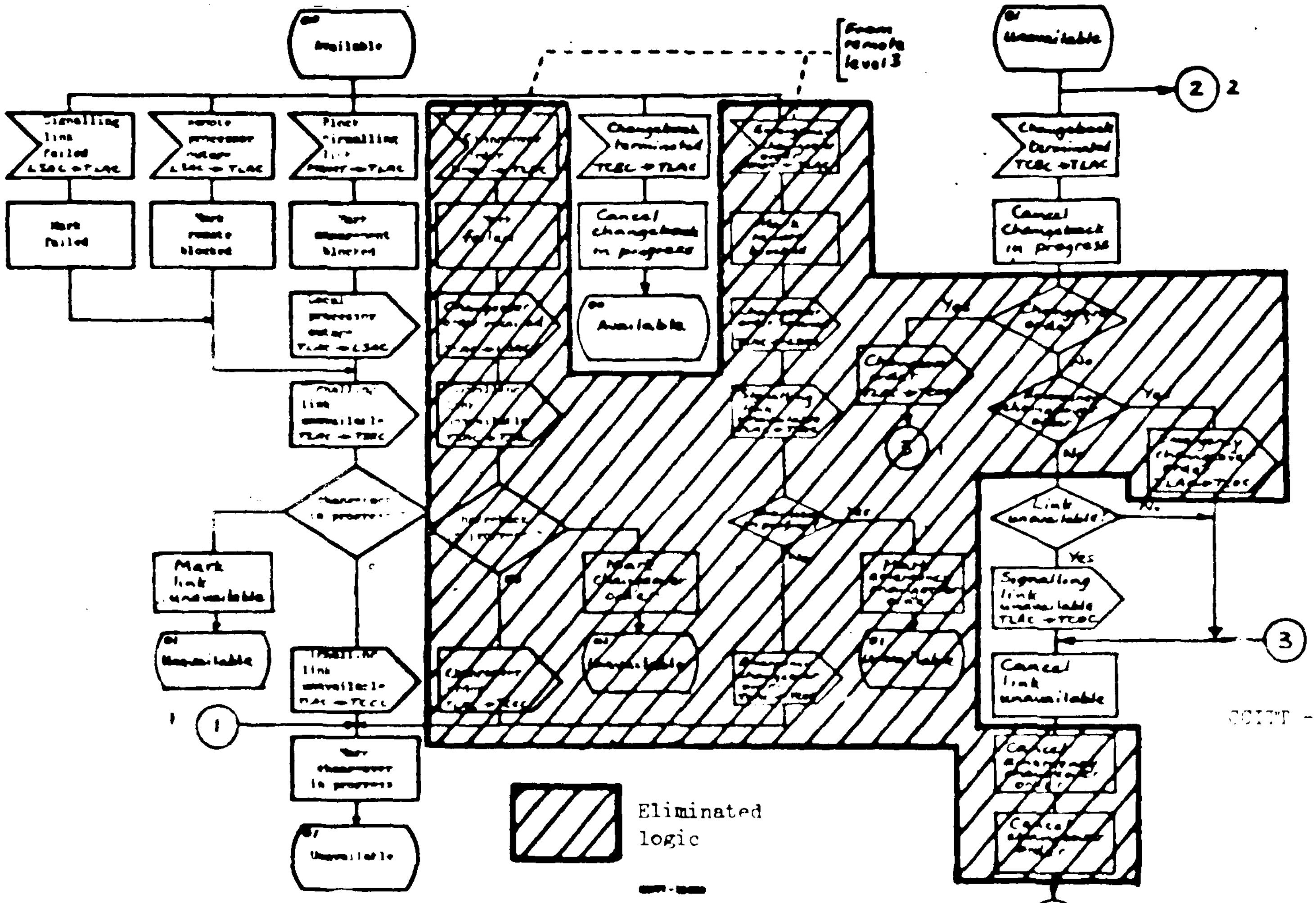


Figure A.6-6(Q.704) (Sheet 1 of 2) - Level 3 - Signalling traffic management;
Link availability control (TLAC)
(Impact of switchover method)
(c.f. Figure 14-6(Q.704))

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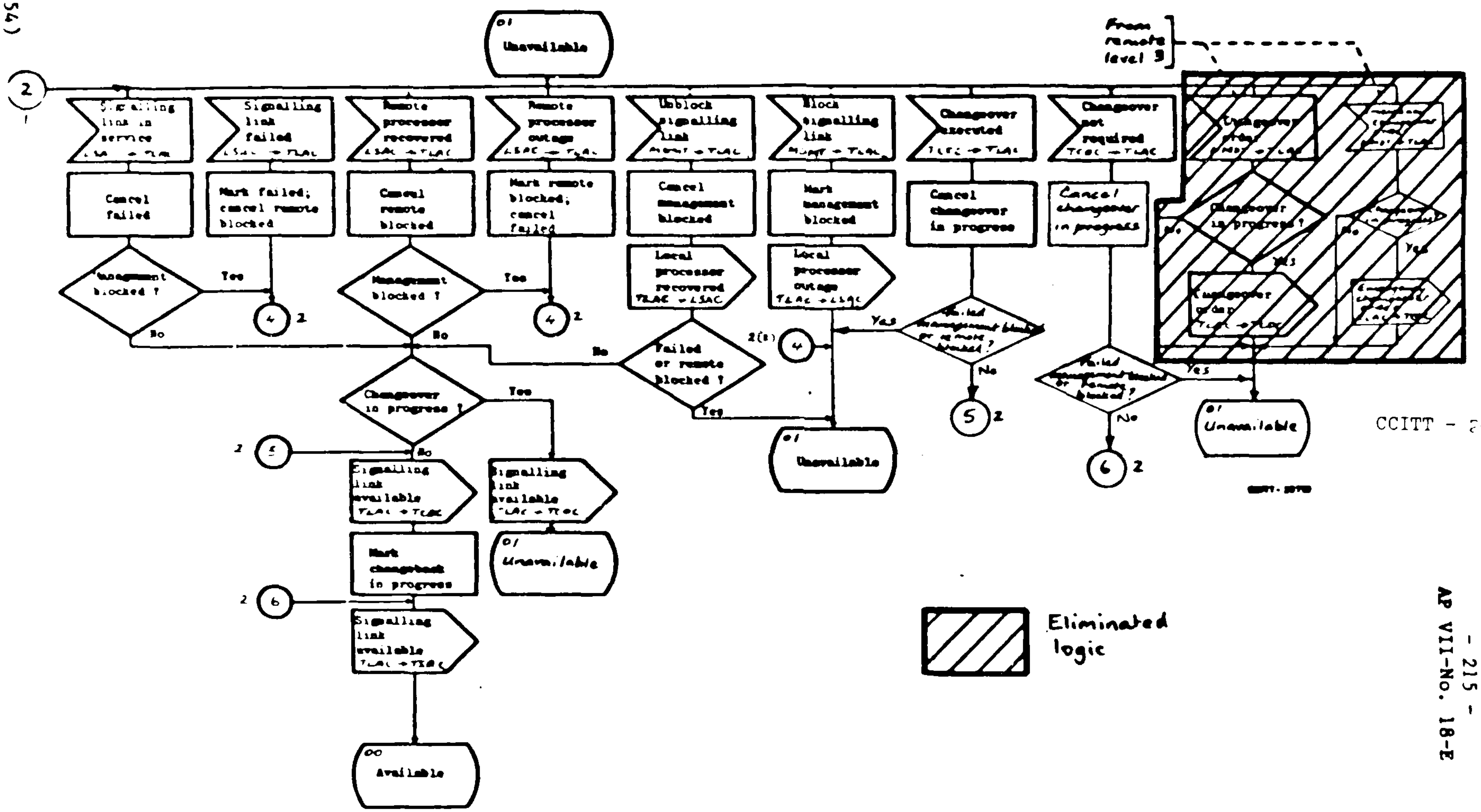
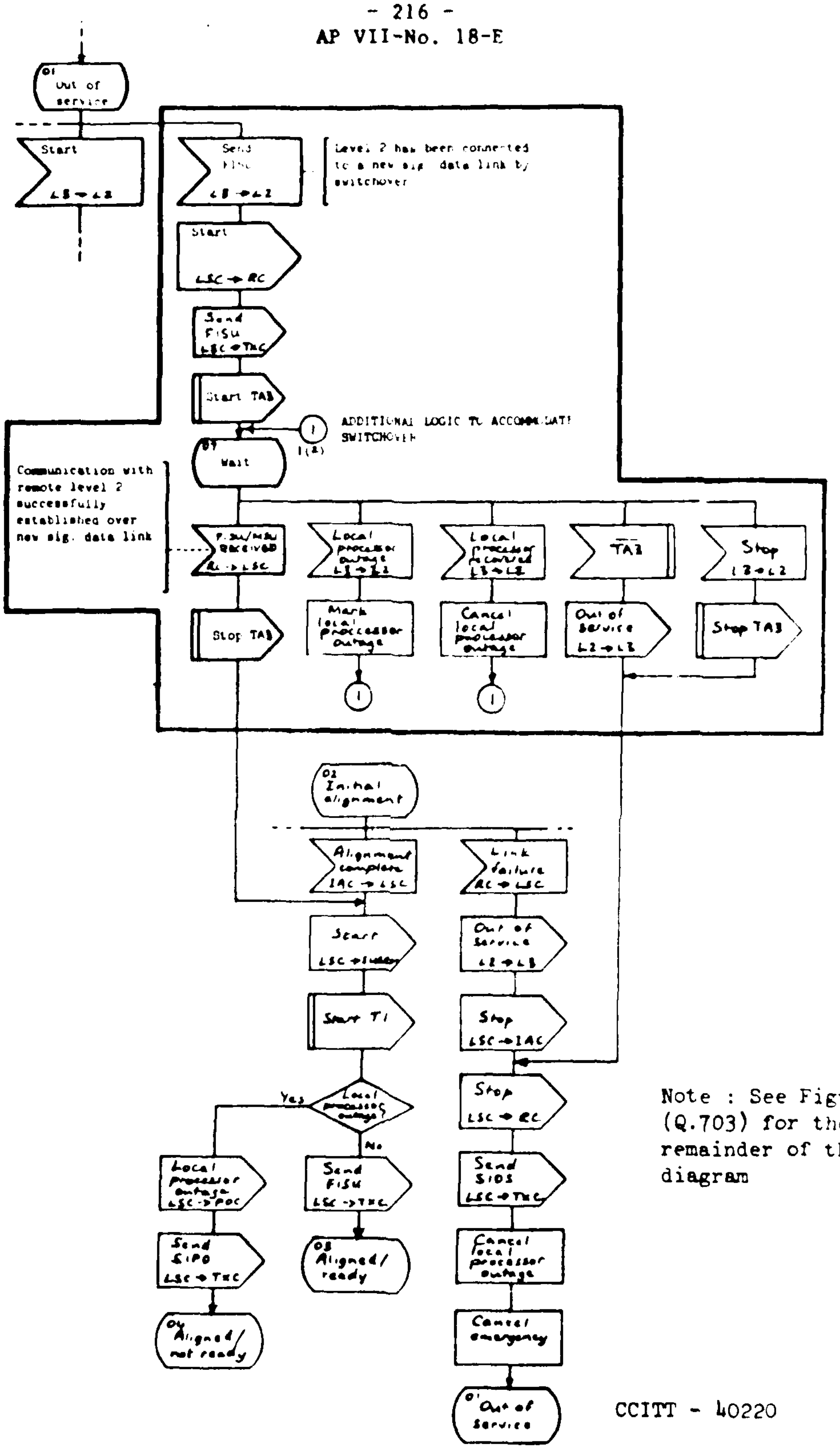


Figure A.6-6 (Q.704) (Sheet 2 of 2) - Level 3 - Signalling traffic management
Link availability control (TLAC)
(Impact of switchover method)
(c.f. Figure 14-6 (Q.704))

(3854)



Note : See Figure 11-2 (Q.703) for the remainder of this diagram

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Figure A.6-7 (Q.704) (Sheet 1 of 3) - Level 2 - Link state control (LSC)
(Impact of switchover method)
(c.f. Figure 11-2 (Q.703))

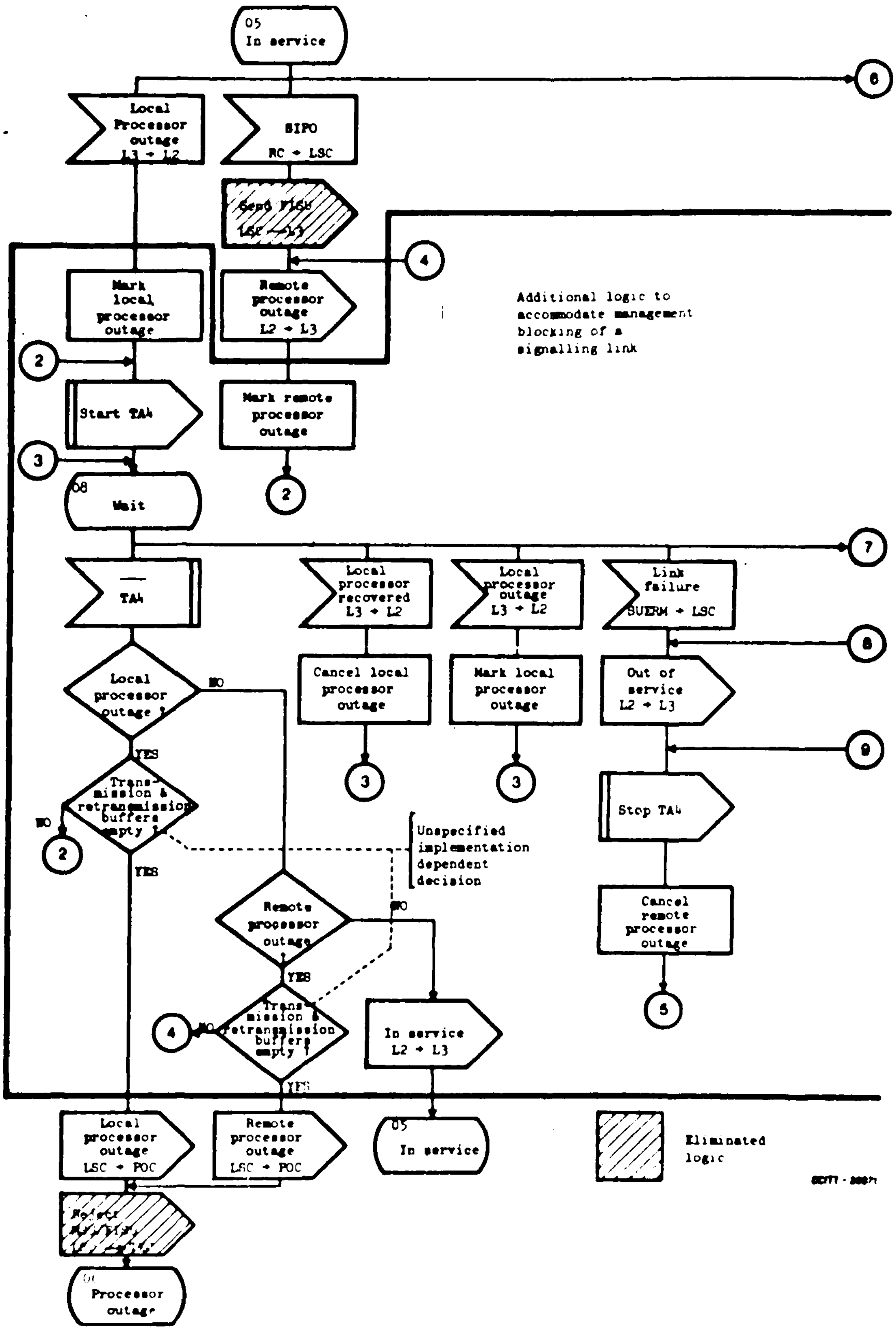


Figure A.6-7 (Q.704) (Sheet 2 of 2) - Level 2 - Link state control (LSC)
(Impact of switchover method)
(c.f. Figure 11-[illegible] (Q.704))

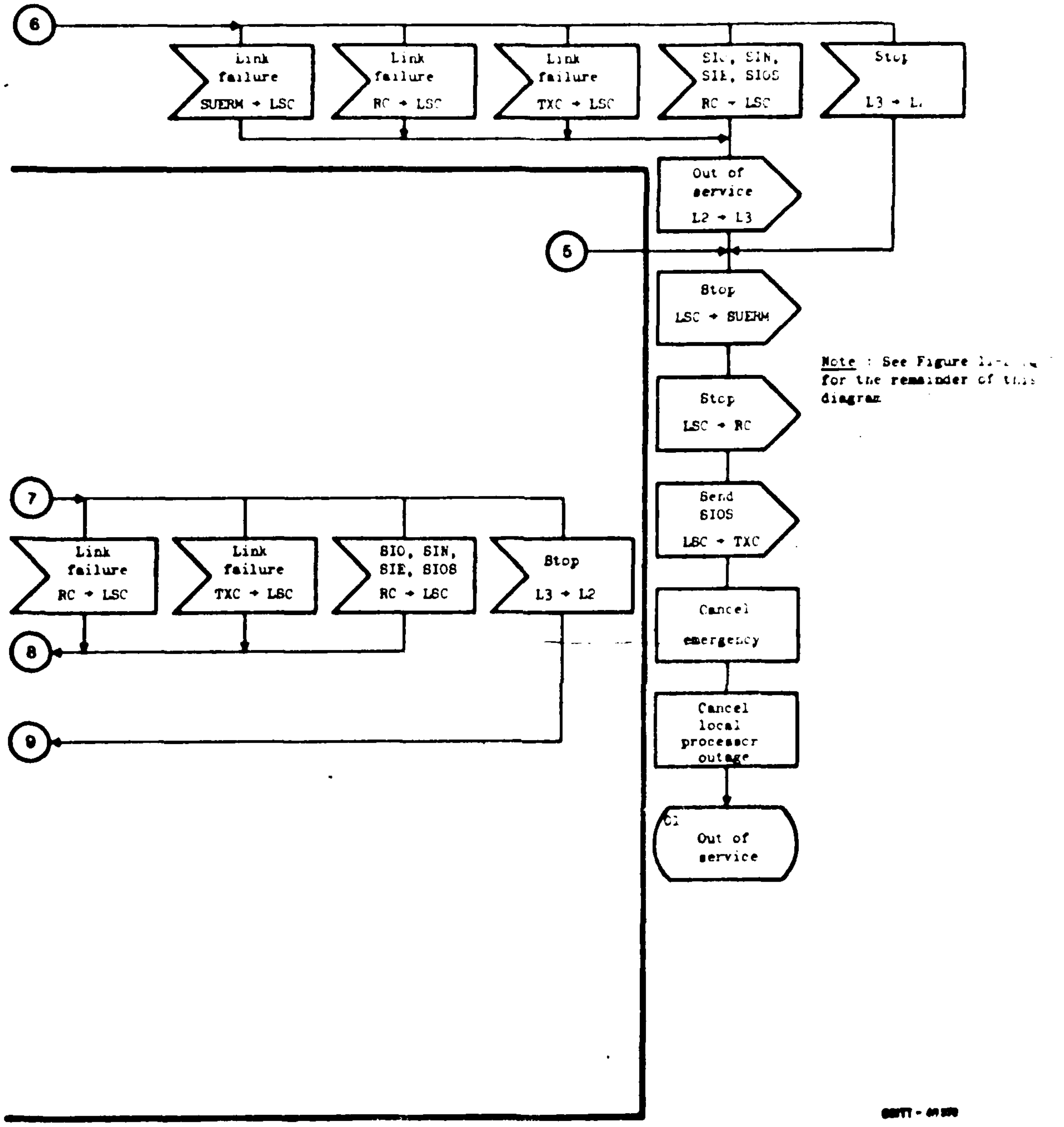


Figure A.6-7 (Q.704) (Sheet 3 of 3) - Level 2 - Link state control (LSC)
(Impact of switchover method)
(c.f. Figure 11-2 (Q.703))

References

[1] CCITT Recommendation, Signalling Data Link, Yellow Book, Vol. VI.7, Rec. Q.702.

[2] CCITT Recommendation, Signalling Link, Yellow Book, Vol. VI.7, Rec. Q.703.

[3] CCITT Recommendation, Signalling System Performance, Yellow Book, Vol. VI.7, Rec. Q.706.

[4] CCITT Recommendation, Testing and Maintenance, Yellow Book, Vol. VI.7, Rec. Q.707.

[5] CCITT Recommendation, Signalling Network Structure, Yellow Book, Vol. VI.7, Rec. Q.705.

[6] CCITT Recommendation, Signalling Link, Yellow Book, Vol. VI.7, Rec. Q.703, Section 9.

[7] CCITT Recommendation, Signalling Link, Yellow Book, Vol. VI.7, Rec. Q.703, Section 4.1.

[8] CCITT Recommendation, Signalling Link, Yellow Book, Vol. VI.7, Rec. Q.703, Section 5.3.

[9] CCITT Recommendation, Signalling Link, Yellow Book, Vol. VI.7, Rec. Q.703, Section 6.3.

[10] CCITT Recommendation, Signalling Link, Yellow Book, Vol. VI.7, Rec. Q.703, Section 1.7.

[11] CCITT Recommendation, Signalling Link, Yellow Book, Vol. VI.7, Rec. Q.703, Section 8.

[12] CCITT Recommendation, Signalling Network Structure, Yellow Book, Vol. VI.7, Rec. Q.705.

[13] CCITT Recommendation, Signalling Network Structure, Yellow Book, Vol. VI.7, Rec. Q.705, Annex A.

[14] CCITT Recommendation, Signalling Link, Yellow Book, Vol. VI.7, Rec. Q.703, Section 7.3.

[15] CCITT Recommendation, Signalling Link, Yellow Book, Vol. VI.7, Rec. Q.703, Section 2.

Recommendation Q.705

SIGNALLING NETWORK STRUCTURE

1 Introduction

This Recommendation describes aspects which are pertinent to and should be considered in the design of international signalling networks. Some or all of these aspects may also be relevant to the design of national networks. Some aspects are dealt with for both international and national networks (e.g. availability), others are discussed in the context of the international network only (e.g. number of signalling transfer points in a signalling relation). A number of aspects require further study for national networks. This Recommendation also gives in Annex A examples of how the signalling network procedures may be applied to the mesh network representation.

The national and international networks are considered to be structurally independent and, although a particular signalling point may belong to both networks, signalling points are allocated signalling point codes according to the rules of each network.

The signalling network procedures are provided in order to effectively operate a signalling network having different degrees of complexity. They provide for reliable message transfer across the network and for reconfiguration of the network in the case of failures.

The most elementary signalling network consists of originating and destination signalling points connected by a single signalling link. To meet availability requirements this may be supplemented by additional links in parallel which may share the signalling load between them. If, for all signalling relations, the originating and destination signalling points are directly connected in this way in a network then the network operates in the associated mode.

For technical or economic reasons a simple associated network may not be suitable and a quasi-associated network may be implemented in which the information between originating and destination signalling points may be transferred via a number of signalling transfer points. Such a network may be represented by a mesh network such as that given in Annex A, as other networks are either a sub set of the mesh network or are structured using this network or its sub sets as components.

2 Network components

2.1 Signalling links

Signalling links are basic components in a signalling network connecting together signalling points. The signalling links encompass the level 2 functions which provide for message error control (detection and subsequent correction). In addition, provision for maintaining the correct message sequence is provided (see Recommendation (Q.703) [1]).

2.2 Signalling Points

Signalling links connect signalling points at which signalling network functions such as message routing are provided at level 3 and at which the user functions may be provided at level 4 if it is also an originating or destination point (see Recommendation (Q.704), Section 2.4 [2]).

A signalling point that only transfers messages from one signalling link to another at level 3 serves as a signalling transfer point (STP).

The signalling links, signalling transfer points, and signalling (originating or destination) points may be combined in many different ways to form a signalling network.

3 Structural independence of international and national signalling networks

The worldwide signalling network is structured into two functionally independent levels, namely the international and national levels, as illustrated in Figure 3-1 (Q.705). This structure makes possible a clear division of responsibility for signalling network management and allows numbering plans of signalling points of the international network and the different national networks to be independent of one another.

A signalling point (SP), including a signalling transfer point (STP), may be assigned to one of three categories:

- national signalling point (signalling transfer point which belongs to the national signalling network only (e.g. NSP1) and is identified by a Signalling Point code (OPC or DPC) according to the national numbering plan of signalling points.

- international signalling point (signalling transfer point) which belongs to the international signalling network only (e.g. ISP3) and is identified by a signalling point code (OPC or DPC) according to the international numbering plan of signalling points.

- a node that functions both as an international signalling point (signalling transfer point) and a national signalling point (signalling transfer point) and therefore belongs to both the international (signalling network and a national signalling network and accordingly is identified by a specific signalling point code (OPC or DPC) in each of the signalling networks.

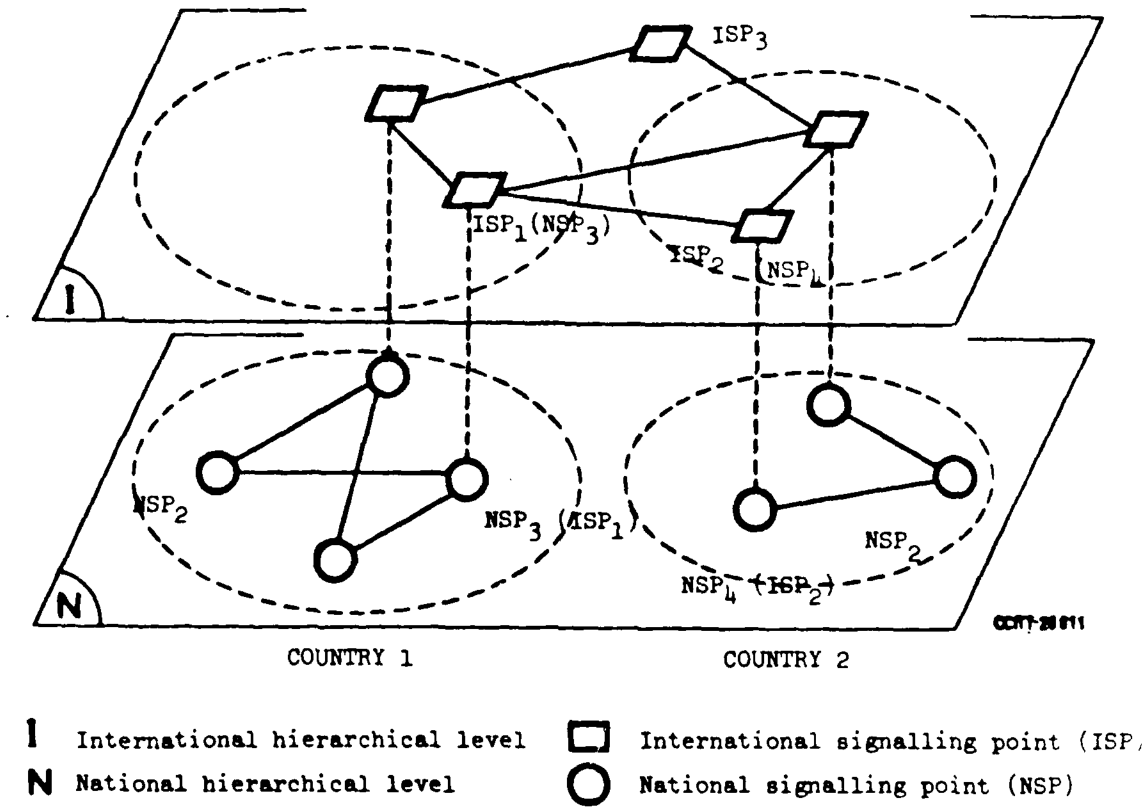


Figure 3-1 (Q.705) - International and national signalling networks

If a discrimination between international and national signalling point codes is necessary at a signalling point, the national indicator is used (see Recommendation (Q.704) Section 12.2 [3]) Rec. (Q.704) Section 12.2 [3].

4 Conside...ons common to both international and national signalling networks

4.1 Availability of the Network

The signalling network structure must be selected to meet the most stringent availability requirements of any User Part served by a specific network. The availability of the individual components of the network (signalling links, signalling points, and signalling transfer points) must be considered in determining the network structure.

4.2 Message Transfer Delay

In order to take account of signalling message delay considerations regard should be given, in the structuring of a particular signalling network, to the overall number of signalling links (where there are a number of signalling relations in tandem) related to a particular user transaction (e.g. to a specific call in the telephone application).

4.3 Message Sequence Control

For all messages for the same transaction (e.g. a telephone call) the Message Transfer Part will maintain the same routing provided that the same signalling link selection code is used in the absence of failure. However, a transaction does not necessarily have to use the same signalling route for both forward and backward messages.

4.4 Number of Signalling Links used in Load Sharing

The number of signalling links used to share the load of a given flow of signalling traffic typically depends on:

- the total traffic load,
- the availability of the links,
- the required availability of the path between the two signalling points concerned, and
- the bit rate of the signalling links,

(see Recommendation (Q.706), Section 5.4 [4]).

Load sharing requires at least two signalling links for all bit rates, but more may be needed at lower bit rates.

When two links are used, each of them should be able to carry the total signalling traffic in case of failure of the other link. When more than two links are used, sufficient reserve link capacity should exist to satisfy the availability requirements specified in Recommendation (Q.706) [5].

5 International signalling network

5.1 General

The international signalling network will use the procedures to be defined in the Signalling System No. 7 recommendations. The international network structure to be defined can also serve as a model for the structure of national networks.

5.2 Number of Signalling Transfer Points in Signalling Relations

In the international signalling network the number of Signalling Transfer Points between two destination signalling points should not exceed two in a normal situation. In failure situations, this number may become three or even four for a short period of time. This constraint is intended to limit the complexity of the administration of the international signalling network.

5.3 Numbering of Signalling Points

A fourteen bit code is used for the identification of signalling point. The allocation of individual signalling point codes requires further study.

5.4 Routing Rules

(Requires further study.)

5.5 Structures

(Requires further study)

5.6 Procedures

(Requires further study)

6 National signalling networks

(Requires further study.)

ANNEX A

Mesh signalling network examples

A.1 General

This Annex is provided to demonstrate the procedures defined in Recommendation (704) [6]. While the example uses a specific mesh network to demonstrate the procedures, it is not the intent of this Annex to recommend either implicitly or explicitly the network described.

The mesh network is used to demonstrate the Message Transfer Part, level 3 procedures because it is thought to be a possible international network implementation as shown, or, it or subsets of it may be used to construct other network structures.

A.2 Basic Network Structures (Example)

Figure A2-1 (Q.705) shows the basic mesh network structure, while three simplified versions derived from this basic network structure are shown in Figure A2-2 (Q.705). More complex signalling networks can be built, using these as building components.

In the following, the basic mesh network Figure A2-1 (Q.705) is taken as an example to explain the procedures defined in Recommendation (Q.704) [6].

In this network, each signalling point with level 4 functions is connected by two link sets to two signalling transfer points. Each pair of signalling transfer points is connected to each other pair by four link sets. Moreover there is a link set between the two signalling transfer points of each pair.

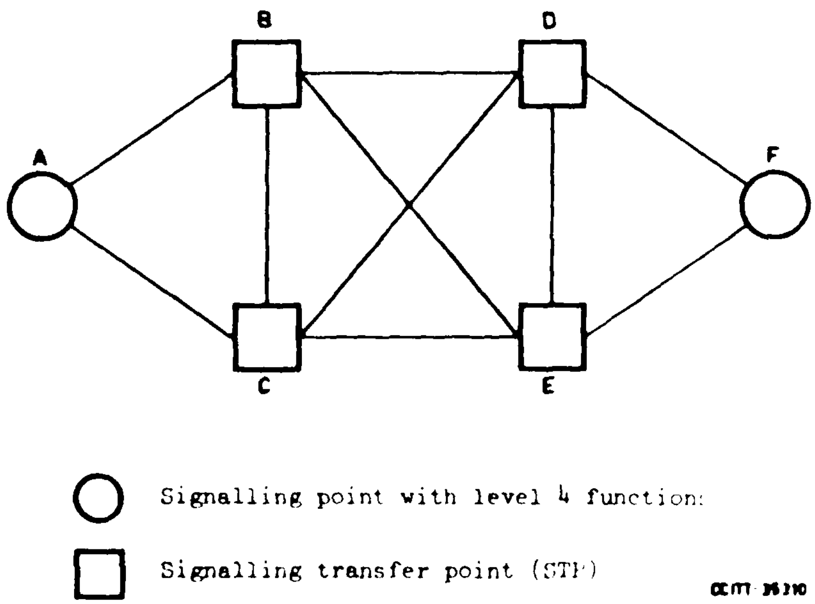
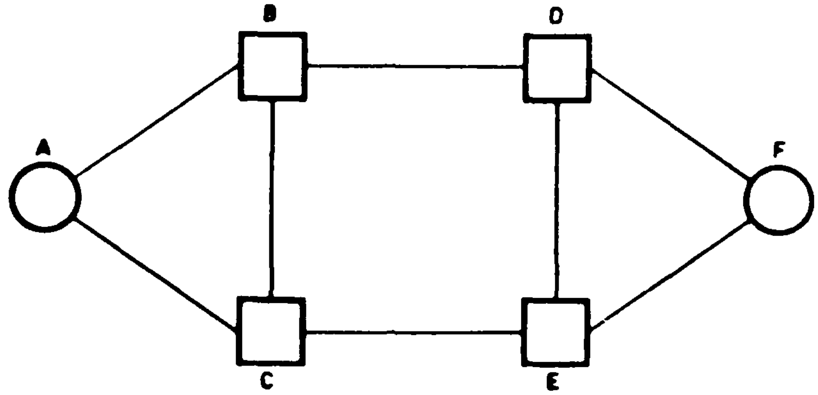
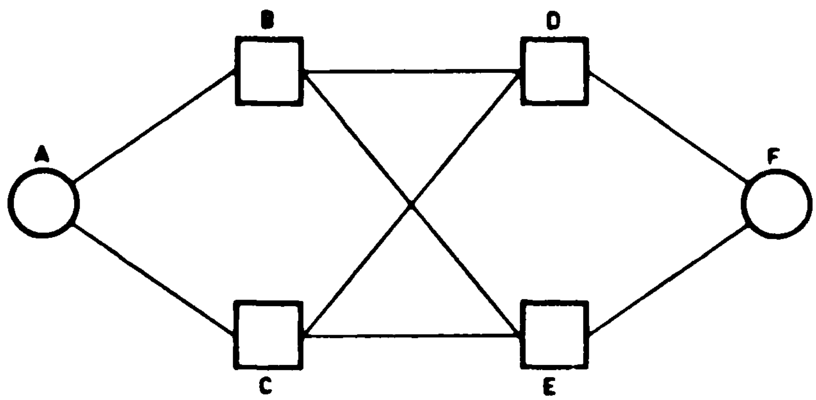


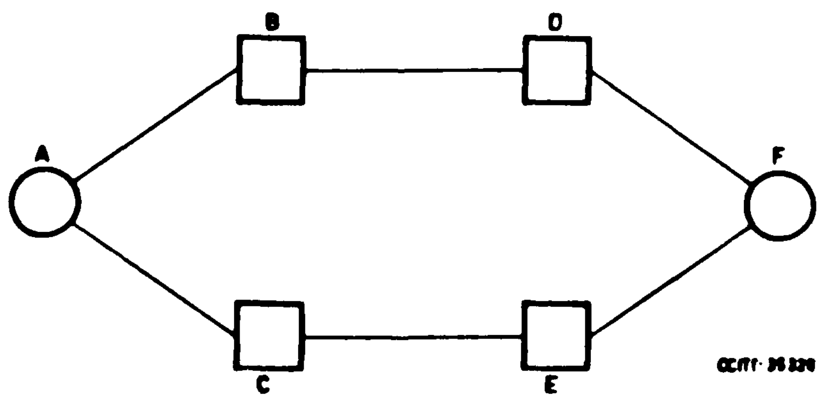
Figure A.2-1 (Q.705) - Basic mesh network



a) two out of four inter-STP link sets deleted



b) link sets between STPs of the same pair deleted



c) two out of four inter-STP link sets and link sets between STPs of the same pair deleted

Figure A.2-2 ($\boxed{Q.705}$) - Simplified versions of the basic mesh network

The simplified versions (a), (b) and (c) of the basic signalling network are obtained by deleting respectively:

a) two out of four inter-signalling transfer point link sets;

b) link sets between signalling transfer points of the same pair; and

c) a and b together.

It should be noted that for a given signalling link availability, the more signalling link sets removed from the basic signalling network [e.g. in going from Figure A.2-1 (Q.705) to Figure A.2-2c (Q.705)], the lower the availability of the signalling network. However, an increase in the availability of the simplified signalling networks may be attained by adding one or more parallel signalling links to each of the remaining signalling link sets.

A.3 Routing

A.3.1 General

This section gives some routing examples in the basic mesh network in Figure A.2-1 (Q.705). Routing actions required to change message routes under failure conditions are described in Section A.4. The following routing principles are assumed for the examples in this section:

- Message routes should pass through a minimum number of intermediate signalling transfer points.

- Routing at each signalling point will not be affected by message routes used up to the concerned signalling transfer points.

- When more than one message route is available, signalling traffic should be load-shared by such message routes.

- Messages relating to a given user transaction and sent in a given direction will be routed over the same message route to ensure correct message sequence.

A.3.2 Routing in the absence of failures

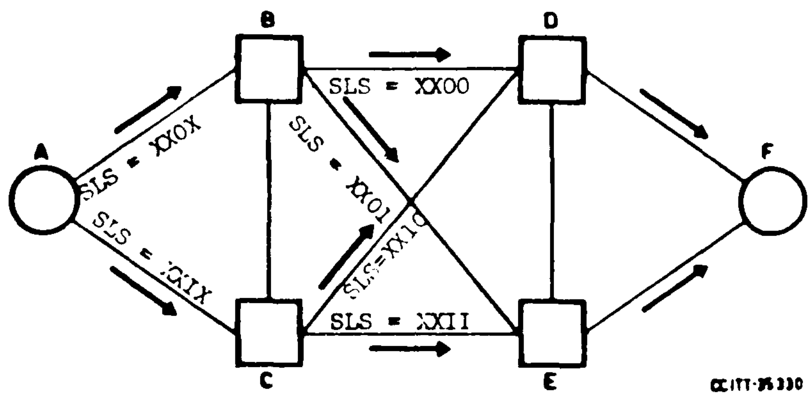
Figure A.3-1 (Q.705) illustrates an example of routing in the absence of failures for messages from signalling point A to signalling point F.

The following points are worthy of note:

a) In distributing traffic for load-sharing at the originating signalling point and intermediate signalling transfer points, care should be taken on the use of signalling link selection (SLS) codes so that traffic will be distributed over four available routes evenly. In the example, originating signalling signalling point A uses the second least significant bit of the signalling link selection code, and signalling transfer points B and C the least significant bit.

b) Other than that des ·ibed above, the choice of a particular link for a given signalling link selection code can be made at each signalling point independently. As a result, message routes for a given user transaction (e.g. SLS = 0010) in two directions may take different paths (e.g. A → C → D → F and F → E → B → A)

c) Links BC and DE are not used in the absence of failures. They will be used in certain failure situations described in Section A.4.



Normal message routes from A to F

- A → B → D → F (SLS = XX00)
- A → C → D → F (SLS = XX10)
- A → B → E → F (SLS = XX01)
- A → C → E → F (SLS = XX11)

SLS : Signalling link selection code in the routing label

Assumption : There is only one link between adjacent signalling points.

Figure A.3-1 ($\boxed{\text{Q.705}}$) - An example of routing in the absence of failures

A.3.3 Routing under failure conditions

A.3.3.1 Alternative routing information

In order to cope with failure conditions that may arise, each signalling point has alternative routing information which specifies, for each normal link set, alternative link set(s) to be used when the former become(s) unavailable. (see Recommendation (Q.704), Section 4.2 [7]).

Table A.3.1 (Q.705) gives, as an example, a list of alternative link sets for all normal link sets at signalling point A and at signalling transfer point B. In the basic mesh network, all link sets except those between signalling transfer points of the same pair are normal links which carry signalling traffic in the absence of failures. In case a normal link set becomes unavailable, signalling traffic formerly carried by that link set should be diverted to the alternative link set with priority 1. Alternative link sets with priority 2 (i.e. link sets between signalling transfer points of the same pair) will be used only when both the normal link set and alternative link set(s) with priority 1 become unavailable.

Sections A.3.3.2 to A.3.3.5 present some typical examples of the consequences of faults in signalling links and signalling points on the routing of signalling traffic. For the sake of simplicity, link sets are supposed to consist of only one link each.

List of alternative link sets at signalling points A and B.

SIGNALLING POINT A

Normal link set	Alternative link set	Priority1)
AB	AC	1
AC	AB	1

SIGNALLING TRANSFER POINT B

Normal link set	Alternative link set	Priority1)
BA	BC	2
BC	None	
BE	BD	1
	BC	2
BD	BE	1
	BC	2

1) Priority 1 - used with normal link set on load-sharing basis in the absence of failures.

Priority 2 - used only when all the link sets with Priority 1 become unavailable.

A.3.3.2 Single link failure examples

Example 1: Failure of a link between a signalling point and a signalling transfer point (e.g. link AB)

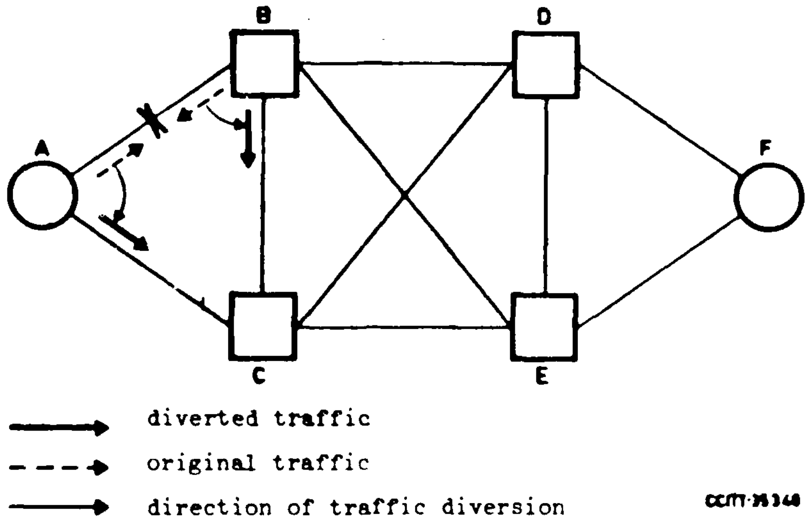


Figure A.3-1 (Q.705) - Failure of link AB

As indicated in Table A3-1 (Q.705), A diverts traffic formerly carried by link AB to link AC, while B diverts such traffic to link BC. It should be noted that the number of signalling transfer points traversed by signalling messages from F to A which passes through B is increased by one and becomes three in this case.

The principle to minimize the number of intermediate signalling transfer points in Section A.3.1 is applied in this case at signalling transfer point B to get around the failure. In fact, the procedures defined in [6] assume that traffic is diverted at a signalling point only in the case of a signalling link being unavailable on the route outgoing from that signalling point. Therefore, the procedures do not provide for sending an indication that traffic routed via signalling transfer point B will traverse a further signalling transfer point.

Example 2: Failure of an inter-signalling transfer points link (e.g. link BD)

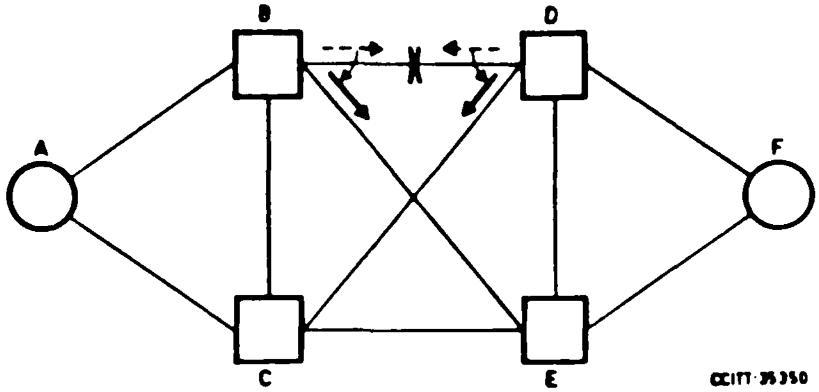


Figure A.3-2 (Q.705) - Failure of link BD

As indicated in Table A.3-1 (Q.705), B diverts traffic carried by link BD to link BE. In the same sense, D diverts traffic carried by link DB to link DC.

Example 3: Failure of a link between signalling transfer points of the same pair (e.g. link BC)

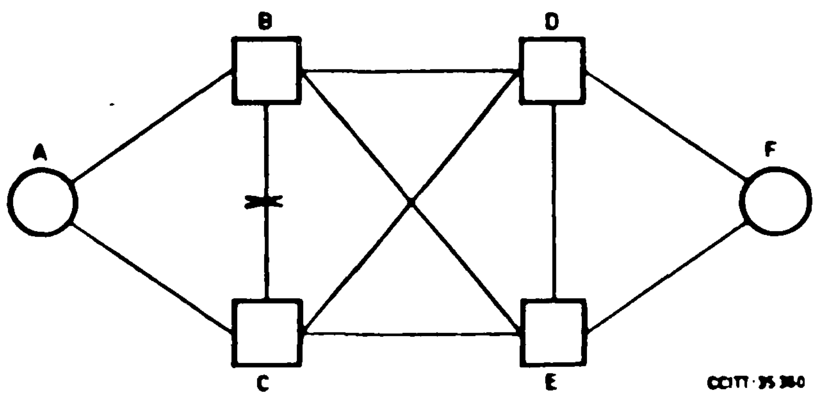


Figure A.3-3 (Q.705) - Failure of link BC

No routing change is required as a result of this kind of failure. Only B and C take note that the link BC has become unavailable.

A.3.3.3 Multiple link failure examples

As there are a variety of cases in which more than one link set becomes unavailable, only some typical cases are given as examples in the following.

Example 1: Failure of a link between a signalling point and a signalling transfer point, and of the link between that signalling transfer points and that of the same pair (e.g. links DF, DE)

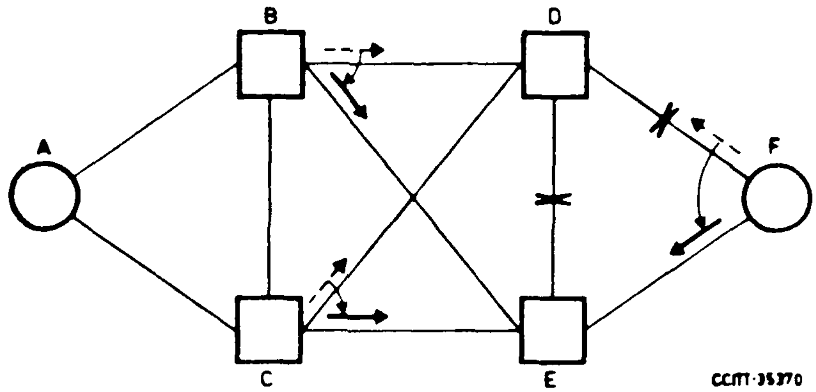


Figure A.3-4 (Q.705) - Failure of links DE and DF

B diverts traffic destined to F from link BD to link BE, because destination F becomes inaccessible via D. It should be noted that only the traffic destined to F is diverted from link BD to link BE, and not all the traffic on link BD. The same applies to C, which diverts traffic destined to F from link CD to link CE. F diverts all the traffic formerly carried by link FD to link FE in the same way as the single link failure example in Section A.3.3.2.

Example 2: Failure of two inter-signalling transfer point links e.g. (links BD, BE)

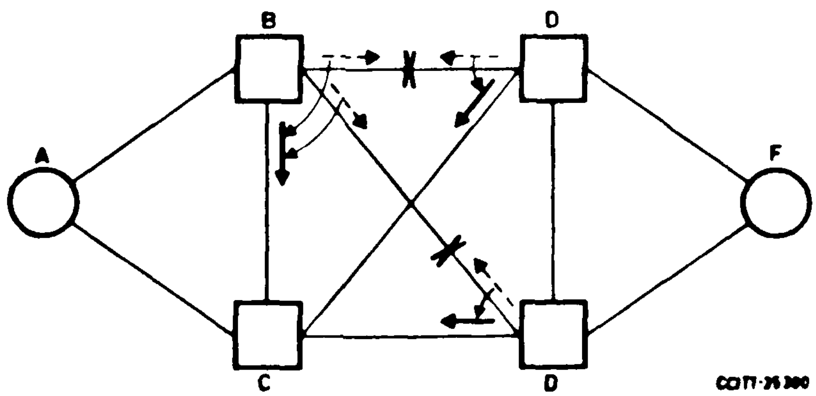


Figure A.3-5 (Q.705) - Failure of links BD and BE

B diverts traffic formerly carried by link BD to link BC, because its alternative link set with Priority 1, i.e. link BE, is also unavailable. The same applies to traffic formerly carried by link BE, and B diverts it to link BC. D and E divert traffic formerly carried by links DB and EB respectively to links DC and EC in the same way as the single link failure example in Section A.3.3.2.

<u>Example 3:</u> Failure of a link between a signalling point and a signalling transfer point, and of an inter-signalling transfer point link (e.g. links DF and BD)

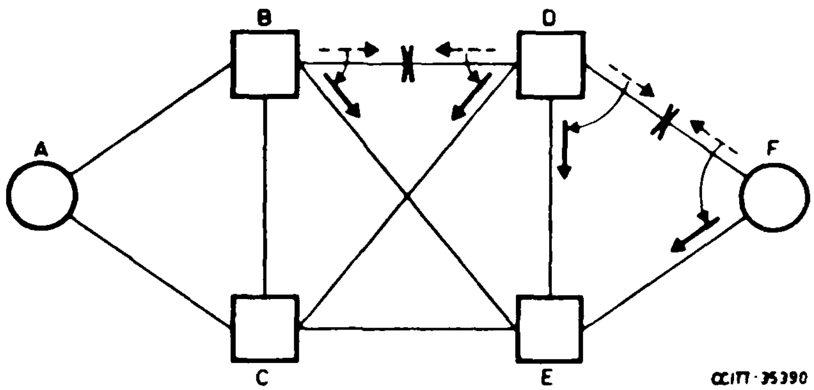


Figure A.3-6 (Q.705) - Failure of links BD and DF

This example is a combination of Examples 1 and 2 in Section A.3.3.2. D diverts traffic formerly carried by link DF to link DE, while F diverts it to link FE. Moreover D diverts traffic formerly carried by link DB to link DC (this traffic will be that generated by signalling points other than F connected to D). In the same sense, B diverts traffic carried by link BD to link BE.

It should be noted that in this case only the portion of traffic sent by C to F via D traverses three signalling transfer points (C, D and E), while all the other portions continue to traverse two.

Example 4: Failure of the two links between a signalling point and its signalling transfer points (e.g. DF and EF)

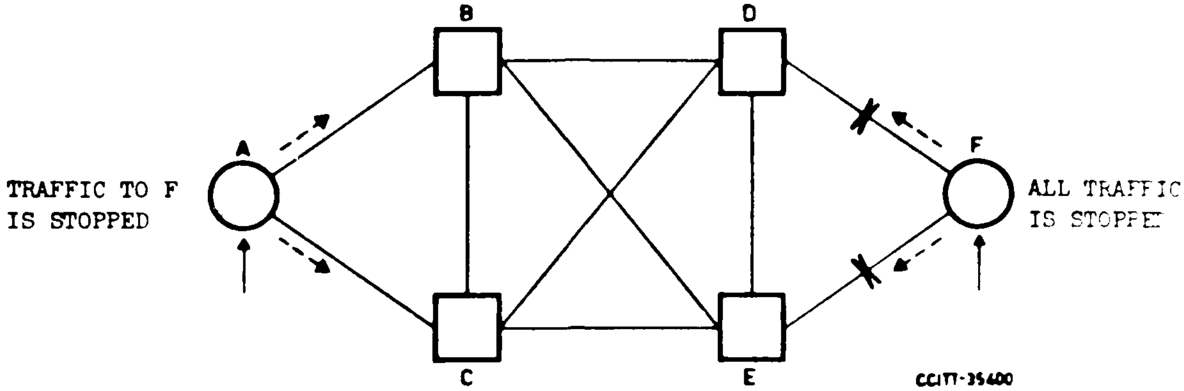


Figure A.3-7 ([Q.705]) - Failure of links DF and EF

In this case the signalling relations between F and any other signalling point of the network are blocked. Therefore F stops all outgoing signalling traffic, while A stops only traffic destined to F.

A.3.3.4 Single signalling point failure examples

Example 1: Failure of a signalling transfer point (e.g. D)

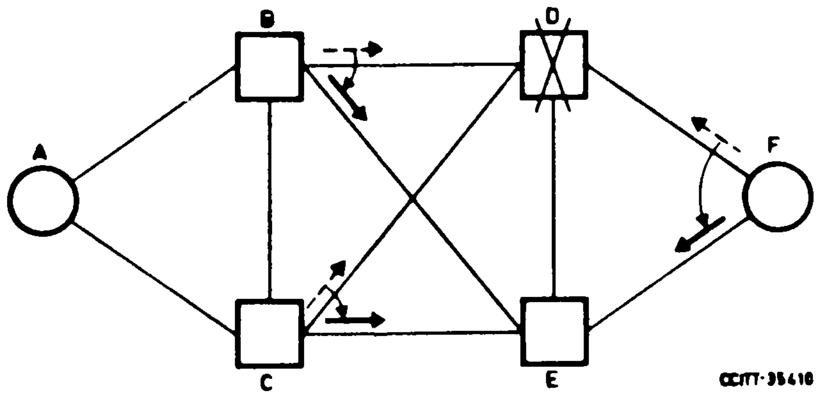


Figure A.3-8 ([Q.705]) - Failure of signalling transfer point D

B diverts all the traffic formerly carried by link BD to link BE. The same applies to C which diverts all the traffic carried by link CD to link CE. Originating point F diverts all the traffic carried by link FD to link FE as in the case of the link FD failure (see Example 1 in Section A.3.3.2).

Attention is drawn to the difference to Example 1 in Section A.3.3.3 where only a part of the traffic previously carried by links BD and CD was diverted.

Example 2: Failure of a destination point (e.g. F)

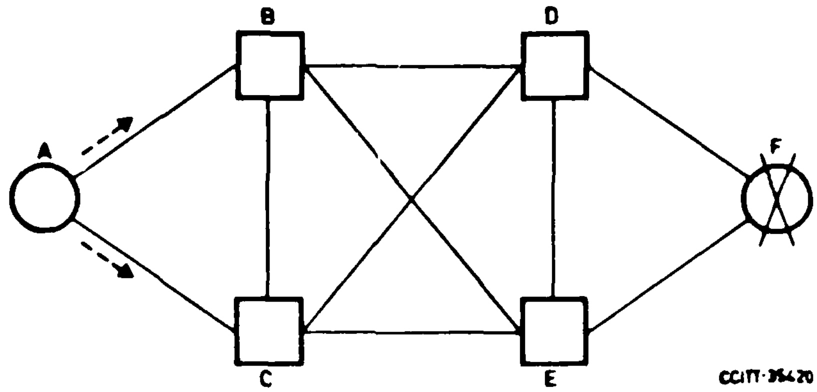


Figure A.3-9 ($\boxed{Q.705}$) - Failure of signalling point F

In this case A stops all the traffic to F formerly carried on links AB and AC.

A.3.3.5 Multiple signalling transfer point failure examples

Two typical cases of two signalling transfer points failing together are presented in the following examples.

Example 1: Failure of two signalling transfer points not pertaining to the same pair (e.g. B and D)

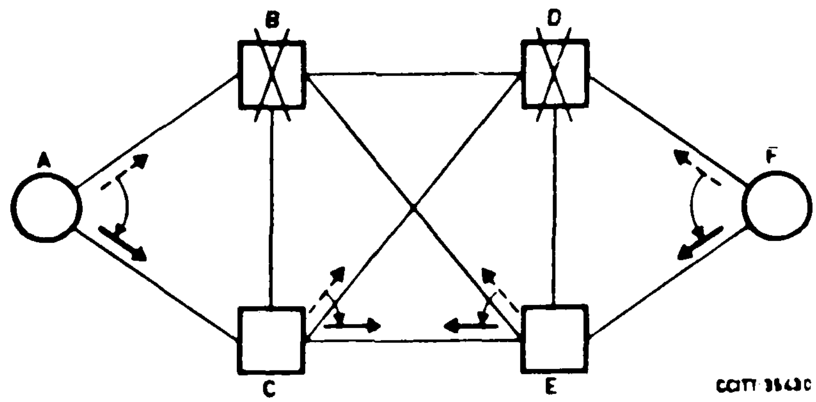


Figure A.3-10 ($\boxed{Q.705}$) - Failure of signalling transfer points B and D

As a result of the failure of B, A diverts traffic formerly carried by link AB to link AC, while E diverts traffic formerly carried by link EB to link EC. Similarly as a result of the failure of D, F diverts traffic formerly carried by link FD to link FE, while C diverts traffic formerly carried by link CD to link CE.

It should be noted that in this example, all the traffic between A and F is concentrated on only one inter-signalling transfer point link, since failure of a signalling transfer point has an effect similar to a simultaneous failure of all the signalling links connected to it.

Example 2: Failure of two signalling transfer points pertaining to the same pairs (e.g. D and E)

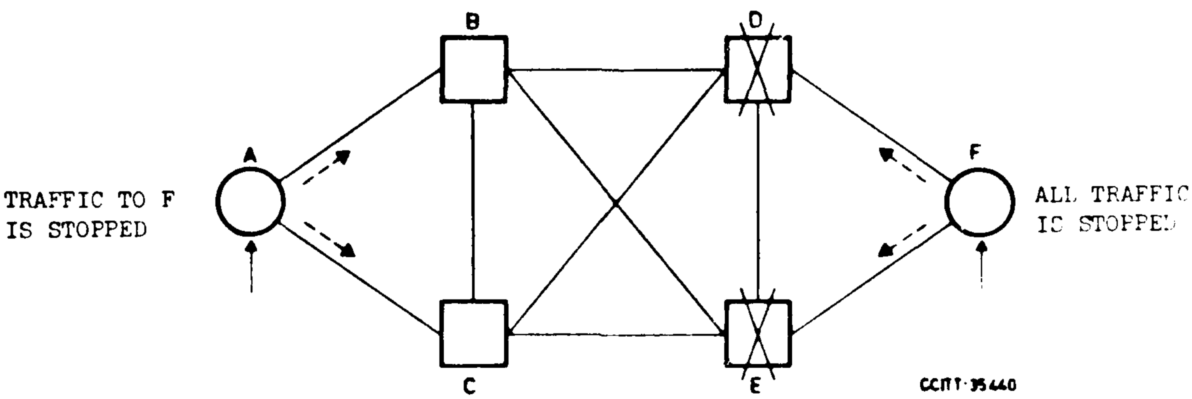


Figure A.3-11 (Q.705) - Failure of signalling transfer points D and E

This example is equivalent to Example 4 in Section A.3.3.3 as far as the inaccessibility of F is concerned, but in this case any other signalling point connected by its links to D and E also becomes inaccessible. In this case A stops signalling traffic destined to F, while ops all outgoing signalling traffic.

A.4 Actions Relating to Failure Conditions

In the following, four typical examples of the application of signalling network management procedures to the failure cases illustrated in Section A.3.3 are shown. In the case of multiple failures, an arbitrary failure (and restoration) sequence is assumed for illustrative purpose.

A.4.1 Example 1: Failure of a link between a signalling point and a signalling transfer point (e.g. link AB)

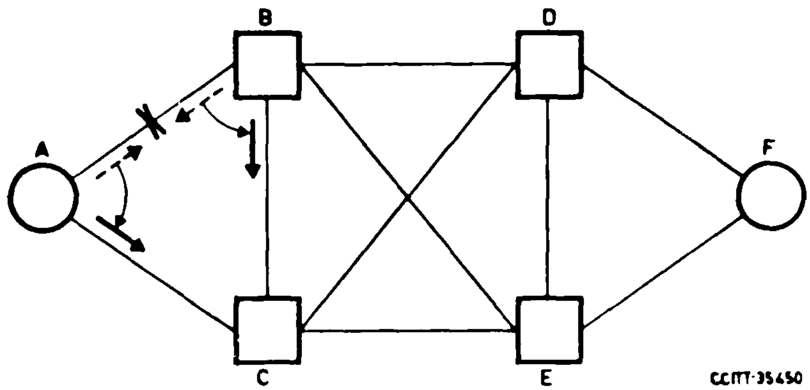


Figure A4-1 ($\boxed{Q.705}$) - Failure of link AB

A.4.1.1 Failure of link AB

a) When the failure of link AB is detected in A and in B, they initiate the changeover procedure, by exchanging changeover messages via C. Once buffer updating is completed, A restarts the traffic originally carried by the failed link on link AC; similarly, B restarts traffic destined to A on link BC.

b) In addition, B sends a transfer-prohibited message to C referred to destination A (according to the criterion indicated in Recommendation (Q.704), Section 11.2.2 [8]).

c) On the reception of the transfer-prohibited message, C sends a transfer-prohibited acknowledgement and starts the periodic sending of signalling-route-set test messages, referred to A, to B (see Recommendation (Q.704), Section 11.4.2 [9].

A.4.1.2 Restoration of link AB

When the restoration of link AB is completd, the following applies:

a) B initiates the changeback procedure, by sending a changeback declaration to A via C. Once it has received the changeback acknowledgement, it restarts traffic on the restored link. Moreover it sends to C a transfer-allowed message, referred to destination A (see Recommendation Q.704, Section 11.3.2 [10]). When C receives the transfer-allowed message, it stops sending signalling-route-set test messages to B.

b) A initiates the changeback procedure, by sending a changeback declaration to B via C; once it has received the changeback acknowledgement, it restarts traffic on the normal link. The only traffic to be diverted is that for which link AB is the normal link set according to the load sharing rule (see Section A.3.3.1). Moreover A sends to B Signalling-route-set test messages, referred to the destination points that it normally accesses via B.

A.4.2 Example 2: Failure of signalling transfer point D

(Same as Section A.3.3.4, Example 1.)

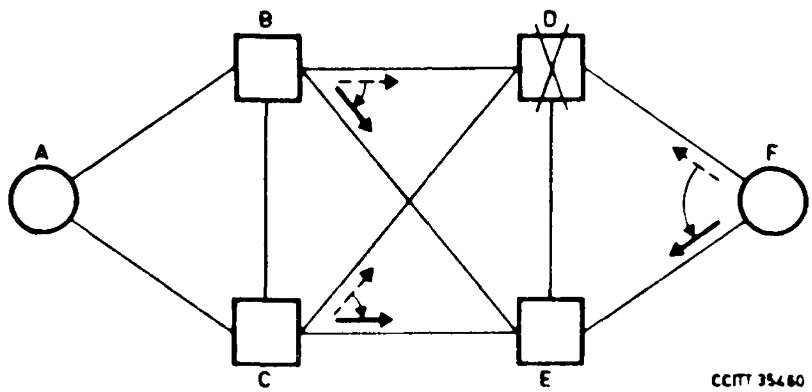


Figure 2 (Q.705) - Failure of signalling transfer point D

A.4.2.1 Failure of signalling transfer point D

a) Changeover is initiated at signalling points B, C and F from blocked links BD, CD and FD to the first priority alternative links BE, CE and FE respectively. Due to the failure of D, the concerned signalling points will receive no changeover message in response, and therefore they will restart traffic on alternative links at the expiry of the time T2 (see Recommendation Q.704, Section 5.7.2 [11]). In addition, E will send to B, C and F Transfer-prohibited messages referred to destination D. These signalling points (B, C and F) will thus start periodic sending to E of Signalling-route-set test messages referred to D.

b) When B receives a transfer-prohibited message from E referred to D, it updates its routing information so that traffic to D will be diverted to C, thus sending a transfer-prohibited message to C referred to D. The same applies to C, and C sends a transfer-prohibited message to B.

c) So, when B receives a transfer-prohibited message from C, it finds that destination D has become inaccessible and sends a transfer-prohibited message to A. The same applies to C and thus C also sends a transfer-prohibited message to A. Having received transfer-prohibited messages from both B and C, A recognizes that D has become inaccessible and stops traffic to D.

d) In the same manner, i.e. link-by-link transmission of transfer-prohibited messages referred to D, other signalling points B, C, E and F will finally recognize that destination D has become inaccessible. Each signalling point will, therefore, start periodic sending of route-set-test messages referred to D to their respective adjacent signalling points.

A.4.2.2 Recovery of signalling transfer point

a) Changeback at signalling points B, C and F from the alternative to the normal links is performed. In all the three cases changeback includes the time-controlled diversion procedure (see Recommendation (Q.704), Section 6.4 [12]), since D is still inaccessible via E at B, C and F (as a result of previous reception of transfer-prohibited message from E).

b) E sends to B, C and F transfer-allowed messages referred to destination D. These signalling points will thus send transfer allowed messages to their respective adjacent signalling points. Thus, the link-by-link transmission of transfer-allowed-messages will declare to all signalling points that destination D has become accessible.

c) On reception of a transfer-allowed message, each signalling point stops periodic sending of route-set-test messages to their respective adjacent signalling points.

d) On recovery of previously unavailable links BD, CD and FD, B, C and F will send a route-set-test message to D, referred to the destination points that they normally access via D.

A.4.3 Example 3: Failure of link between a signalling point and a signalling transfer point, and of the link between that signalling transfer point and that of the same pair (e.g. links DF, DE).

(Same as Section A.3.3.3 Example 1.)

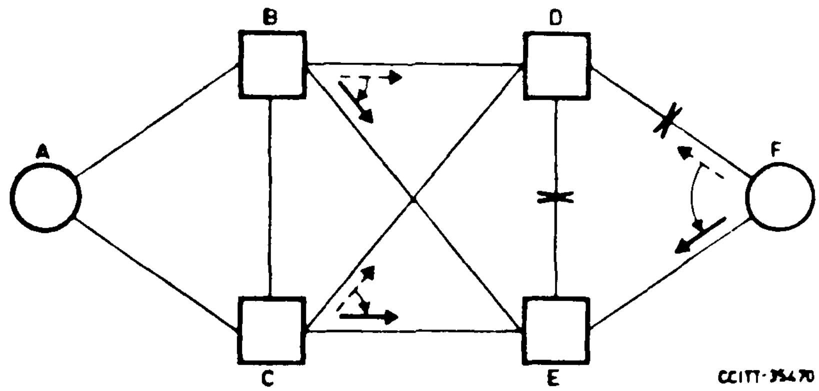


Figure A4-3 (Q.705) - Failure of links DE and DF

A.4.3.1 Failure of link DE

On failure of link DE, this link is marked unavailable at both signalling transfer points D and E. Since in the absence of failures, link DE does not carry signalling traffic, no changes in message routing takes place at this time.

However, D and E send to signalling points B, C and F transfer-prohibited messages referred to destination E or D respectively. These signalling points will thus start periodic sending of signalling-route-set test messages, referred to D or E, to E and D respectively.

A.4.3.2 Failure of link DF in the presence of failure of link DE

a) On failure of link DF the following actions occur:

   i) Signalling point D which no longer has access to signalling point F indicates this condition to signalling transfer points B and C by sending transfer-prohibited messages. B and C will thus start the periodic sending of signalling-route-set test messages referred to F, to D

   ii) Emergency changeover from link FD to link FE is initiated at signalling point F, since D becomes inaccessible to F due also to the previous failure.

b) On receiving the transfer-prohibited messages forced rerouting is initiated at points B and C. This causes traffic destined to F to be diverted from links terminating on D to links terminating on E. Forced rerouting thus permits recovery from a failure condition caused by a fault in a remote part of the network.

A.4.3.3 Restoration of link FD in the presence of failure of link DE

a) On recovery of link FD the following actions occur:

i) Signalling point D sends a transfer-allowed message to B and C to indicate that D once again has access to F. B and C will thus stop the sending of signalling-route-set test messages referred to F to D.

ii) F initiates changeback with time controlled Diversion from link FE to link FD. This procedure permits change back to be executed at one end of a link, when it is impossible to notify the other end of the link (in this example, because link DE is unavailable). Traffic in this case is not diverted from the alternative link until the time interval T4, tentatively set at one second has elapsed, in order to minimize the danger of mis-sequencing of messages (see Recommendation (Q.704), Section 6.4 [12]. In addition, F sends to D a signalling-route-set test messages referred to the destinations that it normally accesses via D.

b) On receiving the transfer-allowed message, controlled re-routing of traffic from the alternative routes (BEF, CEF) to the normal routes (BDF, CDF) is initiated at Points B and C. Controlled re-routing involves diversion of traffic to a route which has become available after a time interval (see Recommendation (Q.704), Section 8.2.1 [13]) provisionally set at one second to minimize the danger of mis-sequencing messages.

A.4.3.4 Restoration of link DE

On recovery of link DE it is marked available at signalling transfer points D and E. Signalling points D and E send to B, C and F transfer-allowed messages referred to destination E or D respectively. These signalling transfer point will thus stop sending of signalling-route-set test messages.

A.4.4 Example 4: Failure of links DF and EF

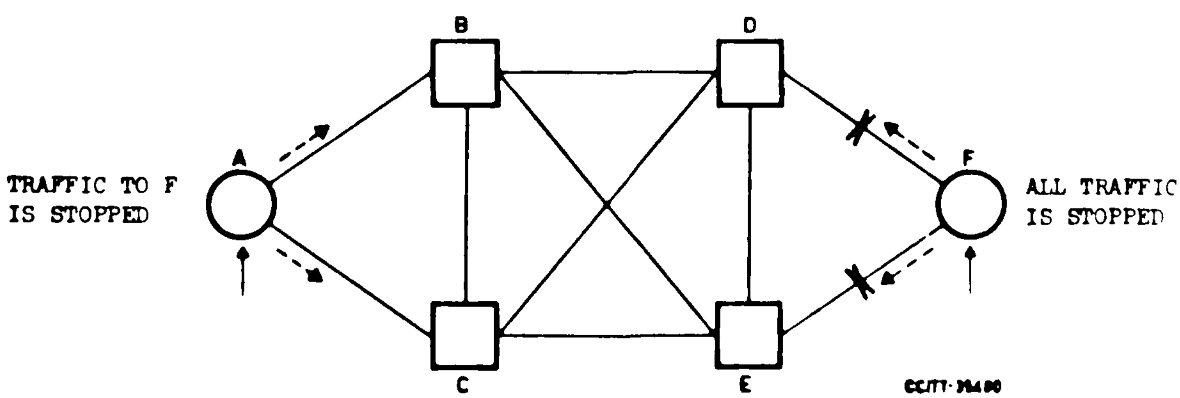


Figure A4-4 (Q.705) - Failure of links DF and EF

A.4.4.1 Failure of link DF

When the failure of link DF is detected, D and F perform the changeover procedure; D diverts traffic, destined to F, to link DE, while F concentrates all the outgoing traffic on link FE.

In addition, D sends to E a transfer-prohibited message, referred to destination F; E will thus start sending of signalling-route-set test messages, referred to F, towards D (cf A.4.1.1).

A.4.4.2 Failure of link EF in the presence of failure of link DF

a) When the failures of link EF is detected, the following applies:

   i) Since all destinations become inaccessible F stops sending all signalling traffic.

   ii) E sends to B, C and D a transfer-prohibited message, referred to destination F. B, C and D start periodic sending of signalling-route-set test messages referred to F to E.

b) When D receives the transfer-prohibited message, it sends to B and C a transfer-prohibited message, referred to destination F (see [8]). B and C start periodic sending of test messages referred to F to D.

c) When B receives the transfer-prohibited messages from D and E, it sends a transfer-prohibited message to C; the same applies for C (it sends the message to B). As soon as B and C have received the transfer-prohibited messages from all the three possible routes (BD, BE and BC, or CD, CE and CB respectively) they send a transfer-prohibited message to A.

   Note - Depending on the sequence of reception of transfer-prohibited messages at B or C, they may start a forced rerouting procedure on a route not yet declared to be unavailable; such procedure is then aborted as soon as a transfer-prohibited message is received also from that route.

d) As soon as A receives the transfer-prohibited messages from B and C, it declares destination F inaccessible and stops sending traffic towards it. Moreover it starts the periodic sending of signalling-route-set test messages, referred to F, to B and C.

A.4.4.3 Restoration of link EF in the presence of failure on link DF

a) When restoration of link EF is completed, the following applies:

   i) F sends to E a signalling-route-set test message, referred to the destination points it can normally access via E, and it restarts traffic on link EF;

   ii) E sends a transfer-allowed message, referred to destination F, to B, C and D; moreover it restarts traffic on the restored link.

b) When B and C receive the transfer-allowed message, they send a transfer-allowed message to A and C or A and B, respectively and they stop sending signalling-route-set test messages to E; moreover they restart the concerned traffic on link BE or CE respectively.

c) When D receives the transfer-allowed message from E, it sends transfer-allowed messages to B and C and stops sending signalling-route-set test messages to E; moreover it starts the concerned traffic on link DE. On receipt of the transfer-allowed message, B and C will divert to links BD and CD, by means of a controlled rerouting procedure, traffic carried by links BE and CE for which they are the normal links (see Section A.3.3). Moreover they will stop sending signalling-route-set test messages to D.

   Note - According to the rules stated in Rec. Q.704, Section 11.3.2 [10], on receipt of transfer-allowed messages from E (phase b above), B and C should send transfer-allowed messages also to D and E. However this is not appropriate in the network configurations such as the one here considered, taking into account that:

   - there is no route, for example, from D (or E) to F via B (or C) and therefore the transfer-allowed messages would be ignored (although acknowledged) by D and E;

   - on restarting traffic to F on links BD, BE, CD and CE it would anyway be necessary that B and C send transfer-prohibited messages to D and E, which would contradict the previous transfer-allowed messages.

d) As soon as A receives a transfer-allowed message from B or C, it restarts signalling traffic to B and C. If traffic has already been restarted on one link when the transfer-allowed message is received on the other link, a changeback procedure is performed to establish the normal routing situation on both links (i.e. to divert part of the traffic on the latter link).

A.4.4.4 Restoration of link DF

When the restoration of link DF is completed, the following applies:

a) D initiates the changeback procedure to link DF; moreover it sends to E a transfer-allowed message, referred to destination F,

b) F sends a signalling-route-set test message to D referred to the destination points it normally accesses via D. It initiates the changeback procedure to link DF; this procedure refers only to the traffic for which link DF is the normal one, according to the routing rules.

References

[1] CCITT Recommendation, Signalling Link, Yellow Book, Vol. VI.7, Rec. (Q.703).

[2] CCITT Recommendation, Signalling Network Functions and Messages, Yellow Book, Vol. VI.7, Rec. (Q.704), Section 2.4.

[3] CCITT Recommendation, Signalling Network Functions and Messages, Yellow Book, Vol. VI.7, Rec. (Q.704), Section 12.2.

[4] CCITT Recommendation, Signalling System Performance, Yellow Book, Vol. VI.7, Rec. (Q.706), Section 5.4.

[5] CCITT Recommendation, Signalling System Performance, Yellow Book, Vol. VI.7, Rec. (Q.706).

[6] CCITT Recommendation, Signalling Network Functions and Messages, Yellow Book, Vol. VI.7, Rec. (Q.704).

[7] CCITT Recommendation, Signalling Network Functions and Messages, Yellow Book, Vol. VI.7, Rec. (Q.704), Section 4.2.

[8] CCITT Recommendation, Signalling Network Functions and Messages, Yellow Book, Vol. VI.7, Rec. (Q.704), Section 11.2.2.

[9] CCITT Recommendation, Signalling Network Functions and Messages, Yellow Book, Vol. VI.7, Rec. (Q.704), Section 11.4.2.

[10] CCITT Recommendation, Signalling Network Functions and Messages, Yellow Book, Vol. VI.7, Rec. (Q.704), Section 11.3.2.

[11] CCITT Recommendation, Signalling Network Functions and Messages, Yellow Book, Vol. VI.7, Rec. (Q.704), Section 5.7.2.

[12] CCITT Recommendation, Signalling Network Functional Messages, Yellow Book, Vol. VI.7, Rec. (Q.704), Section 6.4.

[13] CCITT Recommendation, Signalling Network Functions and Messages, Yellow Book, Vol. VI.7, Rec. (Q.704), Section 8.2.1.

Recommendation Q.706

MESSAGE TRANSFER PART SIGNALLING PERFORMANCE

The message transfer part of Signalling System No. 7 is designed as a joint transport system for the messages of different users. The requirements of the different users have to be met by the message transfer part. These requirements are not necessarily the same and may differ in importance and stringency.

In order to satisfy the individual requirements of each user the message transfer part of Signalling System No. 7 is designed in such a way that it meets the most stringent user part requirements envisaged at the time of specification. To this end, the requirements of the telephone service, the data transmission service and the signalling network management in particular, were investigated. It is assumed that a signalling performance which satisfies the requirements mentioned above will also meet those of future users.

In the light of the above, signalling system performance is understood to be the capability of the message transfer part to transfer messages of variable length for different users in a defined manner. In order to achieve a proper signalling performance, three groups of parameters have to be taken into account:

- The first group covers the objectives derived from the requirements of the different users. The aims are limitation of message delay, protection against all kinds of failures and guarantee of availability.

- The second group covers the features of the signalling traffic, such as the loading potential and the structure of the signalling traffic.

- The third group covers the given environmental influences, such as the characteristics (e.g. error rate and burstiness) of the transmission media.

The three groups of parameters are considered in the specification of the procedures to enable the message transfer part to transfer the messages in such a way that the signalling requirements of all users are met and that a uniform and satisfactory overall signalling system performance is achieved.

1 Basic parameters related to message transfer part signalling performance

Signalling performance is defined by a great number of different parameters. In order to ensure a proper signalling performance for all userr to be served by the common message transfer part, the following design objectives are established for the message transfer part.

1.1 Unavailability of a signalling route set

The unavailability of a signalling route set is determined by the unavailability of the individual components of the signalling network (signalling links and the signalling points) and by the structure of a signalling network.

The unavailability of a signalling route set should not exceed a total of 10 minutes per year.

The unavailability of a signalling route set within a signalling network may be improved by replication of signalling links, signalling paths and signalling routes.

1.2 Unavoidable message transfer part malfunction

The message transfer part of Signalling System No. 7 is designed to transport messages in a correct sequence. In addition, the messages are protected against transmission errors. However, a protection against transmission errors cannot be absolute. Furthermore, missequencing and loss of messages in the message transfer part cannot be excluded in extreme cases.

For all user parts, the following conditions are guaranteed by the message transfer part:

a) Undetected errors

On a signalling link employing a signalling data link which has the error rate characteristic as described in Recommendation Q.702 [5] not more than one in 10^{10} of all signal unit errors will be undetected by the message transfer part.

b) Loss of messages

Not more than one in 10^7 messages will be lost due to failure in the message transfer part.

c) Messages out-of-sequence

Not more than one in 10^{10} messages will be delivered out-of-sequence to the user parts due to failure in the message transfer part. This value also includes duplication of messages.

1.3 Message transfer times

This parameter includes:

- handling times at the signalling points (see Section 4.3);
- queueing delays including retransmission delays (see Section 4.2);
- signalling data link propagation times.

1.4 Signalling traffic throughput capability

Needs further study (see Section 2.2).

2 Signalling traffic characteristics

2.1 Labelling potential

The design of Signalling System No. 7 provides the potential in labels to identify 16,384 signalling points. For each of the 16 different user parts a number of user transactions may be identified, e.g. in the case of the telephone service up to 4,096 speech circuits.

2.2 Loading potential

Considering that the load per signalling channel will vary according to the traffic characteristics of the service, to the user transactions served and to the number of signals in use, it is not practicable to specify a general maximum limit of user transactions that a signalling channel can handle. The maximum number of user transactions to be served must be determined for each situation, taking into account the traffic characteristics applied so that the total signalling load is held to a level which is acceptable from different points of view.

When determining the normal load of the signalling channel account must be taken of the need to ensure a sufficient margin for peak traffic loads.

The loading of a signalling channel is restricted by several factors which are itemized below:

2.2.1 Queueing delay

The queueing delay in absence of disturbances is considerably influenced by the distribution of the message length and the signalling traffic load (see Section 4.2).

2.2.2 Security requirements

The most important security arrangement is redundancy in conjunction with changeover. As load sharing is applied in normal operation, the load on the individual signalling channels has to be restricted so that, in the case of changeover, the queueing delays do not exceed a reasonable limit. This requirement has to be met not only in the case of changeover to one pre-determined link but also in the case of load distribution to the remaining links.

2.2.3 Capacity of sequence numbering

The use of 7 bits for sequence numbering finally limits the number of signal units sent but not yet acknowledged to the value of 127.

In practice this will not impose a limitation on the loading potential.

2.2.4 Signalling channels using lower bit rates

A loading value for a signalling channel using bit rates of less than 64 kbit/s will result in greater queueing delays than the same loading value for a 64 kbit/s signalling channel.

2.3 Structure of signalling traffic

The message transfer part of Signalling System No. 7 serves different user parts as a joint transport system for messages. As a result, the structure of the signalling traffic largely depends on the types of user parts served. It can be assumed that at least in the near future the telephone service will represent the main part of the signalling traffic also in integrated networks.

It cannot be foreseen yet how the signalling traffic is influenced by the integration of existing and future services. The traffic models given in Section 4.2.4 have been introduced in order to consider as far as possible the characteristics and features of different services within an integrated network. If new or more stringent requirements are imposed on signalling (e.g. shorter delays) as a consequence of future services, they should be met by appropriate dimensioning of the load or by improving the structure of the signalling network.

3 Parameters related to transmission characteristics

No special transmission requirements are envisaged for the signalling links of Signalling System No. 7. Therefore, System No. 7 provides appropriate means in order to cope with the given transmission characteristics of ordinary links. The following items indicate the actual characteristics to be expected - as determined by the responsible CCITT Study Groups - and their consequences on the specifications of the Signalling System No. 7 message transfer part.

3.1 Application of Signalling System No. 7 to 64 kbit/s links

The message transfer part is designed to operate satisfactorily with the following transmission characteristics:

a) A long-term bit error rate of the signalling data link of less than 10^{-6} [6].

b) A medium-term bit error rate of less than 10^{-4}.

c) Random errors and error bursts including long bursts which might occur in the digital link due to, for instance, loss of frame alignment or octet slips in the digital link. The maximum tolerable interruption period is specified for the signal unit error rate monitor (see Recommendation Q.703, Section 8.2 [1]).

3.2 Application of Signalling System No. 7 to links using lower bit rates

(Needs further study)

4 Parameters of influence on signalling performance

4.1 Signalling Network

Signalling System No. 7 is designed for both associated and non-associated applications. The reference section in such applications is the signalling route set, irrespective of whether it is served in the associated or quasi-associated mode of operation.

For every signalling route set in a signalling network, the unavailability limit indicated in Section 1.1 has to be observed irrespective of the number of signalling links in tandem of which it is composed.

4.1.1 International signalling network

(Needs further study)

4.1.2 National signalling network

(Needs further study)

4.2 Queueing delays

The message transfer part handles messages from different user parts on a time-shared basis. With time-sharing, signalling delay occurs when it is necessary to process more than one message in a given interval of time. When this occurs, a queue is built up from which messages are transmitted in order of their times of arrival.

There are two different types of queueing delays: queueing delay in the absence of disturbances and total queueing delay.

4.2.1 Assumptions for derivation of the formulae

The queueing delay formulae are basically derived from the M/G/1 queue with priority assignment. The assumptions for the derivation of the formulae in the absence of disturbances are as follows:

a) the interarrival time distribution is exponential (M),

b) the service time distribution is general (G),

c) the number of server is one (1),

d) the service priority refers to the transmission priority within level 2 (see [4]), however the link status signal unit and the independent flag are not considered,

e) the signalling link loop propagation time is constant including the process time in signalling terminals, and

f) the forced retransmission case of the preventive cyclic retransmission method is not considered.

In addition, for the formulae in the presence of disturbances, the assumptions are as follows:

g) the transmission error of the message signal unit is random,

h) the errors are statistically independent of each other,

i) the additional delay caused by the retransmission of the erroneous signal unit is considered as a part of the waiting time of the concerned signal unit, and

j) in case of the preventive cyclic retransmission method, after the error occurs, the retransmitted signal units of second priority are accepted at the receiving end until the sequence number of the last sent new signal unit is caught up by that of the last retransmitted signal unit.

Furthermore the formula of the proportion of messages delayed more than a given time is derived from the assumption that the probability density function of the queueing delay distribution may be exponentially decreasing where the delay time is relatively large.

4.2.2 Factors and parameters

a) The notations and factors required for calculation of the queueing delays are as follows:

Q_a mean queueing delay in the absence of disturbances

σ_a^2 variance of queueing delay in the absence of disturbances

Q_t mean total queueing delay

σ_t^2 variance of total queueing delay

$P(T)$ proportion of messages delayed more than T

a traffic loading by message signal units (excluding retransmission)

T_m mean emission time of message signal units

T_f emission time of fill-in signal units

T_L signalling loop propagation time including processing time in signalling terminal,

P_u error probability of message signal units

$$k_1 = \frac{\text{2nd moment of message signal units emission time}}{T_m^2}$$

$$k_2 = \frac{\text{3rd moment of message signal units emission time}}{T_m^3}$$

Note - As a consequence of zero insertion at level 2 (see Recommendation Q.503, Section 3.2 [6]), the length of the emitted signal unit will be increased by approximately 1.6 percent on average, however, this increase has negligible effect on the calculation.

b) The parameters used in the formulae are as follows:

$t_f = T_f/T_m$

$t_L = T_L/T_m$

for the basic method,

$$E_1 = 1 + P_u t_L$$

$$E_2 = k_1 + P_u t_L (t_L + 2)$$

$$E_3 = k_2 + P_u t_L (t_L^2 + 3t_L + 3k_1)$$

for the preventice cyclic retransmission method,

$a_3 = \exp(-at_L)$ traffic loading caused by fill-in signal units

$$a_z = \frac{a_3}{1-a}$$

$$t_{aL} = \frac{at_L}{1-a}$$

$$F = 1 + \frac{P_u t_{aL}}{2}$$

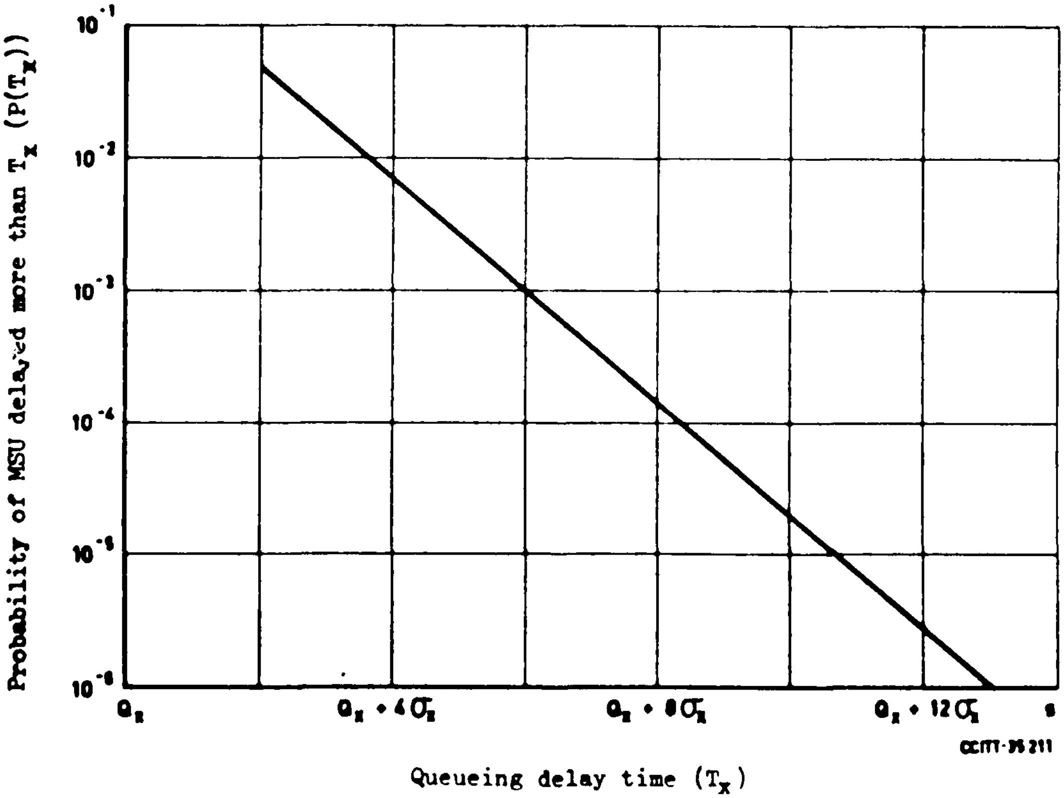
$$\varepsilon = P_u \frac{Fa^3}{(1-2a)(1-2aF)} t_L$$

4.2.3 **Formulae**

The formulae of the mean and the variance of the queueing delays are described in Table 4-1/Q.706. The proportion of messages delayed more than a given time T_x is:

$$P(T_X) \simeq \exp\left(-\frac{T_X - Q_X + \sigma_X}{\sigma_X}\right)$$

where Q_X and σ_X denote the mean and the standard deviation of queueing delay, respectively. This approximation is better suited in absence of disturbances. In presence of disturbances the actual distribution may be deviated further. Relation between $P(T_X)$ and T_X is shown in Figure 4-1/Q.706.



Q_x : Mean queueing delay (see Figure 4-2. Q.706)
σ_x : Standard deviation (see Figure 4-3. Q.706)

Figure 4-1 (Q.706) - Probability of message signal unit delayed more than T_x.

TABLE 4.1(Q.706)

Queueing delay formulae

Error correction method	Disturbance	Mean Q	Variance σ^2
Basic	Absence	$\frac{Q_a}{T_m} = \frac{t_f}{2} + \frac{ak_1}{2(1-a)}$	$\frac{\sigma_a^2}{T_m^2} = \frac{t_f^2}{12} + \frac{a(4k_2-(4k_2-3k_1^2)a)}{12(1-a)^2}$
	Presence	$\frac{Q_t}{T_m} = \frac{t_f}{2} + \frac{aE_2}{2(1-aE_1)} + E_1 - 1$	$\frac{\sigma_t^2}{T_m^2} = \frac{t_f^2}{12} + \frac{a(4E_3-(4E_1E_3-3E_2^2)a)}{12(1-a)^2}$ $+ P_u(1-P_u)t_L^2$
PCR	Absence	$\frac{Q_a}{T_m} = \frac{k_1+a_z(t_f-k_1)}{2} + \frac{ak_1}{2(1-a)}$	$\frac{\sigma_a^2}{T_m^2} = \frac{4k_2-3k_1^2}{12} + a_z(\frac{4-3a_z}{12} t_f^2$ $+ \frac{a_z-1}{2} k_1 t_f + k_1^2 \frac{2-a_z}{4} - \frac{k_2}{3})$ $+ \frac{a(4k_2-(4k_2-3k_1^2)a)}{12(1-a)^2}$
	Presence	$\frac{Q_t}{T_m} = \frac{1+c}{2(1-aF)}(\frac{aP_u t_{aL}}{6}(2t_{aL}+3k_1)+k_1)$ $+F-1$	(for further study)

4.2.4 Example

Assuming the traffic models given in Table 4-2 (Q.706) examples of queueing delays are calculated as listed in Table 4-3 (Q.706).

TABLE 4-2 (Q.706) - Traffic model

Model	A	B	
Message length (bits)	120	104	304
Percent	100	92	8
Mean message length (bits)	120	120	
k_1	1.0	1.2	
k_2	1.0	1.9	

TABLE 4-3 (Q.706) - List of examples

Figure	Error control	Queueing delay	Disturbance	Model
4-2	Basic/PCR	Mean	Absence	A and B
4-3	Basic/PCR	Standard deviation	Absence	A and B
4-4	Basic	Mean	Presence	A
4-5	Basic	Standard deviation	Presence	A
4-6	PCR	Mean	Presence	A

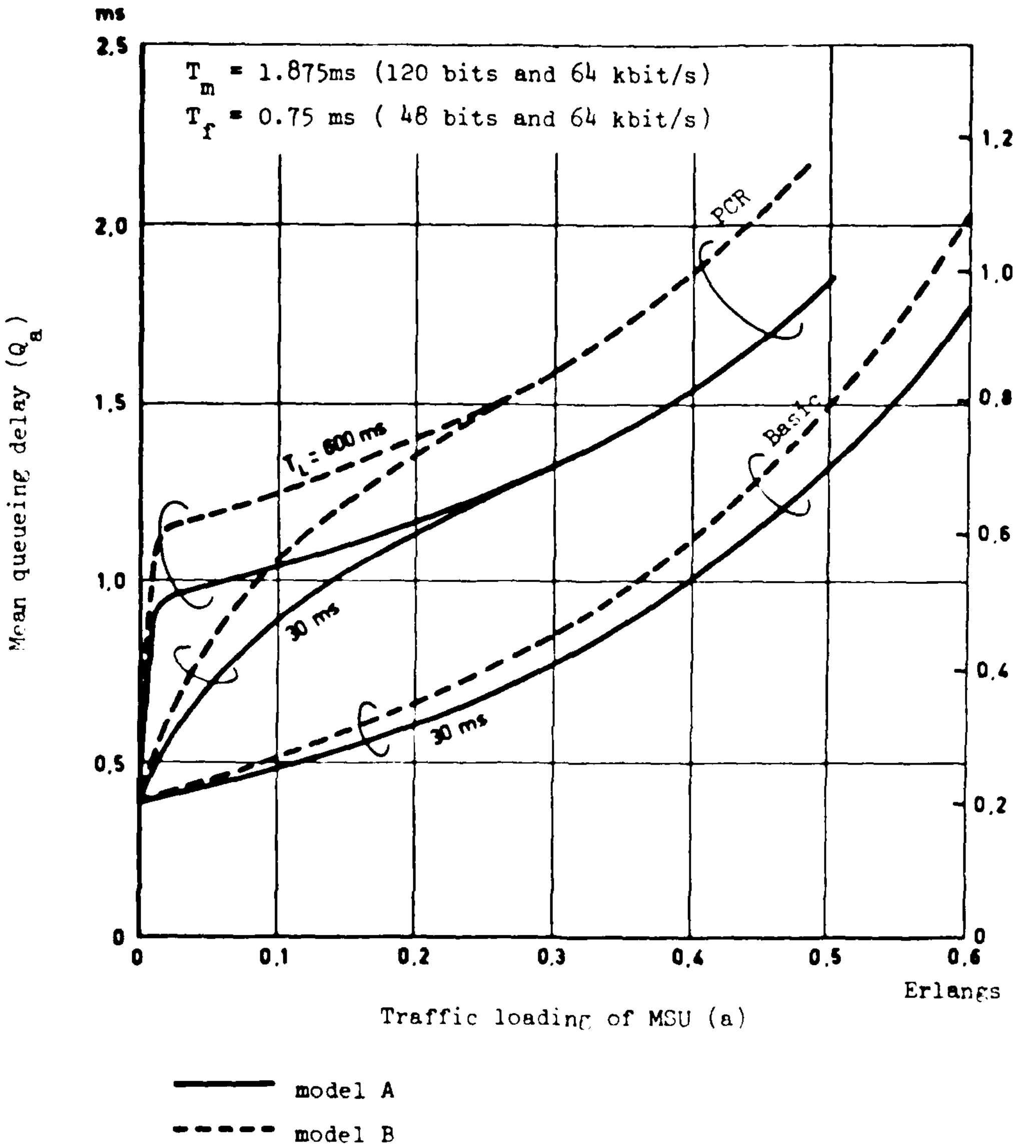


Fig. 4-2 (Q.706) Mean queueing delay of each channel of traffic in absence of disturbance.

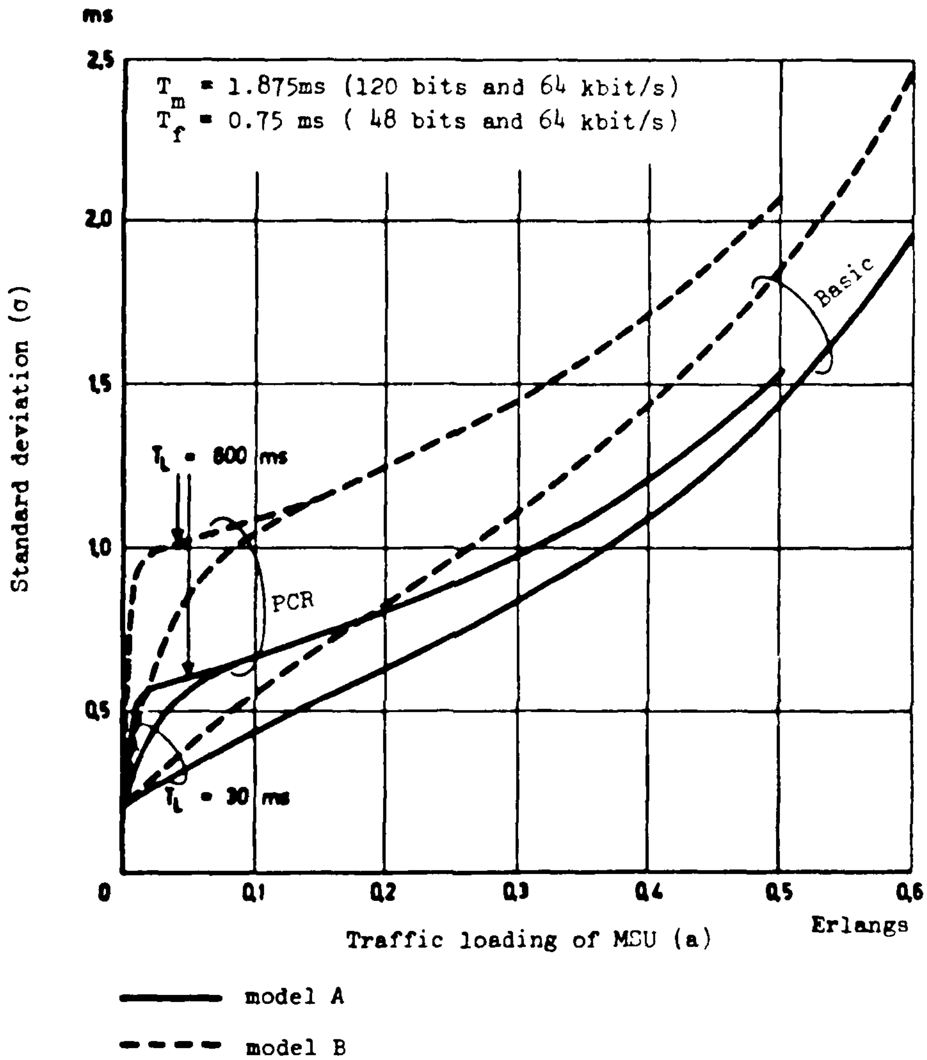
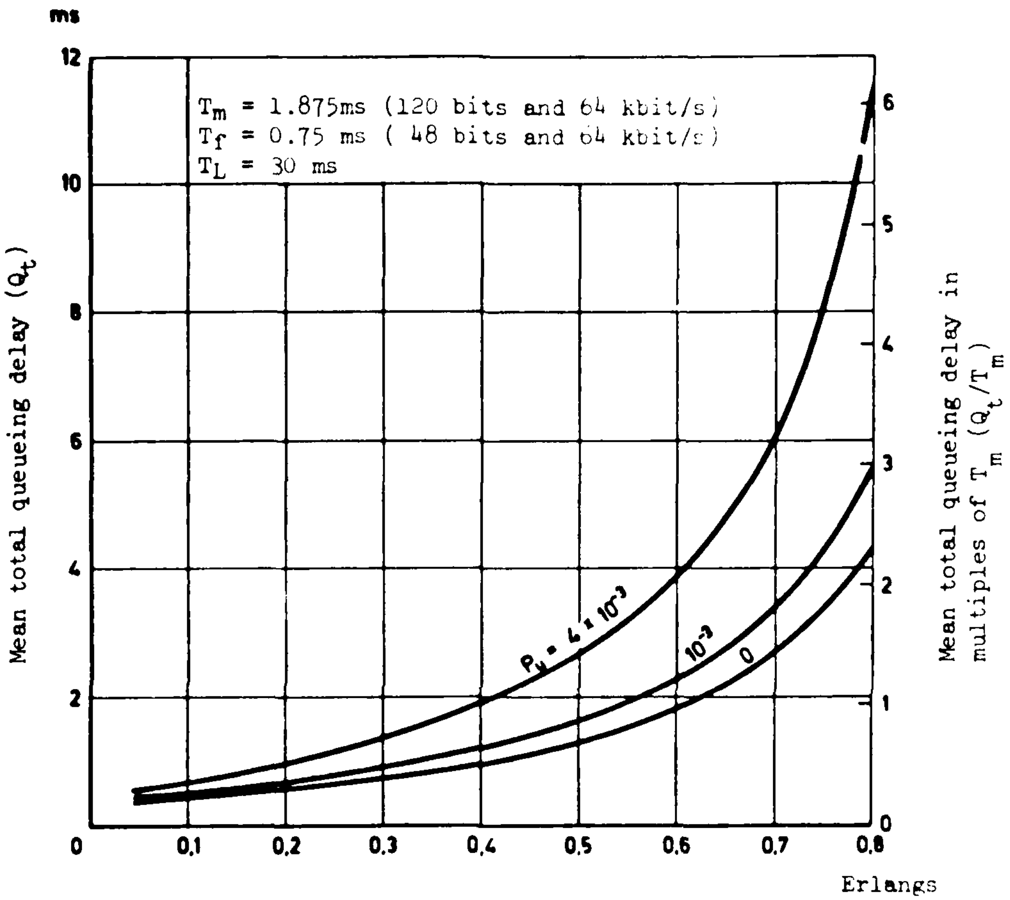
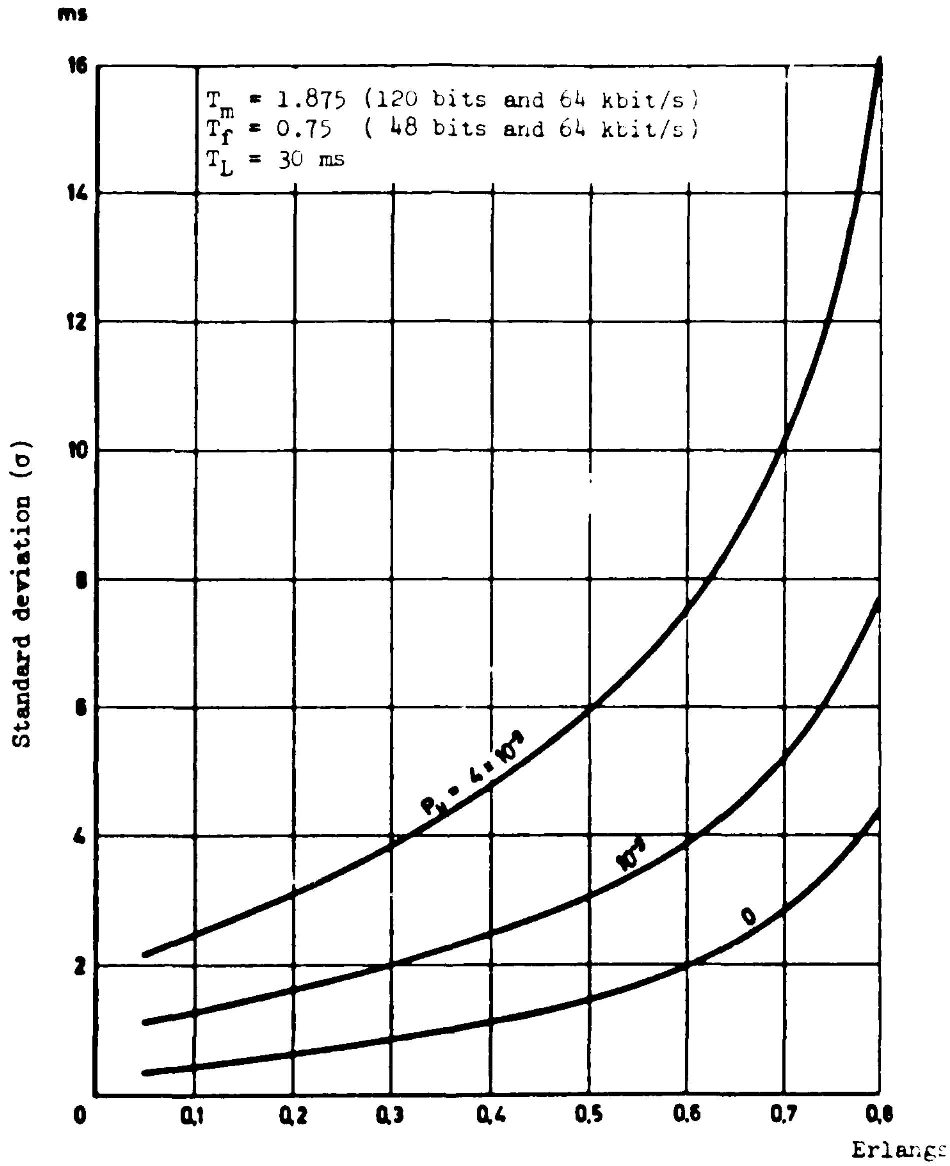


Fig. 4-3 (Q.706) Standard deviation of queueing delay of each channel of traffic in absence of disturbance.



Traffic loading of MSU (a)

Fig. 4-4 (Q.706) Mean total queueing delay of each cnannel of traffic.
- Basic error correction method -



Traffic loading of MSU (a)

Fig. 4-5 (Q.706) Standard deviation of queueing delay of each channel of traffic.
- Basic error correction method -

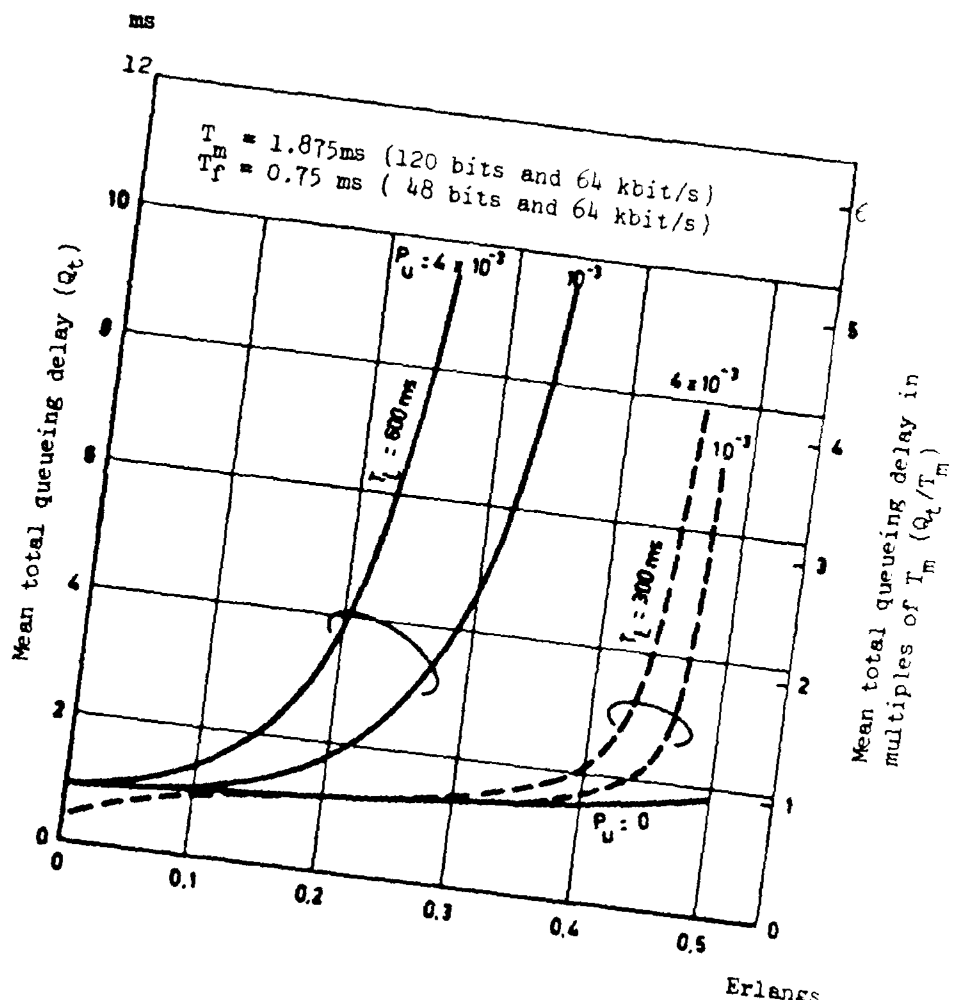


Fig. 4-6 (Q.706) Mean total queueing delay of each channel of traffic.
- Preventive cyclic retransmission error correction method -

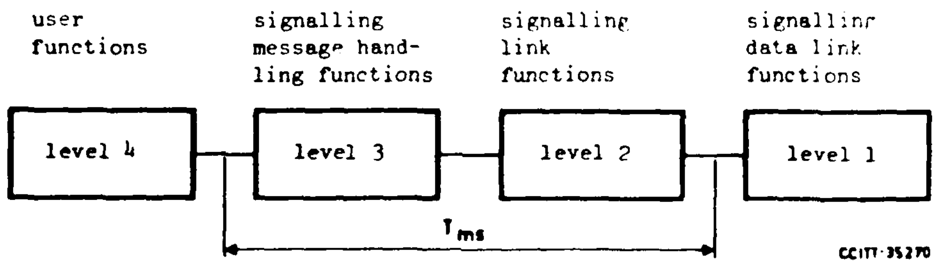
4.3 Message transfer times

Within a signalling relation, the message transfer part transports messages from the originating user part to the user part of destination, using several signalling paths. The overall message transfer time needed depends on the message transfer time components (a) to (e) involved in each signalling path.

4.3.1 Message transfer time components and functional reference points

A signalling path may include the following functional signalling network components and transfer time components.

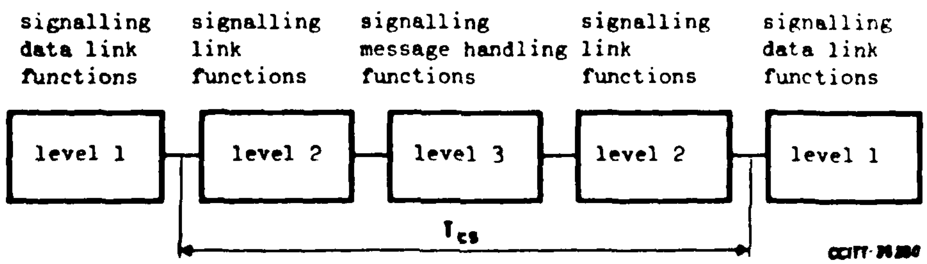
a) Message transfer part sending function at the point of origin.



T_{ms} = Message transfer part sending time

Figure 4-7 ([Q.706]) - Functional diagram of the message transfer part sending time

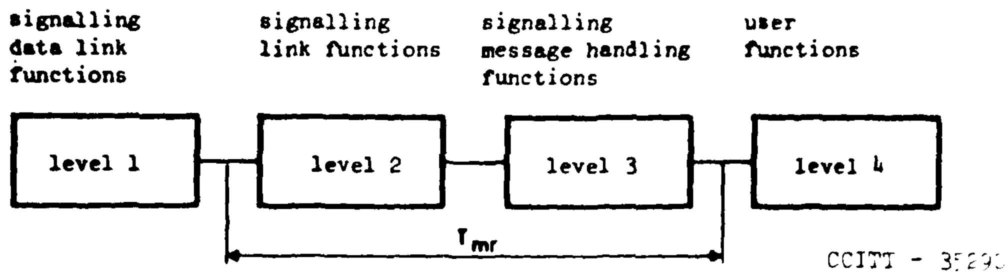
b) Signalling transfer point function



T_{cs} = Message transfer time at signalling transfer points

Figure 4-8 ([Q.706]) - Functional diagram of the message transfer time at signalling transfer points.

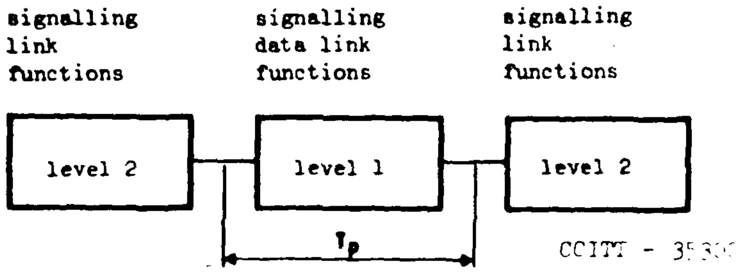
c) Message transfer part receiving function at the point of destination.



T_{mr} = Message transfer part receiving time

Figure 4-9 (Q.706)- Functional diagram of the message transfer part receiving time

d) Signalling data link propagation time.



T_p = propagation time of the data channel

Figure 4-10 (Q.706)- Functional diagram for the propagation time

e) Queueing delay

An additional increase of the overall message transfer times is caused by the queueing delays. They are described in Section 4.2.

4.3.2 Definitions

a) Message transfer part sending time T_{ms}

T_{ms} is the period which starts when the last bit of the message has left the user part and ends when the last bit of the signal unit enters the signalling data link for the first time. It includes the queueing delay in the absence of disturbances, the transfer time from level 4 to level 3, the handling time at level 3, the transfer time from level 3 to level 2, and the handling time in level 2.

b) Message transfer time at signalling transfer points T_{cs}

T_{cs} is the period, which starts when the last bit of the signal unit leaves the incoming signalling data link and ends when the last bit of the signal unit enters the outgoing signalling data link for the first time. It also includes the queueing delay in the absence of disturbances but not the additional queueing delay caused by retransmission.

c) Message transfer part receiving time T_{mr}

T_{mr} is the period which starts when the last bit of the signal unit leaves the signalling data link and ends when the last bit of the message has entered the user part. It includes the handling time in level 2, the transfer time from level 2 to level 3, the handling time in level 3 and the transfer time from level 3 to level 4.

d) Data channel propagation time T_p

T_p is the period which starts when the last bit of the signal unit has entered the data channel at the sending side and ends when the last bit of the signal unit leaves the data channel at the receiving end irrespective of whether the signal unit is disturbed or not.

4.3.3 Overall message transfer times

The overall message transfer time T_o is referred to the signalling relation. T_o starts when the message has left the user part (level 4) at the point of origin and ends when the message has entered the user part (level 4) at the point of destination.

The definition of the overall message transfer time and the definitions of the individual message transfer time components give rise to the following relationships:

a) In the absence of disturbances

$$T_{oa} = T_{ms} + \sum_{i=1}^{n+1} T_{pi} + \sum_{i=1}^{n} T_{csi} + T_{mr}$$

b) In the presence of disturbances

$$T_o = T_{oa} + \sum (Q_t - Q_a)$$

Here

T_{oa} = overall message transfer time in the absence of disturbances

T_{ms} = Message transfer part sending time

T_{mr} = Message transfer part receiving time

T_{cs} = Message transfer time at signalling transfer points

n = number of STPs involved

T_p = data propagation time channel

T_o = overall message transfer time in the presence of disturbances

Q_t = total queueing delay (see Section 4.2)

Q_a = queueing delay in the absence of disturbances (see Section 4.2)

Note - For $(Q_t - Q_a)$, all signalling points in the signalling relation must be taken into account.

4.3.4 Estimates for Message Transfer Times

(Needs further study)

The estimates must take account of:

- the length of the signal unit,
- the signalling traffic load,
- the signalling bit rate.

The estimates for T_{mr} and T_{ms} will be presented in the form of:

- mean values,
- 95% level values.

The estimates for T_{cs} for a signalling transfer point are given in Table 4-3 (Q.706).

TABLE 4-3 ($\boxed{\text{Q.706}}$)

STP Signalling Traffic Load	Message transfer time at an STP 1) in ms (T_{cs})	
	Mean	95%
Normal	20	40
+15%	40	80
+30%	100	200

1) Provisional values

These figures are related to 64 kbit/s signalling bit rate. The normal signalling traffic load is that load for which the signalling transfer point is engineered. A mean value of 0.2 Erlang per signalling link is assumed. The message length distribution is as given in Table 4-2 (Q.706).

4.4 Error control

During transmission, the signal units are subject to disturbances which lead to a falsification of the signalling information. The error control reduces the effects of these disturbances to an acceptable value.

Error control is based on error detection by redundant coding and on error correction by retransmission. Redundant coding is performed by generation of 16 check bits per signal unit based on the polynomial described in Recommendation Q.703, Section 4.2 [2]. Moreover, the error control does not introduce loss, duplication or missequencing of messages on an individual signalling link.

However, abnormal situations may occur in a signalling relation, which are caused by failures, so that the error control for the signalling link involved cannot ensure the correct message sequence.

4.5 Security arrangements

The security arrangements have an essential influence on the observance of the availability requirements listed in Section 1.1 for a signalling relation.

In the case of Signalling System No. 7, the security arrangements are mainly formed by redundancy in conjunction with changeover.

4.5.1 Types of security arrangements

In gene.al, a distinction has to be made between security arrangements for the individual components of the signalling network and security arrangements for the signalling relation. Within a signalling network, any security arrangement may be used, but it must be ensured that the availability requirements are met.

a) Security arrangements for the components of the signalling network

Network components, which form a signalling path when being interconnected, either have constructional security arrangements which exist from the very beginning (e.g. replication of the controls at the exchanges and signalling transfer points) or can be replicated, if need be (e.g. signalling data links). For security reasons, however, replication of signalling data links is effected only if the replicated links are independent of one another (e.g. multipath routing). In the case of availability calculations for a signalling path set, special care has to be taken that the individual signalling links are independent of one another.

b) Security arrangements for signalling relations

In quasi-associated signalling networks where several signalling links in tandem serve one signalling relation, the security arrangements for the network components, as a rule, do not ensure sufficient availability of the signalling relation. Appropriate security arrangements must therefore be made for the signalling relations by the provision of redundant signalling path sets, which have likewise to be independent of one another.

4.5.2 Security requirements

In the case of 64 kbit/s signalling links, a signalling network has to be provided with sufficient redundancy so that the quality of the signalling traffic handled is still satisfactory (application of the above to signalling links using lower bit rates needs further study).

4.5.3 Time to initiate changeover

If individual signalling data links fail, changeover is initiated by signal unit error monitoring (see Recommendation Q.703, Section 8 [3]). With signal unit error monitoring, the time between the occurrence of the failure and the initiation of changeover is dependent on the message error rate (a complete interruption will result in the error rate 1).

Changeover leads to substantial additional queueing delays. To keep the latter as short as possible, the signalling traffic affected by an outage is reduced to a minimum by the use of load sharing on all existing signalling links.

4.6 Failures

4.6.1 Link failures

During transmission, the messages may be subject to disturbances. A measure of the quality of the signalling data link is its signal unit error rate.

Signal unit error monitoring initiates the changeover at a signal unit error rate of about 4×10^{-3}.

The error rate, which Signalling System No. 7 has to cope with, represents a parameter of decisive influence on its efficiency.

As a result of error correction by retransmission, a high error rate causes frequent retransmission of the message signal units and thus long queueing delays.

4.6.2 Failures in signalling points

(Needs further study)

4.7 Priorities

Priorities resulting from the meaning of the individual signals are not envisaged. Basically, the principle "first-in - first-out" applies.

Although the service indicator offers the possibility of determining different priorities on a user basis, such user priorities are not yet foreseen.

Transmission priorities are determined by message transfer part functions. They are solely dependent on the present state of the message transfer part and completely independent of the meaning of the signals (see Recommendation Q.703, Section 9.2 [4]).

5 Performance under adverse conditions

5.1. Adverse conditions

(Needs further study)

5.2 Influence of adverse conditions

(Needs further study)

References

[1] CCITT Recommendation, Signalling Link, Yellow Book, Vol. VI.7, Rec. Q.703, Section 8.2.

[2] CCITT Recommendation, Signalling Link, Yellow Book, Vol. VI.7, Rec. Q.703, Section 4.2.

[3] CCITT Recommendation, Signalling Link, Yellow Book, Vol. VI.7, Rec. Q.703, Section 8.

[4] CCITT Recommendation, Signalling Link, Yellow Book, Vol. VI.7, Rec. Q.703, Section 9.2.

[5] CCITT Recommendation, Signalling Data Link, Yellow Book, Vol. VI.7, Rec. Q.702.

[6] CCITT Recommendation, Error performance on an international digital connection forming part of an integrated services digital network, Yellow Book, Vol. III, Rec. G.8XZ.

Recommendation Q.707

TESTING AND MAINTENANCE

1 General

In order to realize the performance requirements described in Recommendation Q.706 [1], means and procedures for signalling network testing and maintenance are required in addition to the means defined in Recommendation Q.703 [2] and Q.704 [3].

2 Testing

2.1 Signalling data link test

As defined in Recommendation Q.702, Section 1 [4], the signalling data link is a bidirectional transmission path for signalling. Testing and maintenance functions can be initiated independently at either end.

The signalling data link and the constituent parts of the digital and analogue versions are described in Recommendation Q.702, Section 1 [4].

They must be tested before being put into service to ensure that they meet the requirements of Recommendation Q.702, Section 3 [5].

Since interruptions of the signalling data link will affect many transactions, they must be treated with the utmost care. Appropriate special measures should be taken to prevent unauthorized maintenance access which could result in interruptions to service. These special measures may include marking or flagging the equipment and indications on distribution frames or test bays where access is possible (see Recommendation M.1050 [6]).

The signal unit error rate monitor and the alignment error rate monitor described in Recommendation Q.703, Section 8 [7], also provide means for detecting deterioration of a signalling data link.

Further studies are required with reference to Recommendation V.51 [8].

2.2 Signalling link test

As defined in Recommendation Q.703, Section 1.1.1 [9] and illustrated in Figure 2-1 (Q.701) [10], the signalling link comprises a signalling data link with signalling link functions at either end.

In the following, an on-line signalling link test procedure is specified which involves communication between the two ends of the concerned signalling link. This procedure is intended for use while the signalling link is in service. In addition local failure detection procedures should be performed at either end; these are not specified in this Recommendation.

The test procedure is intended to be applied periodically on each operational signalling link with a sufficient frequency to ensure that the signalling link performance requirements are met. The signalling link test message is sent at regular intervals.1) The testing of a signalling link is performed independently from each end.

The ability to send a signalling test acknowledgement, defined below, must always be provided at a signalling point but the provision for transmission of the signalling test message is at the discretion of the signalling points.

The signalling point initiating the tests transmits a signalling link test message on the signalling link to be tested. This message includes a test pattern which is chosen at the discretion of the end initiating the test. After receiving a signalling link test message, a signalling point responds with a signalling link test acknowledgement message on the same signalling link within T = 100 ms (provisional value). The test pattern included in the signalling link test acknowledgement message is identical to the test pattern sent. In the case that a test pattern in a received signalling link test acknowledgement is the same as that sent in a signalling link test message, no further action is taken.

In the case when:

a) a signalling link test acknowledgement message is not received on the link being tested within T1 = 1 s (provisional value), after the signalling link test message has been sent, or

b) a signalling link test acknowledgement message is received with a test pattern that is different from the last pattern sent in a signalling link test message,

the test is considered to have failed and is repeated once. In the case when also the repeated test fails a management system must be informed and further action is for further studies.

The formats and codes of signalling link test and signalling link test acknowledgement messages used for signalling link testing are specified in Section 5.4.

2.3 Signalling route test

In addition to the procedures specified in the Recommendation Q.704, Section 10 [11], the need for, and form of other line procedures are for further studies.

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1) The definition of the lower limit of these intervals is for further study. This must be defined, taking into account the need to ensure that a received signalling link test acknowledgement is in response to the last sent signalling link test message.

3 Fault location

Fault location operations, employing particular manual or automatic internal test equipment are left to the discretion of the individual Signalling Points.

Tests requiring provision of messages are for further studies.

Reference is made to Recommendation V.51, Section 5 [12].

4 Signalling network monitoring

In order to obtain information on the status of the signalling network, monitoring of the signalling activity must be provided (for example measures of the signalling load on the signalling data link). The specification of such means and procedures is for further study.

5 Formats and codes of signalling network testing and maintenance messages

5.1 General

The signalling network testing and maintenance messages are carried on the signalling channel in Message Signal Units, the format of which is described in Recommendation Q.703, Section 2 [13]. As indicated in Recommendation Q.704, Section 12.2 [14], these messages are distinguished by the configuration 0001 of the service indicator (SI). The sub service field (SSF) of signalling network testing and Maintenance messages is used in accordance with Recommendation Q.704, Section 12.3 [15].

The signalling information field (SIF) consists of an integral number of octets and contains the label, the heading code and one or more signals and indications.

5.2 Label

For signalling network testing and maintenance messages, the label has the same structure as the label of signalling network management messages (see Recommendation Q.704, Section 13.2 [16]).

5.3 Heading code Ho

The heading code Ho is the 4-bit field following the label and identifies the message group. The different heading codes are allocated as follows:

0000 Spare

0001 Test messages

The remaining codes are spare.

5.4 Signalling link test messages

The format of the signalling link test messages is shown in Figure 5-1.

			DCBA	0001	
Test pattern	Length indicator	Spare	Heading code H1	Heading code H0	LABEL
n x 8	4[1)]	4[1)]	4	4	32

CCITT-35550

1st bit transmitted

Figure 5-1 (Q.707)

The signalling link test messages, are made up of the following fields:

Label	(32 bits) see Section 5.2
Heading code H0	(4 bits)
Heading code H1	(4 bits)
Spare bits	(4 bits) 1)
Length Indicator	(4 bits) 1)
Test pattern	[n x 8 bits with n < 16 1)]

In the label, the signalling link code identifies the signalling link on which the test message is sent.

The heading code H1 contains signal codes as follows:

bits DCBA

0001 signalling link test message

0010 signalling link test acknowledgement message

The length indicator gives the number which octets, the test pattern comprises:

The test pattern is an integral number of octets and is chosen at the discretion of the originating point.

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1) Provisional value.

6 State transition diagram

The state transition diagram is intended to show precisely the behaviour of the signalling system under normal and abnormal conditions as viewed from a remote location. It must be emphasized that the functional partitioning shown in the following diagram is used only to facilitate understanding of the system behaviour and is not intended to specify the functional partioning to be adopted in a practical implementation of the signalling system.

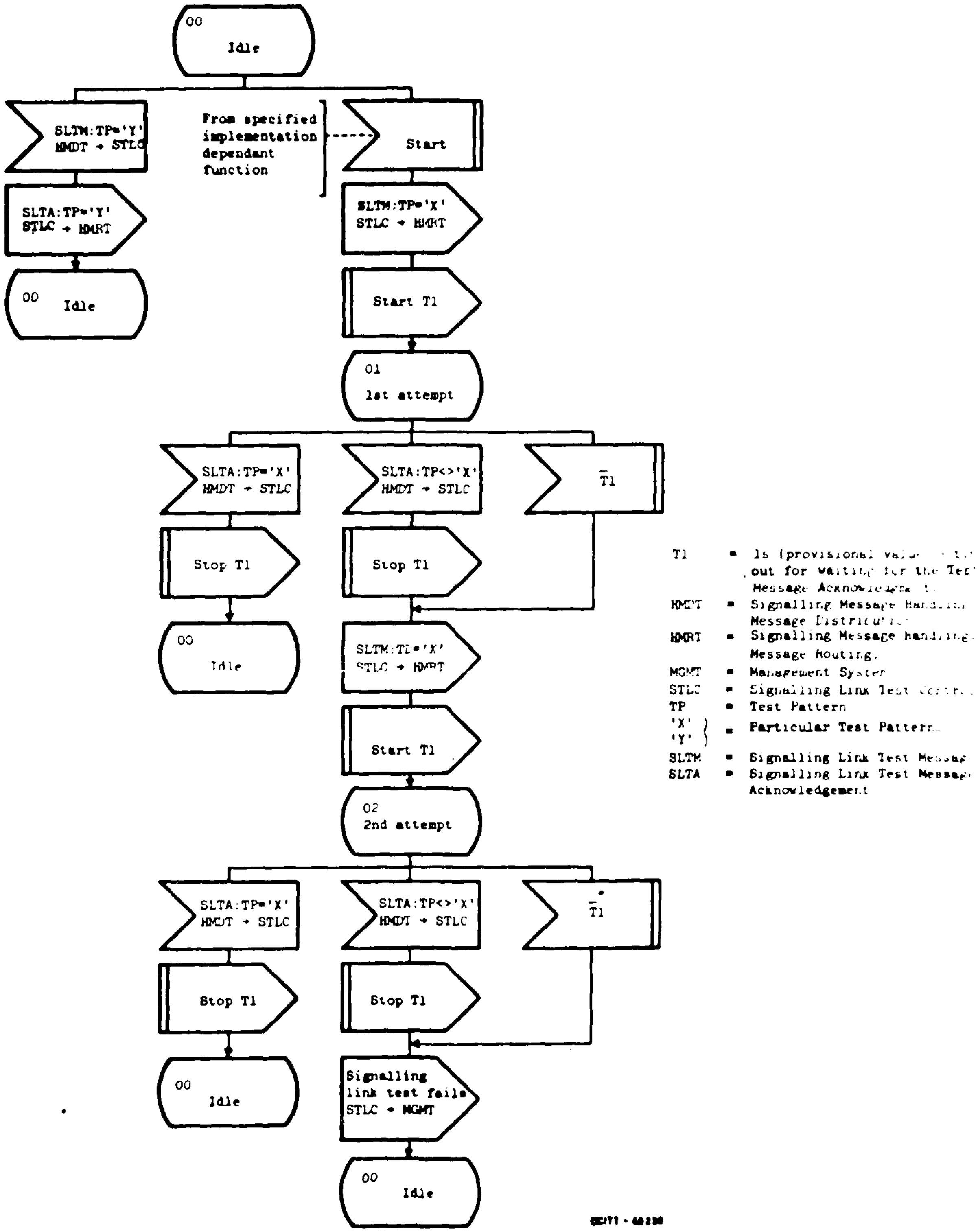

Figure 6-1 (Q.707) - Signalling link test control

(3854)

References

[1] CCITT Recommendation, Signalling System Performance, Yellow Book Vol. VI.7, Rec. Q.706.

[2] CCITT Recommendation, Signalling Link, Yellow Book, Vol. VI.7, Rec. Q.703.

[3] CCITT Recommendation, Signalling Network Functions and Messages, Yellow Book, Vol. VI.7, Rec. Q.704.

[4] CCITT Recommendation, Signalling Data Link, Yellow Book, Vol. VI.7, Rec. Q.702, Section 1.

[5] CCITT Recommendation, Signalling Data Link, Yellow Book, Vol. VI.7, Rec. Q.702, Section 3.

[6] CCITT Recommendation, Lining-up an international point-to-point leased circuit, Yellow Book, Vol. IV ------, Rec. M.1050.

[7] CCITT Recommendation, Signalling Link, Yellow Book, Vol. VI.7, Rec. Q.703, Section 8.

[8] CCITT Recommendation, Organization of the maintenance of international telephone-type circuits used for data transmission, Yellow Book, Vol. VIII -----, Rec. V.51.

[9] CCITT Recommendation, Signalling Link, Yellow Book, Vol. VI.7, Rec. Q.703, Section 1.1.1.

[10] CCITT Recommendation, Functional Description of the Signalling System, Yellow Book, Vol. VI.7, Rec. Q.701, Figure 2-1.

[11] CCITT Recommendation, Signalling Network Functions and Messages, Yellow Book, Vol. VI.7, Rec. (Q.704), Section 10.

[12] CCITT Recommendation, Organization of the maintenance of international telephone-type circuits used for data transmission, Yellow Book, Vol. VIII ---, Rec. V.51, Section 5.

[13] CCITT Recommendation, Signalling Link, Yellow Book, Vol. VI.7, Rec. Q.703, Section 2.

[14] CCITT Recommendation, Signalling Network Functions and Messages, Yellow Book, Vol. VI.7, Rec. Q.704, Section 12.2

[15] CCITT Recommendation, Signalling Network Functions and Messages, Yellow Book, Vol. VI.7, Rec. Q.704, Section 12.3.

[16] CCITT Recommendation, Signalling Network Functions and Messages, Yellow Book, Vol. VI.7, Rec. Q.704, Section 13.2.

Recommendation Q.721

FUNCTIONAL DESCRIPTION OF THE SIGNALLING SYSTEM (TUP)

1 General

Use of Signalling System No. 7 for telephone call control signalling requires:

- application of Telephone User Part (TUP) functions, in combination with,

- application of an appropriate set of Message Transfer Part (MTP) functions.

A general description of the signalling system is given in Recommendation Q.701 [1]. That Recommendation also defines the division of functions and the requirements of interaction between the Message Transfer Part and the Telephone User Part.

2 Telephone User Part

The Telephone User Part specified in these specifications defines the necessary telephone signalling functions for use of Signalling System No. 7 for international telephone call control signalling. It is specified with the aim of providing the same features for telephone signalling as other CCITT telephone signalling systems.

Signalling System No. 7 can be used to control the switching of all types of international circuits to be used in a world-wide connection, including circuits with speech interpolation and satellite circuits.

The system meets all requirements defined by the CCITT concerning the service features for world-wide international semi-automatic and automatic telephone traffic. It is designed for the bothway operation of speech circuits.

When used with homogenous digital telephone circuits the continuity of these circuits is ensured by the means for transmission quality supervision and failure detection that are inherent in the digital systems providing these circuits. However, the system includes means for link-by-link assurance of continuity check of the speech path when used with analogue telephone circuits.

The signalling system is suitable for national telephone applications. Most telephone signalling messages types and signals specified for international use are also required in typical national applications. In addition to these, national applications typically require additional signalling message types and signals; the system provides ample spare capacity for such additions.

The standard label structure specified for telephone signalling messages requires that all exchanges using the signalling system are allocated codes from code plans established for the purpose of unambiguous identification of signalling points. The principles to apply to the international signalling network are for further study.

3 Message Transfer Part

The Message Transfer Part of Signalling System No. 7 is specified in separate recommendations. An overview description of the Message Transfer Part is contained in Recommendation Q.701 [1].

The Message Transfer Part defines a range of functions by which different signalling modes and different signalling network configurations may be realised. Any application of Signalling System No. 7 requires that an appropriate selection of these functions is applied depending on the intended use of the system and the characteristics of the telecommunications network concerned.

Reference

[1] CCITT Recommendation Functional Description of the Signalling System (MTP), Yellow Book, Vol. VI.7, Rec. Q.701.

Recommendation Q.722

GENERAL FUNCTION OF TELEPHONE MESSAGES AND SIGNALS

This Recommendation describes the general function of telephone signalling messages and the telephone signals and other information components contained in those messages. The requirements relating to the use of the signalling messages and their signal content are specified in Recommendation Q.723 [1] and Recommendation Q.724 [2].

1 Telephone signalling messages

The definition of formats and codes for telephone messages is based on a functional grouping as indicated in the following. It is expected that national application of the signalling system typically will require further message types in addition to the internationally defined message types indicated in the following. As a result of the criteria on which the grouping of message types are based some groups as yet only contain one message type.

1.1 Forward address message group

This message group includes messages sent in the forward direction containing address information. Signals from Section 3.3 may be included. Messages so far specified are as follows.

1.1.1 Initial address message

A type of message sent first in the forward direction at call set-up. It contains address information and other information relating to the routing and handling of the call.

1.1.2 Subsequent address message

A type of message sent in the forward direction subsequent to the initial address message and containing further address information.

1.2 Forward set-up message group

This message group includes messages sent in the forward direction, subsequent to address messages containing further information for call set-up. Signals from Section 3.3 may be included. Messages so far specified are as follows.

1.2.1 Calling-line-identity message

A type of message containing the identity of, and possibly other information relating to, the calling line.

1.2.2 Calling-line-identity-unavailable message

A type of message containing the information that the identity of the calling line is not available.

1.2.3 Continuity message

A type of message containing a continuity signal.

1.3 Backward set-up request message group

This message group includes messages sent in the backward direction requesting further information for call set-up. Signals from Section 3.4 may be included. Messages so far specified as follows.

1.3.1 Calling-line-identity-request message

A type of message containing a signal requesting transfer of the identity of, and possibly other information relating to, the calling party.

1.4 Successful backward set-up information message group

This message group includes messages sent in the backward direction containing information relating to a successful call set-up. Signals from Section 3.4 may be included. Messages so far specified as follows.

1.4.1 Successful-call-attempt message

A type of message containing a signal indicating that the call has been connected to the called party and giving additional information relating to this.

1.4.2 Charging message

A type of message containing charging information.

1.5 Unsuccessful backward set-up information message group

This message group includes messages sent in the backward direction containing information relating to an unsuccessful call set-up. Signals from Section 3.4 may be included. Messages so far specified as follows.

1.5.1 Unsuccessful-call-attempt message

A type of message containing a signal indicating the failure of the call and the reason for the failure.

1.6 Call supervision message group

A message containing a signal, from Section 3.5, relating to the supervision of the call.

1.7 Circuit supervision message group

A message containing a signal, from Section 3.6, relating to the supervision of the circuit.

2 Service information

The service information provides the highest level of discrimination between different sets of signalling messages. It contains the following components.

2.1 Service indicator

Information used to identify the User Part to which the signalling message belongs.

2.2 National indicator

Information used for discrimination between international and national messages. In case of national messages, it may for example also be used for discrimination between different label alternatives for national use.

3 Signalling information

3.1 Label components

In the case of the telephone signalling messages the label is used for message routing and, in general, identification of the concerned telephone circuit. The standard label structure consists of the following components.

3.1.1 Destination point code

Information identifying the signalling point to which the message is to be routed.

3.1.2 Originating point code

Information identifying the signalling point from which the message has been originated.

3.1.3 Circuit identification code

Information identifying the telephone circuit among those interconnecting the destination point and originating point.

3.2 Message format identifiers

3.2.1 Heading

Information discriminating, as applicable, between different groups or individual types of messages within the set of messages identified by the service information. The heading is split into two levels. The first level discriminates between different groups. The second level either discriminates between different message types or contains a signal.

3.2.2 Field length indicator

Information associated with and indicating the length of a variable length field.

3.2.3 Field indicator

Information associated with and indicating the presence or absence of an optional field.

3.3 Forward set-up telephone signals

3.3.1 Address Signal

A call set-up signal sent in the forward direction containing one element of information (digit 0, 1, 2 .... 9, Code 11 or Code 12) about the called party's number or the end-of-pulsing (ST) signal.

For each call, a succession of address signals is sent.

3.3.2 End-of-pulsing (ST) signal

An address signal sent in the forward direction indicating that there are no more address signals to follow.

3.3.3 Nature-of-address indicator

Information sent in the forward direction indicating whether the associated address or line identity is an international, national significant or subscriber number.

3.3.4 Nature-of-circuit indicator

Information sent in the forward direction about the nature of the circuit or any preceding circuit(s) already engaged in the connection:

- a satellite circuit, or
- no satellite circuit.

An international exchange receiving this information will use it (in combination with the appropriate part of the address information) to determine the nature of the outgoing circuit to be chosen.

3.3.5 Echo suppressor indicator

Information sent in the forward direction indicating whether or not an outgoing half-echo suppressor is included in the connection.

3.3.6 Calling-party's-category indicator

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

The following categories are provided:

- operator,
- ordinary calling subscriber,
- calling subscriber with priority,
- data call,
- test call.

3.3.7 Continuity-check indicator

Information sent in the forward direction indicating whether or not a continuity check will be performed on the circuit concerned.

3.3.8 Calling line identity

Information sent in the forward direction indicating the national significant number of the calling party.

3.3.9 Calling-line-identity-unavailable signal

A signal sent in the forward direction indicating that the identity of the calling line is not available.

3.3.10 Continuity signal

A signal sent in the forward direction indicating continuity of the preceding No. 7 speech circuit(s) as well as of the selected speech circuit to the following international exchange, including verification of the speech path across the exchange with the specified degree of reliability.

3.3.11 Continuity failure signal

A signal sent in the forward direction indicating failure of continuity of the No. 7 speech circuit.

3.4 Backward set-up telephone signals

3.4.1 Calling-line-identity-request signal

A signal sent in the backward direction requesting transfer of the calling line identity from the originating exchange.

3.4.2 Address-complete signal

A signal 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 no called-party's-line-condition signals (electrical) will be sent.

3.4.3 Address-complete signal, charge

A signal sent in the backward direction indicating that all the address signals required for routing the call to the called party have been received, that no called-party's-line-condition signals (electrical) will be sent and that the call should be charged on answer.

3.4.4 Address-complete signal, no-charge

A signal sent in the backward direction indicating that all the address signals required for routing the call to the called party have been received, that no called-party's-line-condition (electrical) will be sent and that the call should not be charged on answer.

3.4.5 Address-complete signal, coin-box

A signal sent in the backward direction indicating that all the address signals required for routing the call to the called party have been received, that no called-party's-line-condition (electrical) will be sent, that the call should be charged on answer and that the called number is a coin (box) station.

3.4.6 Subscriber-free indicator

Information sent in the backward direction indicating that the called party's line is free.

3.4.7 Switching-equipment-congestion signal

A signal sent in the backward direction indicating the failure of the call set-up attempt due to congestion encountered at international switching equipment.

3.4.8 Circuit-group-congestion signal

A signal sent in the backward direction indicating the failure of the call set-up attempt due to congestion encountered on an international circuit group.

3.4.9 National-network-congestion signal

A signal sent in the backward direction indicating the failure of the call set-up attempt due to congestion encountered in the national destination network [excluding the busy condition of the called party's line(s)].

3.4.10 Address-incomplete signal

A signal sent in the backward direction indicating that the number of address signals received is not sufficient for setting up the call. This condition may be determined in the incoming international exchange (or in the national destination network):

- immediately after the reception of an ST signal, or
- on timeout after the latest digit received.

3.4.11 Call-failure signal

A signal sent in the backward direction indicating the failure of a call set-up attempt due to the lapse of a timeout or a fault not covered by specific signals.

3.4.12 Unallocated number signal

A signal sent in the backward direction indicating that the received number is not in use (for example spare level, spare code, vacant subscriber's number).

3.4.13 Subscriber-busy signal (electrical)

A signal sent in the backward direction indicating that the line(s) connecting the called party with the exchange is (are) engaged. The subscriber-busy signal will also be sent in case of complete uncertainty about the place where the busy or congestions are encountered and in the case where a discrimination between subscriber-busy and national-network congestion is not possible.

3.4.14 Line-out-of-service signal

A signal sent in the backward direction indicating that the called party's line is out-of-service or faulty.

3.4.15 Send-special-information-tone signal

A signal sent in the backward direction indicating that the special information tone should be returned to the calling party. This tone indicates that the called number cannot be reached for reasons not covered by other specific signals and that the unavailability is of long term nature (see also Recommendation A.35).

3.5 Call supervision signals

3.5.1 Forward-transfer signal

A signal 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 signal will normally serve to bring an assistance operator (see Recommendation Q.101 [3]) into the circuit if the call is automatically set up at the exchange. When a call is completed via an operator (incoming or delay operator) at the incoming international exchange, the signal should preferably cause this operator to be recalled.

3.5.2 Answer signal, charge

A signal sent in the backward direction indicating that the call is answered and subject to charge.

In semi-automatic working, this signal has a supervisory function. In automatic working, the signal is used:

- to start metering the charge to the calling subscriber (Recommendation Q.28 [4]), and

- to start the measurement of call duration for international accounting purposes (Recommendation E.260 [5]).

3.5.3 Answer signal, no charge

A signal sent in the backward direction indicating that the call is answered but is not subject to charge. It is used for calls to particular destinations only.

In semi-automatic working, this signal has a supervisory function. In automatic working, the reception of this signal shall not start the metering to the calling subscriber.

3.5.4 Clear-back signal

A signal sent in the backward direction indicating that the called party has cleared.

In semi-automatic working this signal has a supervisory function. In automatic working, the arrangements specified in Recommendation Q.118 [6] apply.

3.5.5 Re-answer signal

A signal sent in the backward direction indicating that the called party, after having cleared, again lifts his receiver or in some other way reproduces the answer condition, e.g. switch-hook flashing.

3.5.6 Clear-forward signal

A signal sent in the forward direction to terminate the call or call attempt and release the circuit concerned. This signal is normally sent when the calling party clears but also may be a proper response in other situations, as for example, when reset circuit is received.

3.6 <u>Circuit supervision signals</u>

3.6.1 <u>Release-guard signal</u>

A signal sent in the backward direction in response to a clear-forward signal, or if appropriate to the reset-circuit signal, when the circuit concerned has been brought into the idle condition.

3.6.2 <u>Reset-circuit signal</u>

A signal that is sent to release a circuit when, due to memory mutilation or other causes, it is unknown whether, for example, a clear-forward or clear-back signal is appropriate. If at the receiving end the circuit is blocked, this signal should remove that condition.

3.6.3 <u>Blocking signal</u>

A signal sent for maintenance purposes to the exchange at the other end of a circuit to cause engaged conditions of that circuit for subsequent calls outgoing from that exchange. An exchange receiving the blocking signal must be capable of accepting incoming calls on that circuit unless it also has sent a blocking signal. Under conditions covered later, a blocking signal is also a proper response to a reset circuit signal.

3.6.4 <u>Unblocking signal</u>

A signal sent to the exchange at the other end of a circuit to cancel in that exchange the engaged conditions of that circuit caused by an earlier blocking signal.

3.6.5 <u>Blocking-acknowledgment signal</u>

A signal sent in response to a blocking signal indicating that the speech circuit has been blocked.

3.6.6 <u>Unblocking-acknowledgment signal</u>

A signal sent in response to an unblocking signal indicating that the speech circuit has been unblocked.

3.6.7 <u>Continuity-check-request signal</u>

A signal sent requesting an independent circuit continuity test.

References

[1] CCITT Recommendation, Formats and Codes, Yellow Book, Vol. VI.7, Rec. Q.723.

[2] CCITT Recommendation, Signalling Procedures, Yellow Book, Vol. VI.7, Rec. Q.724.

[3] CCITT Recommendation, Facilities provided in international semi-automatic working, Yellow Book, Vol. VI.1, Rec. Q.101.

[4] CCITT Recommendation, Determination of the moment of the called subscriber's answer in the automatic service, Yellow Book, Vol. VI.1, Rec. Q.28.

[5] CCITT Recommendation, Basic technical problems concerning the measurement and recording of call durations, Yellow Book, Vol. II ... , Rec. E.260.

[6] CCITT Recommendation, Special release arrangements, Yellow Book, Vol. VI.1, Rec. Q.118.

Recommendation Q.723

FORMATS AND CODES

1 Basic format characteristics

1.1 General

The telephony user messages are carried on the signalling data link by means of signal units the format of which is described in Recommendation Q.703, Section 2.2 [1].

The signalling information of each message constitutes the signalling information field of the corresponding signal unit and consists of an integral number of octets. It basically contains the label, the heading code and one or more signals and/or indications. Structure and function of the label are described in Section 2; the heading codes and detailed message formats are described in Section 3.

1.2 The Service Information Octet

The service information octet comprises the service indicator and the subservice field.

The service indicator is used to associate signalling information with a particular user part and is only used with message signal units (see Recommendation Q.704, Section 12.2 [2]).

The information in the subservice field permits a distinction to be made between national and international signalling messages. In national applications when this discrimination is not required possibly for certain national user parts only, the subservice field can be used independently for different user parts.

AD-A101 055 NATIONAL COMMUNICATIONS SYSTEM WASHINGTON DC F/G 17/2
SPECIFICATIONS OF CCITT SIGNALLING SYSTEM NUMBER 7.(U)
MAY 81
UNCLASSIFIED NCS-TIB-81-3 NL

4 OF 4
AD A
101055

END
DATE
FILMED
7-81
DTIC

The format of the service information octet is shown in Figure 1-1 (Q.723).

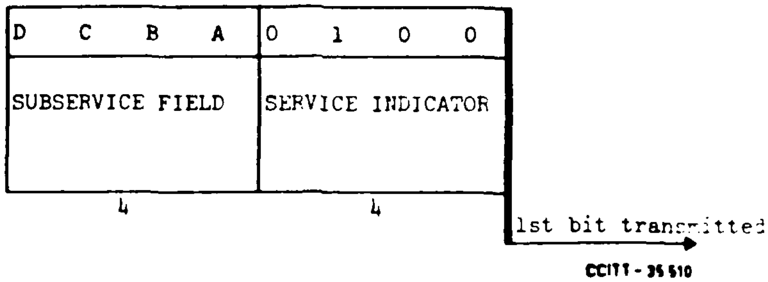

Figure 1-1 (Q.723) - Service Information Octet

The following codes are used in the fields of the service information octet:

a) The service indicator is coded 0100.

b) Subservice field

bits BA	Spare (Note)
bits DC:	National indicator
00	International message
01	Spare (for international use only)
10	National message
11	Reserved for national use

Note - The two unused bits in the service information octet are spare for possible future needs that may require a common solution for all international user parts and Message Transfer Part level 3. The bits are coded 00.

1.3 Format Principles

The user generated information in the signalling information field is, in general, divided into a number of subfields which may be either of fixed or variable length. For a given message type identified by a unique message heading, the presence of a given subfield may be either mandatory or optional. The various types of subfields are further defined below.

1.3.1 Mandatory Subfields

Subfields which have been declared mandatory for a given message type appear in all messages of that type.

1.3.2 Optional Subfields

Subfields which have been declared optional for a given message type only appear when required in messages of that type. The presence or absence of each optional field is indicated by the state of a field indicator located in an indicator field, which in this case is a mandatory subfield.

1.3.3 Fixed Length Subfields

Subfields which have been declared fixed length for a given message type, contain the same number of bits in all messages of that type.

1.3.4 Variable Length Subfields

For subfields which have been declared variable length for a given message type the number of bits may vary between messages of that type. The size of a variable length subfield is indicated in an immediately preceding fixed length subfield in terms of a predefined unit such as bits, octets or half-octets.

1.3.5 Order of Subfield Transmission

For a given type of message the various types of subfields are transmitted in the following order:

a) Mandatory subfields

b) Optional subfields

Within each of these two classes, the order of subfield transmission is, in general, as follows:

a) Fixed length subfields (with the exception of the indicator field and subfiels indicating in size of a variable length subfield)

b) Variable length subfields

1.3.6 Order of Bit Transmission

Within each defined subfield the information is transmitted least significant bit first.

1.3.7 Coding of Spare Bits

Spare bits are coded 0 unless indicated otherwise.

2 Label

2.1 General

The label is an item of information which forms part of every signalling message and is used by the message routing function at Message Transfer Part level 3 to select the appropriate signalling route and by the user part function to identify the particular transaction (e.g. the call) to which the message pertains.

In general, label information encompasses an explicit or implicit indication of the message source and destination and, depending on the application, various forms of transaction identification.

For messages which are related to circuits or calls, the transaction is conveniently identified by including the corresponding circuit identity in the label. In future the introduction of new subscriber services may require the transfer of call related messages between exchanges at a time when no circuit is associated with the call. The type of call identification to be used in that case is for further study.

One standard label format is specified (Section 2.2) for international use. The same standard label is applicable for national use; admitted deviations from the format of the standard label are described in Section 2.3.

2.2 Standard Telephone Label

2.2.1 Label Format

The standard label has a length of 40 bits and is placed at the beginning of the signalling information field. The label structure is as shown in Figure 2-1 (Q.723).

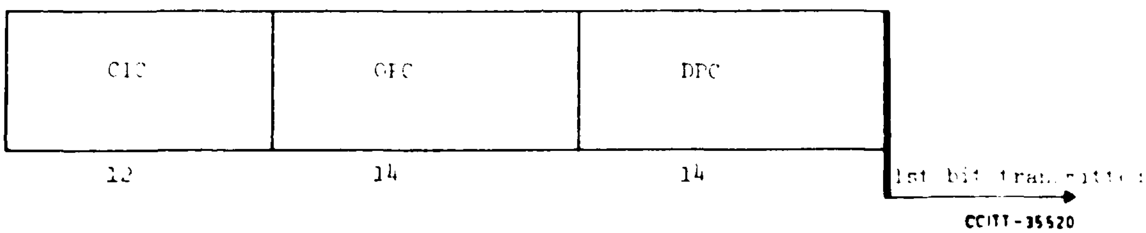

Figure 2-1 (Q.723) - Standard Telephone Label Structure

The destination point code (DPC) indicates the signalling point for which the message is intended, while the originating point code (OPC) indicates the signalling point which is the source of the message. The circuit identification code (CIC) indicates one speech circuit among those directly interconnecting the destination and the originating points.

The portion of the label that consists of the destination point code and originating point code fields and of the four least significant bits of the circuit identification code field corresponds to the standard routing label specified in Recommendation Q.704, Section 13.2 [3] .

2.2.2 Destination and Originating Point Codes

The standard label structure requires that each telephone exchange in its role as signalling point is allocated a code from code plans established for the purpose of unambiguous identification of signalling points.

Separate code plans will be used for the international signalling network and for different national signalling networks.

The principles of code allocation which apply to the international signalling network are for further study.

The destination point code will be the code applicable to the telephone exchange to which the message is sent. The originating point code will be the code applicable to the telephone exchange from which the message is sent.

2.2.3 Circuit Identification Code

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

In the following sections allocation rules for certain applications are defined:

a) 2048 kbit/s Digital Path

For circuits which are derived from a 2048 kb/s digital path (Recommendations G.732 [3] and G.734 [6]) the circuit identification code contains in the 5 least significant bits a binary representation of the actual number of the time slot which is assigned to the speech circuit. The remaining bits in the circuit identification code are used where necessary, to identify one among several systems interconnecting an originating and destination point.

b) 8448 kbit/s Digital Path

For circuits which are derived from a 8448 kb/s digital path (Recommendation G.744 [7] and G.746 [4]) the circuit identification code contains in the 7 least significant bits an identification of the channel which is assigned to the speech circuit. The following codes are used:

0000000	channel 1
0000001	channel 2
|	|
0011111	channel 32
0100000	channel 33
|	|
1111110	channel 127
1111111	channel 128

The remaining bits are used, where necessary, to identify one among several systems interconnecting an originating and destination point.

c) Frequency division multiplex (FDM) systems in networks using the 2.048 Mb/s pulse code modulation standard

For frequency division multiplex systems existing in networks that also use the 2.048 Mb/s pulse code modulation standard, the circuit identification code contains in the 6 least significant bits the identification of a channel within a group of 60 channels carried by 5 basic frequency division multiplex groups which may or may not be part of the same supergroup.

The following codes are used:

000000	unallocated	
000001	channel 1	1st basic (FDM) group
001100	channel 12	
001101	channel 1	2nd basic (FDM) group
001110	channel 2	
001111	channel 3	
010000	unallocated	
010001	channel 4	
011001	channel 12	
011010	channel 1	3rd basic (FDM) group
011111	channel 6	
100000	unallocated	
100001	channel 7	
100110	channel 12	
100111	channel 1	4th basic (FDM) group
101111	channel 9	
110000	unallocated	
110001	channel 10	
110010	channel 11	
110011	channel 12	
110100	channel 1	5th basic (FDM) group
111111	channel 12	

2.3 Optional National Labels

For the purpose of satisfying the requirements imposed by specific characteristics of some national signalling networks, field sizes different from those specified for the standard label are admitted for the destination point code, originating point code and circuit identification code fields in national labels.

3 Telephone signal message formats and codes

3.1 General

All telephone signal messages contain a heading consisting of two parts, heading code H0 and heading code H1. Code H0 identifies a specific message group (see Recommendation Q.722, Section 3.2.1) while H1 either contains a signal code or in case of more complex messages, identifies the format of these messages. The allocation of the H0 and H1 code is summarized in Table 3-1 (Q.723).

3.2 Heading Code H0

The heading code H0 occupies the 4-bit field following the label and is coded as follows:

0 0 0 0	spare, reserved for national use
0 0 0 1	Forward Address Messages
0 0 1 0	Forward Set-up Messages
0 0 1 1	Backward Set-up Request Messages
0 1 0 0	Successful Backward Set-up Information Messages
0 1 0 1	Unsuccessful Backward Set-up Information Messages
0 1 1 0	Call Supervision Messages
0 1 1 1	Circuit Supervision Messages
1 0 0 0 to 1 0 1 1	Reserved for international and basic national use
1 1 0 0 to 1 1 1 1	Reserved for national use

3.3 Forward Address Messages

The following types of forward address messages are specified and are each identified by a different heading code H1.

- Initial address message
- Initial address message with additional information (note)

- Subsequent address message (with one or more address signals)

- Subsequent address message with one (address) signal

Note - The initial address message with additional information is classified, for the time being, in the basic national category of messages. The use of this message in the international network is for further study.

3.3.1 Initial Address Message

The basic format of the initial address message is shown on Figure 3-1 (Q.723).

	F E D C B A	0001	0001	
SPARE	CALLING PARTY CATEGORY	HEADING CODE H1	HEADING CODE H0	LABEL
2	6	4	4	40

1st bit transmitted

		L K J I H G F E D C B A
ADDRESS SIGNALS	NUMBER OF ADDRESS SIGNALS	MESSAGE INDICATORS
n x 8	4	12

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Figure 3-1 ($\boxed{\text{Q.723}}$) - Initial Address Message

The following codes are used in the fields of the initial address message.

a) Label: See Section 2

b) Heading code H0 is coded 0 0 0 1

c) Heading code H1 is coded 0 0 0 1

d) Calling party category indicator

bits F E D C B A	
0 0 0 0 0 0	spare
0 0 0 0 0 1	operator, language French
0 0 0 0 1 0	operator, language English
0 0 0 0 1 1	operator, language German
0 0 0 1 0 0	operator, language Russian
0 0 0 1 0 1	operator, language Spanish
0 0 0 1 1 0 0 0 0 1 1 1 0 0 1 0 0 0	available to administrations for selecting a particular language provided by mutual agreement
0 0 1 0 0 1	reserved (see Recommendation Q.104 [6]) (note)
0 0 1 0 1 0	ordinary calling subscriber
0 0 1 0 1 1	calling subscriber with priority
0 0 1 1 0 0	data call
0 0 1 1 0 1	test call
0 0 1 1 1 0 to 1 1 1 1 1 1	spare

Note - In national networks code 001001 may be used to indicate that the calling party is a national operator.

e) Spare

The bits in this field are spare for international allocation.

f) Message indicators

bits BA : nature of address indicator

00 subscriber number

01 spare, reserved for national use

10 national (significant) number

11 international number

bits DC : nature-of-circuit indicator

00 no satellite circuit in the connection

01 one satellite circuit in the connection

10 spare

11 spare

bits FE : continuity-check indicator

00 continuity-check not required

01 continuity-check required on this circuit

10 continuity-check on previous circuit

11 spare

bit G : echo-suppressor indicator

0 outgoing half-echo-suppressor not included

1 outgoing half-echo-suppressor included

bits H-L: spare (note)

Note - Spare indicators may be used, e.g. to provide the following indications, pending further study:

- incoming international call

- redirected call

- all digital path required

- /A law conversion control

g) Number of address signals

A code expressing in pure binary representation the number of address signals contained in the initial address message.

h) Address signals

0 0 0 0	digit 0
0 0 0 1	digit 1
0 0 1 0	digit 2
0 0 1 1	digit 3
0 1 0 0	digit 4
0 1 0 1	digit 5
0 1 1 0	digit 6
0 1 1 1	digit 7
1 0 0 0	digit 8
1 0 0 1	digit 9
1 0 1 0	spare
1 0 1 1	code 11
1 1 0 0	code 12
1 1 0 1	spare
1 1 1 0	spare
1 1 1 1	ST

The most significant address signal is sent first. Subsequent address signals are sent in successive 4-bit fields.

i) Filler

In case of an odd number of address signals, the filler code 0 0 0 0 is inserted after the last address signal This ensures that the variable length field which contains the address signals consists of an integral number of octets.

3.3.2 Initial Address Message with Additional Information

The basic format of the initial address message with additional information is shown on Figure 3-2 (Q.723).

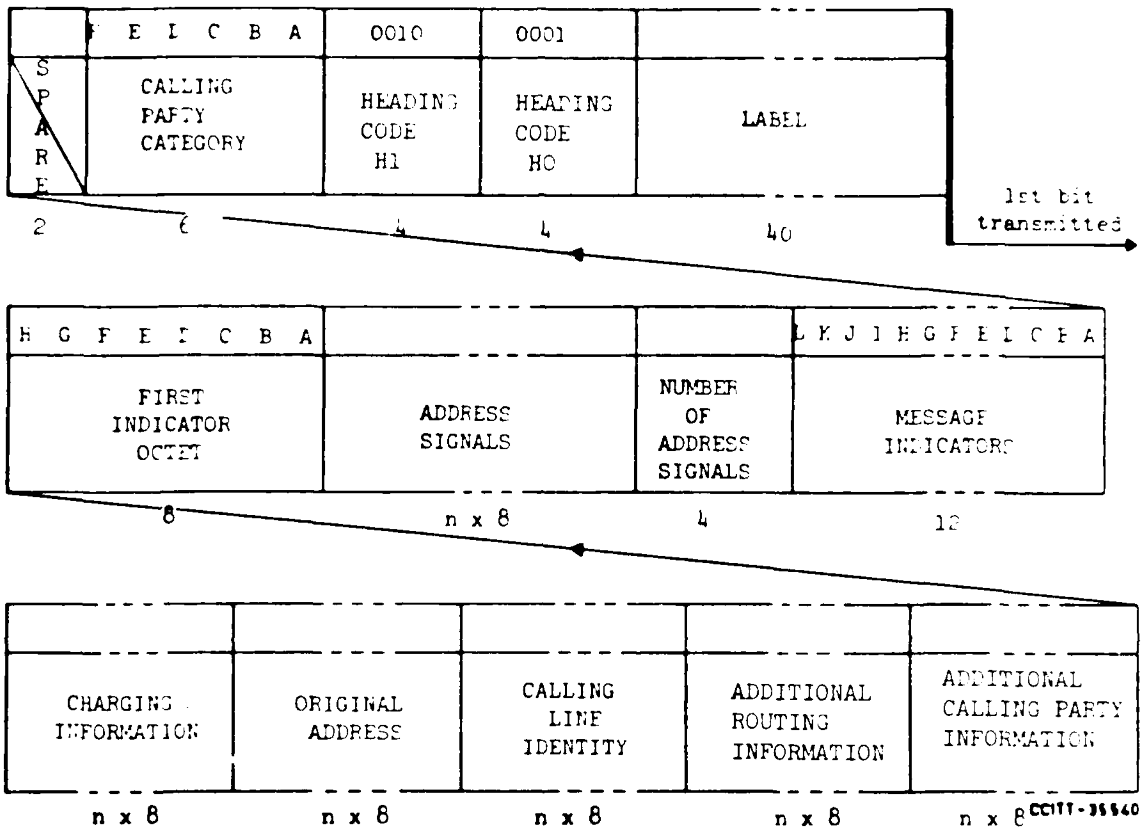

Figure 3-2 ($\boxed{\text{Q.723}}$) - Initial Address Message with Additional Information

The following codes are used in the initial address message with additional information:

a) Label: See Section 2

b) Heading code H0 is coded 0001

c) Heading code H1 is coded 0010

d) Calling party category indicator: (see Section 3.3.1d)

e) Message indicators: (see Section 3.3.1f)

f) Number of address signals: (see Section 3.3.1g)

g) Address signals: (see Section 3.3.1h)

h) First indicator octet

bit A : additional calling party information indicator

0 additional calling party information not included

1 additional calling party information included

bit B : additional routing information indicator

0 additional routing information not included

1 additional routing information included

bit C : calling line identity indicator

0 calling line identity not included

1 calling line identity included

bit D : original address indicator

0 original address not included

1 original address included

bit E : charging information indicator

0 charging information not included

1 charging information included

bits F, G : spare

bit H : spare, reserved for indicating the presence or absence of a second indicator octet.

i) Additional calling party information: for further study

(This optional field is of fixed length and will indicate additional information concerning the calling party, which is not carried by the calling party's category indicator.)

j) Additional routing information: for further study

(This optional field is of fixed length and will indicate that the call has to be routed in some particular way, due for example to additional customer services.)

k) Calling line identity: for further study

(This optional field is of variable length and will contain the identity of the calling line in a format similar to that used in the calling line identity message, including an explicit indication of the number of address signals and a nature of address indicator.)

l) Original Address: for further study

(This optional field is of variable length and will contain the identity of the original destination address to be used in connection with additional subscriber services. Included will be an explicit indication of the number of address signals and a nature of address indicator.)

m) Charging Information: for further study

(This optional field will contain information to be sent to a successive exchange for charging and/or accounting purposes.)

3.3.3 Subsequent Address Message

The basic format of the subsequent address message is shown in Figure 3-3 (Q.723).

		0000	0011	0001	
ADDRESS SIGNALS	NO. OF ADDRESS SIGNALS	FILLER	HEADING CODE H1	HEADING CODE H0	LABEL
n x 8	4	4	4	4	40

1st bit transmitted

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Figure 3-3 ($\boxed{\text{Q.723}}$) - Subsequent Address Message

The following codes are used in the fields of the SAM:

a) Label: see Section 2

b) Heading code H0 is coded 0 0 0 1

c) Heading code H1 is coded 0 0 1 1

d) Address signal is coded as indicated in Section 3.3.1h (as applicable).

e) Number of address signals: A code expressing in pure binary representation the number of address signals contained in the subsequent address message.

3.3.4 Subsequent Address Message with One Signal

The basic format of the subsequent address message with one signal is shown in Figure 3-3a (Q.723).

0000		0100	0001	
FILLER	ADDRESS SIGNAL	HEADING CODE H1	HEADING CODE H0	LABEL
4	4	4	4	40

1st bit transmitted

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Figure 3-3a (Q.723) - Subsequent Address Message with One Signal

The following codes are used in the fields of the subsequent address message with one signal:

a) Label: See Section 2.

b) Heading code H0 is Coded 0 0 0 1.

c) Heading code H1 is Coded 0 1 0 0.

d) Address signal is coded as indicated in Section 3.3.1h (as applicable).

3.4 Forward Set-up Messages

The following types of forward set-up messages are specified and are each identified by a different heading code H1:

- Calling-line-identity message
- Calling-line-identity-unavailable message
- Continuity check message

Unallocated H1 codes in this message group are spare.

3.4.1 Calling Line Identity Message (Note)

The basic format of the calling line identity message is shown in Figure 3-4 (Q.723)

		D C B A	0001	0010	
CALLING LINE ADDRESS SIGNALS	NO. OF ADDRESS SIGNALS	MESSAGE INDICATORS	HEADING CODE H1	HEADING CODE H0	LABEL
n x 8	4	4	4	4	40

1st bit transmitted

CCITT - 35550

Figure 3-4 (Q.723) - Calling-Line-Identity Message

The following codes are used in the fields of the calling line identity message:

a) Label: see Section 2

b) Heading code H0 is coded 0010

c) Heading code H1 is coded 0001

d) Message indicators

bits BA : nature of address indicator

00 subscriber number

01 spare, reserved for national use

10 national significant number

11 international number

bits DC spare

e) Number of address signals

A code expressing in pure binary representation the number of calling line address signals.

f) Calling line address signals (as applicable)

Each signal is coded as indicated in Section 3.3.1h.

Note — The calling-line-identity message is classified, for the time being, in the basic national category of messages. The use of this message in the international network is for further study.

3.4.2 Calling-Line-Identity-Unavailable Message

The basic format of the calling-line-identity-unavailable message is shown in Figure 3-4a.

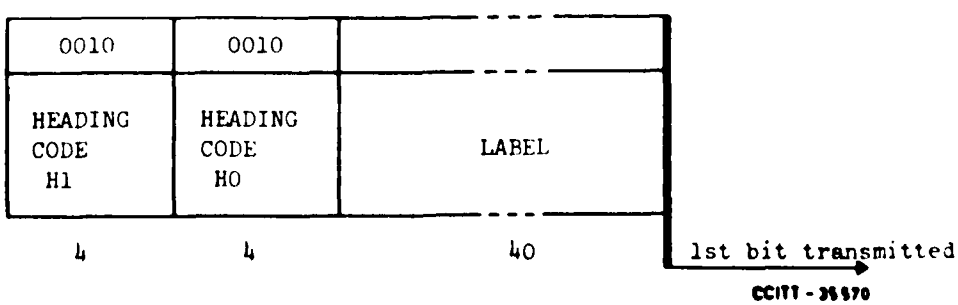

Figure 3-4a ($\boxed{Q.723}$) - Calling-Line-Identity-Unavailable Message

The following codes are used in the fields of the calling-line-identity unavailable message:

a) Label: see Section 2

b) Heading code H0 is coded 0010

c) Heading code H1 contains the calling-line-identity-unavailable signal and is coded 0010

3.4.3 Continuity-Check Message

The basic format of the continuity-check message is shown in Figure 3-5 (Q.723).

	0010	
HEADING CODE H1	HEADING CODE H0	LABEL
4	4	40

1st bit transmitted

CCITT - 35570

Figure 3-5 (Q.723) - Continuity-Check Message

The following codes are used in the fields of the continuity-check message:

a) Label: see Section 2

b) Heading code H0 is coded 0010

c) Heading code H1 contains signal codes as follows:

0 0 1 1 continuity signal

0 1 0 0 continuity-failure signal

3.5 Backward Set-up Request Message

The basic format of the backward set-up request message is shown in Figure 3-6 (Q.723).

	0011	
HEADING CODE H1	HEADING CODE H0	LABEL
4	4	40

1st bit transmitted

CCITT - 35570

Figure 3-6 (Q.723) - Backward Set-up Request Message

The following codes are used in the fields of the backward set-up request message:

a) Label: see Section 2

b) Heading code H0 is coded 0011

c) Heading code H1 contains signal codes as follows:

0 0 0 0	spare
0 0 0 1	calling-line-identity-request signal
0 0 1 0 to 1 1 1 1	spare

<u>Note</u> — The calling-line-identity-request signal is classified for the time being in the basic national category of messages. The use of this message in the international network is for further study.

3.6 <u>Successful Backward Set-up Information Message</u>

The following types of successful backward set-up information messages are specified and are each identified by a different heading code H1:

- Address-complete message
- Charging message

3.6.1 <u>Address-Complete Message</u>

The basic format of the <u>address-complete</u> message is shown in Figure 3-7 (Q.723).

H G F E D C B A	0001	0100	
MESSAGE INDICATORS	HEADING CODE H1	HEADING CODE H0	LABEL
8	4	4	40

1st bit transmitted

CCITT - 36 600

Figure 3-7 (Q.723) - Address-Complete Message

The following codes are used in the fields of the address-complete message:

a) Label: see Section 2

b) Heading code H0 is coded 0100

c) Heading code H1 is coded 0001

d) Message indicators

bits BA : Type of address-complete signal indicators

00 address-complete signal

01 address-complete, signal, charge

10 address-complete, signal, no charge

11 address-complete, signal, coin box

bit C : subscriber free indicator

0 no indication

1 subscriber-free

bit D : spare, for international use

bits E-H: spare, for national use

3.6.2 Charging Message (note)

The basic format of the charging message is shown in Figure 3-8 (Q.723).

	0010	0100	
CHARGING INFORMATION	HEADING CODE H1	HEADING CODE H0	LABEL
n x 8	4	4	40

1st bit transmitted

CCITT-35585

Figure 3-8 (Q.723) - Charging Message

The following codes are used in the fields of the charging message:

a) Label: see Section 2

b) Heading code H0 is coded 0100

c) Heading code H1 is coded 0010

d) Charging information

(The format and codes of the charging information field are for further study.)

Note - The charging message is classified, for the time being, in the basic national category of messages. The use of this message in the international network is for further study.

3.7 Unsuccessful Backward Set-up Information Message

The basic format of the unsuccessful backward set-up information message is shown in Figure 3-9 (Q.723).

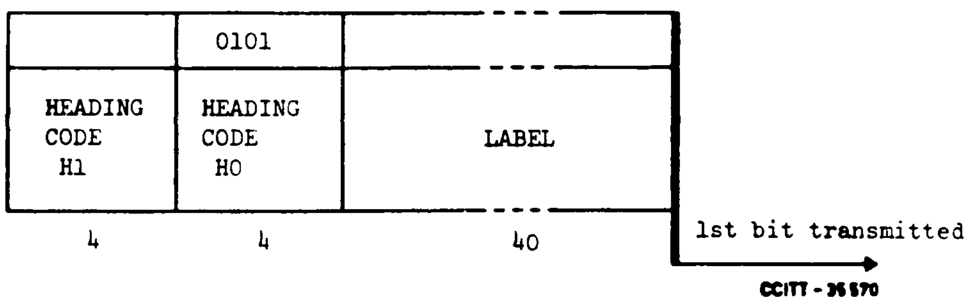

Figure 3-9 (Q.723) - Unsuccessful Backward Set-Up Information Message

The following codes are used in the fields of the unsuccessful backward set-up information message.

a) Label: see Section 2

b) Heading code H0 is coded 0101

c) Heading code H1 contains signal codes as follows

0 0 0 0 spare

0 0 0 1 switching-equipment-congestion signal

0 0 1 0 circuit-group-congestion signal

0 0 1 1 national-network-congestion signal

0 1 0 0 address-incomplete signal

0 1 0 1 call-failure signal

0 1 1 0 subscriber-busy signal (electrical)

0 1 1 1 unallocated-number signal

1 0 0 0 line-out-of-service signal

1 0 0 1 send-special-information-tone signal

1 0 1 0 to 1 1 1 0 } spare

1 1 1 1 extended unsuccessful backward set-up information message indication

3.8 Call Supervision Message

The basic format of the call supervision message is shown in Figure 3-10 (Q.723)

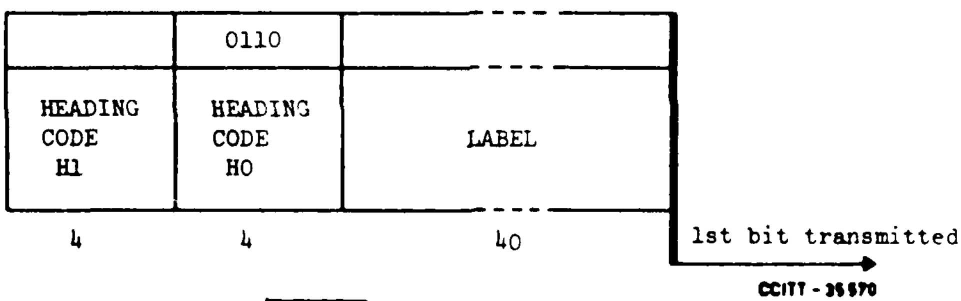

Figure 3-10 (Q.723) - Call Supervision Message

The following codes are used in the fields of the call supervision message:

a) Label: see Section 2

b) Heading code HO is coded 0110

c) Heading code H1 contains signal codes as follows

0 0 0 0 spare

0 0 0 1 answer signal, charge

0 0 1 0 answer signal, no charge

0 0 1 1 clear-back signal

0 1 0 0 clear-forward signal

0 1 0 1 re-answer signal

0 1 1 0 forward-transfer signal

0 1 1 1 to 1 1 1 0 spare

1 1 1 1 extended answer message indication

3.9 Circuit Supervision Message

The basic format of the circuit supervision message is shown in Figure 3-11 (Q.723).

	0111	
HEADING CODE H1	HEADING CODE H0	LABEL
4	4	40

1st bit transmitted

CCITT - [illegible]

Figure 3-11 ($\boxed{Q.723}$) - Circuit Supervision Message

The following codes are used in the fields of the circuit supervision message:

a) Label: see Section 2.

b) Heading code H0 is coded 0111

c) Heading code H1 contains signal codes as follows:

0 0 0 0 spare

0 0 0 1 release-guard signal

0 0 1 0 blocking signal

0 0 1 1 blocking-acknowledgement signal

0 1 0 0 unblocking signal

0 1 0 1 unblocking-acknowledgement signal

0 1 1 0 continuity-check-request signal

0 1 1 1 reset-circuit signal

1 0 0 0 to 1 1 1 1 spare

TABLE 3.1 (Q.723)

Heading Code Allocation

MESSAGE GROUP	H0 \ H1	0000	0001	0010	0011	0100	0101	0110	0111	1000	1001	1010	1011	1100	1101	1110	1111
	0000	Spare, reserved for national use															
FAM	0001		IAM	IAI	SAM	SAO											
FSM	0010		CLI	CLU	CCT	CCF											
BSM	0011		CIR														
SBM	0100		ACM	CHG													
UBM	0101		SEC	CGC	NNC	ADI	CFL	SSB	UNN	LOS	SST						EUM
CSM	0110		ANC	ANN	CBK	CLF	RAN	FOT									EAM
CCM	0111		RLG	BLO	BLA	UBL	UBA	CCR	RSC								
	1000	Spare, reserved for international and basic national use															
	1001																
	1010																
	1011																
	1100	Spare, reserved for national use															
	1101																
	1110																
	1111																

CCITT - 35590

ABBREVIATIONS USED IN Q.723 TABLE 3.1

ACM - Address complete message

ADI - Address incomplete signal

ANC - Answer signal, charge

ANN - Answer signal, no charge

BLA - Blocking-acknowledgement signal

BLO - Blocking signal

BSM - Backward set-up message

CBK - Clear-back signal

CCF - Continuity-failure signal

CCM - Circuit supervision message

CCR - Continuity-check request signal

CFL - Call-failure signal

CGC - Circuit-group-congestion signal

CHG - Charging message

CIR - Calling-line-identity-request signal

CLF - Clear-forward signal

CLI - Calling-line-identity message

CLU - Calling-line-identity-unavailable signal

COT - Continuity signal

CSM - Call supervision message

EAM - Extended answer message indication

EUM - Extended unsuccessful backward set-up information message indication

FAM - Forward address message

FOT - Forward-transfer signal

FSM - Forward set-up message

IAI - Initial address message with additional information

IAM - Initial address message

LOS - Line-out-of-service signal

NNC - National-network-congestion signal

RAN - Reanswer signal

RLG - Release-guard signal

RSC - Reset-circuit signal

SAM - Subsequent address message

SAO - Subsequent address message with one signal

SBM - Successful backward set-up information message

SEC - Switching-equipment-congestion signal

SSB - Subscriber-busy signal (electrical)

SST - Subscriber-transferred signal

UBA - Unblocking-acknowledgement signal

UBL - Unblocking signal

UBM - Unsuccessful backward set-up information message

UNN - Unallocated-national-number signal

References

[1] CCITT Recommendation, Signalling Link, Yellow Book, Vol.VI.7, Rec. Q.703, Section 2.2.

[2] CCITT Recommendation, Signalling Network Functions and Messages, Yellow Book, Vol. VI.7, Rec. Q.704, Section 2.2.

[3] CCITT Recommendation, Characteristics of primary PCM multiplex equipment operating at 2048 kbit/s, Yellow Book, Vol. III, Rec. G.732.

[4] CCITT Recommendation, Characteristics of 8448 Kbit/s structure for use with digital exchanges, Yellow Book, Vol. III, Rec. G.746.

[5] CCITT Recommendation, Language digit or discriminating digit, Yellow Book, VI.1, Rec. Q.104.

[6] CCITT Recommendation, Characteristics of 2048 kbit/s frame structure for use with digital exchanges, Yellow Book, Vol. III, Rec. G.734.

[7] CCITT Recommendation, Second order PCM multiplex equipment operating at 8448 kbit/s, Yellow Book, Vol. III, Rec. G.744.

(3854)

Recommendation Q.724

SIGNALLING PROCEDURES

1 Normal call set-up

In this Recommendation the signalling procedures are described for the normal call set-up of an international call. The messages and signals are defined in Recommendation Q.722 [1] and the format and content is given in Recommendation Q.723 [1].

1.1 Initial address message

An initial address message which is sent as the first message of a call set-up generally includes all of the information required by the next international exchange to route the call. The seizing function is implicit in the reception of this initial address message.

The sending sequence of address information will be the country code (not sent to an incoming international exchange) followed by the national (significant) number. For calls to operator positions (code 11 and code 12), refer to Recommendation Q.107 [3].

All digits required for routing the call through the international network will be sent in the initial address message. On calls with a country code in the address (except in the case of calls to special operators), the initial address message will contain a minimum of 4 digits and should contain as many digits as are available. All digits of the address may be included, however the initial address message can contain one digit in specific circumstances e.g. national applications.

Selection of the outgoing national circuit normally can start at the incoming international exchange on receipt of the initial address message and signalling can proceed on the first national link.

When no echo suppressor or nature-of-circuit indication is received from a preceding circuit using a signalling system with fewer facilities, the indicators will be considered as received no unless positive knowledge is available.

1.2 Subsequent address message

The remaining digits, if any, of the address may be sent individually in one-digit messages or in groups in multi-digit messages. Efficiency can be gained by grouping together as many digits as possible.

However, to prevent an increase in post-dialling delay in those cases where overlap operation with subscribers' dialling is used, it may be desirable to send the last few digits individually.

Subsequent address messages can be sent on the national network as they are received. If continuity-check has to be performed on one or more of the international circuits involved in the connection appropriate measures [e.g. by withholding the last digit(s) of the national number] must be taken at the last common channel exchange, to prevent ringing the called subscriber or alerting the operator until the continuity of such speech circuits has been verified.

1.3 End-of-pulsing (ST) signal

The end-of-pulsing (ST) signal is always sent in the following situations:

a) semi-automatic calls,

b) test calls, and

c) when the end-of-pulsing signal is received from a preceding circuit.

In automatic working, the end-of-pulsing signal will be sent whenever the outgoing international exchange is in a position to know, by digit analysis, that the final digit has been sent. Digit analysis may consist of an examination of the country code and counting of the maximum (or fixed) number of digits of the national number. In other cases, the end-of-pulsing signal is not sent and the end-of-address information is determined by the receipt of one of the address-complete signals from the incoming international exchange.

1.4 Continuity-check of the telephone circuits

Because the signalling in Signalling System No. 7 does not pass over the speech path, facilities should de provided for making a continuity-check of the speech path in the circumstances described below.

The application of the continuity-check depends on the type of the transmission system used for the telephone circuit.

For transmission systems having some inherent fault indication features giving an indication to the switching system in case of fault, a continuity-check is not required. This situation occurs when fully digital circuits are applied.

For analogue circuits with pilot supervision it is sufficient to perform the continuity-check on a statistical basis or by test calls (see Section 7.5) 1). For analogue circuits not using pilot supervision and for mixed circuits, i.e. analogue and digital the continuity-check should be performed on a per call basis. Within mixed connections, i.e. connections composed of circuits with and without continuity-check on a per call basis, it shall be ensured that the continuity signal be forwarded to the destination point although no continuity-check may have been performed on one or more parts of the end-to-end connection.

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1) The application to the international ciruits and the quantitive aspects (in particular, the frequency of performing the continuity-check) are for further study.

The continuity-check is not intended to eliminate the need for routine testing of the transmission path.

The continuity-check of the speech circuit will be done, link-by-link, on a per call basis or by a statistical method prior to the commencement of conversation. Procedures and requirements are specified in Section 7.

The actions to be taken when pilot supervision is used are described in Section 9.

1.5 Cross-office check

For digital exchanges the requirements mentioned in Recommendation Q.504 [10] shall be met. For other exchanges Administrations shall ensure the reliability of a connection through a switching machine (cross-office check) either on a per call basis or by a statistical method. With either method, the probability of the connection being established with an unacceptable speech path transmission quality should not exceed 10^{-5} as the long-term average.

1.6 Address-complete signals

An address-complete signal will not be sent until the continuity signal has been received and the cross-office check made, if applicable.

If the succeeding network does not provide electrical called-party's-line-condition signals, the last Signalling System No.7 exchange shall originate and send an address-complete signal when the end of address signalling has been determined:

a) by receipt of an end-of-pulsing signal;

b) by receipt of the maximum number of digits used in the national numbering plan;

c) by analysis of the national (significant) number to indicate that a sufficient number of digits has been received to route the call to the called party;

d) by receipt of an end-of-selection signal from the succeeding network (e.g. number received signal in Signalling System No. 4); or

e) exceptionally, if the succeeding network uses overlap signalling and number analysis is not possible, by observing that 4 to 6 seconds have elapsed since the last digit was received, and that no fresh information has been received; in such circumstances, transmission to the national network of the last digit received must be prevented until the end of the waiting period which causes an address-complete signal to be sent over the international circuit. In this way, it is ensured that no national answer signal can arrive before an address-complete signal has been sent.

If in normal operation delay in the receipt of an address-complete or equivalent signal from the succeeding network is expected, the last common channel signalling exchange will originate and send an address-complete signal 15 to 20 seconds after receiving the latest address message. This time-out condition is an upper limit considering the clauses of Section 6.4.1 (20 to 30 seconds for outgoing international exchanges in abnormal release conditions).

On receipt of an address-complete signal, the first Signalling System No. 7 exchange will through-connect the speech path of the interconnected circuit 1).

After an address-complete signal, only the following signals relating to the call set-up may be sent in the backward direction:

a) in normal operation, one of the answer or release-guard signals;

b) call-failure signal; or

c) one of the congestion signals.

Any further information about the called-party's-line-condition will be transmitted to the calling subscriber or operator as audible tones or announcements.

The address-complete signal with the subscriber-free indication is sent when it is known that the called subscriber's line is free (not busy). It must be originated in the called subscriber's exchange, and therefore cannot be followed by one of the unsuccessful backward set-up information signals.

1.7 Address-incomplete signal

The determination that the proper number of digits has not been received can be made at once if the end-of-pulsing signal is received or by receipt of an address-incomplete signal (or equivalent) from the national network. When overlap working is used and the end-of-pulsing signal has not been received, the address-incomplete signal will be sent by the last Signalling System No. 7 exchange 15 to 20 seconds after receipt of the latest digit.

Each Signalling System No. 7 exchange on receipt of the address-incomplete signal will send the signal to the preceding Signalling System No. 7 exchange, if any, and clear forward the connection. The first Signalling System No. 7 exchange will send a suitable signal on the preceding circuit if the related signalling system permits to do so otherwise the appropriate tone or announcement for the national network concerned will be sent to the calling party.

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1) It is envisaged that in the future evolution of the Telephone User Part (e.g. in the context of an integrated services digital network) the through-connection immediately after sending of the initial address message may become a mandatory requirement.

1.8 Congestion signals

As soon as the congestion condition is detected one of the congestion signals (see Recommendation Q.722, Section 3.4 [4]) is sent without waiting for the completion of a possible continuity-check sequence.

Reception of a congestion signal at any Signalling System No. 7 exchange will cause the clear-forward signal to be sent and cause an appropriate signal to be sent to the preceding exchange if the signalling system allows this or an appropriate tone or announcement to be sent to the originating subscriber or operator.

1.9 Called-party's-line-condition signals

The following signals will be sent when the appropriate electrical signals are received at the incoming international exchange from the national network:

- subscriber-busy signal,
- line-out-of-service signal,
- unallocated-number signal,
- send-special-information-tone signal.

The called-party's-line-condition signals will be sent without waiting for the completion of a possible continuity check. On receipt of one of these signals, the first Signalling System No. 7 exchange (or the outgoing international exchange) will clear forward the connection and cause an appropriate signal to be sent to the preceding exchange if the signalling system allow this or an appropriate tone or announcement to be sent to the originating subscriber or operator.

Each Signalling System No. 7 exchange on receipt of one of these signals has to clear forward the connection.

1.10 Answer signals

The signals answer, charge and answer, no charge are sent as received from the national network or from the succeeding international link.

The signals answer, charge and answer, no charge are used only as a result of the first off-hook signal from the called party.

1.11 Clear-back signal

A clear-back signal must not disconnect the speech path at a Signalling System No. 7 exchange. The requirements for the release of a connection in the event that a clear-forward signal is not received are given in Recommendation Q.118 [5].

1.12 Reanswer and clear-back signal sequences

Subsequent off-hook, on-hook signals from the called party, such as will result from switch-hook flashing, will cause the following sequence of signals to be sent:

Clear-back
Reanswer
Clear-back
Reanswer
etc.

It is necessary that a flashing sequence be retransmitted to the operator (or the preceding link) and that the final condition of the circuit represents the final position of the called party's switch hook.

1.13 Forward-transfer signal

The forward-transfer signal may be sent in semi-automatic working in either of the following two cases:

a) following a call switched automatically to a subscriber, or following a call established via a special operator, the controlling operator wishes to call in an assistance operator. On receipt of the forward-transfer signal at the incoming international exchange, an assistance operator is called in;

b) following a call via code 11 and 12, the controlling operator wishes to recall the incoming operator at the incoming international exchange. Receipt of the forward-transfer signal at the incoming international exchange recalls the incoming operator on calls completed via the operator positions at the exchange.

1.14 Clear-forward and release-guard sequence

The clear-forward signal is overriding and all exchanges must be in a position to respond by releasing the circuit and sending a release-guard signal at any time during the progress of a call and even if the circuit is in the idle condition. If sent while a circuit is blocked it will not result in unblocking the circuit concerned (see Section 5). The fact that the circuit is blocked will not delay the transmission of the release-guard signal.

1.15 Reset-circuit signal

In systems which maintain circuit status in memory there may be occasions when the memory becomes mutilated. In such a case the circuits must be reset to the idle condition at both exchanges to make them available for new traffic. Since the exchange with the mutilated memory does not know whether the circuit is idle, busy outgoing, busy incoming, blocked, etc., a reset-circuit signal should be sent for each affected circuit. On receipt of a reset-circuit signal the unaffected exchange will:

a) accept the signal as a clear-forward signal and respond by sending a release-guard signal, after the circuit has been made idle, if it is the incoming exchange on a connection in any state of call set-up or during a call;

b) accept the signal as a clear-back or call-failure signal whichever is appropriate and respond by sending a clear-forward signal if it is the outgoing exchange on a connection;

c) accept the signal as a clear-forward signal and respond by sending a release-guard signal if the circuit is in the idle condition;

d) if it has previously sent a blocking signal, or if it is unable to release the circuit as described above, respond by the blocking signal. If an incoming or outgoing call is in progress, this call should be disconnected and the circuit returned to the idle (blocked) state. A clear-forward or release-guard signal may be sent. The bloking signal should be acknowledged by the affected exchange. If the acknowledgement is not received, the repetition procedure specified in Section 6.4.4 should be followed;

e) if it had previously sent the blocking signal, respond by disconnecting any connected call, remove the blocked condition and restore the circuit to the idle state. If an outgoing call had been in progress, respond with a clear-forward or, in all other case, a release-guard signal;

f) if a reset-circuit signal is received after the sending of an initial address message but before receipt of a backward signal relating to that call, clear the circuit and make an automatic repeat attempt on another circuit if appropriate;

g) if a reset-circuit signal is received after having sent a reset-circuit signal, respond by a release-guard signal. The circuit should be restored to traffic;

h) send a appropriate clearing signal on an interconnected circuit (e.g., clear-forward, or a suitable backward signal).

The affected exchange will then reconstruct its memory according to the received acknowledgement to the reset-circuit signal, and respond to the signals received in the normal way, i.e. release-guard in response to a clear-forward, blocking-acknowledgement in response to a blocking signal.

In additional, an interconnected circuit may be cleared by the use of an appropriate signal. If no acknowledgement to the reset-circuit signal is received before 4-15 seconds, the reset-circuit signal should be repeated. If an acknowledgement for the signal is not received within 1 minute after the sending of the initial reset-circuit signal, maintenance personnel should be notified to permit manual restoration procedures. However, the sending of the reset-circuit signal should continue at 1-minute intervals until maintenance intervention occurs.

1.16 Diagrams showing signal sequence

In the following some examples of call set-up sequences are shown diagrammatically (Tables 1-1 and 1-2 (Q.724).

TABLE 1-1 (Q.724)

TABLE 1 SEMI-AUTOMATIC (SA) AND AUTOMATIC (A) TERMINAL TRAFFIC
(error-free operation assumed)

Outgoing International Exchange		Incoming International Exchange
	NORMAL CALL TO A FREE SUBSCRIBER (using continuity-check)	
Address signals from the national network are analysed. The outgoing circuit is seized.		
The initial address message is sent: - all address signals including ST in "en bloc" operation, or - all available address signals in overlap operation (a minimum of 4 digits)	Initial address message* →	The address message is analysed to determine: - the circuit to be seized - country code not included - nature-of-circuit (satellite or terrestrial) - echo-suppressor control - calling-party's-category - continuity-check control
The echo-suppressor, if present, is disabled so that the speech path continuity-check may be performed. The transceiver for the speech path continuity-check is attached, and the check-tone is transmitted on the outgoing circuit.		The echo-suppressor, if present, is disabled so that the speech path continuity-check may be performed. The loop for the speech path continuity-check is attached to the incoming circuit.
When the speech path continuity-check and cross-office check have been completed, and if the incoming circuit is used with common channel signalling, when the continuity signal has been received from the national network, the continuity signal is sent, and the transceiver is removed. (When the continuity-check fails, the continuity-failure signal is sent forward. An automatic repeat attempt is made.) The echo-suppressor, if present, is enabled as appropriate. The remaining address signals are sent forward in overlap operation.	Check-tone* → ← Check-tone Continuity →	Set-up the call in the national network begins when enough address signals are received for routing (overlap operation). The check-loop is removed and the echo-suppressor, if present, is enabled. Address signals are passed into the national network. The speech path is switched through.
	Subsequent address messages →	The address messages are analysed to determine that all the required address signals have been received (where applicable)**. Set-up of the speech path is completed. Subsequent supervisory signals are handled by the processor as appropriate.
On receipt of the address-complete signal, registers (if any) are released and the speech path through-connected, the address signals are erased. Subsequent supervisory signals are handled by the processor as appropriate.	← Address-complete	
The operator (SA), or the calling subscriber (A) hears ringing tone	← Audible ringing tone	Ringing tone of the country of destination is sent back. Signals from the national network are passed to the outgoing international exchange as follows.
On receipt of the answer signal, charging*** measurement of call duration and conversation begin.	← Answer	The called subscriber answers (charge or no charge).
"Clear-back" is recognised. SA: A clearing supervisory signal is given to the controlling operator. A: After 1-2 min, if there is no clear-forward signal, the international connection is released and charging and measurement of the call duration are ceased.	← Clear-back	The called subscriber hangs up. SA and A: After 2-3 minutes, if there is no clear-forward signal, the national part of the connection is released.
The outgoing operator (SA) or the calling subscriber (A) clears. When the outgoing equipment is released, the clear-forward signal is sent.	Clear-forward →	"Clear-forward" is recognised. The connection is released, and "clear-forward" is sent to the national network of destination.
"Release-guard" is recognised, and the outgoing circuit is made available for new traffic.	← Release-guard	When the incoming equipment has released, a release-guard signal is sent back. The circuit is made available for new traffic.

* Solid arrows denote common channel signals; dotted arrows are tones sent via the speech path (check-tone and audible tones)

** Address-complete signal may come from the national network.

*** Unless a no-charge answer or address-complete signal has been received.

TABLE 1-2 (Q.724)
SEMI-AUTOMATIC (SA) AND AUTOMATIC (A) TRANSIT TRAFFIC
(error-free operation assumed)

Outgoing International Exchange		International Transit Exchange		Incoming International Exchange
		CALL TO A FREE SUBSCRIBER (using continuity-check)		
Address signals from the national network are analysed. The outgoing circuit is seized. The initial address message is sent: - all address signals including ST in "en bloc" operation or - all available address signals in overlap operation.	Initial address message →	The address message is analysed to determine: - the circuit to be seized - country code included - nature-of-circuit (satellite or terrestrial) - echo suppressor control - calling-party's-category - continuity-check control		
The echo suppressor, if present, is disabled so that the speech path continuity-check may be performed.				
The transceiver is attached and the check-tone is transmitted on the outgoing circuit.	Check-tone →		Initial address message →	
		The incoming half-echo suppressor, *if present, is disabled*; the loop for the speech path continuity-check is attached. When enough address signals have been received to select a route, the outgoing circuit is seized. The address message is sent. The outgoing half-echo suppressor, if present, is disabled.		The address message is analysed to determine: - the circuit to be seized - country code not included - nature-of-circuit (satellite or terrestrial) - echo suppressor control - calling-party's-category. - continuity-check control.
	← Check-tone			
When the speech path continuity-check and the cross-office check have been completed, the continuity signal is sent and the transceiver is removed. (When the continuity-check fails, the continuity-failure signal is sent forward. An automatic repeat attempt is made.)		The transceiver is attached and the check-tone is transmitted.	Check-tone →	The echo suppressor, if present, is disabled and the loop is attached so that the speech path continuity-check may be performed. When enough address signals are received to select the national route, a circuit is seized and the available address signals are passed into the national network (overlap operation).
	Continuity →	On receipt of continuity signal, the loop is removed.		
The echo suppressor, if present, is enabled as appropriate.	Subsequent address messages →	Address signals are passed to the incoming international exchange.	Subsequent address messages →	Address signals are passed into the national network.
		Cross-office check.		
		The transceiver is removed.	← Check-tone	
			Continuity →	On receipt of continuity signal, the loop is removed. The echo suppressor, if present, is enabled as appropriate. The last address signal, if with-held, is passed into the national network.
		(When the continuity-check fails, the continuity-failure signal is sent forward. An automatic repeat attempt is made.)		
		The speech path is switched - through.		
On the receipt of the address-complete signal, registers (if any) are released and the speech path is through-connected. The address signals are erased. Subsequent supervisory signals are handled by the processor as appropriate.	← Address complete	"Address-complete" is passed on to the outgoing international exchange. The address signals are erased. Subsequent supervisory signals are handled by the processor, as appropriate.	← Address-complete	The address messages are analysed to determine that all required address signals have been received (where applicable).* On receipt of continuity signal, set-up of the speech path is completed. Subsequent supervisory signals are handled by the processor as appropriate.
The operator (SA) or the calling subscriber (A) hears the audible ringing tone	←	Audible ringing tone	←	Audible ringing tone of the incoming national network is sent back.

TABLE 1-2 ($\boxed{\text{Q.724}}$) continued

Outgoing International Exchange		International Transit Exchange		Incoming International Exchange
		CALL TO A FREE SUBSCRIBER (CONTD)		Signals from the national network are passed to the outgoing international exchange as follows.
On receipt of the answer signal, charging,** measurement of call duration and conversation begin.	← Answer	"Answer" is passed on to the outgoing international exchange.	← Answer	The called subscriber answers (charge or no charge).
"Clear-back" is recognized.	← Clear-back	"Clear-back" is passed on to the outgoing international exchange.	← Clear-back	The called subscriber hangs up.
SA: A clearing supervisory signal is given to the controlling operator. A: After 1-2 min, if there is no clear-forward signal, the international connection is released and charging and measurement of the call duration are ceased.				SA and A: After 2-3 min, if there is no clear-forward signal, the national part of the connection is released.
The outgoing operator (SA) or the calling subscriber (A) clears. When the outgoing equipment is released, the clear-forward signal is sent.	Clear-forward →	"Clear-forward" is passed on to the incoming international exchange after release of the connection and outgoing equipment.	Clear-forward →	"Clear-forward" is recognized, the connection is released, and "clear-forward" is sent to the national network of destination.
"Release-guard" is recognized and the outgoing circuit is made available for new traffic.	← Release-guard	When the incoming equipment has released, "release-guard" is sent back to the outgoing international exchange. The incoming circuit is made available for new traffic.		
		"Release-guard" is recognized, and the outgoing circuit is made available for new traffic.	← Release-guard	When the incoming equipment has released, the release-guard signal is sent back. The circuit is made available for new traffic.
		CALL TO A BUSY SUBSCRIBER		
The signal sequence is the same as for a call to a free subscriber up to the point where all of the address signals have been passed into the incoming national network.				
			← Subscriber-busy signal (electrical)	First case: The incoming national network returns the subscriber-busy signal (electrical).
SA: A busy indication is given to the operator. A: The calling subscriber hears the local national busy tone sent by the outgoing (national or international) exchange.	← Subscriber-busy signal (electrical)	"Subscriber-busy" (electrical) is passed back to the outgoing international exchange. The circuit is cleared automatically.	Clear-forward →	"Clear-forward" is recognized, the connection is released, and "clear-forward" is sent to the national network of destination.
		"Release-guard" is recognized, and the outgoing circuit is made available for new traffic.	← Release-guard	When the incoming equipment has released, "release-guard" is sent back. The circuit is made available for new traffic.
The circuit is cleared automatically.	Clear-forward →	When the incoming equipment has released, "release-guard" is sent back to the outgoing international exchange. The incoming circuit is made available for new traffic.		
"Release-guard" is recognized and the outgoing circuit is made available for new traffic.	← Release-guard			
The operator (SA) or the calling subscriber (A) hears the busy tone of the distant country and clears. The clear-forward sequence follows as above.	← Busy tone			Second case: The busy tone of the incoming national network is sent back.

TABLE 1-2 (Q.724)

Outgoing International Exchange		International Transit Exchange		Incoming International Exchange
		CONGESTION		
		(For simplicity, the continuity-check is not shown.)		
Address signals from the national network are analysed. The outgoing circuit is seized. The initial address message is sent.	Initial address message →	When enough address signals have been received to select a route, an attempt is made to seize an outgoing circuit. When blockage occurs in the switching equipment, the switching-equipment-congestion signal is sent backward.		
Appropriate action is taken. (For example, an indication is given to the calling subscriber or an automatic repeat attempt is made, etc.)	← Switching-equipment-congestion			
	← Circuit-group congestion	When the circuit group is fully occupied, the circuit-group-congestion signal is sent backward (if overflow is inappropriate).		
SA: An indication is given to the operator. A: An indication is given to the calling subscriber. The outgoing operator (SA) or the calling subscriber (A) clears.	← National-network-congestion	The national-network-congestion signal is passed backward. For the other congestion signals, appropriate action is taken. (For example, the congestion signal is sent backward or an automatic repeat attempt is made, etc.)	← National-network-congestion	If congestion occurs in the national network, the national-network-congestion signal is sent backward.
			← Switching-equipment-congestion	If blockage occurs in the switching equipment at the international exchange, the switching-equipment-congestion signal is sent backward.
Appropriate action is taken. (For example, an indication is given to the calling subscriber, or an automatic repeat attempt is made, etc.)	← Switching-equipment-congestion			

* The address-complete signal may come from the national network.
** Unless a no-charge answer or address-complete signal has been received.

2 Dual seizure with both-way operation

2.1 Dual seizure

Since Signalling System No. 7 circuits have the capability of both-way operation, it is possible that the 2 exchanges will attempt to seize the same circuit at approximately the same time.

2.2 Unguarded interval

Considering that with Signalling System No. 7:

a) signalling date link propagation time may be relatively long,

b) there may be significant delay due to retransmissions,

c) quasi-associated operation may add extra message transfer time(s) at signalling transfer points,

the unguarded interval during which dual seizure can occur may be relatively long in some instances. The exchange must therefore detect dual seizure and take action as defined in Section 2.5.

2.3 Detection of dual seizure

A dual seizure is detected by an exchange from the fact that it receives an initial address message for a circuit for which it has sent an initial address message (see also Section 7.5.1).

2.4 Preventive action

Different methods for circuit selection can be envisaged to minimise the occurrence of dual seizure. In the following two methods are described. Further study is required to determine the field of application of each method and to ensure that the two methods do interwork satisfactorily.

Other methods for circuit selection may also be used provided that they give the same degree of protection against dual seizure also when one of the methods specified is used at the other end.

- Method 1

  An opposite order of selection is used at each terminal exchange of a both-way circuit group.

- Method 2

  Each terminal exchange of a both-way circuit group has priority access to the group of circuits which it is controlling (see Section 2.5). Of this group the circuit which has been released the longest is selected (first-in - first-out). In addition each terminal exchange of a both-way circuit group has non-priority access to the group of circuits which it is non-controlling. Of this group the latest released circuit is selected (last-in - first-out).

For call control purposes a both-way circuit group can be sub-divided into sub-groups in an exchange.

It is necessary to take preventive action in cases where Signalling System No. 7 uses a signalling data link with long propagation time.

2.5 Action to be taken on detection of dual seizure

Each exchange will control one half of the circuits in a both-way circuit group. On detection of a dual seizure, the call being processed by the control exchange for that circuit will be completed and the received initial address message will be disregarded.

Under these conditions, the call being processed by the control exchange will be allowed to complete although when continuity-check has to be performed the continuity of the circuit may have been checked in the direction from non-control to control only. The call being processed by the non-control exchange will be backed off, switches released, the continuity-check transceiver removed, and the check-loop connected unless or until a continuity signal has been received from the control exchange. A clear-forward signal will not be sent. The non-control exchange will make an automatic repeat attempt on the same or on an alternative route.

For the purpose of resolution of dual seizure on both-way circuits, the exchange with the higher signalling point code will control all even-numbered circuits (circuit identification code) and the other exchange the odd-numbered circuits. The designation of control may also be used for maintenance control purposes.

3 Automatic repeat attempt

Automatic repeat attempt, as defined in Recommendation Q.12 [6], is provided in Signalling System No. 7.

An automatic repeat attempt will be made:

- upon failure of the continuity-check (see Section 7.3);
- on detection of dual seizure (at the non-control exchange) (see Section 2.5);
- on receipt of the blocking signal after sending an initial address message and before any backward signal has been received (see Section 6);
- on receipt of a reset-circuit signal after sending an initial address message and befor a backward signal has been received.

4 Speed of switching and signal transfer in international exchanges

4.1 Outgoing international exchange

At the outgoing international exchange:

- if overlap operation is used, the sending of the initial address message shall take place as soon as sufficient digits are received and analysed to permit the selection of an outgoing circuit;

- if "en bloc" operation is used, the initial address message should be sent as soon as all the digits of the address including the end-of-pulsing signal are available and the outgoing circuit has been chosen.

4.2 International transit exchange

At the international transit exchange, the selection of an outgoing circuit should begin as soon as the digits necessary to determine the routing have been received and analysed.

4.3 Incoming international exchange

At the incoming international exchange:

- if overlap operation is used in the national network, the setting-up of the national part of the connection should start as soon as a sufficient number of digits has been received for routing;

- if "en bloc" operation is used in the national network, the setting-up of the national part of the connection should start as soon as all the digits of the address including the end-of-pulsing signal have been received.

5 Blocking and unblocking sequences

The blocking (unblocking) signal is provided to permit the switching equipment or maintenance personnel to remove from (and return to) traffic the distant terminal of a circuit because of a fault or to permit testing. Specific conditions for automatic sending of blocking and unblocking signals by the switching equipment in case of use of the interruption control on FDM-circuits appear in Section 9.

Since the circuits served by Signalling System No. 7 have both-way capability, the blocking signal can be originated by either exchange. The receipt of the blocking signal will have the effect of prohibiting calls on the relevant circuit outgoing from that exchange until an unblocking signal is received, but will not in itself prohibit calls incoming to that exchange. Acknowledgement sequences are always required for both the blocking and unblocking signals, using the blocking-acknowledgement signal, and the unblocking-acknowledgement signal, respectively. The acknowledgement is not sent until the appropriate action, either blocking or unblocking, has been taken. The clear-forward signal should not override the blocking signal and return circuits to service which might be faulty. The blocked circuit will be returned to service on transmission of the unblocking-acknowledgement signal at one exchange and on receipt of the unblocking-acknowledgement signal at the other exchange.

In the event of the receipt of a blocking signal:

- after and initial address message has been sent, and,

- before a backward signal relating to that call has been received, an automatic repea attempt will be made on another circuit. The exchange receiving the blocking signal should clear forward the original attempt in the normal manner after sending the blocking-acknowledgement signal.

If the blocking signal is sent while the speech circuit is engaged on a call and after at least one backward signal relating to that call has been sent by the exchange receiving the blocking signal, this exchange will not seize that circuit for subsequent outgoing calls.

The fact that the circuit is engaged on a call will not delay transmission of the blocking (unblocking)-acknowledgement signal.

If a blocking signal is sent and subsequently an initial address message is received in the opposite direction the following action is taken:

- for test calls, the call should be accepted, if possible. In the case where the test call cannot be accepted, the blocking signal must be returned;

- for calls other than test calls, the blocking signal must be returned.

Blocking of a circuit by use of the blocking signal should not exceed five minutes, after which an alarm should be given at each terminal of the circuit. Should a call be in progress on the circuit involved, the five minutes time will commence when that call is cleared. If the work on the circuit must exceed five minutes, the circuit should be withdrawn from service.

6 Release of international connections and associated equipment

6.1 Normal release conditions

Connections are normally released in the forward direction as a result of the receipt of a clear-forward signal from the preceding exchange.

In addition, the normal release of connections (or circuits) occurs as follows:

- on continuity-check failure (see Section 7.3);

- on receipt of an address-incomplete signal (see Section 1.6);

- on receipt of one of the congestion signals (see Section 1.7);

- on receipt of one of the called-party's-line-condition signals (see Section 1.8);

- on receipt of the blocking signal after sending an initial address message and before a backward signal relating to that call has been received (see Section 5).

If the conditions for the normal release of connections as described above are not fulfilled, release is provided as follows:

- in the release under abnormal conditions (see Section 6.4);

- on receipt of a call-failure signal (see Section 6.3);

- on failure to receive a clear-forward signal after sending a clear-back signal (see Section 6.4);

- on failure to receive an answer signal (see Section 6.4);

- on receipt of a reset-circuit signal (see Section 1.15).

Address and routing information are released from memory in each of the exchanges of a connection as described in the following subsections.

6.1.1 Outgoing international exchange

Address and routing information stored at the outgoing international exchanges can be erased on receipt of one of the following backward signals:

a) one of the address-complete signals,

b) the address-incomplete signal,

c) one of the congestion signals,

d) one of the called-party's-line-condition signals,

e) the call-failure signal,

or when the connection is cleared earlier and no automatic repeat attempt has to be made.

6.1.2 Incoming international exchange

Address and routing information stored at the incoming international exchange can be erased on receipt of one of the backward signals indicated in Section 6.1.1 (or equivalent) from a national signalling system, or when one of the following signals has been originated and sent to the outgoing international exchange:

a) one of the address-complete signals,

b) the address-incomplete signal,

c) one of the congestion signals,

d) the call-failure signal,

e) the reset-circuit signal,

or on receipt of a clear-forward signal.

6.1.3 International transit exchange

Address and routing information stored at an international transit exchange can be erased on receipt of one of the backward signals indicated in Section 6.1.1, on receipt of a clear-forward signal, or when one of the congestion signals is originated in that exchange.

6.2 Abnormal release conditions - Clear-forward, release-guard sequences

6.2.1 Inability to release in response to a clear-forward signal

If an exchange is unable to return the circuit to the idle condition in response to a clear-forward signal, it should remove the circuit from service and send the blocking signal. Upon receipt of the blocking-acknowledgement signal, the release-guard signal is sent in acknowledgement of the original clear-forward signal.

6.2.2 Inability to release in response to a backward signal

If an exchange is unable to release a circuit in response to an address-incomplete, congestion, called-party's-line-condition or call-failure signal, it should remove the circuit from service by sending the blocking signal. Upon receipt of the blocking-acknowledgement signal, the clear-forward signal should be sent in reply to the original backward signal.

6.2.3 Failure to receive a release-guard signal in response to a clear-forward signal

If a release-guard signal is not received in response to a clear-forward signal before 4-15 seconds, the clear-forward signal will be repeated.

If, after sending a clear-forward signal, a release-guard signal is not received within a period of one minute after the first clear-forward signal, the maintenance personnel shall be alerted. The repetition of the clear-forward signal is ceased, the circuit is taken out of service, and the blocking signal is sent.

6.3 Call-failure signal

The call-failure signal is sent as the result of time-out situations, described in Section 6.4 and whenever a call attempt fails and other specific signals do not apply, viz:

- the address-incomplete signal,
- the congestion signals, or
- the called-party's-line-condition signals.

Reception of the call-failure signal at any Signalling System No. 7 exchange will cause the clear-forward signal to be sent and if the signalling system permits to do so the appropriate signal to be sent to the preceding exchange or the appropriate tone or announcement to be sent to the national network.

6.4 Abnormal release condition - Other sequences

If the conditions for normal release as covered in Section 6.1 are not fulfilled, release will take place under the following conditions.

6.4.1 Outgoing international exchange

An outgoing international exchange shall:

a) release all equipment and clear forward the connection on failure to meet the conditions for normal release of address and routing information as covered in Section 6.1.1 before 20-30 seconds after sending the latest address message,

b) release all equipment and clear forward the connection on failure to receive an answer signal within the interval specified in [5],

c) release all equipment and clear forward the connection on failure to receive a clear-forward signal from the national network after having received a clear-back signal within the interval specified in [5].

6.4.2 Incoming international exchange

An incoming international exchange shall:

a) release all equipment, clear forward the connection into the national network and send back a call-failure signal in the following cases:

- on failure to receive a continuity or continuity-failure signal if applicable (see Recommendation Q.723 Section 3.3.1 [7]) before 10-15 seconds after receipt of the initial address message, or

- on failure to receive one of the blackward signals indicated in Section 6.1.1 (or equivalent) from a national network (where expected) before 20-30 seconds after receipt of the latest address message, unless the timing for sending the address-incomplete signal (see Section 1.7) is provided, or

- on receipt of an address-incomplete signal after an address-complete signal has been generated.

b) send the call-failure signal on failure to receive a clear-forward signal for the incoming circuit before 4-15 seconds after sending an address-incomplete, congestion, call-failure or a called-party's-line-condition signal indicating inability to complete the call.

If a clear-forward signal is not received within a period of one minute after sending the call-failure signal, the repetition of the call-failure signal should be ceased, maintenance personnel should be alerted, the circuit should be removed from service, and the blocking signal sent.

c) release all equipment and clear forward the connection into the national network on failure to receive a clear-forward signal after sending a clear-back signal within the interval specified in [5].

6.4.3 International transit exchange

An international transit exchange shall:

a) release all equipment, clear forward the connection and send back the call-failure signal in the following cases:

- on failure to receive a continuity or continuity-failure signal if applicable (see [7]) before 10-15 seconds after receipt of the initial address message, or

- on failure to meet the conditions for normal release as covered in Section 6.1.3 before 20-30 seconds after sending the latest address message, or

b) send the call-failure signal on failure to receive a clear-forward signal for the incoming circuit before 4-15 seconds after sending an address-incomplete, congestion, call-failure or a called-party's-line-condition signal indicating inability to complete the call. If a clear-forward signal is not received within a period of one minute after sending the call-failure signal, the repetition of the call-failure signal should be ceased, maintenance personnel should be alerted, the circuit should be removed from service, and the blocking signal sent.

6.4.4 Failure in the blocking/unblocking sequence

An international exchange will repeat the blocking or unblocking signal on failure to receive an acknowledgement signal in response to either the blocking or unblocking signals before 4-15 seconds. (See Section 5, for the blocking/unblocking sequence.)

If an acknowledgement signal is not received within a period of one minute after sending the initial blocking or unblocking signal, maintenance personnel should be alerted, the repetition of the blocking or unblocking signal should be ceased and the circuit taken out of the service as appropriate.

6.5 Receipt of unreasonable signalling information

The message transfer part of the signalling system will avoid mis-sequencing of or double delivery of messages with a high reliability (Recommendation Q. 706, Section 2 [8]). However, undetected errors at the signalling link level and exchange malfunctions may produce signalling information in messages that is either ambiguous or inappropriate.

In order to resolve some possible ambiguities in the state of a circuit when unreasonable signals are received the following will apply:

a) if a clear-forward signal is received relating to an idle circuit it will be acknowledged with a release-guard signal;

b) if a release-guard signal is received relating to an idle circuit it will be discarded;

c) if a release-guard signal is received relating to a busy circuit for which a clear-forward signal has not been sent, the circuit will be released and a clear-forward signal will be sent;

d) if a blocking signal is received for a blocked circuit, a blocking-acknowledgement signal will be sent;

e) if an unblocking signal is received for an unblocked circuit an unblocking-acknowledgement signal will be sent.

Except in certain cases (see Section 2) any other unreasonable signalling information received will be discarded. If the discarding of the information prevents a call from being completed that call will eventually be released by the expiry of a time out [1].

7 Continuity-check for four-wire speech circuits

7.1 General

This specification relates only to that part of a four-wire connection served by Signalling System No. 7. The part of the speech path to be checked may include a circuit with speech interpolation. As the presence of active echo suppressors in the circuit would interfere with the continuity-check, it is necessary to disable the suppressors during the check and to re-enable them, if required, after the check has been completed.

The transceiver (check-tone transmitter and receiver) is connected to the go and return paths of the outgoing circuit at the first and each succeeding exchange, excluding the last exchange, in that part of the connection served by Signalling System No. 7. The check-loop should be connected to the go and return paths of the incoming circuit at each exchange except the first in that part of the connection served by Signalling System No. 7. A continuity-check is considered successful when a tone is sent on the go path and is received on the return path within acceptable transmission and timing limits.

7.2 Transmission requirements

7.2.1 Transmitting equipment

The check-tone frequency will be 2000 ± 20 Hz. For international application the sending level of the check-tone will be -12 ± 1 dBm0.

7.2.2 Check-loop

The check-loop will have a loss of 0 dB, taking into account any difference between the relative levels of the 2 paths at the point of attachment.

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1) Possible further actions to be taken on receiving unreasonable signalling information are for further study.

7.2.3 Receiving equipment

The check-tone receiver will have the following characteristics:

a) Operating requirements

Check-tone frequency: 2000 ± 30 Hz

Check-tone level range for international application:

The absolute power level N of the check-tone shall be within the limits $(-18 + n) \leq N \leq (-6 + n)$ dBm

This time belongs to the text on the previous page where n is the relative power level at the receiver input

Recognition time: 30 - 60 ms

The frequency and level range tolerances allow for variations at the sending end and for variations in line transmission that are considered acceptable.

b) Non-operating requirements

Signal frequency: outside the frequency band 2000 ± 200 Hz
Signal level for international application:

below or equal to $-22 + n$ dBm.

The limit is 10 dB below the nominal absolute level of the check-tone at the input of the receiver. If the level falls below this point, transmission is considered unacceptable.

Signal duration: shorter than 30 ms

The level range of $(-18 + n) \leq N \leq (-6 + n)$ dBm will serve as a GO/NO-GO check on the links in that part of the international connection served by Signalling System No. 7.

c) Release requirements

If the receiver is used to test for the removal of check-tone (see Section 7.3):

- after recognition of tone, interruptions of up to 15 ms shall be ignored; this will prevent switching through the speech path prematurely;

- the indication of tone removal should not be delayed more than 40 ms, and

- the release level of the receiver should be lower than $-27 + n$ dBm for international application.

7.3 Continuity-check procedure

Decision on whether continuity-check should be performed or not on a given circuit should be made by an outgoing exchange according to the criteria described in Section 1.4. The outgoing exchange will indicate whether continuity-check is required or not by the continuity-check indicator in the initial address message [7]. If it is required, the outgoing exchange will connect a transceiver to the speech circuit when it sends an initial address message. If continuity-check is not required neither on the incoming circuit nor on the outgoing circuit, the outgoing exchange can switch-through the speech path immediately after having sent the initial address message.

A description of the procedure using the specification and description language is given in the state transition diagrams in Figures 10-4 (Q.724) and 10-5 (Q.724). The Signalling System No. 7 exchange will send forward the continuity signal after completion of all the following actions:

- the continuity-check performed on the outgoing circuit is completed,

- the speech path across the exchange has been checked and found correct (see Section 1.4), and

- if the continuity-check indicator in the received initial address message indicates that continuity-check was performed on previous circuit(s) receipt of a continuity signal from the preceding exchange.

The speech path may be switched through at an international transit or incoming exchange and the transceiver disconnected after the continuity-check of the circuit has been successfully completed. However, the switching through of the speech path should be delayed until the residual check-tone has propagated through the return path of the speech circuit.

This determination may be made by timing, or by using the check-tone receiver to test for the removal of the check-tone or other appropriate means.

On receipt of the continuity signal in the following international exchange, the continuity-check loop will be removed if inserted. Also, any digits of the national number which were withheld may be released (see Section 1.2).

At the Signalling System No. 7 exchange, on failure of the outgoing circuit to satisfy the continuity-check:

- the continuity-check transceiver will be removed and an automatic repeat attempt will be made on another circuit,

- a continuity-failure signal will be sent to the following exchange.

A repeat of the continuity-check of the speech path will be made on the failed outgoing circuit within 1-10 seconds of detection of the continuity-check failure.

The second continuity-check will be initiated by the Signalling System No. 7 exchange detecting the failure using the continuity-check-request signal.

If the repeated check passes on this call, the speech circuit will be returned to idle with a clear-forward/release-guard sequence. If the second check fails, the maintenance staff will be alerted that a failure has occurred and the check will be repeated at intervals of 1-3 minutes. The repeated continuity-check will only be finished when continuity is detected.

According to transmission maintenance requirements, Signalling System No. 7 should provide for:

a) a print-out each time a second continuity-check is started. In such cases, the circuit involved should be identified;

b) a print-out each time a continuity-check results is a warning being given to maintenance personnel.

Since a continuity-check failure can be caused by a faulty transceiver, precautions should be taken to ensure a low probability of selecting a faulty one for both the initial continuity-check and the second check, e.g. by ensuring the selection of a different transceiver for each of the checks.

7.4 Continuity-check timing

7.4.1 Time-out period

The continuity-check is considered to have failed if the receiver has not responded within a period determined by the Administration concerned. This period should not exceed two seconds.

The time-out period of the continuity-check should always exceed the continuity recognition time, T_{CR}, given by:

$$T_{CR} = 2T_P + T_{IAM} + T_{TC} + T_L + T_R - T_T \quad (7\text{-}1)$$

where

T_P = one-way propagation time of the speech circuit and the signalling link (w e these times are the same)

T_{TC} = speech interpolation clip time for 2 speech interpolation systems in series (for connections not using speech interpolation $T_{TC} = 0$)

T_R = receiver response time

T_L = loop connecting time (maximum)

T_T = transceiver connecting time (minimum)

T_{IAM} = emission time of the longest initial address message

If retransmission of an initial address message is to be included in T_{CR}, the following formula may be used:

$$T_{CR} = 4T_P + 2T_{IAM} + T_{FISU} + 2T_X + T_L + T_R - T_T$$

where:

T_{FISU} = emission time of a fill-in signal unit (length of a fill-in signal unit)

T_X = time between receiving an initial address message and emitting a signal unit containing an acknowledgement for that initial address message,

or

time between receiving a signal unit asking for retransmission and emitting the initial address message to be retransmitted.

7.4.2 Switching of continuity-check equipment

The connection and disconnection of the equipment used for the continuity-check and also the disabling and subsequent enabling of echo suppressors should be related to the following stages of progress in the establishment of the connection:

a) preparation at Signalling System No. 7 exchange applying the transceiver;

action should be initiated when the initial address message is available for transmission in the message transfer part;

b) preparation at Signalling System No. 7 exchange connecting the check-loop;

action should be initiated at the moment of recognition of the initial address message received;

c) disconnection at Signalling System No. 7 exchange connecting the check-loop;

action follows the receipt of the continuity signal, the continuity-failure signal or the clear-forward signal, or the emission of signals indicating that the call cannot be established, e.g. circuit-group-congestion signal;

d) disconnection at Signalling System No. 7 exchange applying the transceiver;

action should be initiated on the successful completion or the failure of the continuity-check.

Exceptionally, if disconnection has not previously occurred, action should be initiated at the moment of recognition of the address-complete signals, the answer signals, signals indicating that the call cannot be established, or on the emission of a clear-forward signal.

It is recommended that the mean time, both for the connection and for the disconnection, is less than 100 ms. A mean time of 200 ms should not be exceeded.

7.5 Continuity-check test calls

7.5.1 The following procedure may be used in the cases when continuity-check is performed by test calls. This procedure is used to test a single interexchange circuit, which must be idle when the procedure is initiated.

7.5.2 When the outgoing Signalling System No. 7 exchange intends to initiate the procedure, it sends to the following exchange a continuity-check-request message and it connects the transceiver to the outgoing speech circuit. On receipt of the continuity-check-request message, the following exchange connects the loop to the involved circuit. On detection of the backward tone within the time-out specified in Section 7.4.1, the outgoing exchange will disconnect the transceiver and the circuit will be returned to idle with a clear-forward/release-guard sequence.

7.5.3 In the case that no backward tone is detected within the specified time-out, the same actions apply as in the case of continuity-check failure during normal call set-up, see Section 7.3 (the clause referring to the repeat attempt is not relevant in this case).

7.5.4 If an exchange will receive an initial address message relating to a circuit for which it has sent a continuity-check-request message (i.e. in case of collision on a both-way operated circuit), it will abort the continuity-check test call, disconnect the transceiver and complete the incoming call.

An exchange receiving a continuity-check-request message after having sent an initial address message, will ignore it and continue the call set-up procedure.

8 Continuity-check for two-wire speech circuits

In general the same procedure as described in Section 7 is used for the continuity-check of two-wire speech circuits except the check-loop which has to be replaced by a transponder and the fact that in the backward direction the frequency 1780 ± 20 Hz is used. A more detailed specification of this particular case needs further study.

9 Interruption control on FDM-circuits

9.1 General

Interruption of the pilot in frequency division multiplex systems corresponds to loss of continuity of speech circuits or a considerable reduction of level. Therefore a switching equipment monitoring this indication (see Section 1.4) should inhibit local seizure of the concerned speech circuits in case of interruption. Moreover seizure by the remote exchange should be prevented, as long as the interruption persists, by sending blocking and unblocking signals as specified in Section 9.2 below. When interruption control is implemented possible use of the specifications contained in Recommendation Q. 416 [9] could be applied.

9.2 Blocking and unblocking of speech circuits

Blocking signals are sent to the other end, with regard to the relevant speech circuits, whenever an interruption is detected, which lasts more than 4-15 seconds (provisional values).

When an interruption indicated terminates, unblocking signals are sent to the other end after 4-15 seconds (provisional value), provided that blocking signals were previously sent on occurrence of the interruption.

10 State transition diagrams

10.1 General

This Section contains the description of the signalling procedures described in this Recommendation in the form of state transition diagrams according to the CCITT Specification and Description language (SDL).

In order to facilitate functional description, the telephone user part signalling procedure function is divided into functional blocks, as shown in Figure 10-1; state transition diagrams are provided for each functional block, as shown below:

- Signalling procedure control (SPC): Figure 10-2
- Call processing contral (CPC): Figure 10-3
- Continuity-check outgoing (CCO): Figure 10-4
- Continuity-check incoming (CCI): Figure 10-5
- Continuity-recheck outgoing (CRO): Figure 10-6
- Continuity-recheck incoming (CRI): Figure 10-7
- Other functional blocks (for further study).

The detailed functional breakdown shown in the following diagrams is intended to illustrate a reference model and to assist interpretation of the text in the earlier sections. The state transition diagrams are intended to show precisely the behaviour of the signalling system as viewed from a remote location. It must be emphasized that the functional partioning shown in the following diagrams is used only to facilitate understanding of the system behaviour and is not intended to specify the functional partioning to be adopted in a practical implementation of the signalling system.

10.2 Draughting conventions

a) Acronyms used in Figures 10-1 to 10-7 are listed in Table 10-1.

b) External inputs and outputs are used for interactions with different functional blocks. Internal inputs and outputs are used for interactions withing each functional block, e.g. to indicate control of time-outs.

c) External inputs and outputs contain as part of their name acronyms of their source and destination functional block names with an arrow in between, e.g. Start → CPC([illegible]).

d) For inter-exchange signals or signal messages, external input and output symbols are used as shown below to indicate the direction of each signal on message.

 : Input from a preceding exchange

 : Output to a preceding exchange

 : Input from a succeeding exchange

 : Output to a succeeding exchange.

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<u>Note</u> - The functions covered by the present Figures 10-1 to 10-7 are limited in the following points:

- they refer only to call processing functions in international transit exchanges;

- they do not include the blocking and unblocking procedures, the handling of the forward-transfer signal and that of the reset-circuit signal;

- they do not necessarily cover all the abnormal situations.

However, they include operations on receipt of unreasonable signalling information as specified in Section 6.5, except the case of the blocking and unblocking signals as mentioned above.

The diagrams for functions not presently covered are for further study.

TABLE 10-1 (Q.724)

Abbreviations used in Figures 10-1 to 10-7 (Q.724)

General

OGC - Outgoing trunk circuit

ICC - Incoming trunk circuit

NOK - Not OK

CC - Continuity-check

Function block names (see Figure 10-1 (Q.724))

SPC - Signalling procedure control

CPC - Call processing control

CCO - Continuity-check outgoing

CCI - Continuity-check incoming

CRO - Continuity-recheck outgoing

CRI - Continuity-recheck incoming

L3 - Level 3 (Signalling network functions)

L4 - Level 4 (Telephone user part)

Messages and signals

ACM - Address complete message

ADI - Address incomplete signal

ANC - Answer signal, charge

ANN - Answer signal, no charge

CBK - Clear-back signal

CCF - Continuity-failure signal

CCH - Continuity-check indicator :

- 0 : CC not required
- 1 : CC required on this circuit
- 2 : CC on previous circuit

CCR - Continuity-check-request signal

CFL - Call-failure signal

CGC - Circuit-group-congestion signal

CLF - Clear-forward signal

COT - Continuity signal

IAM - Initial address message

LOS - Line-out-of-service signal

NNC - National-network-congestion signal

RAN - Reanswer signal

RLG - Release-guard signal

SAM - Subsequent address message

SEC - Switching-equipment-congestion signal

SSB - Subscriber-busy signal (electrical

SST - Send-special-information-tone signal

UNN - Unallocated-number signal.

Timers

T1 - Timer "waiting for continuity or continuity-failure signal" (10-15 seconds, see 6.4.3.a)

T2 - Timer "waiting for address-complete signal" (20-30 seconds, see 6.4.3.a)

T3 - Timer "waiting for clear-forward signal after sending unsuccessful message" (4-15 seconds, see 6.4.3.b)

T4 - Timer "waiting for clear-forward signal after sending call-failure signal" (4-15 seconds, see 6.4.3.b)

T5 - Timer "stop sending call-failure messages on time out" (1 minute, see 6.4.3.b)

T6 - Timer "waiting for release-guard signal" (4-15 seconds, see 6.2.3)

T7 - Timer "stop sending clear-forward signal on time out" (1 minute, see 6.2.3)

T8 - Timer "waiting for backward check-tone" (should not exceed 2 seconds, see 7.4.1)

T9 - Timer "delay to start first-time continuity-recheck" (1-10 seconds, see 7.3)

T10 - Timer "delay for multiple retests of continuity" (1-3 minutes, see 7.3)

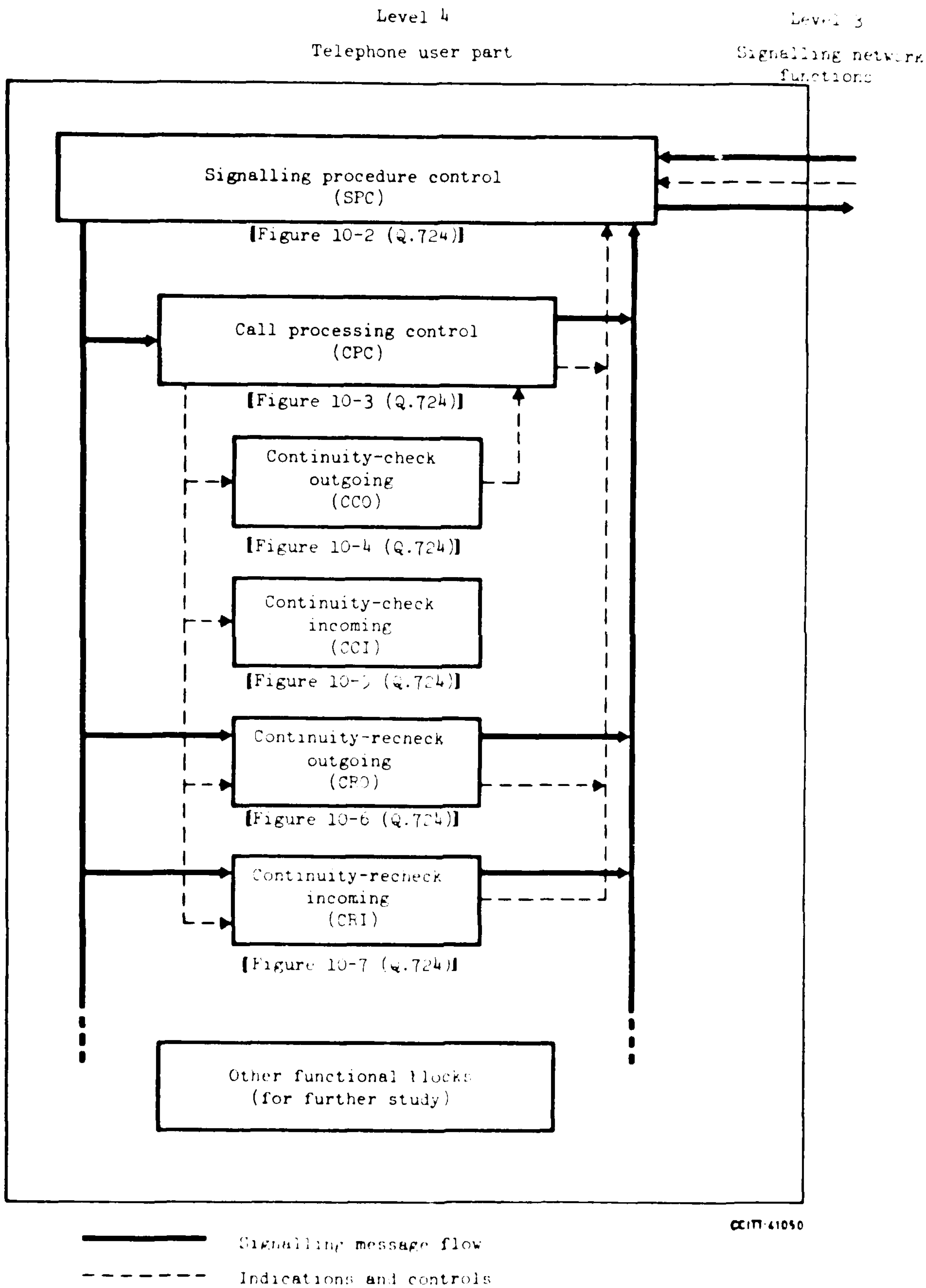
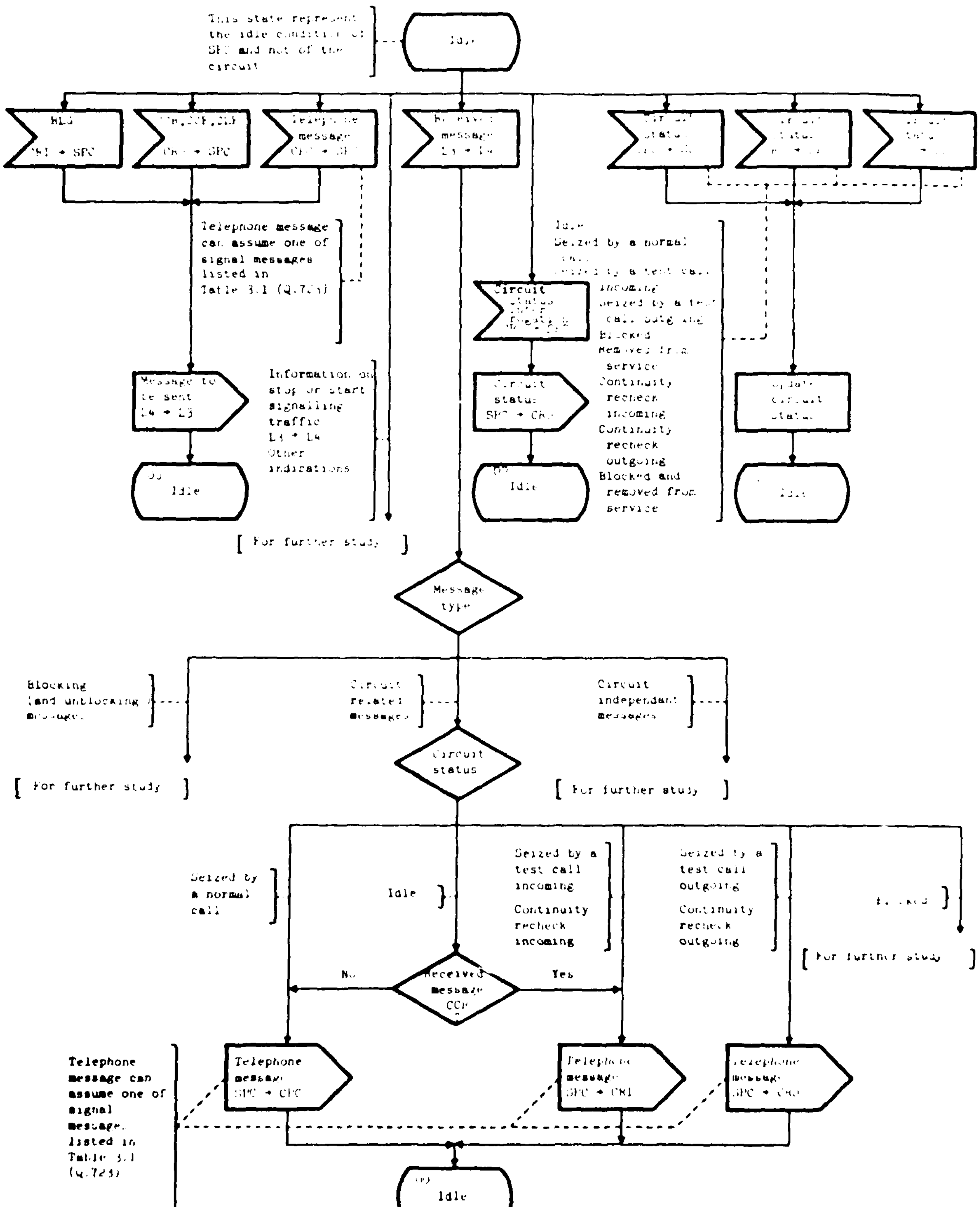


Figure 10-1 (Q.724) - Level 4 - Telephone user part functions



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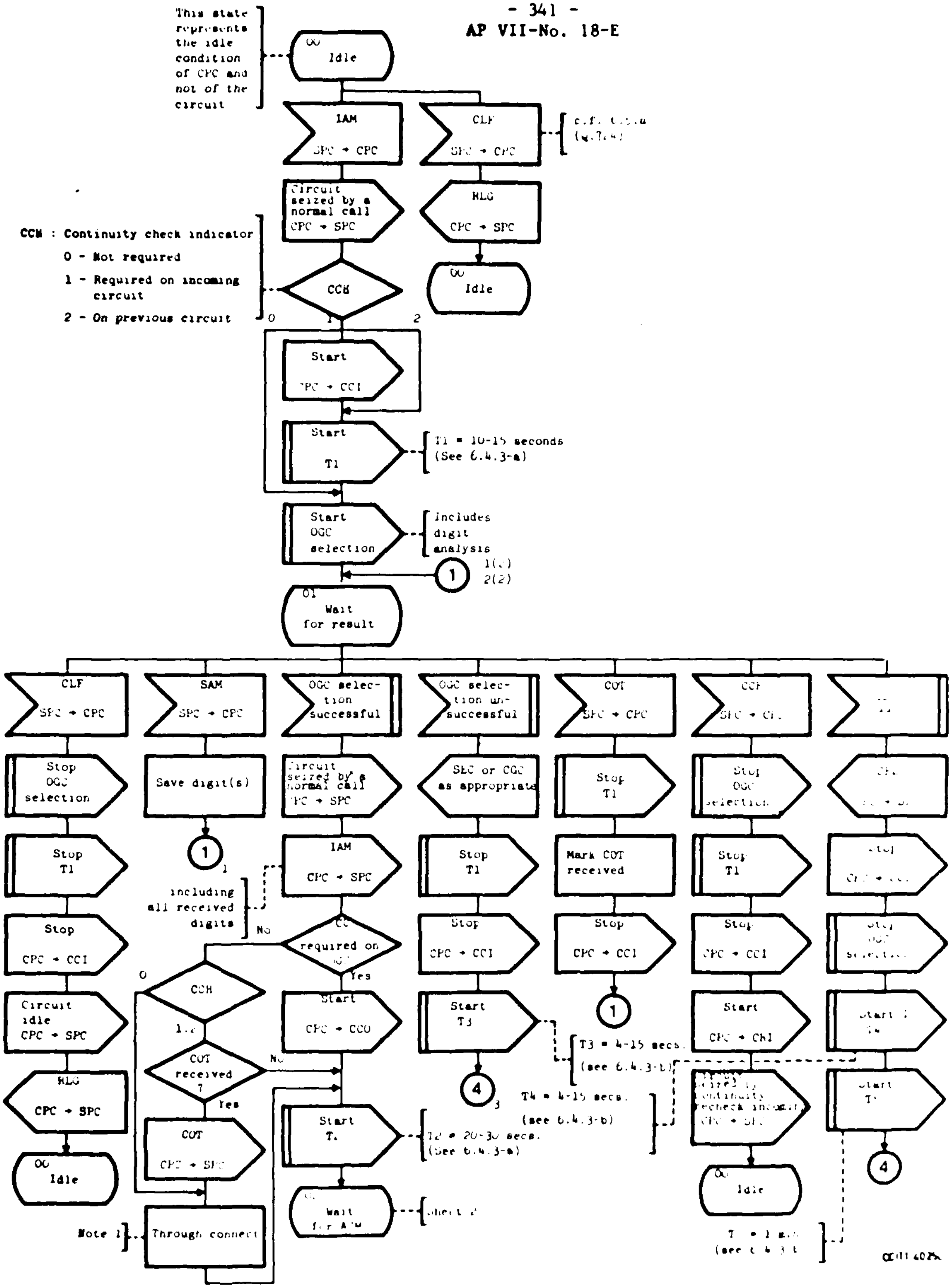
Note – In this particular figure, the direction of input and output symbols does not necessarily represent the forward or backward direction of messages contained in them.

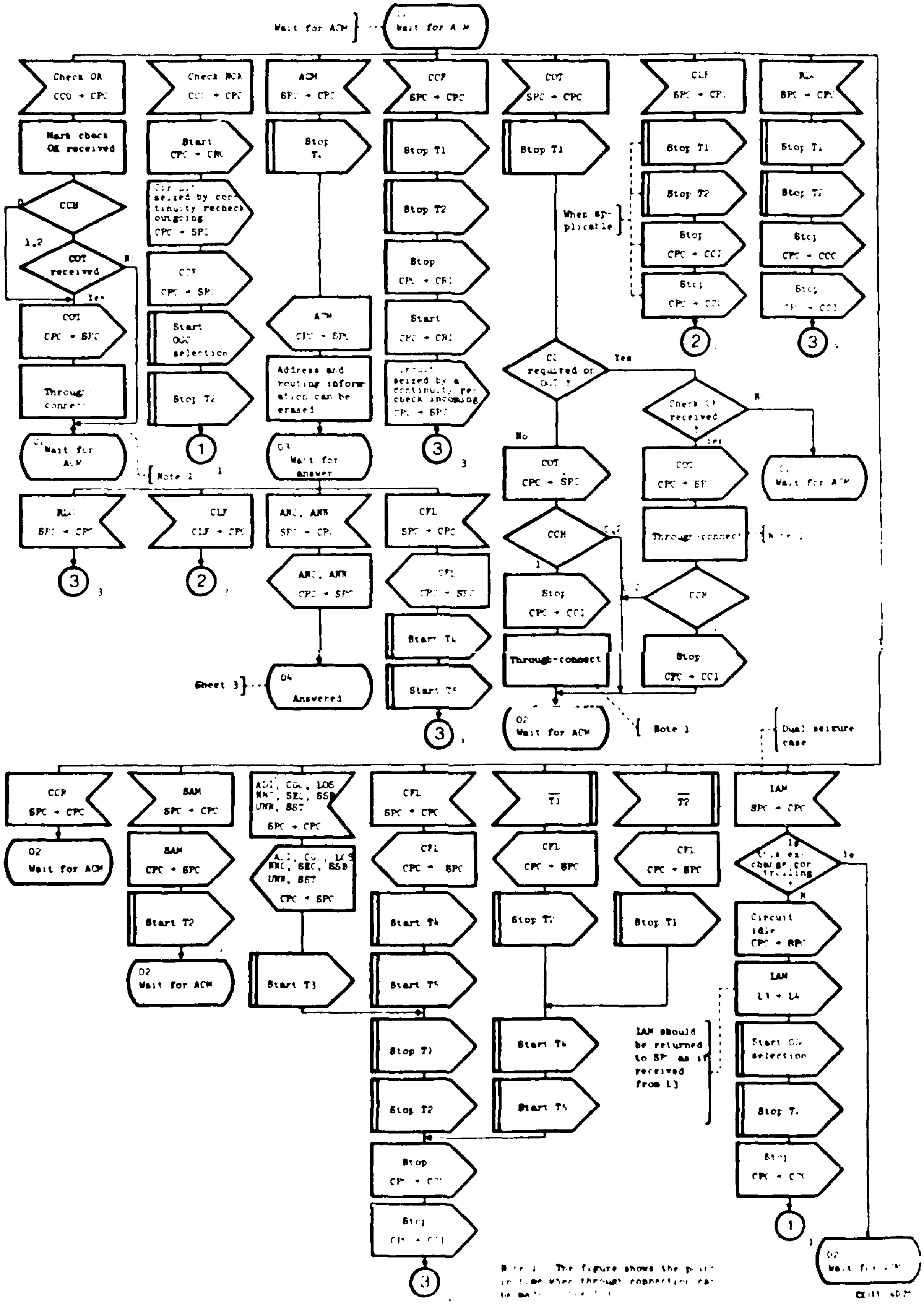
Figure ... (Q.7.4) – Signalling procedure control ...



Note 1 : The Figure shows the point in time when through connection can be made (see 7.3)

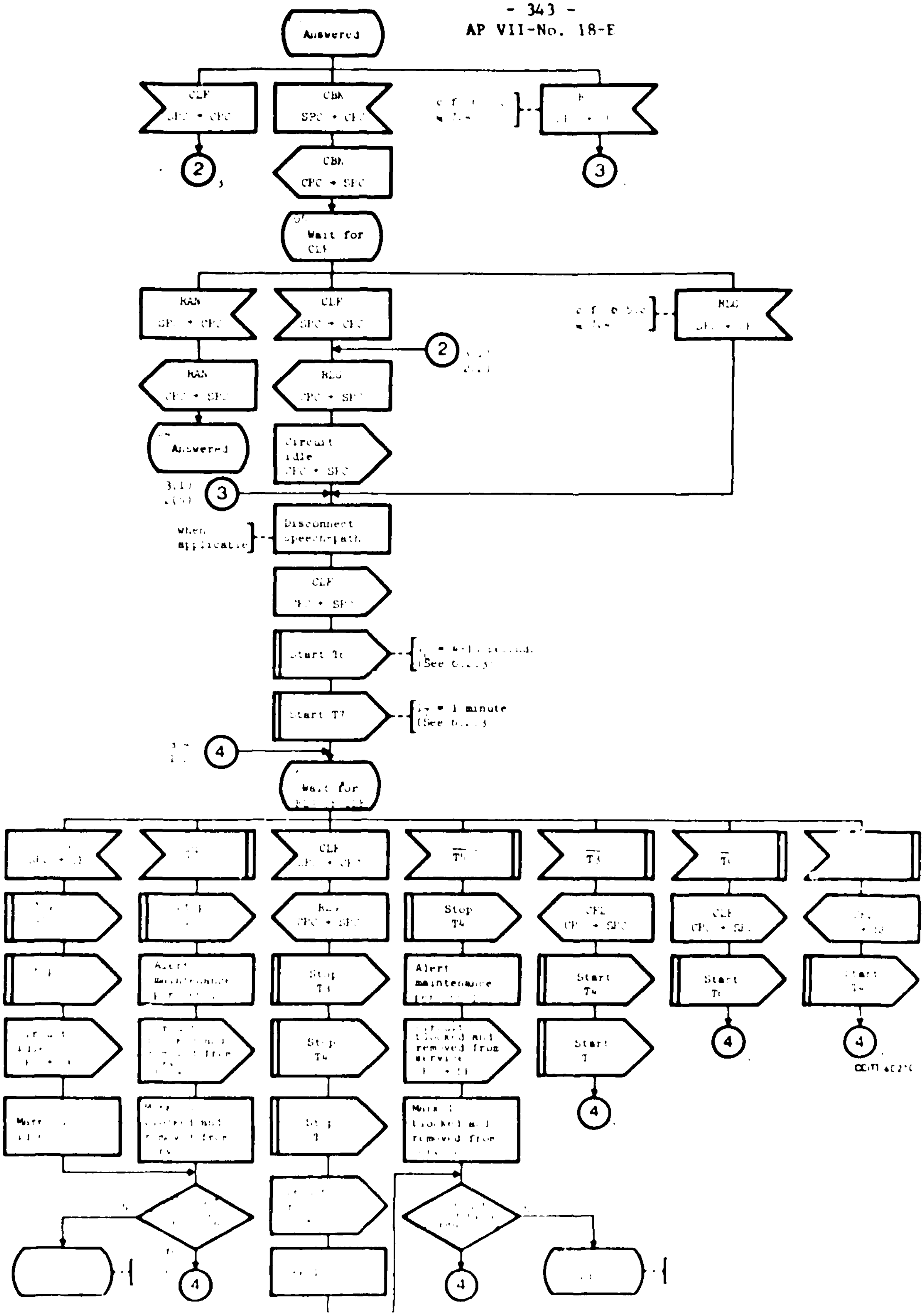
(3854)

Figure [illegible]



Note 1. The figure shows the point in time when through connection can be made ...

(3856)


Answered
CLF
CBK
SPC → CPC
CBK
CPC → SPC
Wait for
CLF
RAN
CLF
SPC → CPC
RLG
RAN
CPC → SPC
RLG
Answered
Circuit
idle
CPC → SPC
Disconnect
speech-path
when
applicable
CLF
Start T6
(See
Start T7
= 1 minute
(See
Wait for
CLF
RAN
CPC → SPC
Stop
T4
Alert
maintenance
Stop
T4
Circuit
blocked and
removed from
service
Mark
blocked and
removed from
Start
T4
Start
Start
CLF
CPC → SPC
Start

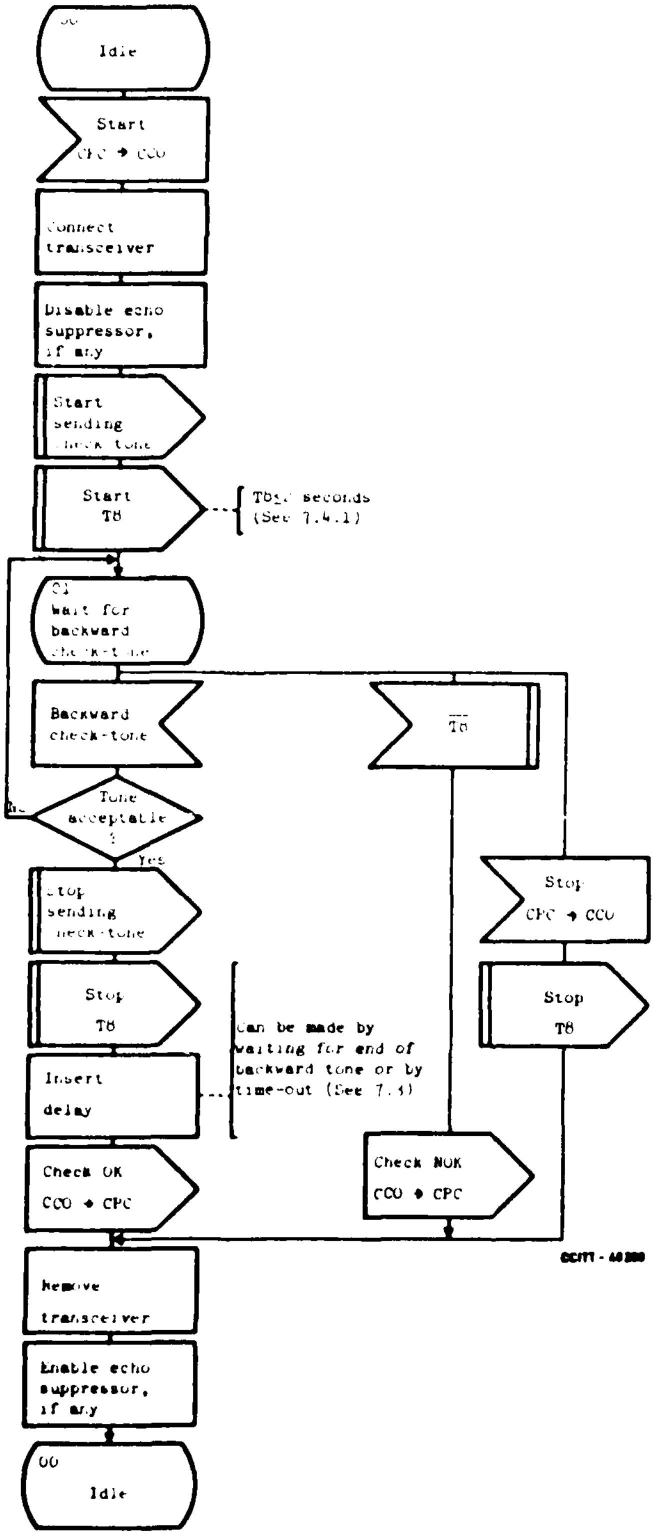
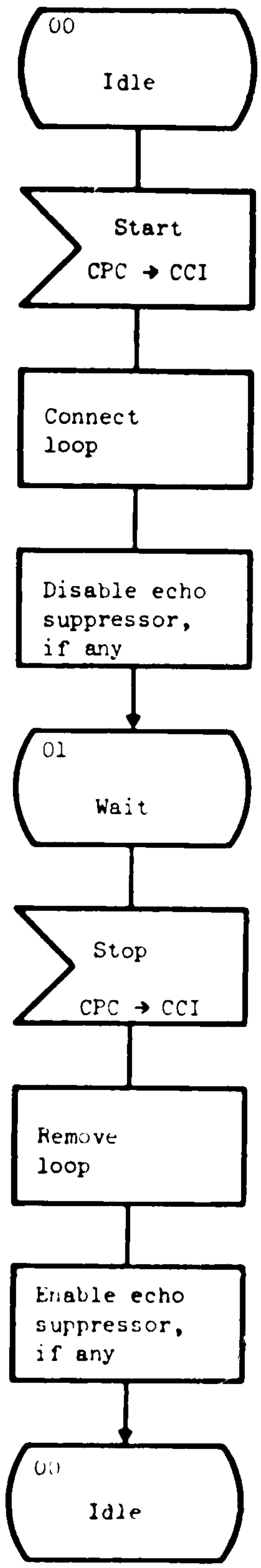


Figure 10-4 (Q.724) Continuity-check outgoing (CCO)



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(3854) Figure 10-5 (Q.724) Continuity-check incoming (CCI)

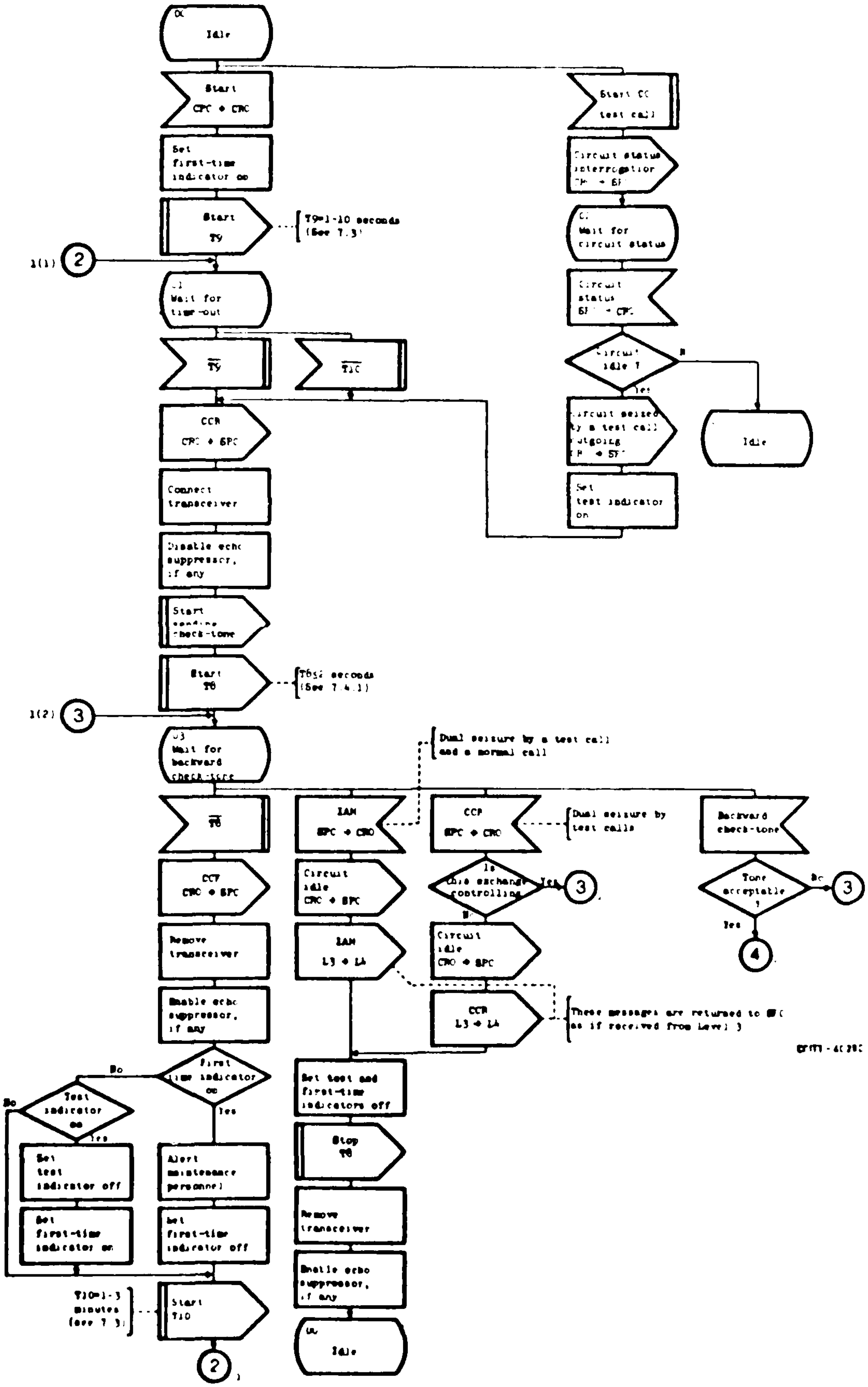
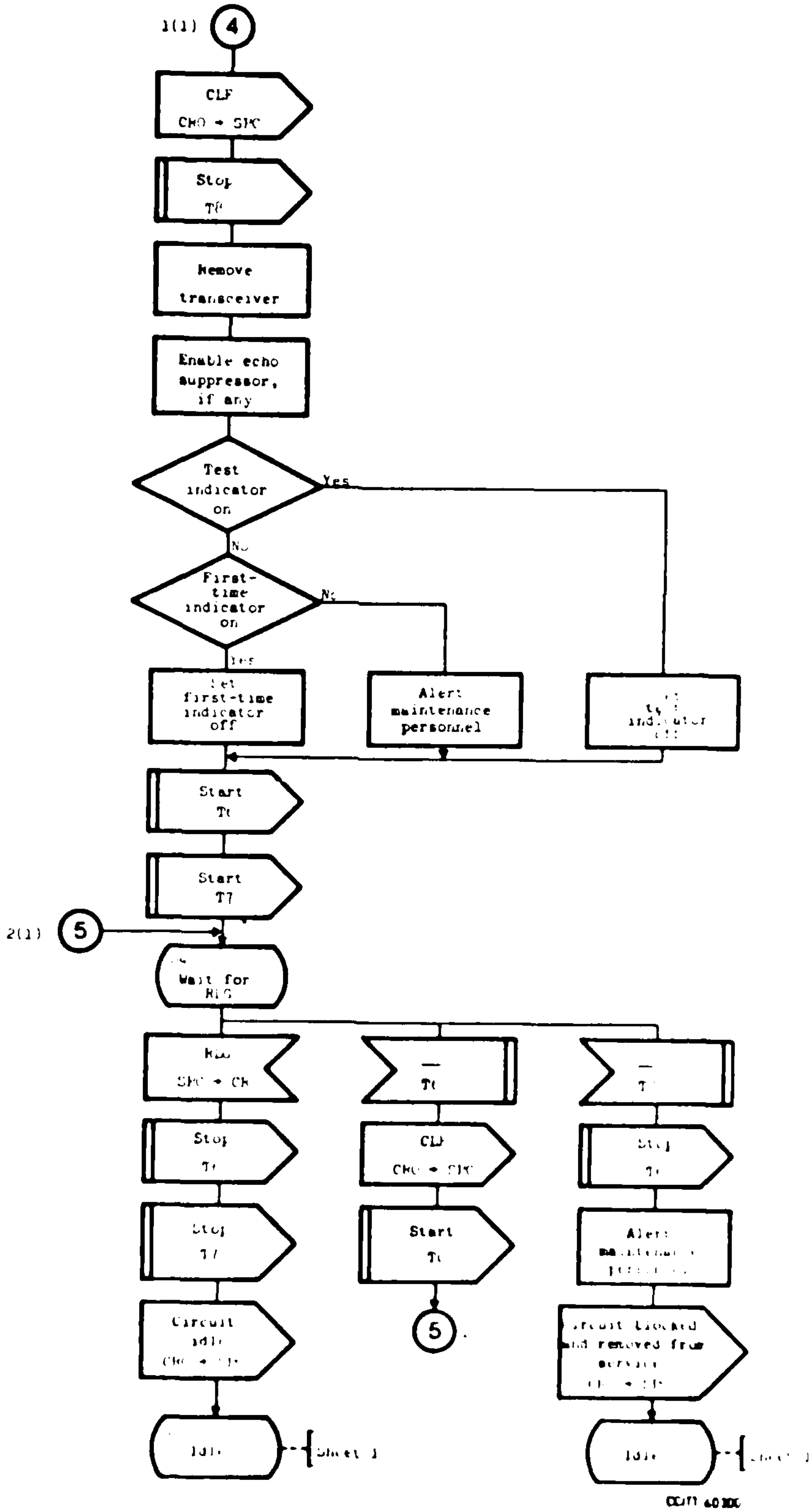
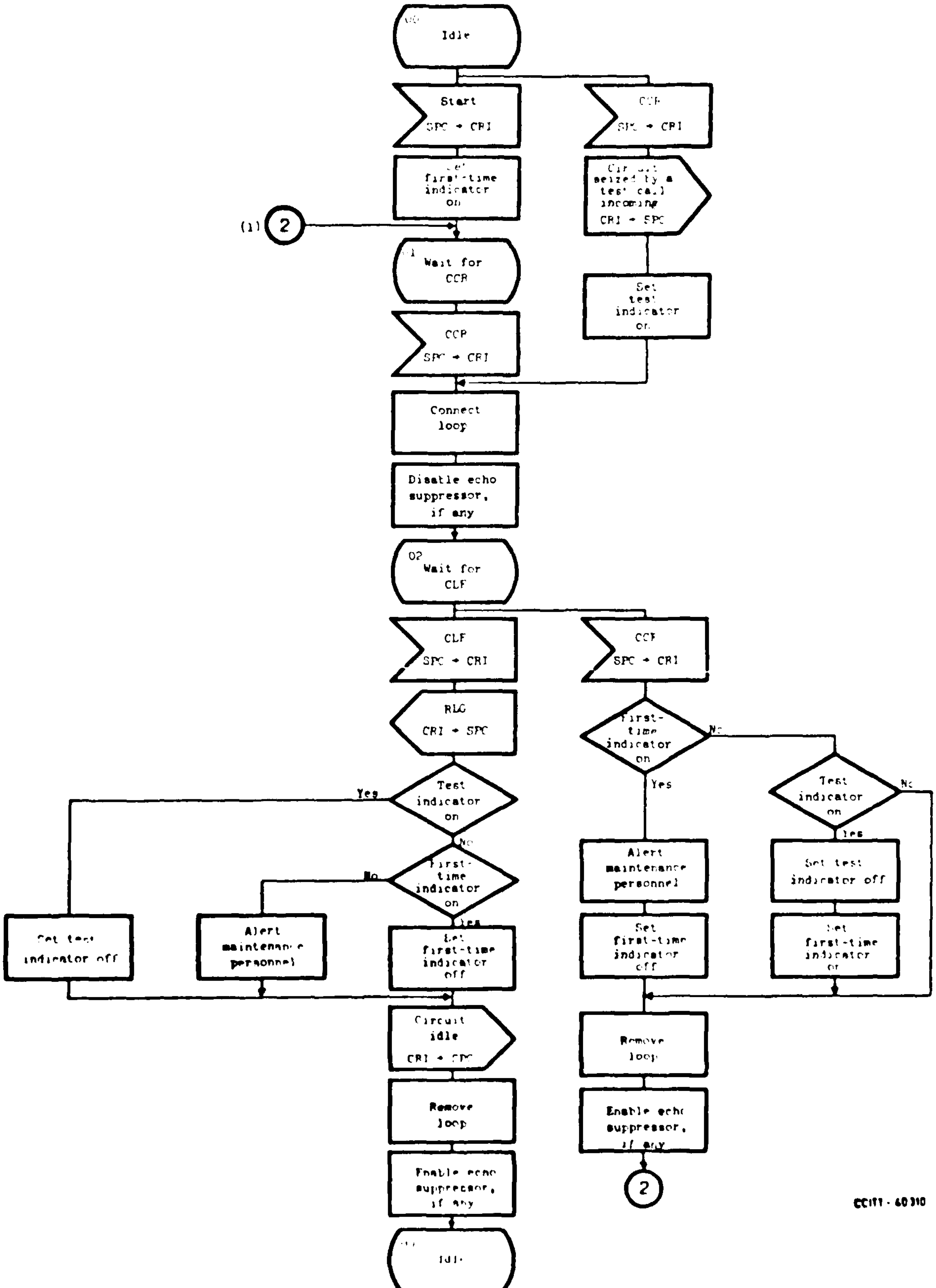


Figure 10-6 (Q.724) Continuity-checks outgoing (CP) (sheet 3 of :


1(1)
4
CLF
Stop
Remove transceiver
Enable echo suppressor, if any
Test indicator on
Yes
First-time indicator on
Set first-time indicator off
Alert maintenance personnel
Start
Start
T7
2(1)
5
Wait for
Stop
Start
Alert
5
Circuit idle
Idle
Idle
CCITT 60300



(3854)

Figure [illegible] - Continuity - recheck incoming [illegible]

References

[1] CCITT Recommendation, General Function of Telephone Messages and Signals, Yellow Book, Vol. VI.7, Rec. Q.722.

[2] CCITT Recommendation, Formats and Codes, Yellow Book, Vol. VI.7, Rec. Q.723.

[3] CCITT Recommendation, Sending Sequence of numerical (or address) Signals, Yellow Book, Vol. VI.1, Rec. Q.107.

[4] CCITT Recommendation, General Function of Telephone Messages and Signals, Yellow Book, Vol. VI.7, Rec. Q.722, Section 3.4.

[5] CCITT Recommendation, Special release arrangements, Yellow Book, Vol. VI.1, Rec. Q.118.

[6] CCITT Recommendation, Overflow-alternative, routing-rerouting automatic repeat attempt, Yellow Book, Vol, VI.1, Rec. Q.12.

[7] CCITT Recommendation, Formats, Format and Codes, Yellow Book, Vol. VI.7, Rec. Q.723, Section 3.3.1.

[8] CCITT Recommendation, Signalling systems performance, Yellow Book, Vol. VI.7, Rec. 706, Section 2.

[9] CCITT Recommendation, Interruption control, Yellow Book, Vol. VI.4, Rec. Q.416.

[10] CCITT Recommendation, Performance requirements, Yellow Book, Vol. VI.5, Rec. Q.504.

Recommendation Q.725

SIGNALLING PERFORMANCE IN THE TELEPHONE APPLICATION

1 Introduction

This Recommendation gives the requirements of the telephone application of Signalling System No. 7.

In Recommendation Q.706 [1], the message transfer part performance is described. The message transfer part is the basis of the telephone application of Signalling System No. 7 and provision of a signalling network to serve the telephone service must take account of the performance of the message transfer part and the requirements of the telephone application. For example, taking account of the message transfer times detailed in [1] and the requirements for message transfer times between two telephone exchanges, a figure may be derived for the total permissible number of signalling links in signalling relations in tandem for a particular call.

2 Unsuccessful calls due to signalling malfunction

The proportion of calls that are unsuccessful due to signalling malfunction should be less than 1 in 10^5.

By means of error detection (see Recommendation Q.703 [2]) as well as transmission fault indication (see Recommendation G.732 [3] and G.733 [4]), it is ensured that overall, not more than one error in 10^8 of all signal units transmitted is accepted and will cause false operation.

Unsuccessful calls may be caused by undetected errors, loss of messages or messages delivered out of sequence (during emergency situations within the signalling network) and may result in:

- incomplete call set-up,
- misrouted calls (e.g. connection of wrong numbers),
- calls routed correctly but mishandled (e.g. false clearing).

3 Unavailability of a signalling route set

The overall unavailability of a signalling route set causing the unavailability of a signalling relation should not exceed a total of 10 minutes per year.

Note - The availability of a signalling route set within a signalling network may be enhanced by replication of signalling links, signalling paths and signalling routes.

4 Labelling potential

The label of the Telephone User Part of Signalling System No. 7 provides the potential to identify 16,384 signalling points and up to 4,096 speech circuits for each signalling relation.

5 Cross-Office transfer time

5.1 Functional reference points and transfer time components

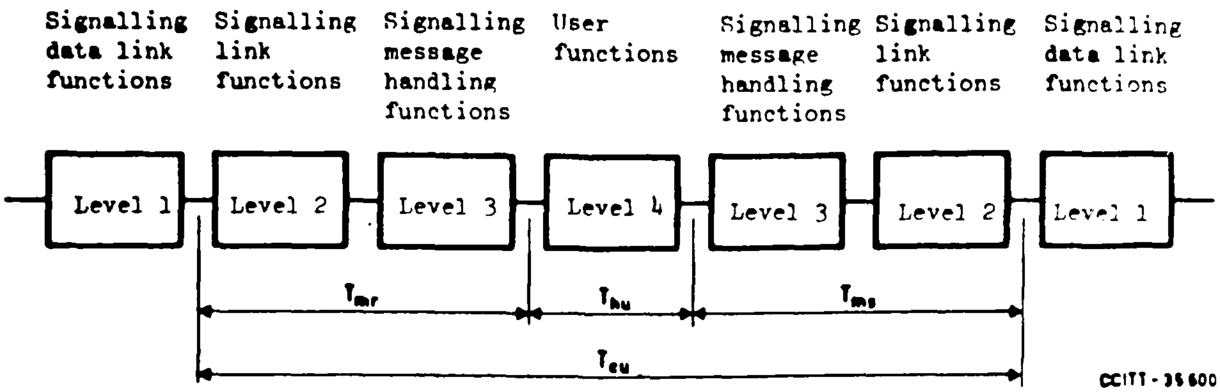


Figure 5-1 (Q.725) - Functional diagram of the cross-office transfer time

T_{cu} = Cross-office transfer time

Thu = Telephone user part handling time

T_{mr} = Message transfer part receiving time

T_{ms} = Message transfer part sending time

The definitions of these times are given in Recommendation Q.725 [1]

5.2 Definitions

a) Cross-office transfer time T_{cu}

T_{cu} is the period which starts when the last bit of the signal unit leaves the incoming signalling data link and ends when the last bit of the signal unit enters the outgoing signalling data link for the first time. It also includes the queueing delay in the absence of disturbances but not the additional queueing delay caused by retransmission.

b) User handling time Thu

Thu is the period which starts when the last bit of the message has entered the Telephone User Part and ends when the last bit of the derived message has left the Telephone User Part.

5.3 Queueing delay

The formulae for the queueing delays are described in Recommendation Q.706, Section 4.2 [5].

The telephone traffic model assumed is given in Table 5.1 (Q.725), from which the proportion of signal messages may be obtained as shown in Table 5.2 (Q.725). Using Table 5.2 (Q.725), examples of queueing delays are calculated as show in Figures 5.2, 5.3, 5.4 and 5.5 (Q.725), where one call attempt per second per 64 kbit/s signal'ing data link may yield 0.00577 Erlang of the traffic loading of each channel.

Table 5.1 Q.725 - Traffic model

Sending procedure			"En bloc"				Overlap			
Type of call			AW	SB	CC	AB	AW	SB	CC	AB
Per cent calls			30	10	5	5	30	10	5	5
Messages per call		Length(bits)								
	12-digit IAM	176	1	1	1	0				
	6-digit IAM	152					1	1	1	1
	3-digit SAM	128					1	1	0	1
	1-digit SAM	112					3	3	0	0
	Address complete	112	1	1	0	0	1	1	0	0
	Others	104	3.5	2	3	0	3.5	2	3	2

Note - AW = answered, SB = subscriber busy and not answered, CC = circuit congestion, AB = abortive. The assumptions used in this model are chosen for illustrative purposes, and should not be considered to be typical.

Table 5.2 Q.725 - Proportion of messages

Length(bits)	176	152	128	112	104	Total
Messages per call in both directions	0.45	0.5	0.45	2.0	2.9	6.3
Percent	7.1	7.9	7.1	31.7	46.0	100
Mean message length (T_m)	117.2 bits					
k_1	1.032					
k_2	1.107					

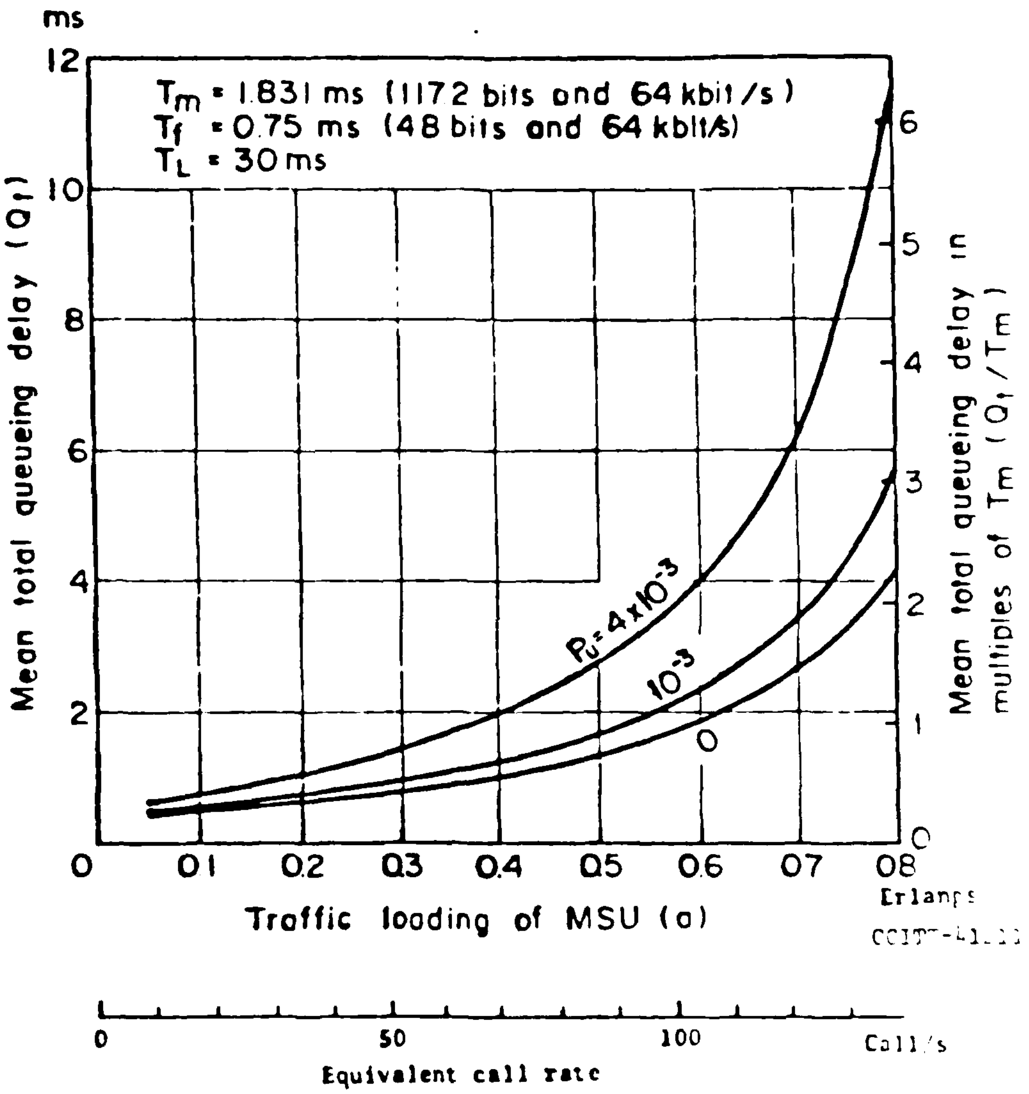


Fig. 5-2 (Q.725) Mean total queueing delay of each channel of traffic
— Basic error correction method —

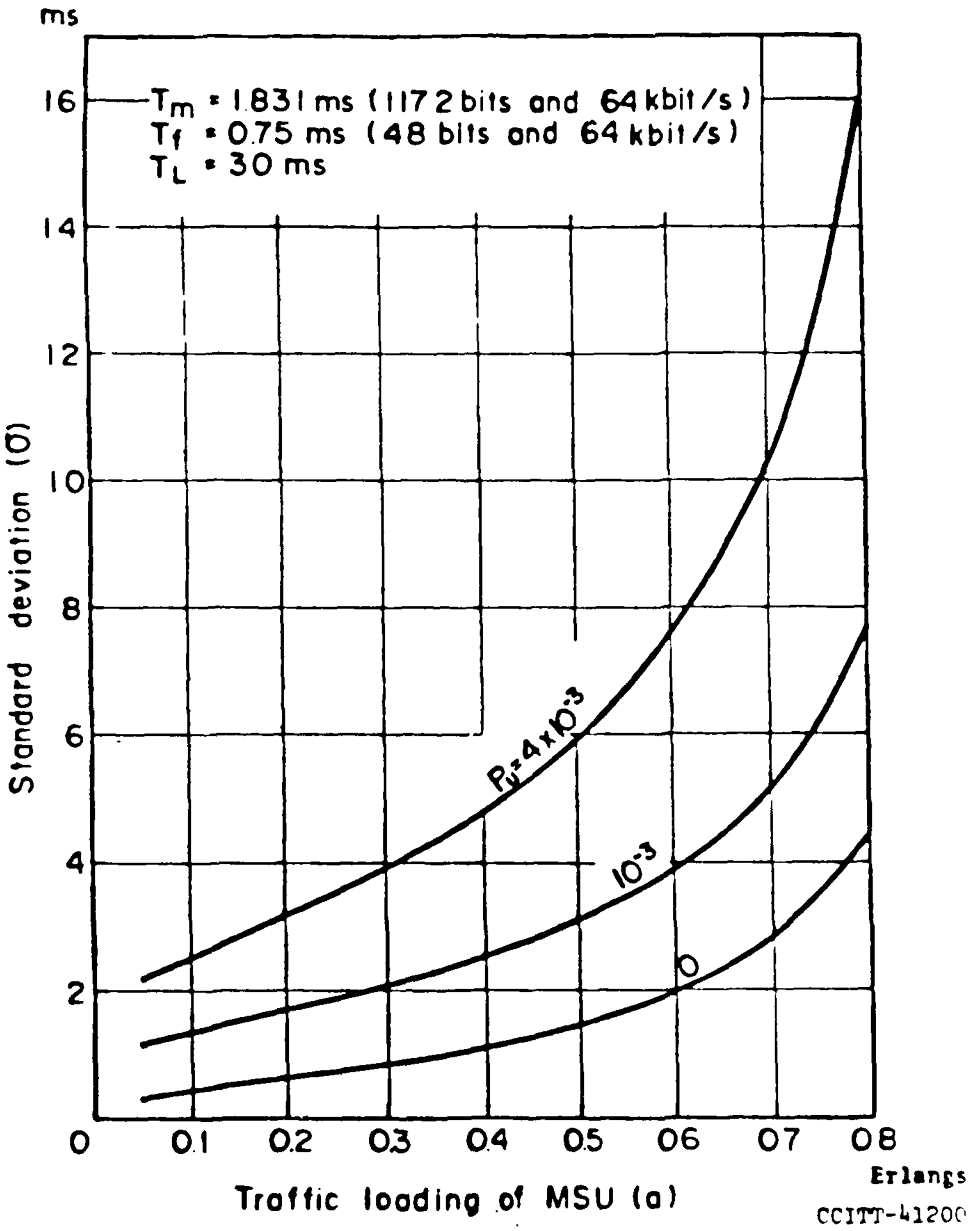


Fig. 5-3 (Q.725) Standard deviation of queueing delay of each channel of traffic.
— Basic error correction method —

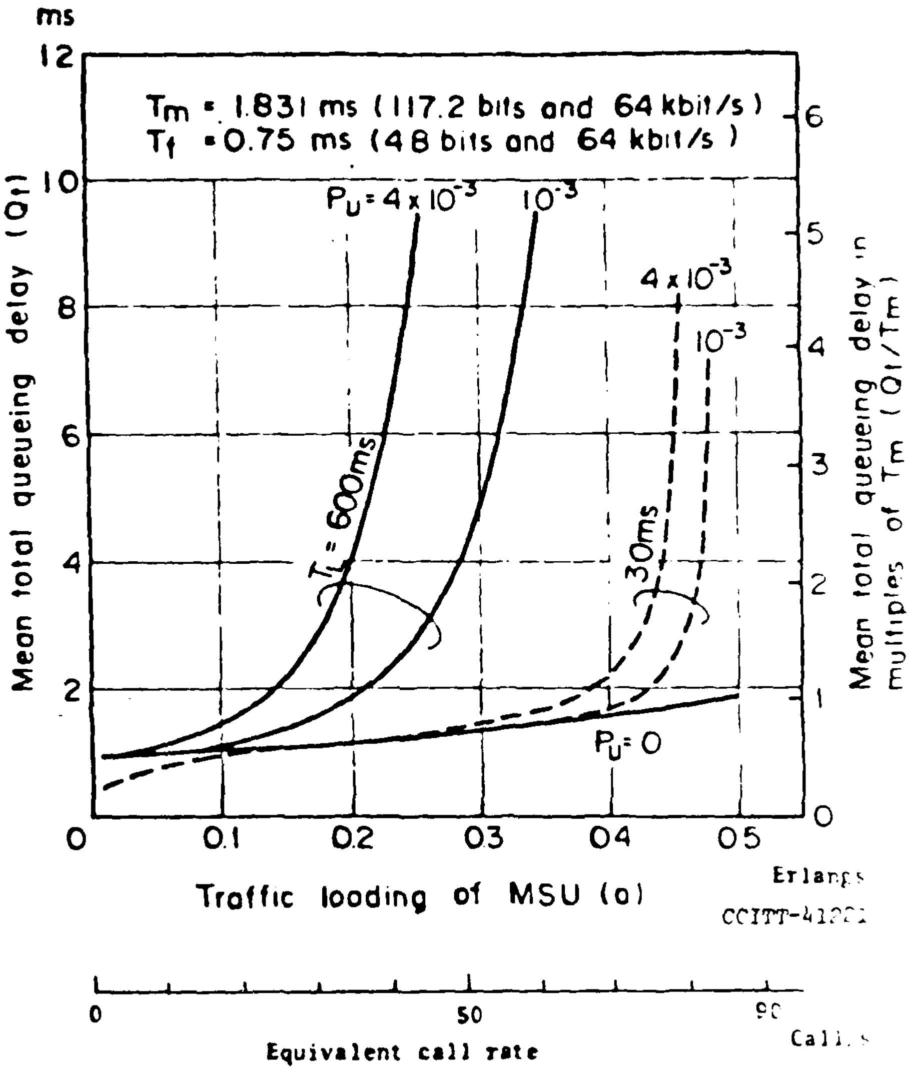


Figure 5-4 (Q.725) - Mean total queueing delay of each channel of traffic
Preventive cyclic retransmission error correction

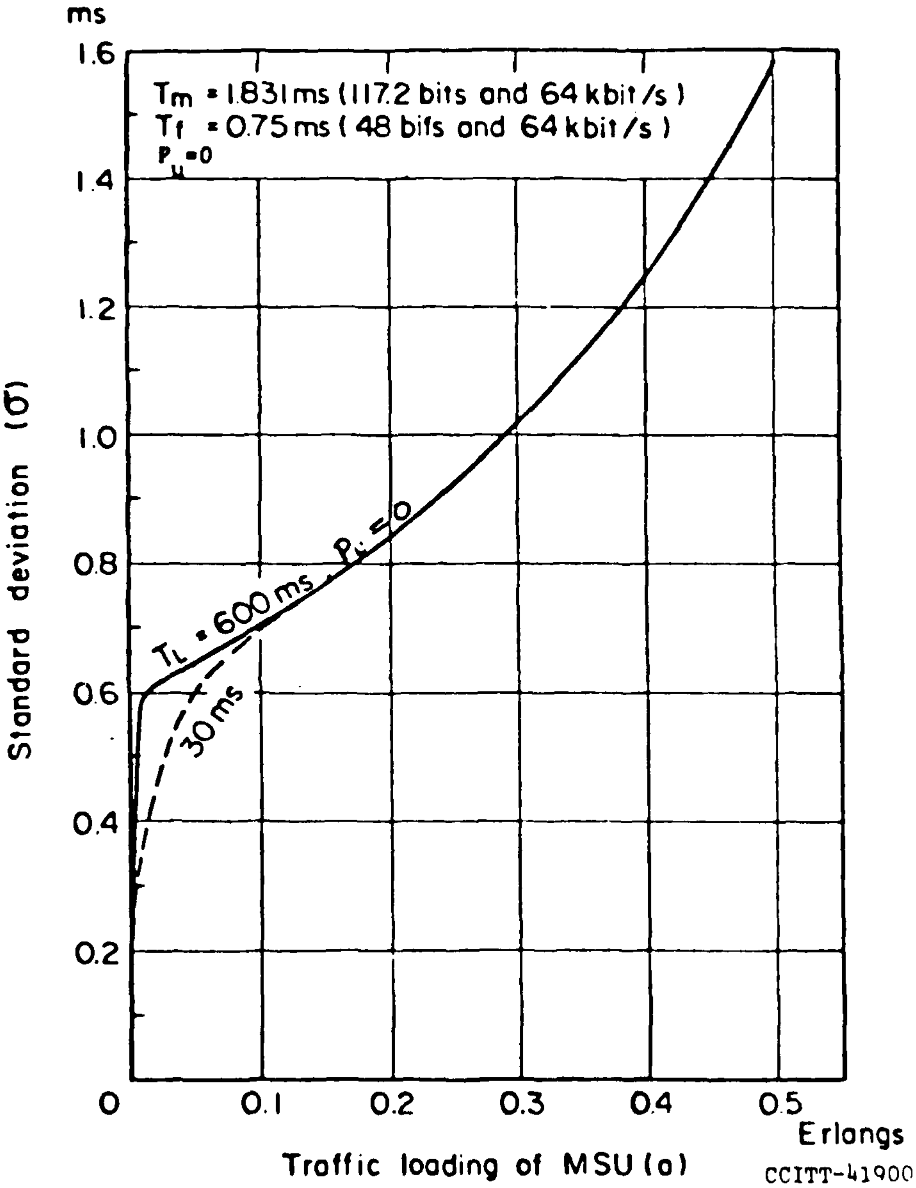


Figure 5-5 (P.725) - Standard deviation of queueing delay of each channel of traffic.
Preventive cyclic retransmission error correction method

5.4 Estimates for message transfer time

TABLE 1-3 Q.725

Exchange call attempt loading	T_{cu} in ms 1)	
	Mean	95%
Normal	50	100
+ 15%	100	200
+ 30%	250	500

1) Provisional values

These figures are related to a signalling bit rate of 64 kbit/s.

5.5 Effect of retransmission

As a consequence of correction by retransmission, not more than one in 10^4 signals should be delayed more than 300 ms as a long-term average. This requirement refers to each signalling link.

This requirement is laid down in order to ensure satisfactory answer delays.

References

[1] CCITT Recommendation, Signalling System Performance, Yellow Book, Vol. VI.7, Rec. Q.706.

[2] CCITT Recommendation, Signalling link, Yellow Book, Vol. VI.7, Rec. Q.703.

[3] CCITT Recommendation, Characteristics of primary PCM multiplex equipment operating at 2048 kbit/s, Yellow Book, Vol. III, Rec. G.732.

[4] CCITT Recommendation, Characteristics of primary PCM multiplex equipment operating at 1544 kbit/s, Yellow Book, Vol. III, Rec. G.733.

[5] CCITT Recommendation, Signalling systems performance, Yellow Book, Vol. VI.7, Rec. Q.706, Section 2.2.

GLOSSARY OF TERMS SPECIFIC TO SIGNALLING SYSTEM No. 7

Term	Definition
Active signalling link	A signalling link which has successfully completed the initial alignment procedures and carries (or is ready to carry) signalling traffic
Adjacent signalling points	Two signalling points that are directly interconnected by (a) signalling link(s)
Allignment error rate monitoring	A procedure by which the error rate of a signalling link is measured during the initial alignment
Alternative routing (of signalling)	The routing of a given signalling traffic flow in case of failures affecting the signalling links, or routes, involved in the normal routing of that signalling traffic flow
Associated mode (of signalling)	The mode where messages for a signalling relation involving two adjacent signalling points are conveyed over a directly interconnecting signalling link
Backward indicator bit	A bit in a signal unit which is used to request a retransmission when a signal unit is received out of sequence
Backward sequence number	A field in a signal unit which contains the forward sequence number of a correctly received signal unit being acknowledged
Basic (error correction) method	A non-compelled, positive/negative acknowledgement, retransmission error control system
Changeback	The procedure of transferring signalling traffic from one or more alternative signalling links to a signalling link which has become available
Changeback code	A field in the signalling network management messages used in the changeback procedure; it is used to descriminate messages relating to different changeback procedures performed at the same time towards the same signalling link
Changeover	The procedure of transferring signalling traffic from one signalling link to one or more different signalling links, when the link in use fails or is required to be cleared of traffic.
Check bit	A bit associated with a character or block for the purpose of checking the absence or error within the character or block

Check loop	A device which is attached to interconnect the GO and RETURN paths of a circuit at the incoming end of a circuit to permit the outgoing end to make a continuity check on a loop basis.
Common channel signalling	A signalling method in which a single channel conveys by the means of labelled messages, signalling information relating to a multiplicity of circuits and other information such as that used for network management.
Continuity check	A check made to a circuit or circuits in a connection to verify that an acceptable path (for transmission of data, speech, etc) exists.
Continuity check transponder	A device which is used to interconnect the GO and RETURN paths of a circuit at the incoming end which on detection of a check tone transmits another check tone to permit a continuity checking of a 2-wire octet.
Controlled rerouting	A procedure of transferring in a controlled way, signalling traffic from an alternative signalling route to the normal signalling route, when this has become available.
Cross-office check	A check made across the exchange to verify that a speech path exists.
Data user part	The User Part specified for data services.
Destination point code	A part of the label in a signalling message which uniquely identifies, in a signalling network, the [signalling] destination point of the message.
Dual seizure	The condition which occurs when in bothway operation two exchanges attempt to seize the same circuit at approximately the same time.
Emergency changeover	A modified changeover procedure to be used whenever the normal one cannot be accomplished, i.e. in case of some failures in the signalling terminal equipment or in case of inaccessibility between the two involved signalling points.
Error burst	A group of bits in which two successive erroneous bits are always separated by less than a given number (X) of correct bits. The number X should be specified when describing an error burst. Note - The last erroneous bit in a burst and the first erroneous bit in the following burst are accordingly separated by X correct bits or more.
Fill-in signal units	A signal unit containing only error control and delimitation information, which is transmitted when there are no message signal units or link status signal units to be transmitted.

Flag	The unique pattern on the signalling data link used to delimit a signal unit.
Forced rerouting	A procedure of transferring signalling traffic from one signalling route to another, when the signalling route in use fails or is required to be cleared of traffic.
Forward indicator bit	A bit in a signal unit which indicates the start of a retransmission cycle.
Forward sequence number	A field in a signal unit which identifies the last message signal unit transmitted.
Inactive signalling link	A signalling link which has been deactivated and cannot therefore carry signalling traffic.
Integrated digital network	A network in which connections established by digital switching are used for the transmission of digital signals.
Integrated services digital network	An integrated digital network in which the same digital switches and digital paths are used to establish connections for different services, for example, telephony, data.
Interruption control	A system which monitors a pilot for interruptions on FDM systems and which transmits an indication to the switching equipment.
Label	Information within a signalling message used to identify typically the particular circuit, call or management transaction to which the message is related.
Length indicator	A six bit field which differentiates between message signal units, link status signal units and fill-in signal units and in the case that its binary value is less than 63 indicates the length of a signal unit.
Link status signal unit	A signal unit which contains status information about the signalling link in which it is transmitted.
Load sharing (general)	A process by which signalling traffic is distributed over two or more signalling or message routes, in view of traffic equalization or security.
Long term bit error rate	Bit error rate measured over a sufficiently long time period, e.g. one month.
Medium term bit error rate	Bit error rate that can be encountered for relatively short time periods, e.g. some minutes, due to temporary malfunctions of transmission equipment.

Message signal unit	A signal unit containing a service information octet and a signalling information field which is retransmitted by the signalling link control if it is received in error.
Message Transfer Part	The functional part of a common channel signalling system which transfers signalling messages as required by all the users, and which performs the necessary subsidiary functions, for example error control and signalling security.
National indicator	Information within a signalling message which permits typically a distinction to be made between national and international messages.
Non-associated mode (of signalling)	The mode where messages for a signalling relation involving two [non adjacent] signalling points are conveyed, between those signalling points, over two or more signalling links in tandem passing through one or more signalling transfer points.
No. 7 exchange	An exchange utilizing Signalling System No. 7.
No. 7 exchange - first	The exchange closest to the calling party in each No. 7 section of a connection where, unless it is the calling party's exchange, interworking with other signalling systems takes place.
No. 7 exchange - last	The exchange closest to the called party in each No. 7 connection where, unless it is the called party's exchange, interworking with other signalling systems takes place.
Normal routing (of signalling)	The routing of a given signalling traffic flow in normal conditions (i.e. in the absence of failures).
Originating point code	A part of the label in a signalling message which uniquely identifies, in a signalling network, the [signalling] originating point of the message.
Pilot	Sinusoidal signal transmitted over analogue FDM links for regulation and supervision purposes.
Preventive Cyclic Retransmission (error control) method.	A non-compelled, positive acknowledgement, cyclic retransmission forward error correction system.
Processor outage	A situation in which a signalling link becomes unavailable, due to factors at a functional level higher than level 2. This may be because of, for example, a central processor failure. It may also be due to a manually initiated blocking of an individual signalling link.

Quasi-associated mode (of signalling)	A non-associated mode [of signalling] in which the [signalling] message route is determined basically, for each signalling message, by information contained in this message [namely in its routing label] and is fixed in normal operation.
Random errors	Errors distributed over the digital signal so that they can be considered statistically independent from each other.
Retransmission buffer	Storage in the signalling link control for signal units transmitted but not yet positively acknowledged.
Retrieval	The process of transferring all those messages in the retransmission buffer of a signalling link (A), which have not yet been positively acknowledged, to the transmission buffer of an alternative signalling path (B).
Routing label	The part of the message label that is used for message routing in the signalling network. It includes the destination point code, the originating point code and the signalling link selection field.
Service indicator	Information within a signalling message identifying the user to which the message belongs.
Service information (octet)	Eight bits, contained in a message signal unit, comprising the service indicator and the sub service field.
Signal Units	A group of bits forming a separately transferable entity used to convey information on a signalling link.
Signal Unit alignment	Signal unit alignment exists when flags are received at intervals which correspond to integral numbers of octets and which fall within certain upper and lower limits.
Signal Unit error rate monitoring	A procedure by which the error rate of an active signalling link is measured on the basis of a count of correctly checking and erroneous signal units.
(Signalling) Destination point	A signalling point to which a message is destined.
Signalling information (field)	The bits of a message signal unit which carry information particular to a certain user transaction and always contain a label.
Signalling link	A transmission means which consists of a signalling data link and its transfer control functions, used for reliable transfer of a signalling message.

Signalling link blocking	An event causing the unavailability of a signalling link, typically consisting in a "processor outage" condition at one end of that signalling link.
Signalling link code	A field of the label in the signalling network management messages, which indicates the particular signalling link to which the message refers among those interconnecting the two involved signalling points.
Signalling link error monitoring	This comprises two functions: Initial alignment error rate monitoring and signal unit error rate monitoring.
Signalling link failure	An event causing the unavailability of a signalling link, typically consisting in a failure in signalling terminal equipment or in the signalling data link.
Signalling link group	A set of signalling links directly connecting two signalling points and having the same physical characteristics (bit rate, propagation delay, etc.).
Signalling link management functions	Functions that control and take actions, when required, to preserve integrity of locally connected signalling links, e.g. by reconfiguration of the signalling link sets.
Signalling link restoration	An event consisting in the completion of the initial alignment procedure on a signalling link following the removal of the previous causes of failure; if no other causes of unavailability exist (i.e. a signalling link blocked condition) then the signalling link becomes available.
Signalling link selection field	A field of the routing label which is typically used by the message routing function to perform load sharing among different signalling links/link sets.
Signalling link set	A set of signalling link(s) directly connecting two signalling points.
Signalling link unblocking	An event consisting in the removal of the previous causes of signalling link blocking; if no other causes of unavailability exist (i.e. a signalling link failed condition), then the signalling link becomes available.
Signalling message	An assembly of signalling information pertaining to a call, management transaction, etc. that is transferred as an entity.

(Signalling) message discrimination	The process which decides, for each incoming message, whether the signalling point is destination point or if it should act as signalling transfer point for that message and accordingly, whether the message should be handled to (signalling) message distribution or to (signalling) message routing functions.
(Signalling) Message distribution	The process of determining, upon receipt of a signalling message at its destination point, to which User Part the signalling message is to be delivered.
Signalling message handling functions	Functions that, at the actual transfer of a message, direct the message to the proper signalling link or User Part.
(Signalling) Message route	The signalling link or consecutive links connected in tandem that are used to convey a signalling message from an originating point to its destination point.
(Signalling) Message routing	The process for selecting, for each signalling message to be sent, the signalling link to be used.
Signalling network	A network used for signalling and consisting of signalling points and connecting signalling links.
Signalling network functions	The functions which are performed by the Message Transfer Part at Level 3 and are common to, and independent of, the operation of individual signalling links. They include the signalling message handling functions and the signalling network management functions.
Signalling network management functions	Functions that, on the basis of predetermined data and information about the status of the signalling network, control the current message routing and configuration of signalling network facilities.
(Signalling) Originating point	A signalling point in which a message is generated.
Signalling point	A node in a signalling network which either originates and receives signal messages, or transfers signal messages from one signalling link to another, or both.
Signalling point code	A binary code uniquely identifying a signalling point in a signalling network. This code is used, according to its position in the label, either as destination point code or as originating point code.

Signalling relation	A relation between two signalling points involving the possibility of information interchange between correcponding User Part functions.
Signalling route	A predetermined path described by a succession of signalling points that may be traversed by signalling messages directed by a signalling point towards a specific destination point.
Signalling route management functions	Functions that transfer information about changes in the availability of signalling routes in the signalling network.
Signalling route-set test procedure	A procedure, included in the signalling route management which is used to test the availability of a given signalling route, previously declared unavailable.
(Signalling) Traffic flow control	Actions and procedures intended to limit signalling traffic at its source in the case when the signalling network is not capable of transferring all signalling traffic offered by the User Parts, because of network failures or overload situations.
Signalling traffic management functions	Functions that control and, when required, modify routing information used by the Message routing function and control the transfer of signalling traffic in a manner that avoids irregularities in message flow.
Signalling transfer point	A signalling point with the function of transferring signalling messages from one signalling link to another.
Status field	The bits of a link status signal unit which indicate one of the major signalling link states.
Telephone user part	The User Part specified for telephone services.
Transfer-allowed (procedure)	A procedure, included in the signalling route management, which is used to inform a signalling point that a signalling route has become available.

Transfer-prohibited (procedure)	A procedure, included in the signalling route management, which is used to inform a signalling point of the unavailability of a signalling route.
Transmission buffer	Storage in the signalling link control for signal units not yet transmitted.
User Part	A functional part of the common channel signalling system which transfers signalling messages via the message transfer part. Different types of user parts exist (e.g. for telephone and data services), each of which is specified to a particular use of the signalling system.
User (of the signalling system)	A functional entity, typically a telecommunication service, which uses a signalling network to transfer information.

ABBREVIATIONS SPECIFIC TO SIGNALLING SYSTEM No. 7

English	French	Spanish	Meaning
ACM	ACO	MDC	Address complete message : Q.723, Table 3.1
ADI	ADI	SDI	Address incomplete signal : Q.723, Table 3.1
AERM	STEA	MA	Alignment error rate monitor : Q.703; Fig. 11-1, Fig. 11-2, Fig. 11-3, Fig. 11-5, Fig. 11-11
ANC	RAT	RCT	Answer signal, charge : Q.723, Table 3.1
ANN	RST	RST	Answer signal, no charge : Q.723, Table 3.1
BIB	BIR	BII	Backward indicator bit : Q.703; Fig. 2-1, Fig. 11-7, Fig. 11-9
BLA	BLA	ARB	Blocking-acknowledgement signal : Q.723, Table 3.1
BLO	BLO	BLO	Blocking signal : Q.723, Table 3.1
BSM	DE	MPE	Backward set-up message : Q.723, Table 3.1
BSN	NSR	NSI	Backward sequence number : Q.703; Fig. 2-1, Fig. 11-8, Fig. 11-10
BSNR		NSIR	Backward sequence number received : Q.703; Fig. 11-1, Fig. 11-7, Fig. 11-8, Fig. 11-10
BSNT		NSIT	Backward sequence number of next SU to be transmitted : Q.703; Fig. 11-1, Fig. 11-2, Fig. 11-3, Fig. 11-7, Fig. 11-8, Fig. 11-9, Fig. 11-10; Q.704, Fig. 14-5, Fig. 14-8
CBA	RCA	ARS	Changeback acknowledgement signal : Q.704; Table 13.1
CBD	RCO	ORC	Changeback declaration signal : Q.704; Table 13.1
CBK	RAC	COL	Clear-back signal : Q.723, Table 3.1
CCF	CCN	FCO	Continuity-failure signal : Q.723, Table 3.1
CCI	CCE	PCL	Continuity-check, incoming : Q.724, Fig. 10-1 to 10-7
CCM	SC	MSC	Circuit supervision message : Q.723, Table 3.1
CCO	CCS	CCS	Continuity-check, outgoing : Q.724, Fig. 10-1 to 10-7
CCR	CCD	PPC	Continuity-check request signal : Q.723, Table 3.1
CCS	CS	SCC	Common channel signalling : Q.7[illegible], 1.1
CFL	ECH	SLI	Call-failure signal : Q.7[illegible], Table 3.1
CGC	EFC	CHC	Circuit-group-congestion : Q.72[illegible], Table 3.1
CHG	TAX	MTA	Charging message : Q.72[illegible], Table 3.1
CHM	PR	MPA	Changeover and changeback messages : Q.7[illegible]; Table 1[illegible]
CIC	CIC	CIC	Circuit identification code : Q.7[illegible]4, [illegible]
CIR	IDD	PIL	Calling-line-identity-request signal : Q.7[illegible]3, Table 3.1
CK	CRT	BCE	Check bits : Q.703; Fig. [illegible]-1
CLF	FIN	FIN	Clear-forward signal : Q.7[illegible], Table 3.1
CLI	IDL	MIL	Calling-line-identity message : Q.7[illegible]3, Table 3.1
CLU	IDN	MIN	Calling-line-identity-unavailable [illegible], Table 3.1

English	French	Spanish	Meaning
CNP	CLI	CIM	Connection-not-possible signal : Q.704; Table 13.1
CNS	CLN	CIN	Connection-not-successful signal : Q.704; Table 13.1
COA	PCA	APR	Changeover acknowledgement signal : Q.704; Table 13.1
COO	PCO	OPR	Changeover order signal : Q.704; Table 13.1
COT	CCP	CON	Continuity signal : Q.723, Table 3.1
CPC	STA	CTL	Call processing control : Q.724, Fig. 10-1 to 10-7
CRI	CRE	RPL	Continuity-recheck outgoing : Q. 724, Fig. 10-1 to 10-7
CRO	CRS	RPC	Continuity-recheck incoming : Q.724, Fig. 10-1 to 10-7
CSM	SA	MSL	Call supervision message : Q.723, Table 3.1
CSS	CLR	ACC	Connection-successful-signal : Q.704; Table 13.1
DAEDR	DAD-R	DADR	Delimitation; alignment, error detection (reception) : Q.703, Fig. 11-1, Fig. 11-5, Fig. 11-8, Fig. 11-10, Fig. 11-11, Fig. 11-12
DAEDT	DAD-E	DADT	Delimitation; alignment, error detection (transmission) : Q.703, Fig. 11-6, Fig. 11-7, Fig. 11-[illegible]
DCE	ETCD	ETCD	Data circuit terminating equipment : Q.7[illegible], Fig. [illegible]
DLC	CLO	CED	Signalling-data-link-connection-order signal : Q.704; Table 13.1
DLM	CL	MED	Signalling-data-link-connection-order message : Q.704; Table 13.1
DPC	CPD	CPD	Destination point code : Q.7[illegible], [illegible], Fig. 13-1, Sec. 13.2, Fig. 14-[illegible]
DUP	SSUD	PUD	Data user part : Q.7[illegible]; [illegible]
EAM	EXR	MAR	Extended answer message indication : Q.7[illegible], Table [illegible]
ECA	PUA	AER	Emergency changeover acknowledgement signal : Q.7[illegible], Table 13.1
ECM	PU	MEP	Emergency changeover message : Q.7[illegible]; Table [illegible]
ECO	PUO	PER	Emergency changeover order signal : Q.704; Table 13.1
EUM	EXT	IAL	Extended unsuccessful backward set-up information message indication : Q.723, Table 3.1
F	F	BAN	Flag : Q.703; Fig. 2-1
FAM	AD	MDA	Forward address message : Q.723, Table 3.1
FCM	CF	MCF	Signalling traffic flow control messages : Q.704, Table 13.1
FDM	MRF	MDF	Frequency division multiplex : Q.723 2.2.3; Q.724, [illegible]
FIB	BIA	BID	Forward indicator bit : Q.703; Fig. 2-1, Fig. 11-7, Fig. 11-9
[illegible]	[illegible]	[illegible]	Fill-in signal unit : Q.703; Fig. 11-1, Fig. 11-2, Fig. 11-7, Fig. 11-8, Fig. 11-9, Fig. 11-10; Q.704, Fig. A.6-1, Fig. A.6-2, Fig. A.6-7
			Forward transfer signal : Q.723, Table 3.1
			[illegible] message : Q.7[illegible], Table [illegible]

English	French	Spanish	Meaning
FSN	NSA	NSD	Forward sequence number : Q.703; Fig. 2-1, Fig. 11-7
HMDC	ODC	HDCM	Message discrimination : Q.704; Sec. 14.3, Fig. 14-1, Fig. 14-2, Fig. 14-3, Fig. 14-4
HMDT	ODT	HDTM	Message distribution : Q.704; Sec. 14.3, Fig. 14-1, Fig. 14-2, Fig. 14-3, Fig. 14-6, Fig. 14-8, Fig. 14-9, Fig. 14-20, Fig. 14-22, Fig. 14-23, Fig. 14-24
HMRT	OAC	HENM	Message routing : Q.704; Sec. 14.3, Fig. 14-1, Fig. 14-2, Fig. 14-4, Fig. 14-5, Fig. 14-6, Fig. 14-9, Fig. 14-10, Fig. 14-11, Fig. 14-20, Fig. 14-22, Fig. 14-23, Fig. 14-24, Fig. A.6-5
HO	HO	EO	Heading code : Q.704, 13.3, Fig. 13-3; Q.707, 5.3, Fig. 5.1, Q.723, 3.1, 3.2
H1	H1	E1	Heading code : Q.704, 13.4.3, Fig. 13-3; Q.723, 3.1
IAC	CAI	CAI	Initial alignment control : Q.703; Fig. 11-2, Fig. 11-3, Fig. 11-7, Fig. 11-8, Fig. 11-9, Fig. 11-10, Fig. 11-11; Q.704, Fig. A.6-7
IAI	MIS	MIA	Initial address message with additional information : Q.723, Table 3.1
IAM	MIA	MID	Initial address message : Q.723, Table 3.1
ISP	PSI	PSI	International signalling point : Q.705, 3, Fig. 3-1
L1 Fig. A	N1	N1	Level 1 : Q.703; Fig. 11-[illegible]; Q.704, Fig. 14-1[illegible], Fig. 14-1[illegible], Fig. 14-17, Fig. 14-18, Fig. A.6-1, Fig. A.6-2, Fig. A.6-4
L2	N2	N2	Level 2 : Q.703; Fig. 11-[illegible], Fig. 11-3, Fig. 11-[illegible], Fig. 11-7, Fig. 11-[illegible]; Q.704, Fig. 14-1, Fig. 14-[illegible], Fig. 14-4, Fig. 14-[illegible], Fig. 14-[illegible], Fig. 14-13, Fig. 14-15, Fig. A.6-1, Fig. A.6-4, Fig. A.[illegible]
L3	N3	N3	Level 3 : Q.703; Fig. 11-2, Fig. 11-3, Fig. 11-7, Fig. 11-9; Q.704, Fig. 14-[illegible], Fig. 14-[illegible], Fig. 14-[illegible], Fig. 14-8, Fig. 14-[illegible], Fig. 14-1[illegible], Fig. 14-1[illegible], Fig. 14-15, Fig. 14-1[illegible], Fig. 14-17, Fig. A.[illegible], Fig. A.6-4, Fig. A.6-7
L4	N4	N4	Level 4 : Q.704; Fig. 14-1, Fig. 14-3, Fig. 14-[illegible], Fig. 14-5, Fig. 14-1[illegible]
LI	INL	II	Length indicator : Q.70[illegible], [illegible], Fig. [illegible]
LLSC	GCSF	CCE	Link set control : Q.704; Fig. 14-7, Fig. 14-13, Fig. 14-14, Fig. 14-1[illegible], Fig. A.6-1, Fig. A.6-[illegible]
LOS	LHS	LFS	Line-out-of-service signal : Q.703, Table 3.1
LSAC	GCSA	CAE	Signalling link activity control : Q.704; Sec. 14.[illegible], Fig. 14-6, Fig. 14-7, Fig. 14-8, Fig. 14-13, Fig. 14-1[illegible], Fig. 14-15, Fig. 14-16, Fig. 14-17, Fig. 14-1[illegible], Fig. 14-19, Fig. A.6-1, Fig. A.6-2, Fig. A.6-3, Fig. A.6-4, Fig. A.6-[illegible]
LSC	SET	CEE	Link state control : Q.703; Fig. 11-1, Fig. 11-[illegible], Fig. 11-3, Fig. 11-4, Fig. 11-7, Fig. 11-8, Fig. 11-[illegible], Fig. 11-10, Fig. 11 11, Fig. 11-1[illegible]; Q.704, Sec. [illegible], Fig. 14-19, Fig. A.6-1, Fig. A.6-4, Fig. A.6-7

English	French	Spanish	Meaning
LSDA	GCAL	AED	Signalling data link allocation : Q.704; Sec. 14.6, Fig. 14-13, Fig. 14-15, Fig. 14-16, Fig. 14-17, Fig. 14-18, Fig. 14-20, Fig. A.6-1, Fig. A.6-3, Fig. A.6-4
LSDS	GCLR	SED	Stand-by data link selection : Q.704, Fig. A.6-1, Fig. A.6-3, Fig. A.6-4
LSLA	GCAC	AES	Signalling link activation : Q.704; Sec. 14.6, Fig. 14-13, Fig. 14-15, Fig. 14-16, Fig. 14-19, Fig. 14-20, Fig. A.6-1, Fig. A.6-4
LSLD	GCDA	DES	Signalling link deactivation : Q.704; Sec. 14.6, Fig. 14-13, Fig. 14-15, Fig. 14-18, Fig. 14-19, Fig. 14-20, Fig. A.6-1, Fig. A.6-4
LSLR	GCRE	RES	Signalling link restoration : Q.704, Sec. 14.6, Fig. 14-13, Fig. 14-15, Fig. 14-17, Fig. 14-19, Fig. 14-20, Fig. A.6-1, Fig. A.6-2, Fig. A.6-4
LSSU	TSE	UEE	Link status signal units : Q.703; Fig. 11-7, Fig. 11-8, Fig. 11-9, Fig. 11-10
LSTA	GCAT	ATS	Signalling terminal allocation : Q.704; Sec. 14.6, Fig. 14-13, Fig. 14-16, Fig. 14-17, Fig. 14-18, Fig. 14-19, Fig. A.6-1
MGMT	GES	SGE	Management system : Q.703; Fig. 11-[illegible]; Q.704, Fig. 14-5, Fig. 14-6, Fig. 14-13, 14-14, Fig. 14-[illegible], Fig. A.6-1, Fig. A.6-6
MSU	TSM	USM	Message signal unit : Q.703; Fig. 11-1, Fig. 11-[illegible], Fig. 11-8, Fig. 11-9, Fig. 11-10; Q.704, Fig. A.[illegible]-7
MTP	SSTM	PTM	Message transfer part : Q.701; Introduction
NACK	ACN	RN	Negative acknowledgement : Q.703; Fig. 11-1, Fig. 11-7, Fig. 11-8
NNC	ERN	CRN	National-network-congestional signal : Q.72[illegible], Table [illegible]
NSP	PSN	PSN	National signalling point : Q.7[illegible]; [illegible], Fig. [illegible]
OPC	CPO	CPO	Originating point code : Q.704; Fig. [illegible], [illegible], Fig. 13-1, Sec. 13.2
PCM	MIC	MIC	Pulse code modulation : Q.702, 5.[illegible]
PCR	RCP	RCP	Preventive cyclic retransmission : Q.70[illegible], Tables 4-[illegible] and 4-2
POC	SIP	CBP	Processor outage control : Q.703; Fig. 11-[illegible], Fig. 11-4; Q.704, Fig. A.6-7
RAN	NRP	RRE	Reanswer signal : Q.723, Table 3.1
RC	REC	CR	Reception control : Q.703; Fig. 11-2, Fig. 11-3, Fig. 11-5, Fig. 11-7, Fig. 11-8, Fig. 11-9, Fig. 11-10; Q.704, Fig. A.6-7
RLG	LIG	LGU	Release-guard signal : Q.723, Table 3.1
RSC	RZC	RCI	Reseat-circuit signal : Q.723, Table 3.1
RSM	TR	MPR	Signalling-route-set-test message : Q.704; Table 13.1
RSRT	GRTF	CPC	Signalling route set test control : Q.704, Sec. 14.5, Fig. 14-1, Fig. 14-7, Fig. 14-21, Fig. 14-22, Fig. 14-23, Fig. 14-24

English	French	Spanish	Meaning
RST	TRS	PRS	Signalling-route-set-test
RTAC	GRTA	CTA	Transfer allowed control : Q.704; Sec. 14.5, Fig. 14-7, Fig. 14-11, Fig. 14-15, Fig. 14-21, Fig. 14-23, Fig. 14-24
RTB	TRT	MRT	Retransmission buffer : Q.703; Fig. 11-1, Fig. 11-7, Fig. 11-9
RTPC	GRTI	CTP	Transfer prohibited control : Q.704; Sec. 14.5, Fig. 14-4, Fig. 14-7, Fig. 14-10, Fig. 14-21, Fig. 14-22, Fig. 14-24

English	French	Spanish	Meaning
SAM	MSA	MSD	Subsequent address message : Q.723, Table 3-1
SAO	MSS	SDU	Subsequent address message with one signal : Q.723, Table 3-1
SBM	SE	MEC	Successful backward set-up information message : Q.723, Table 3-1
SDL	LDS	LED	Functional specification and description language : Q.704, Sec. 14.1
SEC	EEC	CEC	Switching-equipment-congestion signal : Q.723, Table 3-1
SF	ETC	CE	Status field : Q.703, Fig. [illegible]
SI	INS	IS	Service indicator : Q.704, Sec. [illegible]
SIE	ETAU	IAE	Status indication "emergency terminal status" [illegible] Q.703, Fig. 7-1, Sec. 7.[illegible], [illegible] Fig. 11-[illegible], Fig. 11-3, Fig. 11-[illegible], [illegible] Fig. 11-9, Fig. 11-10, Sec. [illegible]
SIF	INF	CIS	Signal information field : Q.7[illegible], [illegible]
SIN	ETAN	IAN	Status indication "normal terminal status" [illegible] Q.703, Fig. 7-1, Sec. 7.[illegible], [illegible] Fig. 11-[illegible], Fig. 11-[illegible], Fig. 11-7, [illegible] Fig. 11-9, Fig. 11-1[illegible], [illegible]
SIO	SER	OIS	Service information [illegible] Q.7[illegible], Fig. [illegible]
SIO	ETAP	IFA	Status indication "out of alignment" [illegible] Fig. 7-1, Sec. 7.[illegible], [illegible], Fig. [illegible] Fig. 11-[illegible], Fig. 1[illegible], Fig. 11-7, [illegible] Fig. 11-9, Fig. 11-1[illegible], [illegible]
SIOS	ETHS	[illegible]	Status indication "out-of-alignment" [illegible] Fig. 7-1, Sec. 7.[illegible], Sec. 7.[illegible], Fig. [illegible] Fig. 11-[illegible], Fig. 11-[illegible], Fig. 11-7, Fig. [illegible] Fig. 11.9, Fig. 11-10, Sec. [illegible], Q.7[illegible] Fig. A.6-7
SIPO	ETIP	IEP	Status indication "processor outage" [illegible] Fig. 11-1, Fig. 11-[illegible], Fig. 11-7, Fig. 11-[illegible] Fig. 11-9, Fig. 11-10, Sec. [illegible].3, Q.7[illegible] Fig. A.6-7
SLC	COC	COE	Signalling link code : Q.704, Fig. 13-1, [illegible]
SLM	GCS	GES	Signalling link management : Q.704, Sec. 14.1, Sec. 14.6, Fig. 14-1, Fig. 14-3, Fig. 14-4, Fig. 14-5, Fig. 14-17
SLS	SCS	SES	Signalling link selection : Q.704, Fig. [illegible], Sec. 2.2.4, Fig. 2-3, Fig. 14-4
SLTM	ESCO	MPES	Signalling link test message : Q.707, Fig. [illegible]
SMH	OMS	TMS	Signalling message handling : Q.704, Sec. 14.1 Sec. 14.3, Fig. 14-1, Fig. 14-[illegible]
SP	PS	PS	Signalling point : Q.704, Fig. [illegible], Fig. 1[illegible]-1, Fig. 14-[illegible], Fig. 14-4, Fig. 14-[illegible], Fig. 14-[illegible], Fig. 14-[illegible], Fig. 14-[illegible], Fig. 14-[illegible], Fig. 14[illegible]

English	French	Spanish	Meaning
SPC	CPS	CPS	Signalling procedure control : Q.724, Fig. 10-1 to Fig. 10-7
SRM	GRS	GRS	Signalling route management : Q.704, Sec. 14.1, Sec. 14.5, Fig. 14-1, Fig. 14-3, Fig. 14-4, Fig. 14-5, Fig. 14-21
SSB	OCC	ABO	Subscriber-busy signal : Q.723, Table 3-1
SSF	DSS	CSS	Sub-service field : Q.704, Sec. 13.1.1
SST	TSI	TIE	Subscriber-transferred signal : Q.723, Table 3-1
SST	TSI	TIL	Send-special-information-tone signal : Q.724, Fig. 10-1 to Fig. 10-7
ST	ST	SFN	End-of-pulsing signal : Q.7[illegible], Sec. [illegible]
STLC	EST	CPES	Signalling link test control : Q.704, Fig. [illegible], Fig. 14.4
STM	GTS	GTS	Signalling traffic management : Q.7[illegible], [illegible], Sec. 14.4, Fig. 14-1, Fig. 14-[illegible], Fig. [illegible], Fig. 14-[illegible], Fig. 14-[illegible], Fig. 14-1[illegible], Fig. [illegible], Fig. 14-21, Fig. A.[illegible]
[illegible]	[illegible]	[illegible]	Signalling transfer [illegible] Q.7[illegible], [illegible], Fig. A.[illegible], Fig. A.[illegible], Q.[illegible], [illegible], Table [illegible]
[illegible]	T[illegible]	[illegible]	Signal unit [illegible] Q.7[illegible], Fig. [illegible]
[illegible]	[illegible]	[illegible]	Signal unit error rate [illegible] Q.[illegible], Fig. [illegible], Fig. [illegible], Fig. [illegible], Q.[illegible], Fig. A.[illegible]
TA[illegible]	TA[illegible]	A[illegible]	Transfer-allowed [illegible], Table [illegible], Fig. [illegible]
T[illegible]	T[illegible]	[illegible]	Transmission buffer [illegible] Q.[illegible], Fig. [illegible], Fig. [illegible]
[illegible]	[illegible]	[illegible]	Changeback [illegible] Q.[illegible], Fig. [illegible], Fig. [illegible], [illegible]
T[illegible]	GT[illegible]	T[illegible]	Changeover control [illegible] Q.[illegible], Fig. 14-6, Fig. 14-[illegible], Fig. [illegible], Fig. [illegible], Fig. A.6-[illegible], Fig. A.[illegible]
TCRC	GTRN	TCRC	Controlled rerouting control [illegible] Q.7[illegible], [illegible], Fig. 14-[illegible], Fig. 14-7, Fig. 14-[illegible], Fig. [illegible]
TFA	TAO	TLA	Transfer-allowed signal : Q.7[illegible], Table [illegible]
TFM	TF	MTR	Transfer-prohibited and transfer-allowed messages : Q.704, Table 15-1
TFP	TIO	PTR	Transfer-prohibited signal : Q.704, Table 1[illegible]
TFRC	GTRS	TCRF	Forced rerouting control : Q.704, Sec. 14.[illegible], Fig. 14-5, Fig. 14-7, Fig. 14-10
TLAC	GTSD	TCDE	Link availability control : Q.704, Sec. 14.4, Fig. 14-5, Fig. 14-6, Fig. 14-7, Fig. 14-[illegible], Fig. 14-9, Fig. 14-1[illegible], Fig. A.6-4, Fig. A.[illegible], Fig. A.6-6

English	French	Spanish	Meaning
TFA	TIA	APT	Transfer-prohibited acknowledgement signal : Q.704, Table 13.1, Fig. 14-[illegible]
TSFC	GTFX	CFTS	Signalling traffic flow control : Q.7[illegible], Fig. [illegible] Fig. 14-7, Fig. 14-1[illegible]
TSRC	GTAC	CEN	Signalling routing control : Q.70[illegible], Sec. [illegible] Fig. 14-5, Fig. 14-6, Fig. 14-7, Fig. 14-[illegible], Fig. 14-9, Fig. 14-10, Fig. 14-11, Fig. 14-[illegible], Fig. 14-14, Fig. 14-15, Fig. 14-[illegible], Fig. [illegible], Fig. 14-24, Fig. A.6-5, Fig. A.6-[illegible]
TUP	SSUT	PUT	Telephone user part : Q.7[illegible], Fig. [illegible]
TXC	EMI	CT	Transmission control : Q.7[illegible], Fig. 11-[illegible], Fig. 11-3, Fig. 11-[illegible], Fig. 11-7, Fig. 11-[illegible], Fig. 11-9, Fig. 11-10; Q.70[illegible], Fig. [illegible]
UBA	DBA	APD	Unblocking-acknowledgement signal : Q.7[illegible], Table 3-1
UBL	DBO	DBL	Unblocking signal : Q.7[illegible], Table [illegible]
UBM	EE	MEI	Unsuccessful backward set-up information message : Q.7[illegible], Table 3-1
UNN	NNU	NNA	Unallocated-national-number signal : Q.7[illegible], Table 3-1
UP	PU	PU	User part : Q.70[illegible], Fig. [illegible], Q.7[illegible], Fig. [illegible]

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