



ATIS-1000111.2005

SIGNALLING SYSTEM NUMBER 7 (SS7) –
MESSAGE TRANSFER PART (MTP)

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ATIS-1000111.2005, *Signalling System Number 7 (SS7) – Message Transfer Part (MTP)*

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American National Standard for Telecommunications

**SIGNALLING SYSTEM NUMBER 7 (SS7) –
MESSAGE TRANSFER PART (MTP)**

Secretariat

Alliance for Telecommunications Industry Solutions

Approved July 15, 2005

American National Standards Institute, Inc.

Abstract

This standard is made up of eight chapters. Chapter T1.111.1 provides the functional description of the Message Transfer Part of Signalling System Number 7 (SS7). Chapter T1.111.2 describes signalling data link to be used for SS7 networks in the United States. Chapter T1.111.3 describes the functions and procedures for, and relating to, the transfer of signalling messages over one signalling data link; in this section, "signal units" of variable lengths are transferred, including control information for proper operation. Chapter T1.111.4 describes the functions and procedures for, and relating to, the transfer of messages between signalling points; these signalling network management functions ensure a reliable transfer of signalling messages, according to the requirements specified in chapter T1.111.6. Chapter T1.111.5 describes aspects that are pertinent to, and should be considered in, the design of national and international signalling networks. Chapter T1.111.6 describes the signalling performance requirements of the Message Transfer Part; the signalling performance is the capability of the Message Transfer Part to transfer messages of variable lengths for different users in a defined manner. Chapter T1.111.7 describes means and procedures for the testing and maintenance of the signalling network in order to realize the performance requirements for the Message Transfer Part, as identified in Chapter T1.111.6. Chapter T1.111.8 describes aspects that are pertinent to the numbering scheme of signalling codes for SS7 networks in the United States.

FOREWORD

The information contained in this Foreword is not part of this American National Standard (ANS) and has not been processed in accordance with ANSI's requirements for an ANS. As such, this Foreword may contain material that has not been subjected to public review or a consensus process. In addition, it does not contain requirements necessary for conformance to the standard.

This document is entitled *Signalling System Number 7 (SS7) – Message Transfer Part (MTP)*. It is based on ANSI T1.111-2001, and is intended to be compatible with ITU-T Recommendations Q.701 through Q.708, issued by the ITU-T Study Group XI (Vol. VI Fascicle VI.8) for international use.

A change bar on the right margin indicates a change from the 2001 issue of this American National Standard. These change bars are advisory only, and reflect the editors' views of which textual changes constitute significant technical changes. Because of the differences in style and content between this standard and the ITU-T Recommendations, it is not possible to indicate differences using margin marks.

This standard contains the following eight chapters:

- ◆ T1.111.1, *Functional Description of the Message Transfer Part (MTP)*.
- ◆ T1.111.2, *Signalling Data Link*.
- ◆ T1.111.3, *Signalling Link*.
- ◆ T1.111.4, *Signalling Network Functions and Messages*.
- ◆ T1.111.5, *Signalling Network Structure*.
- ◆ T1.111.6, *Message Transfer Part Signalling Performance*.
- ◆ T1.111.7, *Testing and Maintenance*.
- ◆ T1.111.8, *Numbering of Signalling Point Codes*. (See below Note.)

This standard is intended for use in conjunction with T1.110-1999, *Signalling system number 7 (SS7) – General information*, which includes an overview of SS7, a glossary, and a chapter on abbreviations.

The following are the key differences between T1.111-2001 and T1.111-2005:

- ◆ Addition of an extension mechanism for the Service Indicator (SI) field; and
- ◆ Update to the signalling point code assignment guidelines to assign point codes for internal CCS network/group use by any carrier.

Information contained in a normative annex in these specifications is considered part of this standard. Information contained in an informative annex in these specifications is *not* considered part of this standard but is rather auxiliary to the standard. Similarly, footnotes are not officially part of this standard.

Caution should be exercised in using the Specification and Description Language (SDL) diagrams to interpret the standard since they may not fully align with the text. Please note that in case of any conflict between the text and the SDL diagrams, the text always takes precedence.

NOTE - Chapter T1.111.8, *Numbering of Signalling Points Codes*: The document entitled *Numbering of Signalling Points Codes* -- approved by the American National Standard Institute (ANSI) as T1.111a-2002 -- is superseded by this document, T1.111-2005, *Signalling System Number 7 (SS7) – Message Transfer Part (MTP)*. This standard is intended for use in conjunction with *American National Standard for Telecommunications – Signalling System Number 7 (SS7) – General information*, T1.110-1999, which includes an overview of SS7, a glossary, and a chapter on abbreviations.

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Future control of this document will reside with PTSC. This control of additions to the specification, such as protocol evolution, new applications, and operational requirements, will permit compatibility among U.S. networks. Such additions will be incorporated in an orderly manner with due consideration to the ITU-T layered model principles, conventions, and functional boundaries.

Suggestions for improvement of this standard will be welcome. These should be sent to the Alliance for Telecommunications Industry Solutions, PTSC Secretariat, 1200 G Street, NW, Suite 500, Washington DC 20005.

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Chapter T1.111.1

Functional Description of the Signalling System Message Transfer Part (MTP)

EDITORIAL NOTE – In this Chapter, all page numbers are in the format T1.111.1-#.

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Signalling System Number 7 (SS7) – Functional Description of the Signalling System Message Transfer Part (MTP)

1 SCOPE, PURPOSE, & APPLICATION

The overall objective of the SS7 Message Transfer Part (MTP) is to provide an internationally standardized general purpose common channel signalling system that provides a reliable means of transfer of information in correct sequence and without loss or duplication.

The signalling system is optimized for operation over 56 or 64 kbit/s digital channels. The signalling system is also optimized for 1.536 Mbit/s data rate links to accommodate the growth of SS7 traffic. For Asynchronous Transfer Mode (ATM) based transmission, the signalling system is optimized for operation at 64 kilobits/s and higher. 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.

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 application.

2 SIGNALLING SYSTEM STRUCTURE

2.1 Basic Functional Division

The fundamental principle of the signalling system structure is the division of functions into separate modules or entities. These consist of a common Message Transfer Part (MTP) and users of the MTP. This is illustrated in Figure 1/T1.111.1.

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 or application functions.

The term *user* in this context refers to any functional entity that utilizes the transport capability provided by the Message Transfer Part.

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 users.

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 users of the MTP exist at the higher functional levels. For ATM-based transmission, the Signalling ATM Adaptation Layer (SAAL), the ATM layer, and physical layer can alternatively be used instead of MTP levels 2 and 1 to provide link and physical layer functions for SS7 signalling.

The level structure is illustrated in Figure 2/T1.111.1. The system structure shown in Figure 2/T1.111.1 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/T1.111.1 may be regarded as a possible model of an implementation.

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, 56 or 64 kbit/s digital paths will normally be used for the signalling data link. When higher speeds are needed, 1.536 Mbit/s digital paths can 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 analog links with modems, can also be used.

The detailed requirements for signalling data links are specified in Chapter T1.111.2.

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, provide 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:

1. Delimitation of signal unit by means of flags;
2. Flag imitation prevention by bit stuffing;
3. Error detection by means of check bits included in each signal unit;
4. Error correction by retransmission and signal unit sequence control by means of explicit sequence numbers in each signal unit and explicit continuous acknowledgments; and
5. 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 Chapter T1.111.3.

2.2.3A Signalling ATM Adaptation Layer (SAAL) and ATM Protocol Architecture

2.2.3A.1 Physical Layer

The physical layer provides a means for ATM cells to be transmitted on a transport facility. At this time, SONET, DS1, and DS3 have been specified as physical layer methods for transmitting ATM cells. The physical transmission rates that have been specified are 51.840 Mbit/s, 155.520 Mbit/s, 622.080 Mbit/s, 2.48832 Gbit/s, 1.544 Mbit/s and 44.736 Mbit/s.

The interface specifications of the SONET layer and DS3 are provided in T1.640-2001 (R2006). The interface specifications of the DS1 are provided in T1.646-2003.

2.2.3A.2 ATM Layer

ATM is the transfer mode solution for implementing a B-ISDN. ATM provides high efficiency and flexibility because it provides “virtual channels” instead of dedicated physical channels, allowing better use of the physical resources with high performance capabilities (low latency and high capacity). For signalling, the virtual channel connection constitutes a signalling link and can operate at a rate of 64 kbit/s or higher. ATM also allows sharing of Operations and Maintenance (OAM) across multiple services, provides variable information transfer rates, and can support versatile call and connection structures. The multiplexed information flow is organized into fixed size cells.

The protocol specification of the ATM layer is provided in T1.627-1993 (R2004).

2.2.3A.3 SAAL

The ATM Adaptation Layer (AAL) is defined to enhance the services provided by the ATM layer to support the functions required by the next higher layer. One particular type of AAL service is the Signalling AAL (SAAL), which comprises AAL functions necessary to support signalling. The SAAL consists of the AAL Common Part (CP) type 5, the Service Specific Connection Oriented Protocol (SSCOP), the Service Specific Coordination Function (SSCF), and the SAAL Layer Management.

The SAAL at the Network Node Interface (NNI) provides signalling link functions for the transfer of signalling messages over one individual signalling data link. The SAAL functions provide a signalling link for reliable transfer of signalling messages between two signalling points. A signalling message delivered by the higher levels is transferred over the signalling link in variable length protocol data units (PDUs).

The overview to SAAL is provided in T1.636-1999 (R2005).

2.2.3A.3.1 Common Part (CP)

Several AAL CPs have been identified in T1.635.1999 (R2005); one is known as AAL type 5. The purpose of the type 5 CP is to support those capabilities necessary to meet the upper layer data transfer needs while using the service of the ATM layer. The protocol provides the transport of variable length frames (1 to 65535 octets in length) with error detection. The frame is padded to align the resulting protocol data unit to fill an integral number of ATM cells. A CRC-32 is used to detect errors and the length field is used to extract the frame.

The protocol specification of the type 5 CP is provided in T1.636-1999 (R2005).

2.2.3A.3.2 Service Specific Connection Oriented Protocol (SSCOP)

SSCOP is a connection oriented protocol with error recovery providing a generic reliable data transfer service for different AAL interfaces defined by the SSCF. Two SSCFs have been defined for signalling: the signalling SSCF at the User Network Interface (UNI), and the signalling SSCF at the Network Node Interface (NNI). SSCOP utilizes the service of the AAL Type 5 CP, which provides an unassured information transfer and a mechanism for detecting corruption of SSCOP PDUs.

The protocol specification of the SSCOP is provided in T1.637-1999 (R2005).

2.2.3A.3.3 Service Specific Coordination Function (SSCF) at the NNI

The function of the SSCF is to map the service of the SSCOP of the AAL to the requirements of MTP Level 3. The SSCF at the NNI also provides communication with the SAAL Layer Management for proper operation of signalling links.

The protocol specification of the SSCF is provided in T1.645-1995 (R2008).

2.2.3A.3.4 SAAL Layer Management

The layer management functions at the NNI perform a coordination function between the system management function and the SAAL. The functions of the layer management at the NNI include error processing, measurements and determination of link quality during proving and normal operation.

The protocol specification of the SAAL Layer Management is provided in T1.652-1996(R2006).

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/T1.111.1, these functions fall into two major categories:

1. *Signalling Message Handling Functions*. These are functions that, at the actual transfer of a message, direct the message to the proper signalling link or higher level function.
2. *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/T1.111.1. 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 or Application Part themselves, these parts of level 3 can be seen as serving *Users of the Message Transfer Part*. As a convention in these specifications, for each description, general references to Users as sources or sinks of signalling messages 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 clause 3. The detailed requirements for signalling network functions are given in Chapter T1.111.4. Some means for testing and maintenance of the signalling network are provided, and the detailed requirements are given in Chapter T1.111.7.

2.2.5 User Functions (Level 4 and Above)

Level 4 and above consist of the different users of the MTP. Each user defines the functions and procedures of the signalling system that are needed by that user. (Additional information on users can be found in clause 3.2.2 of Chapter T1.110.1.)

2.3 *Signalling Message*

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

Each message contains *service information* including a *service indicator* identifying the user of the MTP, whether the message relates to international or national applications, and message priority.

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

1. To be routed by the level 3 functions and through a signalling network to its destination; and
2. To be directed at the destination to the particular user to which the message is related.

On a signalling link using the MTP level 2 protocol, each signalling message is packed into a Message Signal Unit (MSU), which also includes transfer control information related to the level 2 functions of the link. On an ATM-based signalling link, each signalling message is packed into a SSCOP Protocol Data Unit (PDU).

2.4 *Functional Interface*

The following functional interface between the Message Transfer Part and its users can be seen as a model illustrating the division of functions between these parts. The interface (see Figure 3/T1.111.1) is purely functional and need not appear as such in an implementation of the system.

The main interaction between the Message Transfer Part and the higher 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 clause 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. Another example is multiple point codes in signalling network elements within a single network or at the interface of signalling networks. Example of multiple point codes in a signalling element are illustrated in Figure 4/T1.111.1.

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

The corresponding concept for a given User or Application Part is called *user or application 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 user signalling relation between the telephone user functions in those exchanges in their roles as signalling points.

Another example is when administration of customer and routing data in a signalling point is remotely controlled from an operation and maintenance center by means of communication through the common channel signalling system. This communication then constitutes an application signalling relation between the applicable Operation and Maintenance Application Part functions at the signalling point and the corresponding functions at the operation and maintenance center.

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) is 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.

SS7 is specified for use in the associated and quasi-associated modes. The Message Transfer Part alone 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; this would require additional services provided by the Signalling Connection Control Part (SCCP).

Examples of signalling modes are illustrated in Figure 5/T1.111.1.

3.1.3 Signalling Point Modes

A signalling point at which a message is generated -- i.e., the location of the source User or Application 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 or Application 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 or Application 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.

3.1.4 Message Labeling

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:

1. Explicit indications of destination and originating points of the message -- i.e., identification of the signalling relation concerned; and
2. A code used for load sharing.

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 labeling, that is unambiguous within its domain. Messages labeled according to international and national code plans are discriminated by means of an indication in the service information octet included in each message.

3.2 Signalling Message Handling Functions

Figure 6/T1.111.1 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*. A signalling route is the corresponding concept for a possible path, referring to a succession of link sets and signalling transfer points, between a given signalling point and the destination point.

In SS7, 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 a potential for using different routing plans for different User Parts.

3.2.2 Message Distribution

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

3.2.3 Message Discrimination

Message discrimination is the process that, 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., 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 6/T1.111.1 illustrates the signalling network management functions.

3.3.1 Signalling Traffic Management

The tasks of the *signalling traffic management* function are:

1. 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;
2. In conjunction with modification of message routing, to control the resulting transfer of signalling traffic in a manner that avoids irregularities in message flow; and
3. 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 higher level 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 or SAAL by receipt of indications of the status of signalling links. It also initiates actions at level 2 or SAAL such as 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 that 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 or congestion status 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 6/T1.111.1 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 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 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 Chapter T1.111.5.

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:

1. Redundancy in signalling data links (e.g., nominated reserves or switched connections);
2. Redundancy in signalling terminal devices (e.g., common pool of terminals for the whole signalling point);
3. Redundancy of signalling links within a link set (typically operating with load sharing);
or
4. Redundancy in signalling routes for each destination (possibly operating with load sharing).

3.5.3 Application of Signalling Network Functions

The signalling network functions provided by the signalling system are designed to accommodate a range of signalling network configurations. It is not necessary that all of those functions 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, and so on. 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 subclauses summarize 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 or Application Part. This may require allocation of a service indicator code, the specification of which is part of both the Message Transfer Part and user concerned.

4.3 *Message Content*

4.3.1 **Code Transparency**

Information with any code combination generated by a user of the MTP can be transferred by the MTP, provided that the message respects the requirements described in the following subclause.

4.3.2 **Service Information**

Each message must contain service information coded in accordance with the rules specified in clause 14 of Chapter T1.111.4.

4.3.3 **Message Label**

Each message must contain a label consistent with the routing label of the signalling network concerned. See also clause 2 of Chapter T1.111.4.

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; SS7 can accept transfer of user information blocks in the order of 256 octets in single messages (see clause 2.3.8 of Chapter T1.111.3). For ATM-based transmission, the maximum length of a message is 4096 octets as specified in T1.645-1995 (R2008). If ATM-based signalling links are used in a network that also has MTP level 2-based signalling links, precautions must be taken to allow interworking between different signalling links using the two protocols.

Depending on the signalling traffic characteristics of users or applications sharing the same signalling facilities, there may be a need to limit message lengths below the system limit based on queuing delay considerations.

When information blocks generated exceed the allowed message length, it is necessary to implement means for segmentation and blocking of such user information blocks.

4.4 *User Accessibility*

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

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

When quasi-associated signalling is employed, 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 Chapter T1.111.6.

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, and the like.

4.5.2 Message Transfer Failures

The Message Transfer Part 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 failure will occur, the consequences of which cannot be avoided with economic measures. The types of failures that may occur, and some typical probabilities of their occurrence are described below. Chapter T1.111.6 provides further detailed information that can be used to estimate failure rates for particular cases.

In the case when a potential user of the Message Transfer Part requires a reliability of the transport service that cannot be guaranteed by the Message Transfer Part, the reliability for that user or application may be enhanced by adoption of appropriate higher level 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 Chapter T1.111.6):

1. *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.
2. *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} .

3. *Mis-sequencing of Messages.* This failure 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} .
4. *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^{-9} .

5 PRIMITIVES AND PARAMETERS OF THE MESSAGE TRANSFER PART

Refer to Table 1/T1.111.1 at the end of this clause for a summary of the Message Transfer Part Service Primitives.

5.1 *Transfer*

The primitive "MTP-TRANSFER" is used between level 4 and level 3 (SMH) to provide the MTP message transfer service.

5.2 *Pause*

The primitive "MTP-PAUSE" indicates to the "Users" the total inability of providing the MTP service to the specified destination. The signalling point is inaccessible via the MTP. The MTP will determine when the signalling point is again accessible and send MTP-RESUME indication. The user should wait for such an indication and, meanwhile should not send normal signalling messages to that signalling point. If the remote peer user is thought to be unavailable, that condition may be maintained or canceled at the local user's discretion.

5.3 *Resume*

The primitive "MTP-RESUME" indicates to the "User" the total ability of providing the MTP service to the specified destination. This primitive corresponds to the destination accessible state as defined in T1.111.4. When the MTP-RESUME indication is given to each user, the MTP does not know whether the remote peer user is available. This is the responsibility of each user.

5.4 *Status*

The primitive "MTP-STATUS" indicates to the "Users" the partial inability of providing the MTP service to the specified destination. In the case of signalling link congestion with multiple priorities, the MTP-STATUS is used to indicate a change of congestion level. In the case of remote user unavailable, the user is responsible for determining the availability of this peer user. The user is cautioned to not send normal messages to the peer user because, while such peer user is unavailable, each message will not be delivered but will result in a repeated MTP-

STATUS indication. The MTP will not send any further indications about the unavailability or availability of this peer user, unless interrupted by an MTP-PAUSE indication, or unless the local user continues to send messages to the peer user.

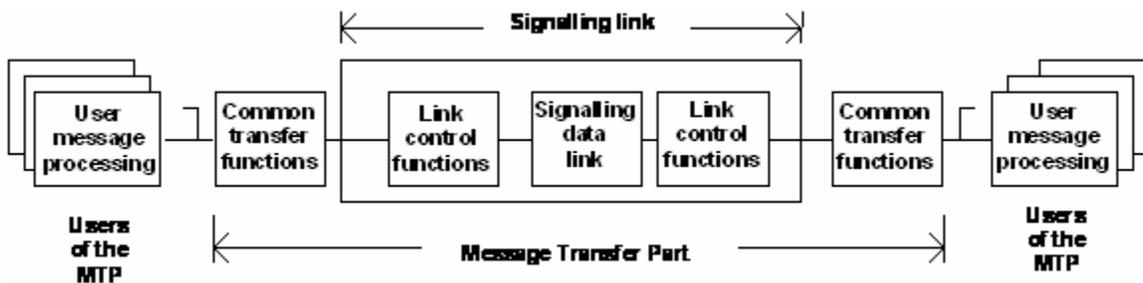
Table 1/T1.111. Message Transfer Part Service Primitives

| Primitives | | Parameters |
|--------------------|-----------------------|--|
| Generic Name | Specific Name | |
| MTP-TRANSFER | Request Indication | OPC (see T1.111.4, clause 2.2) DPC (see T1.111.4, clause 2.2) SLS (see T1.111.4, clause 2.3) (Note 1) SIO (see T1.111.4, clause 14.2) User Data (see T1.111.3, clause 2.3.8) |
| MTP-PAUSE (Stop) | Indication | Affected DPC |
| MTP-RESUME (Start) | Indication | Affected DPC |
| MTP-STATUS | Indication | Affected DPC, Cause (Note 2) |

NOTE 1 - The MTP users should take into account that this parameter is used for load sharing by the MTP; therefore, the SLS values should be distributed as equally as possible. The MTP guarantees (to a high degree of probability) an in-sequence delivery of messages that contain the same SLS code.

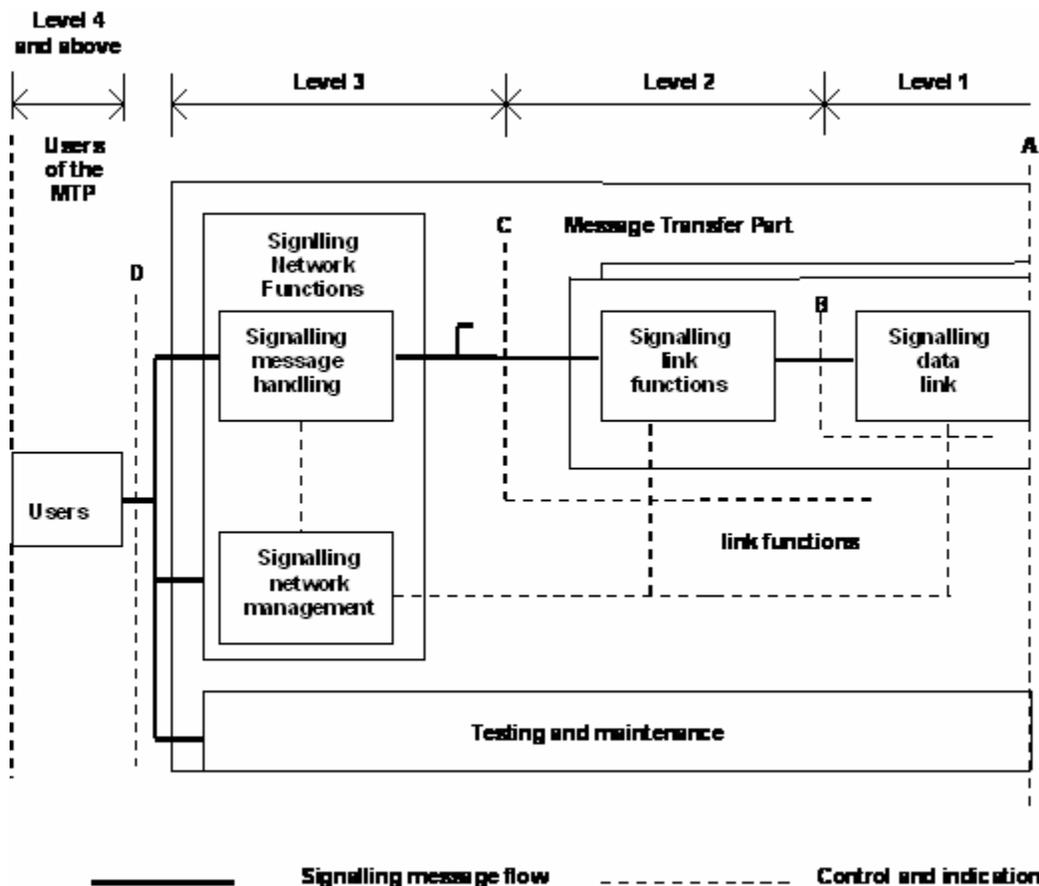
NOTE 2 - The Cause parameter has, at present, four values:

1. Signalling network congested (plus congestion level),
2. User Part Unavailability: unknown,
3. User Part Unavailability: unequipped remote user, or
4. User Part Unavailability: inaccessible remote user.



NOTE - the signalling link control functions are provided by the MTP level 2 protocol and the SAAL protocol. The signalling data link functions are provided by the MTP level 1 protocol or by the ATM and physical layer.

Figure 1/T1.111.1 - Functional Diagram for the Common Channel Signalling System



NOTE - The signalling link control functions are provided by the MTP level 2 protocol and the SAAL protocol. The signalling data link functions are provided by the MTP level 1 protocol or by the ATM and physical layer.

Figure 2/T1.111.1 - General Structure of Signalling System Functions

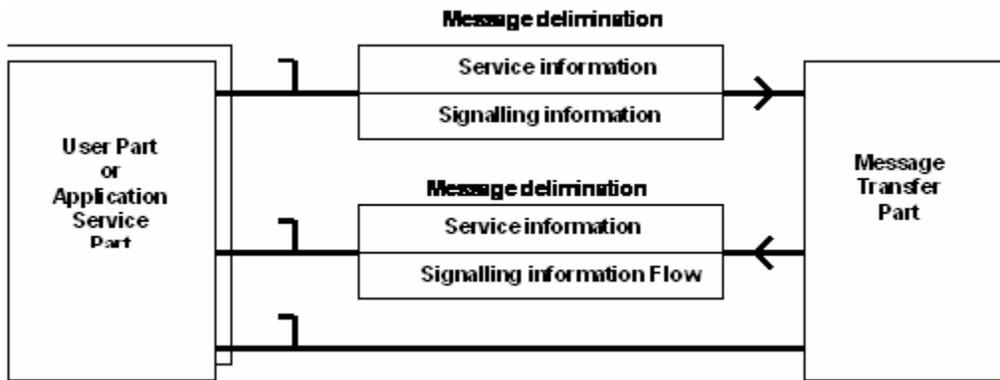
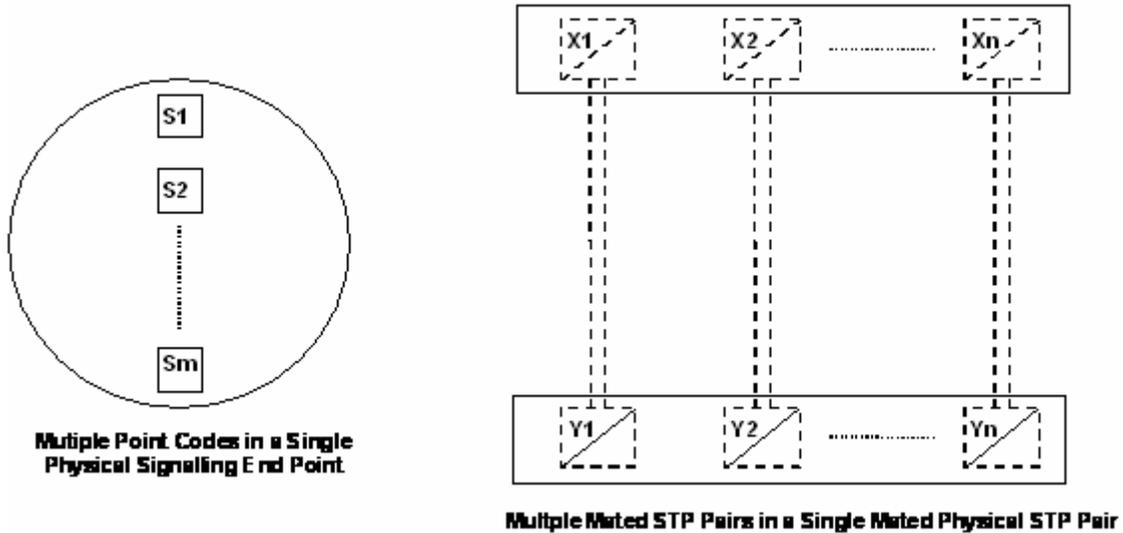


Figure 3/T1.111.1 - Functional Interface between the Message Transfer Part and the Higher Parts



Note - Multiple STP pairs created from a single physical STP pair may each have their own C link set or may share a single C link set. The choice of configuration is implementation dependent.

Figure 4/T1.111.1 - Examples of Multiple Point Codes in a Signalling Point

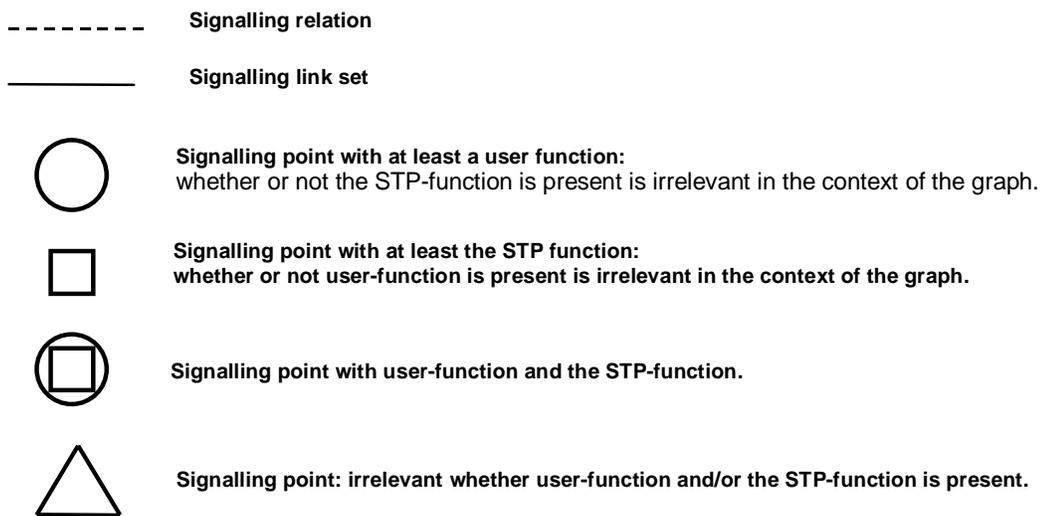
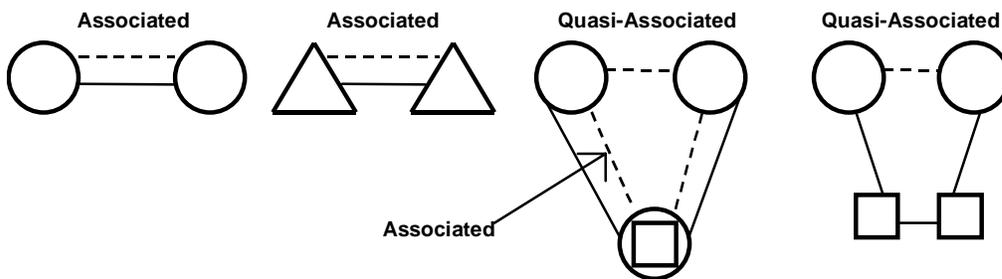
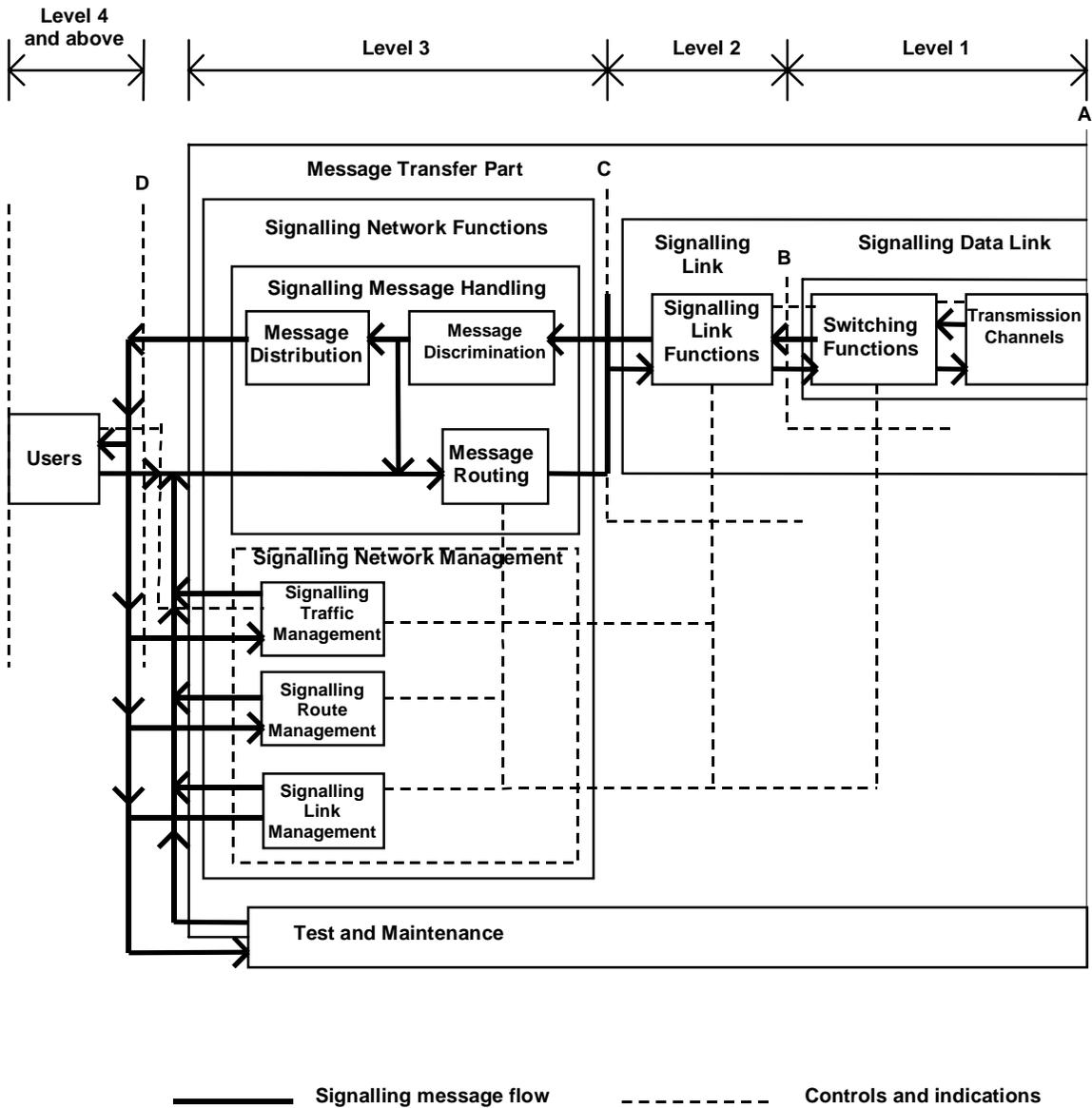


Figure 5/T1.111.1 - Examples of Associated and Quasi-Associated Signalling Modes and Definition of Signalling Network Graph Symbols



NOTE - the signalling link control functions are provided by the MTP level 2 protocol and the SAAL protocol. The signalling data link functions are provided by the MTP level 1 protocol or by the ATM and physical layer.

Figure 6/T1.111.1 - Detailed Structure of Signalling System Functions

Chapter T1.111.2
Signalling Data Link

EDITORIAL NOTE – In this Chapter, all page numbers are in the format T1.111.2-#.

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Signalling System Number 7 (SS7) – Signalling Data Link

1 SCOPE, PURPOSE, & APPLICATION¹

This chapter may contain requirements that reference other American National Standards. If so, when the American National Standards referenced in the requirements are superseded by revisions approved by the American National Standards Institute, Inc., the revisions shall apply.

This chapter does not apply to ATM/SAAL-based MTP.

1.1 *Signalling Data Link*

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*

Functional configuration of a signalling data link is shown in Figure 1/T1.111.2.

1.3 *Digital Transmission Channels*

A digital signalling data link is made up of digital *transmission channels* 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 as described in the first nine (9) references in clause 7.

¹ A "|" indicates a change from T1.111-2001.

1.4 *Analog Signalling Link*

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

1.5 *Signalling System No. 7 (SS7)*

SS7 is capable of operating over both terrestrial and satellite *transmission links*.

1.6 *Operational Signalling Data Link*

The operational signalling data link shall be exclusively dedicated to the use of an SS7 signalling link between two signalling points in SS7. No other information should be carried by the same channel together with the signalling information.

NOTE - The term "signalling information" in this context refers to all information transferred over SS7 using its protocol.

1.7 *Duplex Operation and Bit Integrity*

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

1.8 *Digital Signalling Channel*

Digital signalling channels that are 56 kbit/s, evolving to 64 kbit/s, entering a digital exchange via a multiplex structure shall be switchable as semipermanent channels in the exchange.

2 SIGNALLING BIT RATE

2.1 *General*

2.1.1 Standard Bit Rate

The standard bit rate on a digital bearer will be 56 kbit/s. The standard bit rate will evolve to 64 kbit/s when 64 kbit/s links are available.

2.1.2 Lower Bit Rates

Lower bit rates² may be adopted for each application, taking into account the User Part requirements in ATIS-1000112.2005 through T1.114-2004 and the capability of available transmission links.

2.1.3 The Minimum Signalling Bit Rate

The minimum signalling bit rate for telephone call control applications will be 4.8 kbit/s.

2.1.4 Higher Bit Rates

As an option, a DS1 signal that provides a bit rate of 1.544 Mbit/s may be used for the signalling data link. At this rate, 1.536 Mbit/s is used to transport signalling messages and 8 kbit/s is used for framing and maintenance.

2.2 Use of Bit Rates Lower than 56/64 kbit/s

2.2.1 National Telephone Call Control

For national telephone call control applications, use of SS7 at bit rates lower than 56/64 kbit/s shall take account of the requirement to minimize the answer signal delay when in-band line signalling systems are involved (see ITU-T Rec. Q.27).

2.2.2 International Non-In-Band Line Signalling Systems

(Deleted, not applicable to U.S. Networks)

2.2.3 International In-Band Line Signalling System

(Deleted, not applicable to U.S. Networks)

² The performance requirements of Chapter T1.111.6 assume the use of 56/64 kbit/s signalling links. The use of lower bit rate links is not preferred.

3 ERROR CHARACTERISTICS AND AVAILABILITY

Error characteristics and availability requirements will conform to relevant ITU-T Recommendations, for example, ITU-T Rec. G.821 on digital circuits. No additional characteristics or requirements will be specified in this standard.

4 INTERFACE SPECIFICATION POINTS

4.1 *Interface Requirements*

Interface requirements may be specified at one of three points -- A, B, or C in Figure 2/T1.111.2. 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 *National/International Application*

For the national/international application, interface requirements at either Point B or Point C (Figure 2/T1.111.2) will apply.

4.3 *Interface Requirements - Digital*

Interface requirements for the digital signalling data link will be specified at Point C (Figure 2/T1.111.2) in accordance with the specific multiplex structure used (see clause 5).

4.4 *Interface Requirements - Analog*

Interface requirements for an analog signalling data link will be specified at Point B (Figure 2/T1.111.2) on a single channel basis, and thus are independent of multiplex equipment used (see clause 6).

4.5 *Point A Interface*

Interface at Point A (Figure 2/T1.111.2) 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 ITU-T Rec. G.703 (for 56 kbit/s interface) should be followed as appropriate.

4.6 *Interface Requirements - Testing and Maintenance*

Implementations that do not follow all the requirements in the relevant recommendations cited in 4.1 to 4.5 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 Chapter T1.111.7.

5 **DIGITAL SIGNALLING DATA LINK**

5.1 *Signalling Data Link Derived from the 2048 kbit/s Digital Path*

(Not specified for U.S. Networks)

5.2 *Signalling Data Link Derived from the 8448 kbit/s Digital Path*

(Not specified for U.S. Networks)

5.3 *Signalling Data Link Derived from the 1544 kbit/s Digital Path*

When a signalling data link is to be derived from the 1544 kbit/s digital path, the following shall apply:

1. The interface requirements specified at Point C in Figure 2/T1.111.2 should conform to ITU-T Rec. G.703 for electrical characteristics, and ITU-T Recommendations G.733 and G.736 for other aspects, (e.g., for the frame structure).
2. The signalling bit rate shall be 56 kbit/s evolving to 64 kbit/s at points A and B.
3. Any regular timeslot available for 56 kbit/s evolving to 64 kbit/s user transmission may be used for the signalling data link. (This is subject to further study).
4. No bit inversion is performed.

When a signalling data link directly uses the full 1.544 Mbit/s digital path, the interface requirements specified in T1.403.01-1999 (R2005) shall apply.

5.4 *Different Law Converters*

This subsection concerns a signalling data link established over a digital path made up of digital sections based on different A/ μ law converter encoding laws. (Not specified for U.S. Networks.)

5.5 *Signalling Data Link Established Over Data Circuits*

A signalling data link established over data circuits derived from a 1544 kbit/s digital stream has a frame structure as specified in ITU-T Rec. G.736.

6 ANALOG SIGNALLING DATA LINK

6.1 *Signalling Bit Rate*

6.1.1 Delay Requirements

Applications of the analog signalling data link must take account of the delay requirements described in 2.2.

6.1.2 Telephone Call Control Applications

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

6.2 *Interface Requirements*

As an example, in a 4.8 kbit/s operation, interface requirements³ specified at the interface point B in Figure 2/T1.111.2 shall conform to relevant requirements specified for 4.8 kbit/s modems in ITU-T Recommendations V.27 and V.27 bis. In addition the following should apply:

1. Application of either ITU-T Rec. V.27 or V.27 bis depends on the quality of the analog transmission channels used. ITU-T Rec. V.27 shall apply only to transmission channels conforming to ITU-T Rec. M.1020, while ITU-T Rec. V.27 bis shall apply to transmission channels conforming to ITU-T Rec. M.1020 or of lower quality.
2. Full duplex operation over a 4-wire transmission link should be adopted.
3. If a separate modem is to be used, the interface requirements specified in ITU-T Recommendations V.10 , V.11 , V.24, and V.28 -- applicable at Point A in Figure 2/T1.111.2 -- should be followed as much as possible.

7 REFERENCED PUBLICATIONS

ITU-T Rec. G.733 (11/88), *Characteristic of Primary PCM Multiplex Equipment Operating at 1544 kbit/s*.⁴

³ Data bit rates less than 56 kbit/s are for further study.

⁴ This document is available from the International Telecommunications Union. < <http://www.itu.int/ITU-T/> >.

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Publication 41450, *Digital Data System - Data Service Unit Specifications*. Bell System Data Communications Technical Reference, New York, AT&T, 1981 November.⁵

AT&T Technical Advisory No. 34, *DSX-1 Compatibility Specification*. New York, AT&T, 1979 October, Issue 3.⁵

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ITU-T Rec. Q.27 (11/88), *Transmission of the answer signal*.⁴

ITU-T Rec. G.821 (08/96), *Error performance on an international digital connection operating at a bit rate below the primary rate and forming part of an integrated services digital network*.⁴

ITU-T Rec. G.703 (11/01), *Physical/electrical characteristics of hierarchical digital interfaces*.⁴

ITU-T Rec. V.27 (11/88), *4800 bits per second modems with manual equalizer standardized for use on leased telephone-type circuits*.⁴

ITU-T Rec. V.27 bis(11/88), *4800/2400 bits per second modem with automatic equalizer standardized for Use on leased telephone-type circuits*.⁴

ITU-T Rec. M.1020 (03/93), *Characteristics of special quality international leased circuits with special bandwidth conditioning*.⁴

ITU-T Rec. V.10 (03/93), *Electrical characteristics for unbalanced double-current interchange circuits operating at data signalling rates nominally up to 100 kbit/s*.⁴

ITU-T Re. V.11 (10/96), *Electrical characteristics for balanced double-current interchange circuits operating at data signalling rates up to 10 Mbit/s*.⁴

ITU-T Rec. V.24(02/00), *List of definitions for interchange circuits between data terminal equipment (DTE) and data circuit-terminating equipment (DCE)*.⁴

⁵ This document is available from Lucent Technologies, Inc. Customer Information Center.
< <http://www.lucent8.com> >

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ITU-T Rec. V.28 (03/93), *Electrical characteristics for unbalanced double-current interchange circuits*.⁴

T1.403.01-1999 (R2005), *Network and Customer Installation Interfaces - DS1 - Electrical Interface*.⁶

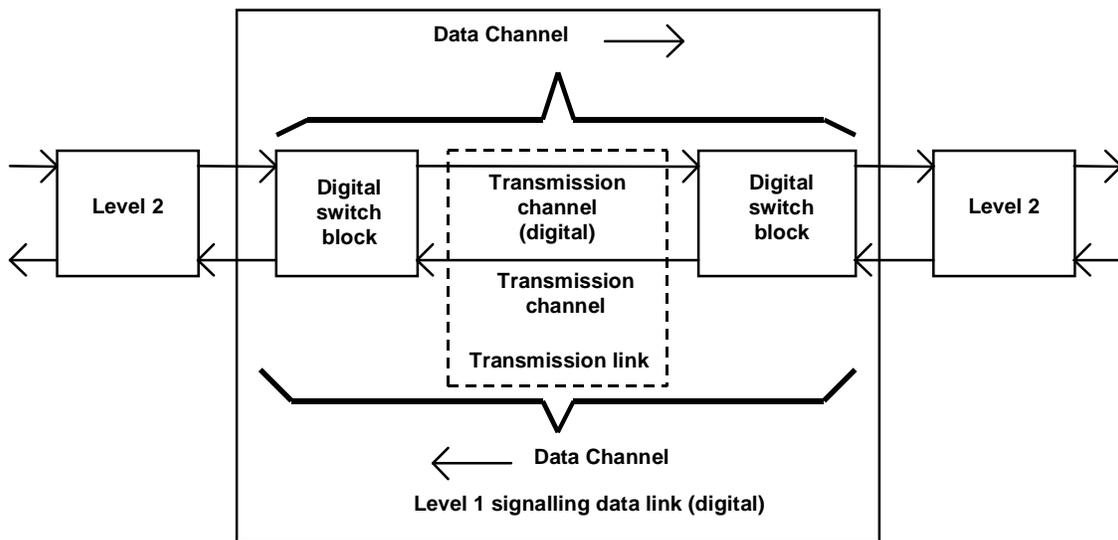
T1.403a-2001 (R2005), *Supplement to T1.403-1999*.⁶

T1.403.01-1999 (R2005), *Network and Customer Installation Interfaces - (ISDN) Primary Rate Layer 1 Electrical Interfaces Specification (Includes revision of ANSI T1.408-1990 and partial revision of ANSI T1.403-1995)*.⁶

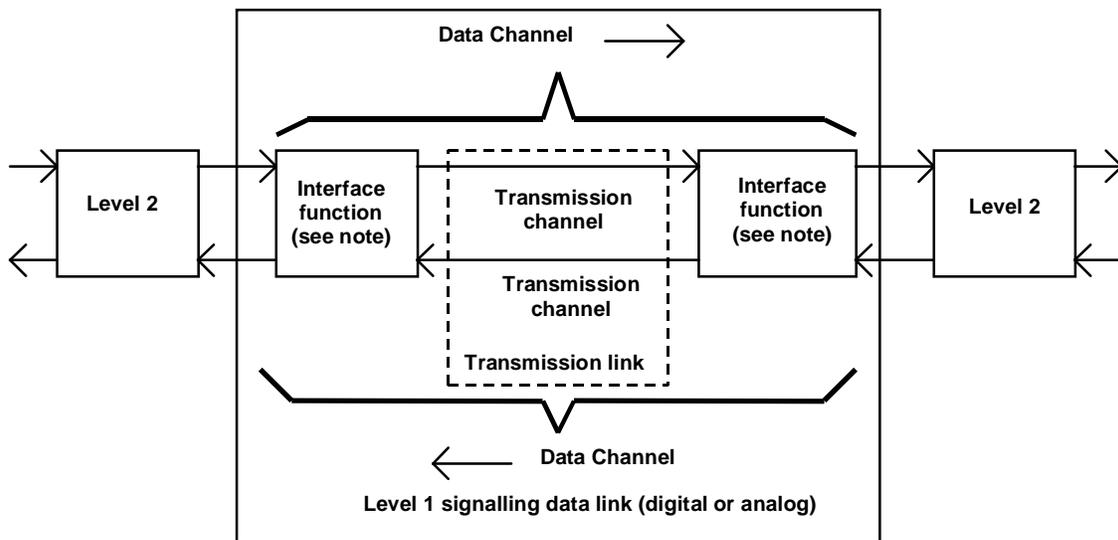
T1.403.02-1999 (R2005), *Network and Customer Installation Interfaces - DS1 - Robbed-Bit Signaling State Definitions*.⁶

T1.403.02a-2001(R2005), *Supplement to T1.403.02-1999*.⁶

⁶ This document is available from the Alliance for Telecommunications Industry Solutions. <<http://www.atis.org>>.



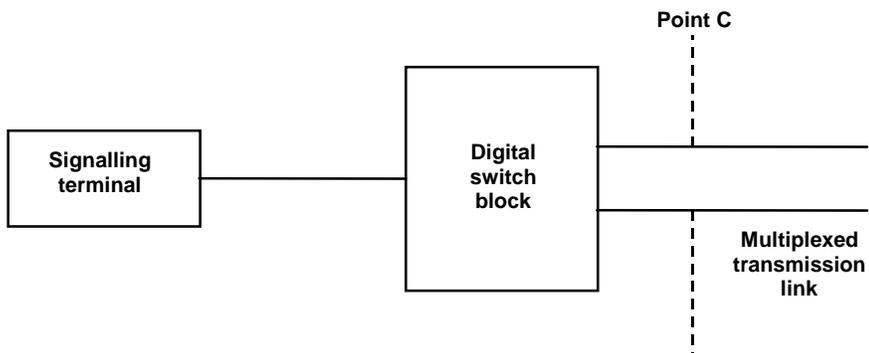
a) Example 1 - Digital signalling data link via digital switch block



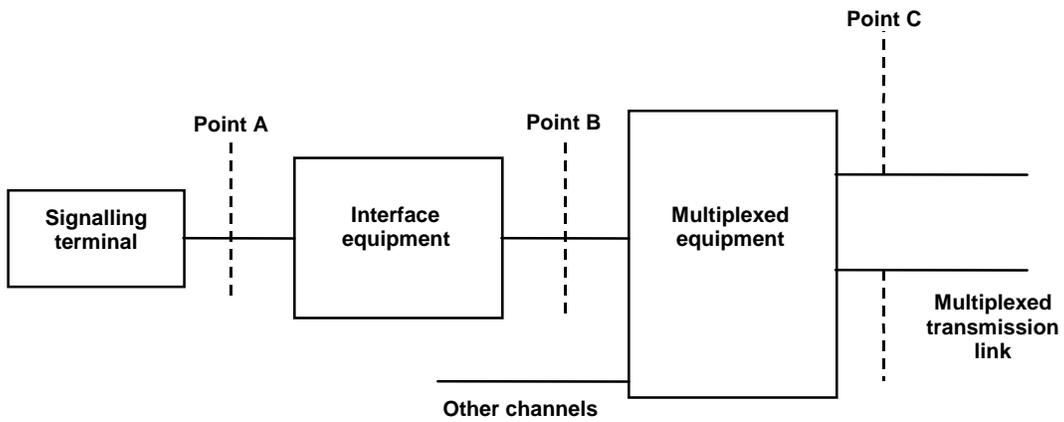
NOTE - The interface function is provided, for example, by a modem in an analog signalling link. A data circuit terminating equipment (DCE) or a time slot access equipment in a digital signalling data link.

b) Example 2 - Signalling data link (digital or analog) via interface equipment

Figure 1/T1.111.2 Functional Configuration of a Signalling Data Link



a) Example 1 _ Digital signalling data link via digital switch



b) Example 2 Signalling data link (digital or analog) via interface

Figure 2/T1.111.2 - Interface Specification Points

Chapter T1.111.3

Signalling Link

EDITORIAL NOTE – In this Chapter, all page numbers are in the format **T1.111.3-#**.

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Signalling System Number 7 (SS7) – Signalling Link

1 SCOPE, PURPOSE, & APPLICATION¹

This standard is intended for use with other American National Standards. When the standards referenced in the requirements are superseded by revisions approved by the American National Standards Institute, Inc. the revisions shall apply.

1.1 *General Characteristics of the Signalling Link*

1.1.1 This chapter describes the functions and procedures for, and relating to, the transfer of signalling 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." This chapter does not apply to ATM/SAAL-based MTP.

Signalling messages delivered by superior hierarchical levels are transferred over the signalling link in variable-length "signal units." There are three types of signal unit defined: 1) *Message Signal Unit (MSU)*; 2) *Link Status Signal Unit (LSSU)*; and *Fill-in Signal Unit (FISU)*. 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:

1. Signal unit delimitation,
2. Signal unit alignment,
3. Signal unit error detection,
4. Signal unit error correction,
5. Signalling link initial alignment,
6. Signalling link error monitoring, and
7. Flow control.

All of these functions are coordinated by the "link state control" (see Figure 1/T1.111.3).

¹ A "|" indicates a change from T1.111-2001.

1.2 *Signal Unit Delimitation and Alignment*

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

Loss of signal unit alignment occurs when a bit pattern disallowed by the delimitation procedure (more than six consecutive 1s) is received, or when a certain maximum length of signal unit is exceeded.

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

1.3 *Signal Unit Error Detection*

The signal unit 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*² by operating on the preceding bits of the signal unit (excluding the opening flag) following a specified algorithm. At the receiving signalling link terminal, the received check bits are operated on using specified rules, which correspond to that algorithm.

If the received check bits and the preceding bits of the signal unit are inconsistent, according to the algorithm, the presence of errors is indicated and the signal unit is discarded.

1.4 *Signal Unit Error Correction*

1.4.1 Two forms of signal unit error correction are provided: the *basic method* and the *preventive cyclic retransmission method*. The following criteria should be used to determine which method applies:

1. The *basic method* applies to signalling links employing terrestrial transmission means.
2. The *preventive cyclic retransmission method* applies to all signalling links established via satellite.

When one signalling link within a link set is established via satellite, the preventive cyclic retransmission method should be used on all signalling links of that link set.

1.4.2 The basic method is a noncompelled, positive/negative acknowledgment, retransmission error-correction system. A transmitted message signal unit is retained at the transmitting signalling link terminal until a positive acknowledgment for that message signal unit is received. If a negative acknowledgment is received, the transmission of new (i.e., not yet transmitted) message signal units is interrupted; those message signal units that have been

² A "signalling link terminal" is the means to perform all of the functions defined at level 2, regardless of their implementation.

transmitted but not yet positively acknowledged, starting with that message signal unit indicated by the negative acknowledgment, will be retransmitted once in the order in which they were first transmitted.

1.4.3 The preventive cyclic retransmission method is a noncompelled, positive acknowledgment, cyclic retransmission, forward error-correction system. A transmitted message signal unit is retained at the transmitting signalling link terminal until a positive acknowledgment for that message signal unit is received. During the period in which there are no new (i.e., not yet transmitted) message signal units to be transmitted, all the message signal units that have not been positively acknowledged are cyclically retransmitted.

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

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

1.5 *Signalling Link Initial Alignment*

The signalling link *initial alignment procedure* is appropriate to both first time signalling link initialization (e.g., after *switch on*) and signalling link alignment in association with restoration after a link failure. The procedure is based on the compelled exchange of status information between the two signalling link terminals 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 types of signalling link error rate monitor functions are provided: one is employed while a link is in the proving state of the initial alignment procedure; the other is employed while a signalling link is in service and provides one of the criteria for taking the link out of service. The first monitor is called the *alignment error rate monitor*, and is used for all link speeds. The second is called the *signal unit error rate monitor* for 56 kbit/s, 64 kbit/s, and lower link rates, and the *errored interval monitor* for 1.536 Mbit/s rate links. The alignment error rate monitor is a linear count of signal unit errors. The characteristics of the signal unit error rate monitor are based on a signal unit error count, incremented and decremented using the "leaky bucket"³ principle. During loss of alignment, the signal unit error rate monitor error count is incremented in proportion to the period of the loss of alignment. The errored interval monitor also uses the leaky bucket principle, but is incremented and decremented based on whether an error occurs within a certain time interval.

³ See 10.2.2 for explanation of the "leaky bucket" principle.

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/T1.111.3 and, with more detail, Figure 7/T1.111.3. The split into 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 represented in the overview diagram, Figure 2/T1.111.3, and the detailed state transition diagram, Figure 8/T1.111.3.

1.8 *Flow Control*

Flow control is initiated when congestion is detected at the receiving end of the signalling link. The congested receiving end of the link notifies the remote transmitting end of the condition by means of an appropriate link status signal unit, and the receiving end withholds acknowledgment of all incoming message signal units. When congestion abates, acknowledgment of all incoming message signal units is resumed. While congestion exists, the remote transmitting end is periodically notified of this condition. The remote transmitting end should indicate the link as failed if this congestion continues for too long.

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 message signal units.

A message signal unit consists of a variable-length *signalling information field* that carries the information generated by a User Part, and a number of fixed-length fields, including the *service information octet*, that carry information required for message transfer control. Fill-in signal units carry neither the signalling information field nor the service information octet; in link status signal units, the signalling information field and the service information octet are replaced by a "status field," which is generated by the signalling link terminal.

2.2 *Signal Unit Format*

Message signal units, link status signal units, and fill-in signal units are differentiated by means of the *length indicator* contained in all signal units. Message signal units are retransmitted in case of error; link status signal units and fill-in signal units are not. The basic signal unit formats are shown in Figures 3A/T1.111.3 and 3B/T1.111.3.

2.3 Functions and Codes of the Signal Unit Fields

2.3.1 General

The message transfer control information, which encompasses eight fixed length fields in the signal unit, contains information required for signal unit error control and 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* field is used to indicate the number of octets that will be following it and preceding the *check bits*, and is a number in binary code in the range 0-63. The value of the length indicator defines the type 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

When a signalling information field spanning 62 octets or more is included in a message signal unit, the length indicator is set to 63.

The level 2 format that is extended for use with 1.536 Mbit/s link speeds has a length indicator field of 9 bits so that it can provide for the accounting of octets in message signal units with signalling information fields of 63 or more octets. When 1.536 Mbit/s links are used, the value of the length indicator field will indicate the number of octets in the signalling information field.

2.3.4 Service Information Octet

The *service information octet* is divided into the *service indicator* and the *subservice field*. The service indicator is used at level 3 to associate signalling information with a particular user part, and is present only in message signal units. The content of the subservice field is described in clause 14.2.2 of Chapter T1.111.4.

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 the backward sequence number are numbers in binary code from a cyclic sequence ranging from 0 to 127 for 56 kbit/s, 64 kbit/s, and lower bit rate signalling links, and 0 to 4095 for 1.536 Mbit/s signalling links (see 5.2 and clause 6).

2.3.6 Indicator Bits

The *forward indicator bit* and *backward indicator bit*, together with the forward sequence number and the backward sequence number, are used in the basic error control method to perform the signal unit sequence control and acknowledgment functions (see 5.2 and clause 6).

2.3.7 Check Bits

Every signal unit has 16 *check bits* for error detection (see clause 4).

2.3.8 Signalling Information Field

The *signalling information field* (used only in message signal units) consists of an integral number of octets, greater than or equal to 2, and less than or equal to 272.⁴

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

2.3.9 Status Field

The formats and codes of the *status field* (used only in link status signal units) are described in clause 11.

2.3.10 Spare Fields

Spare fields are coded 0, unless otherwise indicated (see Figures 3/T1.111.3 and 6/T1.111.3).

2.4 Order of Bit Transmission

Each of the fields mentioned in 2.3 shall be transmitted in the order indicated in Figure 3/T1.111.3.

Within each field or subfield, the bits are transmitted with the least significant bit first. The 16 check bits are transmitted in the order generated (see clause 4).

3. SIGNAL UNIT DELIMITATION

3.1 Flags

A signal unit includes an opening flag (see 2.2). The opening flag of a signal unit is normally considered to be the closing flag of the preceding signal unit. In certain conditions (e.g.,

⁴ This value of 272 octets is for U.S. networks. The value 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.

signalling link overload), a limited number⁵ of flags may be generated between two consecutive signal units. However, a signalling terminal should always be able to receive consecutive signal units with either single or multiple flags between them.

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 0 after every sequence of five consecutive 1s before the flags are attached and the signal unit is transmitted. At the receiving signalling link terminal, after flag detection and removal, each 0 that directly follows a sequence of five consecutive 1s is deleted.

4 SIGNAL UNIT ACCEPTANCE PROCEDURE

4.1 Acceptance of Signal Unit Alignment

4.1.1 A flag that is not immediately followed by another flag is considered to be 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 end of the signal unit. The opening flag of one signal unit is normally the closing flag of the preceding signal unit.

4.1.2 If seven or more consecutive 1s are received, the signal unit error rate monitor or alignment error rate monitor enters the *octet counting* mode (see 4.1.4). The errored interval monitor, however, does not use octet counting mode. In all cases, a search is made for the next valid flag.

4.1.3 After deletion of the 0s inserted for transparency, the received signal unit length is checked for being a multiple of eight bits and at least six octets, including the opening flag. If it is not, the signal unit is discarded and the signal unit error rate monitor or alignment error rate monitor is incremented. If more than N_{max} octets are received before a closing flag, the octet counting mode is entered (see Figure 11/T1.111.3) and the signal unit is discarded. The maximum length of the signalling information field allowed on a particular signalling link is 272 octets. Message signal units whose 9-bit length indicator field (for 1.536 Mbit/s signalling links) does not match the actual octet count of the message are discarded, and the errored interval monitor is incremented. In the case of the basic error control method, a negative acknowledgment will be sent, if required, according to the rules set out in 5.2.

⁵ If the number of consecutive flags exceeds six, the signalling link error control characteristics may be adversely affected. This does not apply to the errored interval monitor.

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, and this signal unit is accepted.

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:

1. The remainder of $x^k(x^{15} + x^{14} + x^{13} + x^{12} + \dots + x^2 + x + 1)$ 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
2. 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 1s, and is then modified by division by the generator polynomial (as described above) on all the fields of the signal unit; the 1s 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 1s, 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 noncompelled method in which signal unit error correction is effected 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 acknowledgments are used to indicate correct transfer of message signal units and *negative acknowledgments* are used as explicit requests for retransmission of message 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 fill-in signal unit or link status 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 negatively acknowledged message signal unit and any subsequently transmitted message signal units are retransmitted in the order in which they were originally transmitted.

As part of the signal unit basic 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 basic error-correction procedure operates independently in the two transmission directions. The forward sequence number and the forward indicator bit in one direction, together with the backward sequence number and the 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.

New MSUs received from Level 3 for transmission are stored in the transmission buffer. Buffer sizes are considered to be implementation dependent. Handling of messages under congestion conditions is specified in T1.111.4, clause 3.8.2, *Congestion Status of Signalling Links*.

The transmission of new (i.e., not yet transmitted) signal units is temporarily stopped under various conditions (see 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 clauses 7, 8, and 11.

5.2 *Positive Acknowledgments and Negative Acknowledgments*

5.2.1 **Sequence Numbering**

For the purposes of acknowledgment 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 acknowledgment 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 for 56 kbit/s, 64 kbit/s, and lower bit rate signalling links, and modulo 4096 for 1.536 Mbit/s signalling links; see 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, forward sequence number, and the length of each message signal unit is retained at the transmitting signalling link terminal until a positive acknowledgment for that signal unit is received (see 5.2.3). In the meantime, the same forward sequence number cannot be used for another message signal unit (see 5.2.3).

A forward sequence number value can be assigned to a new message signal unit when a positive acknowledgment concerning that value incremented by at least 1 (modulo 128 for 56 kbit/s, 64 kbit/s, and lower bit rate signalling links, and modulo 4096 for 1.536 Mbit/s signalling links) is received (see 5.2.3).

This means that not more than 127 message signal units may be available for retransmission on 56 kbit/s, 64 kbit/s, and lower bit rate signalling links, and not more than 4095 message signal units on 1.536 Mbit/s signalling links.

The transmission of new (i.e., not yet transmitted) signal units is temporarily stopped during retransmission and when no forward sequence number values are available to be assigned to new message signal units or when there is no available space in the retransmission buffer (due to a high momentary load or corruption of positive acknowledgments). Under these conditions, FISUs are transmitted with the forward sequence number assigned the sequence number of the last MSU transmitted.

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 for a message signal unit is different than for other types of signal units, the length indicator of the received signal unit must be examined to determine the type of signal unit received.

- 1) If the signal unit is a fill-in signal unit, then:
 - a) If the forward sequence number value equals the forward sequence number value of the last accepted message signal unit, the signal unit is processed within the Message Transfer Part.
 - b) If the forward sequence number value is different from the forward sequence number value of the last accepted message signal unit, 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 acknowledgment is sent.
- 2) If the signal unit is a link status signal unit, then it is processed within the Message Transfer Part.
- 3) If the signal unit is a message signal unit, then:

- a) If the forward sequence number value is the same as that of the last accepted signal unit, the signal unit is discarded, regardless of the state of the indicator bits.
- b) If the forward sequence number value is one more (modulo 128 for 56 kbit/s, 64 kbit/s, and lower bit rate signalling links, and modulo 4096 for 1.536 Mbit/s signalling links; see 2.3.5) 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, the signal unit is accepted and delivered to level 3.

Explicit positive acknowledgments to the accepted signal units are sent as specified in 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, the signal unit is discarded.

- c) If the forward sequence number value is different from those values mentioned in (a) and (b) above, the signal unit is discarded. If the received forward indicator bit is in the same state as the last backward indicator bit that was sent, a negative acknowledgment is sent.

Processing of the backward sequence number value and backward indicator bit value as described in 5.3 is performed for message signal units and fill-in signal units except when an unreasonable backward sequence number value or unreasonable forward indicator bit value is received. Discarding a signal unit means that if it is a message signal unit, it is not delivered to level 3.

5.2.3 Positive Acknowledgment

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

5.2.4 Negative Acknowledgment

If a negative acknowledgment is to be sent (see 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 acknowledgment 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 Acknowledgment

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

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

When the same positive acknowledgment is consecutively received a number of times, no further action is taken.

When a message signal unit or fill-in signal unit is received having a backward sequence number value that 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.

If any two backward sequence number values in three consecutively received message signal units or fill-in 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 they are received, then level 3 is informed that the link is faulty. Management is notified.

A timing mechanism, timer $T7$,⁶ shall be provided that generates an indication of excessive delay of acknowledgment if, assuming that there is at least one outstanding message signal unit in the retransmission buffer, no new acknowledgment has been received within $T7$ seconds. In the case of excessive delay of acknowledgment, a link failure indication is given to level 3. Management is notified.

5.3.2 Response to a Negative Acknowledgment.⁷

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 that has a forward sequence number value of one (modulo 128 for 56 kbit/s, 64 kbit/s, and lower bit rate signalling links, and modulo 4096 for 1.536 Mbit/s signalling links; see 2.3.5) more than the backward sequence number associated with the received backward indicator bit.

⁶ Timers in Chapter T1.111.3 are defined as either a range of values or as a fixed value; this means that due to the possibility to insert multiple flags between signal units (see 3.1) there may be no fixed relation between the time-out values and the number of signal units transmitted/received during the time-out periods.

⁷ The signal unit sequence control makes it possible to repeat a message signal unit that 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 in applications to lower transmission rates, thereby reducing the effective signalling link speed and reducing the average message delay. Each signal unit should be defined by its own opening and closing flags to ensure that the repeated signal unit is not lost by the corruption of only a single flag. This is an option that is not fully specified and requires careful consideration for application.

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 5.2.2), and a new retransmission request is made.

When a message signal unit or fill-in signal unit is received having a forward indicator bit value indicating the start of a retransmission when no negative acknowledgment has been sent, that signal unit is discarded. The following message signal unit or fill-in signal unit is discarded.

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

5A Transmission and Retransmission Buffers Guidelines (For 56/64 Kbps Links)

From a protocol perspective, the transmission and retransmission buffers are functionally separate. The MTP protocol does not specify the size or how these buffers are to be implemented (i.e., the size and whether the buffers are separate or combined are implementation dependent).

The retransmission buffer size is limited by the Level-2 sequence numbers (see clause 5.2.2). The available Level-2 sequence number allows a maximum of 127 MSUs to be stored for retransmission. Since MSUs are of variable length, the size of the retransmission buffer may be based on number of octets. Therefore, a retransmission buffer full condition may occur due to exhaust of sequence numbers or due to a limitation on the number of octets that can be stored in the retransmission buffer. The main consideration for determining an appropriate retransmission buffer size should be based on outstanding MSUs during a *loop delay* (time between transmitting a MSU and receiving an acknowledgment from the remote end) and MSUs length distribution.

The following are some factors that should be considered to determine appropriate Level-2 transmission and retransmission buffers sizes:

1. MSU length distribution
2. MTP Level-2 Timer Values (e.g., T7 and T6)
3. Link transmission rate
4. Queueing delays (see T1.111.6)
5. MTP performance requirements (see T1.111.6)
6. Load in link failure situations
7. Level-3 congestion control mechanism (see T1.111.4)

8. Node type (e.g., STP or SEP)

Factors other than those listed above may also be used to determine appropriate buffer sizes, such as diversity of network architectures (e.g., length of links).

NOTE - Although the transmission and retransmission buffers and their sizes are implementation dependent, care should be taken if the buffers are implemented as a combined buffer and the total size is less than 127 MSUs. In this case, a retransmission buffer full condition may imply a combined transmission and retransmission buffer full condition.

6. PREVENTIVE CYCLIC RETRANSMISSION ERROR CORRECTION METHOD

6.1 General

The preventive cyclic retransmission method is a noncompelled forward error correction method, whereby positive acknowledgments are needed to support the forward error correction.

Each message signal unit must be retained at the transmitting signalling link terminal until a positive acknowledgment 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 (i.e., not yet transmitted) 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 clauses 7, 8, and 11.

6.2 Acknowledgments

6.2.1 Sequence Numbering

For the purpose of acknowledgment 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 acknowledgment 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 for 56 kbit/s, 64 kbit/s, and lower bit rate signalling links, and modulo 4096 for 1.536 Mbit/s signalling links; see 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 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, forward sequence number, and the length of each message signal unit is retained at the transmitting signalling link terminal until the related acknowledgment for that signal unit is received (see 6.2.3). In the meantime, the same forward sequence number value cannot be used for another message signal unit (see 6.2.3).

A forward sequence number value can be assigned to a new message signal unit when a positive acknowledgment concerning that value incremented by at least 1 (modulo 128 for 56 kbit/s, 64 kbit/s, and lower bit rate signalling links, and modulo 4096 for 1.536 Mbit/s signalling links) is received (see 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 for a message signal unit is different than for other types of signal units, the length indicator of the received signal unit shall be examined to determine the type of signal unit received. The forward indicator bit and the backward indicator bit are not used and are set to 1.

- (1) If the signal unit is not a message signal unit, then the signal unit is processed within the Message Transfer Part.
- (2) If the signal unit is a message signal unit, then:
 - (a) If the forward sequence number value is the same as that of the last accepted signal unit, the signal unit is discarded;
 - (b) If the forward sequence number value is one more (modulo 128 for 56 kbit/s, 64 kbit/s, and lower bit rate signalling links, and modulo 4096 for 1.536 Mbit/s signalling links; see 2.3.5) than that of the last accepted signal unit, the signal unit is accepted and delivered to level 3. Explicit positive acknowledgments for the accepted signal units are sent as specified in 6.2.3;
 - (c) If the forward sequence number value is different from the values mentioned in (a) and (b), the signal unit is discarded.

Processing of the backward sequence number value as described in 6.3 is performed for message signal units and fill-in signal units except when an unreasonable backward sequence number value is received. Discarding a signal unit means that if it is a message signal unit, it is not delivered to level 3.

6.2.3 Positive Acknowledgment

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 signal unit is acknowledged, which will cause a change of the backward sequence number sent. The acknowledgment of an accepted message signal unit also represents an acknowledgment of all, if any, previously accepted though not yet acknowledged signal units.

6.3 Preventive Cyclic Retransmission

6.3.1 Response to a Positive Acknowledgment

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 unit or fill-in signal unit that has satisfied the polynomial error check. The previously sent message signal unit that has a forward sequence number value identical to the received backward sequence number value will no longer be available for retransmission.

When an acknowledgment 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 for 56 kbit/s, 64 kbit/s, and lower bit rate signalling links, and modulo 4096 for 1.536 Mbit/s signalling links) are considered to be acknowledged, even though the corresponding backward sequence number has not been received.

When the same positive acknowledgment is consecutively received a number of times, no further action is taken.

When a message signal unit or fill-in signal unit is received having a backward sequence number value that 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 message signal unit or fill-in signal unit is discarded.

If any two backward sequence number values in three consecutively received message signal units or fill-in 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. Management is notified.

A timing mechanism, timer $T7^6$, shall be provided that generates an indication of excessive delay of acknowledgment if, assuming that there is at least one outstanding message signal unit in the retransmission buffer, no new acknowledgment has been received within $T7^6$ seconds. In the case of excessive delay of acknowledgment, a link failure indication is given to level 3. Management is notified.

6.3.2 Preventive Cyclic Retransmission Procedure

1. If no new signal units are available to be sent, the message signal units available for retransmission are retransmitted cyclically;
2. If new signal units are available, the retransmission cycle, if any, must be interrupted and the new signal units be sent with priority; and

3. 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, continuous fill-in signal units or flags may be sent as described in clauses 7, 8, and 11.

6.4 *Forced Retransmission*

To maintain the efficiency of error correction in those cases in which 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 ($N1$) and the number of message signal unit octets available for retransmission ($N2$) are monitored continuously.

If one of them reaches its set limit, no new message signal units or fill-in signal units are sent and the retransmission cycle is continued up to the last message signal unit entered into the retransmission buffer with priority, in the order in which they were originally transmitted. If all those message signal units have been sent once and neither $N1$ nor $N2$ is at its limit value, the normal preventive cyclic retransmission procedure can be resumed. If not, all the message signal units available for retransmission are sent again with priority.

6.4.2 **Limitation of the Values $N1$ and $N2$**

$N1$ is limited by the maximum numbering capacity of the forward sequence number range that dictates that not more than 127 message signal units can be available for retransmission on 56 kbit/s, 64 kbit/s, or lower bit rate signalling links, and not more than 4095 message signal units on 1.536 Mbit/s signalling links.

In the absence of errors, $N2$ 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 acknowledgment for this message signal unit in undisturbed operation; and

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

When some signalling data links of different loop delays are alternated for application to that signalling link, the longest possible signalling link delay may be used to calculate the value of T_L .

7. SIGNALLING LINK INITIAL ALIGNMENT PROCEDURE

7.1 General

The signalling link initial alignment procedure is applicable to the activation and 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 whether to apply the "normal" or the "emergency" procedure is made unilaterally at level 3 (see Chapter T1.111.4). 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 signalling link initial alignment procedure employs four different alignment status indications:

1. *Status indication "O"*: Out of alignment;
2. *Status indication "N"*: "Normal" alignment status;
3. *Status indication "E"*: "Emergency" alignment status; or
4. *Status indication "OS"*: Out of service.

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

A link status signal unit with status indication "O" is transmitted by the local signalling link terminal when initial alignment has been started and none of the status indications "O", "N" or "E" are received on the link from the remote signalling link terminal.

A link status signal unit with status indication "N" is transmitted by the local signalling link terminal when, after it has started initial alignment, status indication "O", "N", or "E" is received on the link from the remote signalling link terminal and the local terminal is in the "normal" alignment status.

A link status signal unit with status indication "E" is transmitted by the local signalling link terminal when, after it has started initial alignment, status indication "O", "N", or "E" is received on the link from the remote signalling link terminal and the local terminal is in the "emergency" alignment status, i.e., it has to employ the short "emergency" proving period.

A status indication of "N" or "E" indicates the status of the signalling link terminal that transmitted it; this status is not changed at the local signalling link terminal 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 indication "N," but initiates the short "emergency" proving period.

A link status signal unit with status indication "OS" informs the remote signalling link terminal that, for reasons other than processor outage (e.g., link failure), the local signalling link terminal can neither receive nor transmit message signal units. Status indication "OS" is also sent on completion of power up (see Figures 2/T1.111.3 and 8/T1.111.3) until initial alignment is started.

7.3 Initial Alignment Procedure

The signalling link initial alignment procedure passes through a number of states during the initial alignment (the following states are shown in Figure 9/T1.111.3):

1. *State 00, idle*: the procedure is suspended.
2. *State 01, not aligned*: the signalling link is not aligned and the local terminal is sending status indication "O." Time-out $T2^6$ is started on entry to State 01 and stopped when leaving State 01.

NOTE -It must be ensured that the value of this time-out is different at each end of the signalling link for automatic allocation of signalling data links (see clause 12 of Chapter T1.111.4).
3. *State 02, aligned*: the signalling link is aligned and the local terminal is sending status indication "N" or "E"; status indication "N," "E," or "OS" are not received on the link from the remote terminal. Time-out $T3^6$ is started on entry to State 02 and stopped when leaving State 02.
4. *State 03, proving*: the local signalling link terminal is sending status indication "N" or "E"; status indication "O" or "OS" are not received; proving has been started.

Proving is the means by which the signalling link terminal validates the link's ability to carry signal units correctly by inspecting the signal units. Proving must last for a period $T4$ before the link can enter the "aligned/ready" link state (the aligned/ready state is shown on Figure 8/T1.111.3 and is not one of the numbered states given above). Expiration of timer $T4$ (see 12.3) indicates a successful proving period unless the proving period has been previously aborted up to four times.

Following successful alignment proving procedure, the signalling terminal enters aligned/ready state and the aligned/ready time-out $T1^6$ is started. Time-out $T1$ is stopped on entry in the in-service state (see Figure 8/T1.111.3), and the duration of time-out $T1$ should be chosen such that the remote end can perform four additional proving attempts.

The procedure itself is described in the overview diagram, Figure 4/T1.111.3, and in state transition diagram, Figure 9/T1.111.3.

7.4 Proving Periods

The values of proving periods are

$$P_n = 2^{14} \text{ octet transmission time}$$

$$P_e = 2^{12} \text{ octet transmission time}$$

for a 56 kbit/s rate or 64 kbit/s rate, or lower bit rate.⁸ These values correspond to times of 2.3 seconds and 0.6 second, respectively, at 56 kbit/s and to times of 2.0 seconds and 0.5 second, respectively at 64 kbit/s.

When 1.536 Mbit/s rate is used, the values of the proving periods are:

$$P_n = 30 \text{ seconds}$$

$$P_e = 5 \text{ seconds}$$

7.4.A Initial Alignment Timers

The values of the "initial alignment timers" for 56 kbit/s and 64 kbit/s rates are as follows:

1. $T_1 = 5 \times P_n + \text{ERROR} = 13.0$ seconds, accuracy range [12.9 to 16 sec.] (where ERROR is the safety margin)
2. $T_2 = 11.5$ seconds or 23.0 seconds (see 7.3), range [5 to 14 seconds] or [16 to 30 seconds], respectively⁹
3. $T_3 = 11.5$ seconds, range [5 to 14 seconds]
4. { $T_4: P_e \leq T_4 \leq P_n$, for $P_e = 0.6$ seconds, $P_n = 2.3$ seconds } where P_e and P_n are within an accuracy range of $\pm 10\%$

The values of the "initial alignment timers" for the 1.536 Mbit/s rate are as follows:

1. $T_1 = 5 \times P_n = 170$ seconds, accuracy range [165 to 200 seconds]
2. $T_2 = 11.5$ seconds or 23.0 seconds (see 7.3), range [5 to 14 seconds] or [16 to 30 seconds], respectively
3. $T_3 = 11.5$ seconds, range [5 to 14 seconds]
4. $T_4 = 30$ seconds for P_n and 5 seconds for P_e , accuracy range [$\pm 10\%$]

8. PROCESSOR OUTAGE

A processor outage situation occurs when, due to factors at a functional level higher than level 2, use of the link is precluded -- for example, it may be impossible to transfer signalling messages to functional levels 3 or 4. Though a possible cause for the processor outage condition is central processor failure, a processor outage condition may 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.

⁸ The values of proving periods in conjunction with lower bit rates are not specified.

⁹ If automatic allocation of signalling terminals or signalling data links is applied at both ends of a signalling link, it must be ensured that the values of this time-out are different at each end of a signalling link (see T1.111.4-2001, clause 12). In this case, T2 low (see clause 12.3) is allocated to the signalling point with the lower point code and T2 high to the signalling point with the higher point code. In all other cases, the value to time-out T2 can be the same at both ends of the link.

Detection of a local processor outage condition is implementation dependent. Provided that the link is aligned when the local processor outage condition is detected, level 2 transmits link status signal units indicating processor outage and discards message signal units received. Upon receiving link status signal units indicating processor outage, the level 2 function at the far end of the signalling link notifies level 3 of the remote processor outage and, provided it is in its normal operating state (i.e., transmitting message signal units or fill-in signal units) begins to continuously transmit fill-in signal units.

It then uses these fill-in signal units to acknowledge all message signal units that have been accepted from the point experiencing local processor outage, including any message signal units for which acknowledgments were previously withheld because of level 2 congestion (see clause 9).

During a local or remote processor outage condition, level 2 timers *T5*, *T6* and *T7* are stopped.

A local processor outage condition concludes when level 3 indicates its recovery by requesting level 2 to resume normal operation or by requesting level 2 to clear its buffers of message signal units (see Chapter T1.111.4, clause 5.6.2 for time controlled changeover procedures). If level 3 requests level 2 to resume normal operation, level 2 resumes acceptance of message signal units from remote level 2 and normal transmission of message signal units and fill-in signal units. The first message signal unit or fill-in signal unit transmitted acknowledges all message signal units that have been accepted from remote level 2, including any message signal units for which acknowledgments were previously withheld because of level 2 congestion (see clause 9). If level 3 requests level 2 to clear its buffers of message signal units, level 2 begins to continuously transmit fill-in signal units and discards all message signal units that it has received from remote level 2 but not yet delivered to local level 3 and all message signal units that it has received from local level 3 but not yet transmitted on the link. The first fill-in signal unit transmitted acknowledges all message signal units that have been accepted from remote level 2 including any message signal units for which acknowledgments were previously withheld because of level 2 congestion (see clause 9). Level 2 then begins accepting message signal units from remote level 2. When the next fill-in or message signal unit is received that passes the acceptance procedures of clause 4 and clauses 5 or 6:

1. all message signal units that are available for retransmission are discarded;
2. the forward sequence number and forward indicator bit of the transmitted fill-in signal units are set equal to the backward sequence number and backward indicator bit of the received signal unit;
3. normal transmission of message signal units and fill-in signal units is resumed; and
4. level 3 is notified that the buffer clearing has been completed and that normal operation has been resumed.

NOTE - In some implementation scenarios (e.g., if a remote processor outage condition has arisen) level 3 may terminate a local processor outage condition by requesting level 2 to transmit fill-in signal units only while level 3 determines whether to subsequently request a clearing of buffers or a return to normal operation. This case is not covered in the state transition diagram.

During a remote processor outage condition, level 3 may request level 2 to clear message signal units from the retransmission buffer. When the next fill-in or message signal unit is received

that passes the acceptance procedures of clause 4 and clauses 5 or 6, actions (1) through (4) of the previous paragraph are performed. If no such request has been received from level 3 when a message signal unit or fill-in signal unit is correctly received from remote level 2, then level 2 notifies level 3 of the termination of remote processor outage and awaits a request from level 3 either to resume normal operation or to clear message signal units from the retransmission buffer and then resume normal operation.

Format and code of link status signal units indicating processor outage (status indicator "PO") appear in clause 11 of this chapter.

9. LEVEL 2 FLOW CONTROL

9.1 *General*

The procedure is used to handle a level 2 congestion situation. After the congestion is detected at the receiving end of the signalling link, both positive and negative acknowledgments to message signal units are withheld and a status indication "B" (BUSY) is sent from the receiving end of the link to the remote end in order to enable the remote transmitting end to distinguish between congestion and failure situations.

This indication is carried in the status field of a link status signal unit.

NOTE - The receiving end continues to process *backward sequence number* and *backward indicator bit* carried in signal units received in order to, as far as possible, avoid disturbance of the message flow in the opposite direction and in addition may continue to accept message signal units.

9.2 *Detection of Congestion*

The mechanism for detecting congestion at the receiving end of a signalling link is implementation dependent and not to be specified.

9.3 *Procedure in the Congestion Situation*

The receiving end of a signalling link that detected a congestion situation periodically returns a link status signal unit containing a status indication "B" to the remote transmitting end of the link at interval $T5^6$. The receiving level 2 also withholds acknowledgment of the message signal unit, which triggered off the congestion detection, and of message signal units received during the congestion situation; that is, fill-in signal units or message signal units are sent as usual, but with the backward sequence number and backward indicator bit assigned the values that are contained in the last transmitted signal unit before the congestion is recognized.

At the remote end of the signalling link, every reception of a link status signal unit containing indication "B" causes the excessive delay of acknowledgment timer $T7^6$ to be restarted if the timer is already running. In addition, first reception of the link status signal unit containing a status indication "B" starts a long supervision timer $T6^6$, only if there are messages signal units in the retransmission buffer and the timer $T6$ is not running. As an option, transmission of new message signal units may be stopped (this option is not reflected in the SDLs). Should the timer $T6$ expire, *link failure indication* is generated. Management is notified.

9.4 Congestion Abatement Procedure

When congestion abates at the receiving end of the signalling link, transmission of link status signal units containing status indication "B" is stopped and normal operation is resumed.

At the remote end, the supervision timer $T6^6$ is stopped when a negative or positive acknowledgment, whose backward sequence number acknowledges a message signal unit in the retransmission buffer, is received in the case of the basic error correction method, or a positive acknowledgment is received in case of the preventive cyclic retransmission method. If transmission of new message signal units had stopped, it is resumed when timer $T6$ is stopped.

NOTE - Congestion onset and abatement detection is an implementation dependent function. Sufficient hysteresis should be provided in the implementation to prevent excessive oscillation between congested and noncongested states.

10. SIGNALLING LINK ERROR MONITORING

10.1 General

Two types of link error rate monitor functions are provided: one is employed while a link is in the proving state of the initial alignment procedure (see 7.3); the other is employed while a signalling link is in service and provides one of the criteria for taking the link out of service. The first monitor is called the "alignment error rate monitor," and is used for all link speeds. The second is called the "signal unit error rate monitor" for 56 kbit/s, 64 kbit/s, and lower link rates, and the "errored interval monitor" for 1.536 Mbit/s rate links.

10.2 Signal Unit Error Rate Monitor for 56 kbit/s and 64 kbit/s and Lower Bit Rate Links

10.2.1 The signal unit error rate monitor has as its function the estimation of the signal unit error rate in order to decide about the signalling link fault condition. The signal units in error are those rejected by the acceptance procedure (see clause 4). The three parameters that determine the signal unit error rate monitor are: the number of consecutive signal units received in error that will cause an error rate high indication to level 3, T (signal units); the lowest signal unit error rate that will ultimately cause an error high indication to level 3, $1/D$ (signal units errors/signal unit); and the number of octets that causes an increment of the counter while in the *octet counting* mode, N (octets).

10.2.2 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 clause 4), but not above the threshold [T (signal units)]. An excessive error rate shall be indicated whenever the threshold T is reached.

10.2.3 In the octet counting mode (see 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).

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

10.2.5 The values of the three parameters are¹⁰:

1. $T = 64$ signal units
2. $D = 256$ signal units/signal unit error for 56 kbit/s or 64 kbit/s
3. $N = 16$ octets

In case of loss of alignment, these Figures shall give a time of approximately 146 ms to initiate changeover for 56 kbit/s operation, or approximately 128 ms for 64 kbit/s.

10.2.6 When only random signal unit errors occur over the signalling link, the relationship between the expected number of signal units until the threshold of T (signal units) is reached and the signal unit error rate (signal unit errors/signal units) can be established. This relationship may be expressed by an orthogonal hyperbola that has parameters $(T, 1/D)$ (see Figure 5/T1.111.3).

10.2A Errored Interval Monitor for 1.536 Mbit/s Links

10.2A.1 The errored interval monitor has as its function the estimation of signalling link fault condition by monitoring errors over a prescribed interval to model the queue build up on the transmitting end. An interval is errored if one or more signal units are rejected by the acceptance procedure (see clause 4) or a flag is lost. The four parameters that determine the errored interval monitor are: the number of intervals where signal units have been received in error that will cause an error rate high indication to level 3, T_E (intervals); the constant U_E for incrementing the counter; the constant D_E for decrementing the counter; and the interval for monitoring errors T_8 .

10.2A.2 The errored interval monitor is implemented in the form of an up/down counter decremented at a fixed rate (D_E for every interval where no signal unit is errored and at least one flag is received), but not below zero, and incremented at a fixed rate (U_E for every interval where one or more signal unit error is detected by the signal unit acceptance procedure (see clause 4) or where no flag is received) but not above the threshold (T_E). An excessive error rate shall be indicated whenever the threshold T_E is reached.

¹⁰ The text that relates to the use of lower bit rates is not specified. The text from the CCITT Blue Book which related to the use of lower bit rates was deleted from this clause.

10.2A.3 The octet counting mode, which provides an estimate of a signal unit, is not used for the errored interval monitor because this procedure is not based on an accounting of individual errors.

NOTE - Since the errored interval monitor is not dependent on message unit counts, it is possible to lower the rate of FISUs transmitted on the link to reduce unnecessary processing burden on the link nodes. A range of 1,000 to 2,000 FISUs/second is recommended.

10.2A.4 When the link is brought into service, the monitor count should start from zero.

10.2A.5 The ranges for the four parameters are given in the table below.

Table 1/T1.111.3 - Values for the Errored Interval Parameters

| PARAMETER | DEFINITION | Value |
|-----------|-----------------------------|---------|
| T_E | Threshold count | 577,169 |
| U_E | Constant for upcount | 144,292 |
| D_E | Constant for downcount | 9,308 |
| T_8 | Monitoring interval (msec.) | 100 |

10.3 Alignment Error Rate Monitor

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

10.3.2 The counter is started from zero whenever the proving state (State 03 of Figure 9/T1.111.3) of the alignment procedure is entered and is then incremented for every signal unit error detected if it is not in the octet counting mode. It is also incremented for every N octets received while in the octet counting mode, as described in 10.2.3.

10.3.3 When the counter reaches a threshold T_j , 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 reentered. If proving is aborted M times, 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 clause 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."

10.3.4 The values of the four parameters for the 56 kbit/s or 64 kbit/s, 1.536 Mbit/s, and lower bit-rates are:

1. $T_{in} = 4$ signal units
2. $T_{ie} = 1$ signal unit
3. $M = 5$ proving periods
4. $N = 16$ octets

NOTE - The emergency proving period may, with some probability, be successfully completed with a marginal and degraded bit error rate (i.e., around one error in 10^4 bits for 56 kbit/s and 64 kbit/s signalling links). Subsequently, the signal unit error rate monitor will quickly indicate an excessive error rate. However, short term operation on a degraded link may be acceptable (e.g., to send management messages).

11. LEVEL 2 CODES AND PRIORITIES

11.1 *Link Status Signal Unit*

11.1.1 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, the status field consists of one octet; if the length indicator has a value of 2, the status field consists of two octets. The first octet contains the status indications, and the second octet, if present, is ignored. However, it is required that a link status signal unit of 1 or 2 octets is receivable.

11.1.2 The format of a one octet status field is shown in Figure 6/T1.111.3.

11.1.3 The use of the link status indications is described in clauses 7-9; 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"

101 - Status indication "B"

The spare bits should be ignored at the receiving side.

11.2 *Transmission Priorities within Level 2*

11.2.1 Five different items can be transmitted:

1. New message signal units;
2. Message signal units that have not yet been acknowledged;
3. Link status signal units;
4. Fill-in signal units; or

5. Flags.

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

11.2.2 For the basic error control method, the priorities are:

- | | |
|---------|--|
| Highest | (1) Link status signal units |
| | (2) Message signal units that have not yet been acknowledged and for which a negative acknowledgment has been received |
| | (3) New message signal units |
| | (4) Fill-in signal units |
| Lowest | (5) Flags |

11.2.3 For the preventive cyclic retransmission method, the priorities are¹¹:

- | | |
|---------|---|
| Highest | (1) Link status signal units |
| | (2) Message signal units that have not yet been acknowledged and that are stored in a retransmission buffer whose contents exceeds one of the parameters $N1$ or $N2$ |
| | (3) New message signal units |
| | (4) Message signal units that have not yet been acknowledged |
| | (5) Fill-in signal units |
| Lowest | (6) Flags |

12. STATE TRANSITION DIAGRAMS

12.1 Diagram Summary

This clause contains the description of the signalling link control functions, described in this chapter, in the form of state transition diagrams according to the ITU-T Specification and Description Language (SDL). The following list summarizes these diagrams:

¹¹ Repetition of signal units for lower bit rates should have a priority immediately below that of link status signal units.

| | | |
|-----|---|--------------------|
| 1. | Level 2-Functional Block Diagram: | Figure 7/T1.111.3 |
| 2. | Link State Control: | Figure 8/T1.111.3 |
| 3. | Initial Alignment Control: | Figure 9/T1.111.3 |
| 4. | Processor Outage Control: | Figure 10/T1.111.3 |
| 5. | Delimitation, Alignment and Error Detection (Receiving): | Figure 11/T1.111.3 |
| 6. | Delimitation, Alignment and Error Detection (Transmitting): | Figure 12/T1.111.3 |
| 7. | Basic Transmission Control: | Figure 13/T1.111.3 |
| 8. | Basic Reception Control: | Figure 14/T1.111.3 |
| 9. | Preventive Cyclic Retransmission (Transmission Control): | Figure 15/T1.111.3 |
| 10. | Preventive Cyclic Retransmission (Reception Control): | Figure 16/T1.111.3 |
| 11. | Alignment Error Rate Monitor: | Figure 17/T1.111.3 |
| 12. | Signal Unit Error Rate Monitor: | Figure 18/T1.111.3 |
| 13. | Congestion Control: | Figure 19/T1.111.3 |
| 14. | Errored Interval Monitor | Figure 20/T1.111.3 |

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 clauses. The state transition diagrams are intended to show precisely the behavior 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 behavior, and is not intended to specify the functional partitioning to be adopted in a practical implementation of the signalling system.

In the following Figures, the term *signal unit* refers to units that do not contain all error control information.

12.2 Abbreviations

| | |
|------|--|
| AERM | Alignment error rate monitor |
| BIB | Backward indicator bit |
| BIBR | Backward indicator bit received |
| BIBT | Backward indicator bit to be transmitted |
| BIBX | Backward indicator bit expected |
| BSN | Backward sequence number |
| BSNR | Backward sequence number received |

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| | |
|-------|---|
| BSNT | Backward sequence number to be transmitted |
| C_a | Alignment error rate monitor counter |
| C_m | Count of MSUs in transmission buffer |
| C_p | Count of aborted proving attempts |
| C_s | Signal unit error rate monitor counter |
| C_E | Errored interval monitor counter |
| CC | Congestion control |
| CK | Check bits |
| D_E | Constant for errored interval monitor downcount |
| DAEDR | Signal unit delimitation, alignment and error detection (receiving) |
| DAEDT | Signal unit delimitation, alignment and error detection (transmitting) |
| EIM | Errored interval monitor |
| F | Flag |
| FIB | Forward indicator bit |
| FIBR | Forward indicator bit received |
| FIBT | Forward indicator bit to be transmitted |
| FIBX | Forward indicator bit expected |
| FISU | Fill-in signal unit |
| FSN | Forward sequence number |
| FSNC | FSN of the last message signal unit accepted by remote level 2 |
| FSNF | FSN of the oldest message signal unit in the retransmission buffer |
| FSNL | FSN of the last MSU entered into the retransmission buffer |
| FSNR | Forward sequence number received |
| FSNT | FSN of the last message signal unit transmitted |
| FSNX | Forward sequence number expected |
| IAC | Initial alignment control |
| L1 | Signalling System No. 7 level 1 functions |
| L2 | Signalling System No. 7 level 2 functions |
| L3 | Signalling System No. 7 level 3 functions |
| LI | Length indicator bits |
| LSC | Link state control |
| LSSU | Link status signal unit |
| max | Window size (127 for 56 kbit/s, 64 kbit/s, and lower rates; 4095 for 1.536 Mbit/s rate) |
| MGMT | Unspecified implementation-dependent management function |
| MSU | Message signal unit |

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| | |
|-----------|---|
| N | Number of octets between flags |
| N_{max} | Maximum number of octets between flags for an SU |
| N_{min} | Minimum number of octets between flags for an SU |
| N_1 | Maximum number of sequence number values that are available for retransmission (fixed by the numbering capacity of the FSN) |
| N_2 | Maximum number of MSU octets that are available for retransmission (fixed by the common channel loop delay time) |
| N_s | Count of correct signal units |
| NACK | Negative acknowledgment |
| PE | Emergency proving period |
| PN | Normal proving period |
| POC | Processor outage control |
| RB | Receive buffer |
| RC | Reception control |
| RTB | Retransmission buffer |
| RTR | Retransmission indicator (if RTR=1, retransmission is expected) |
| SI | Service information octet |
| SIB | Status indication "B" (busy) |
| SIE | Status indication "E" (emergency alignment) |
| SIF | Signalling information field |
| SIN | Status indication "N" (normal alignment) |
| SIO | Status indication "O" (out of alignment) |
| SIOS | Status indication "out of service" |
| SIPO | Status indication "processor outage" |
| SF | Status field |
| SU | Signal unit |
| SUERM | Signal unit error rate monitor |
| T_E | Threshold count for errored interval monitor |
| T_i | Alignment error rate monitor threshold |
| T_{ie} | Emergency alignment error rate monitor threshold |
| T_{in} | Normal alignment error rate monitor threshold |
| TB | Transmission buffer |
| TXC | Transmission control |
| U_E | Constant for errored interval monitor upcount |
| UNB | Counter of unreasonable backward sequence numbers received |

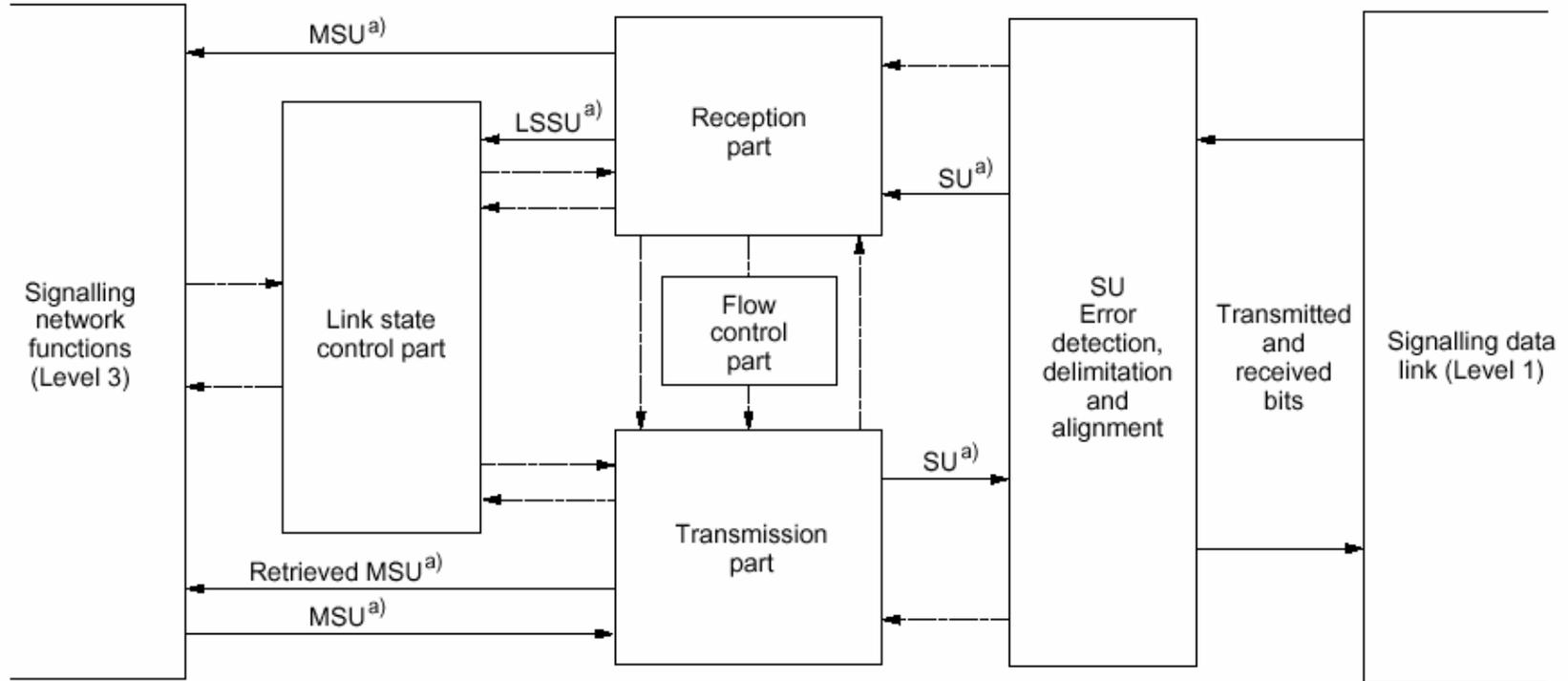
| | |
|-----|--|
| UNF | Counter of unreasonable forward sequence numbers received |
| Z | Pointer to sequence number of next MSU to be retransmitted in transmission cycle |

12.3 Timers

(These timer values apply for all link speeds unless otherwise noted.)

- T1 Timer "aligned/ready"
 = 13.0 seconds for 56 kbit/s and 64 kbit/s links; accuracy range [12.9 to 16 seconds]
 = 170 seconds for 1.536 Mbit/s links; accuracy range [165 to 200]
- T2 Timer "not aligned"
 T2(low) = 11.5 seconds; range [5 to 14 seconds]
 T2(high) = 23.0 seconds; range [16 to 30 seconds]
- T3 Timer "aligned"
 = 11.5 seconds; range [5 to 14 seconds]
- T4 Proving period timer = 2^{14} or 2^{12} octets for 56 kbit/s and 64 kbit/s links
 = 2.3 seconds for P_n for 56 kbit/s and 64 kbit/s links; accuracy range $\pm 10\%$
 = 0.6 second for P_e for 56 kbit/s and 64 kbit/s links; accuracy range $\pm 10\%$
 = 30 seconds for P_n for 1.536 Mbit/s links; accuracy range $\pm 10\%$
 = 5 seconds for P_e for 1.536 Mbit/s links; accuracy range $\pm 10\%$
- T5 Timer "sending SIB"
 = 80 - 120 ms
- T6 Timer "remote congestion"
 = 1 - 6 seconds for 56 kbit/s, 64 kbit/s, and 1.536 Mbit/s links
 = 8 - 12 seconds for 4.8 kbit/s links
- T7 Timer "excessive delay of acknowledgment"
 = 0.5 - 2 seconds for 56 kbit/s, 64 kbit/s, and 1.536 Mbit/s links
 For PCR method, values less than 0.8 seconds should not be used
 = 4 - 6 seconds for 4.8 kbit/s links
- T8 Interval timer for errored interval monitor
 = 100 ms for 1.536 Mbit/s links
- P_e Emergency proving period
 = 2^{12} octets for 56 kbit/s and 64 kbit/s links
 = 5 seconds for 1.536 Mbit/s links
- P_n Normal proving period
 = 2^{14} octets for 56 kbit/s and 64 kbit/s links
 = 30 seconds for 1.536 Mbit/s links

Signalling Link Control
(Level 2)



—— Signalling message flows
 - - - Controls and indications

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

Figure 1/T1.111.3 - Interactions of the Functional Specification Blocks for Signalling Link Control

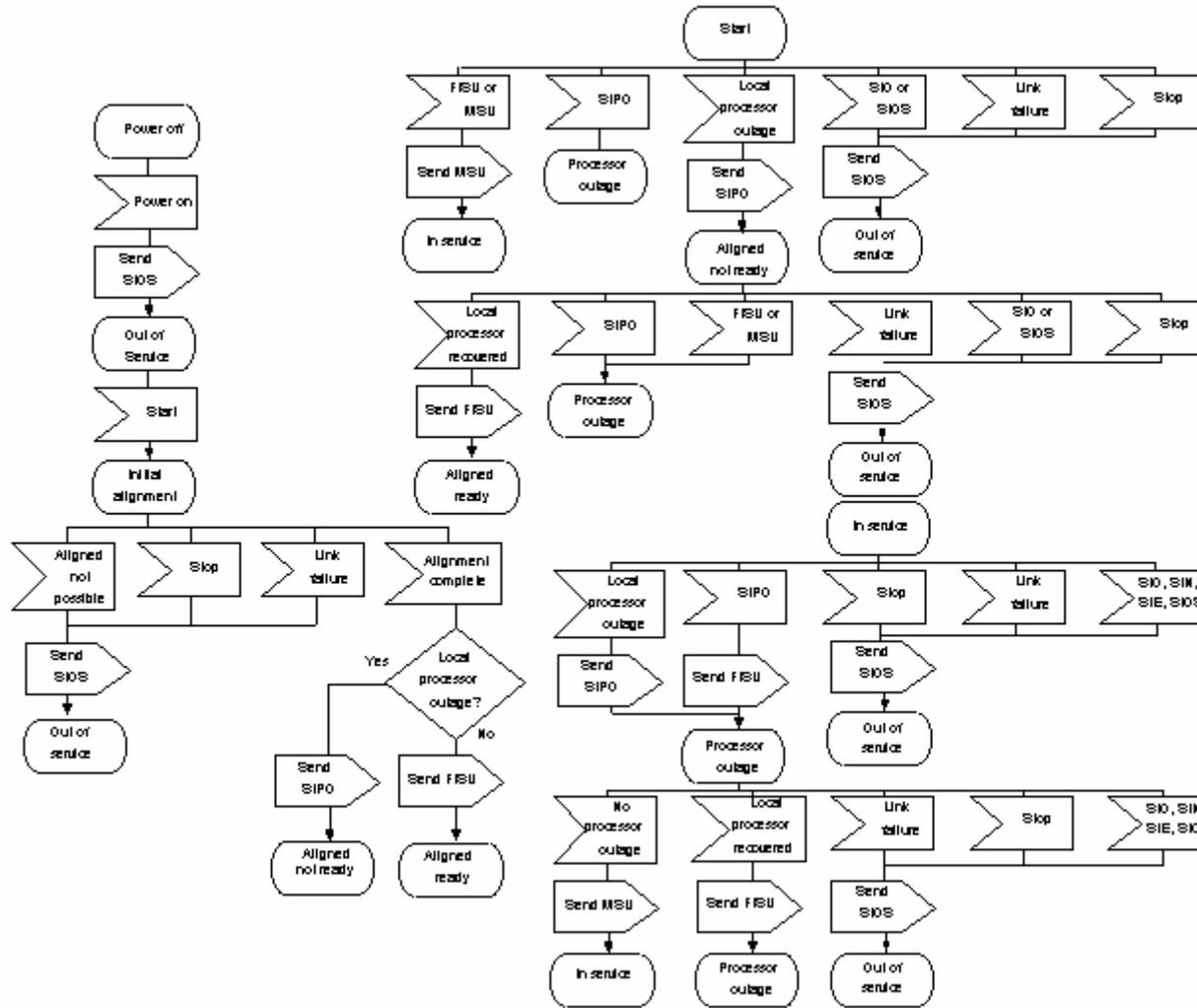


Figure 2/T1.111.3 Overview Diagram of Link State Control

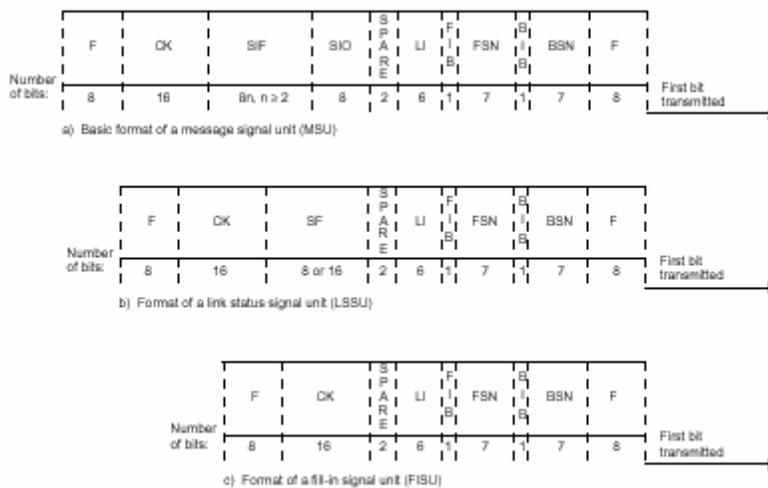


Figure 3A/T1.111.3 Signal Unit Formats for 56 kbit/s and 64 kbit/s Signalling Links

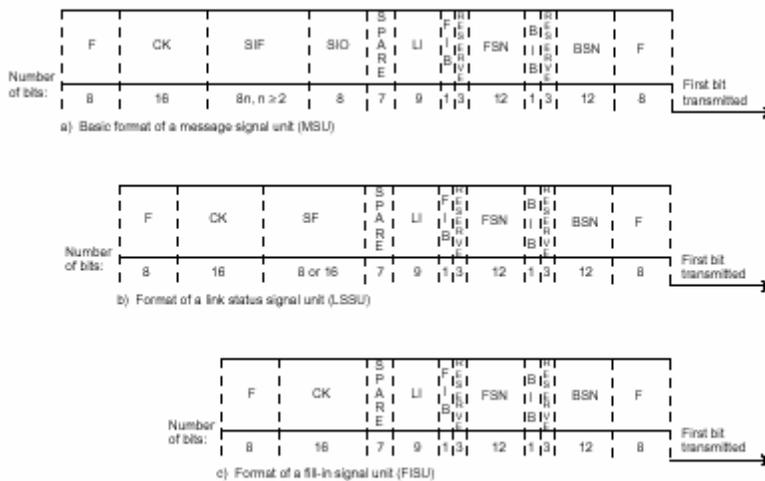


Figure 3B/T1.111.3 Signal Unit Formats for 1.536 Mbit/s Signalling Links

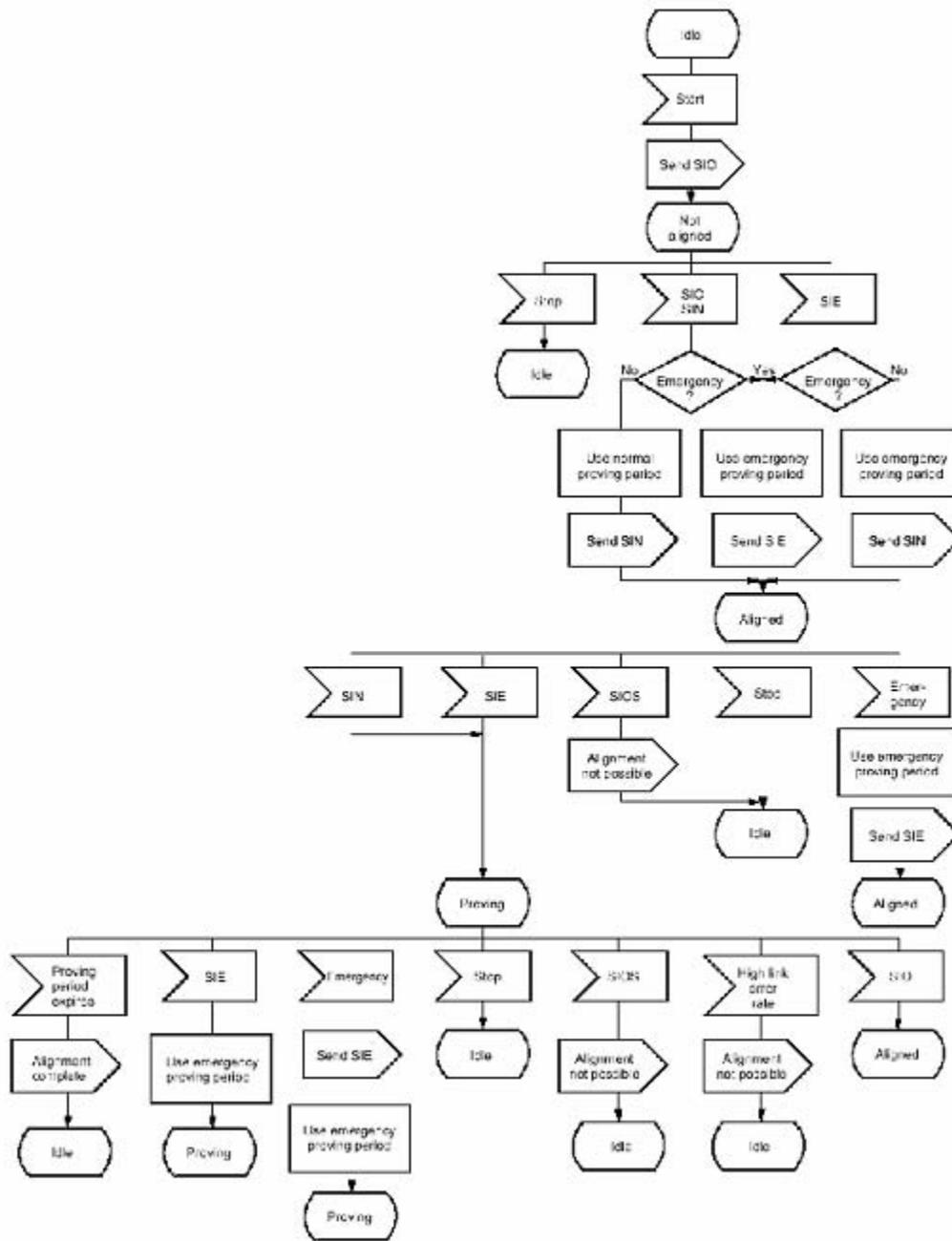


Figure 4/T1.111.3 Overview Diagram of Initial Alignment Control

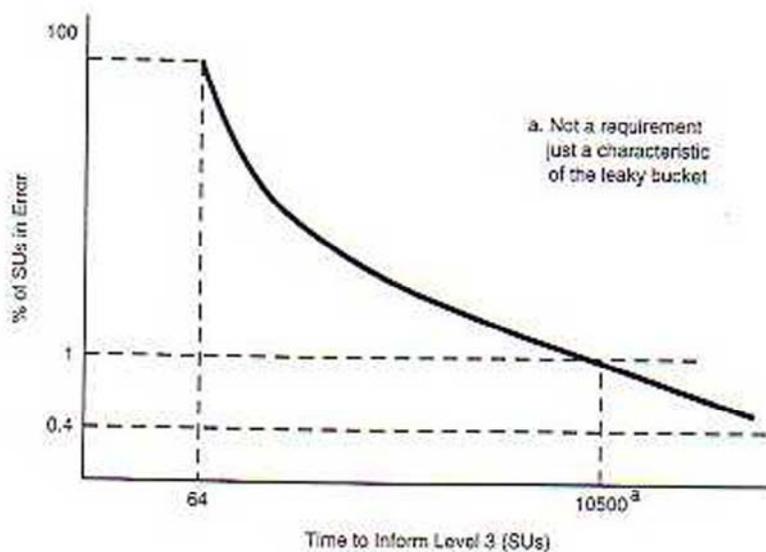


Figure 5/T1.111.3 Relationship between the Expected Number of Signal Units to Fault Indication and Signal Unit Error Rate

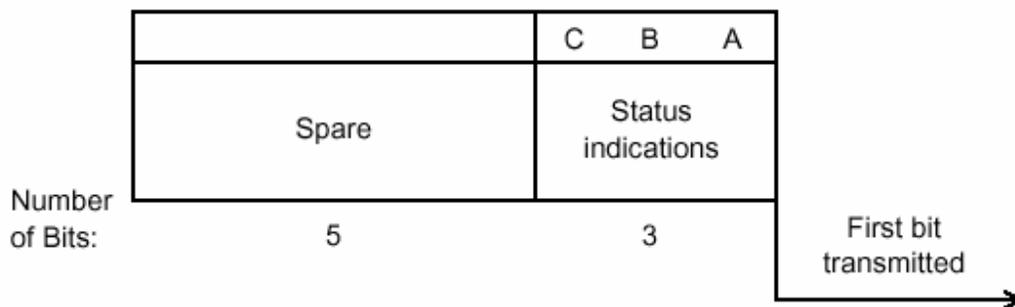
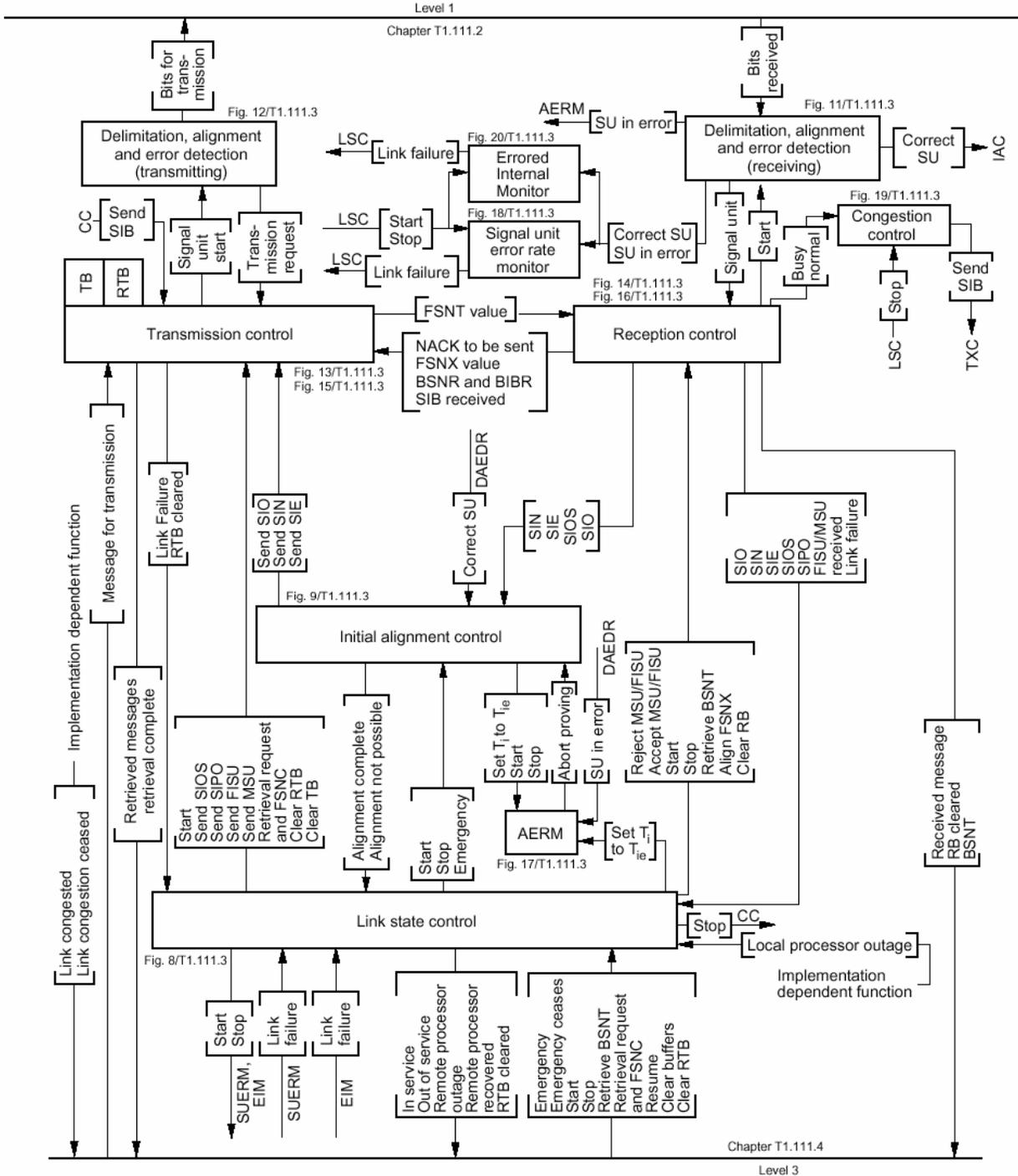


Figure 6/T1.111.3 Status Field Format



Note - Abbreviated message names have been used in this diagram (i.e. origin - destination codes are omitted).

Figure 7/T1.111.3 Level 2 – Functional Block Diagram

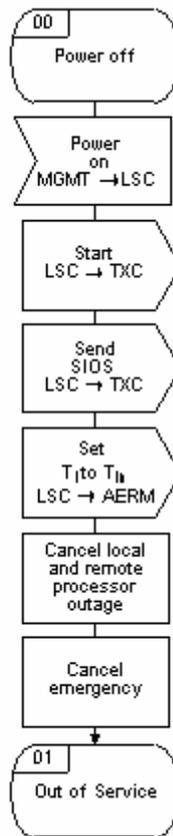


Figure 8/T1.111.3 Link State Control (Sheet 1 of 7)

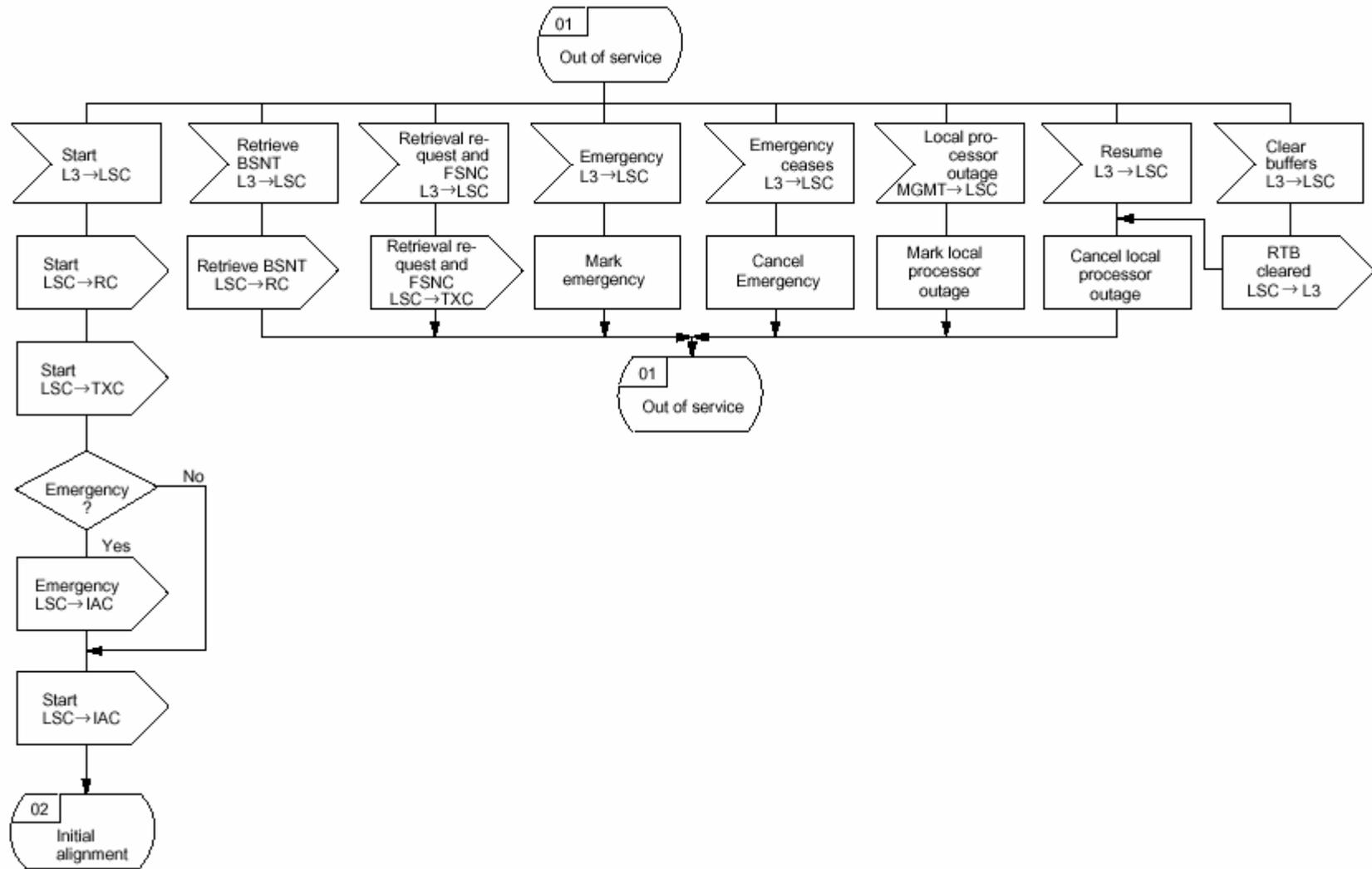


Figure 8/T1.111.3 Link State Control (Sheet 2 of 7)

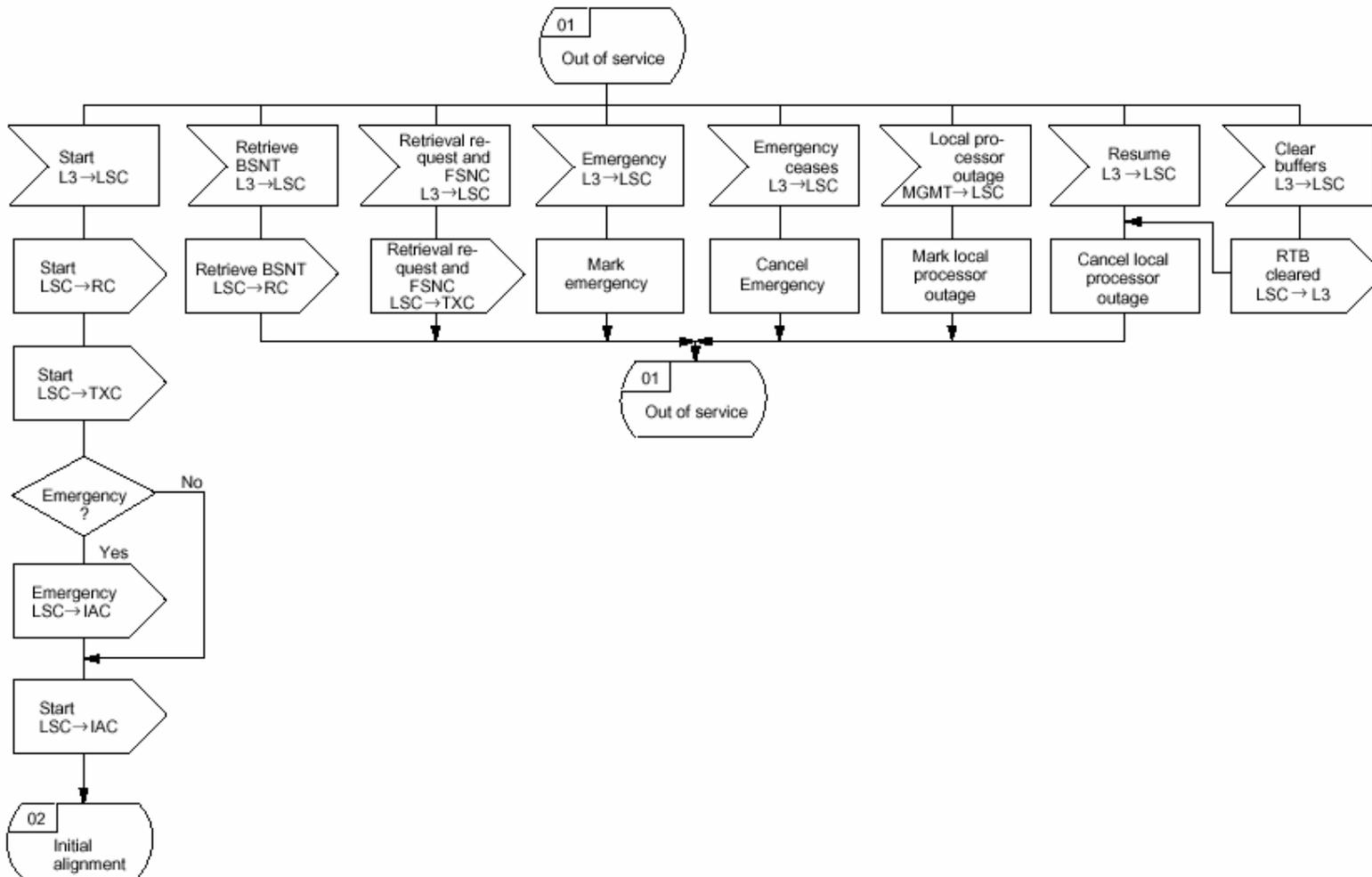


Figure 8/T1.111.3 Link State Control (Sheet 3 of 7)

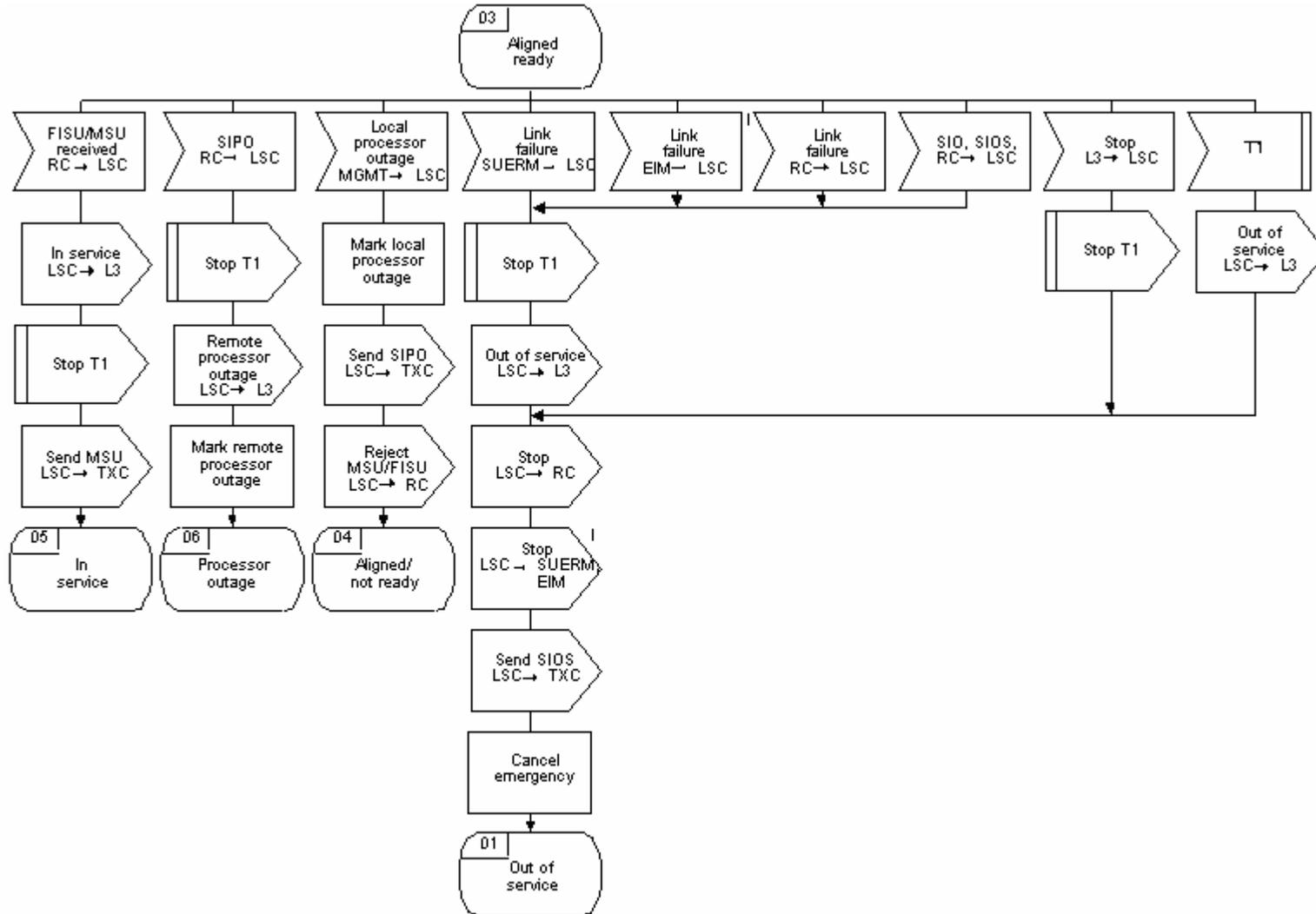


Figure 8/T1.111.3 Link State Control (Sheet 4 of 7)

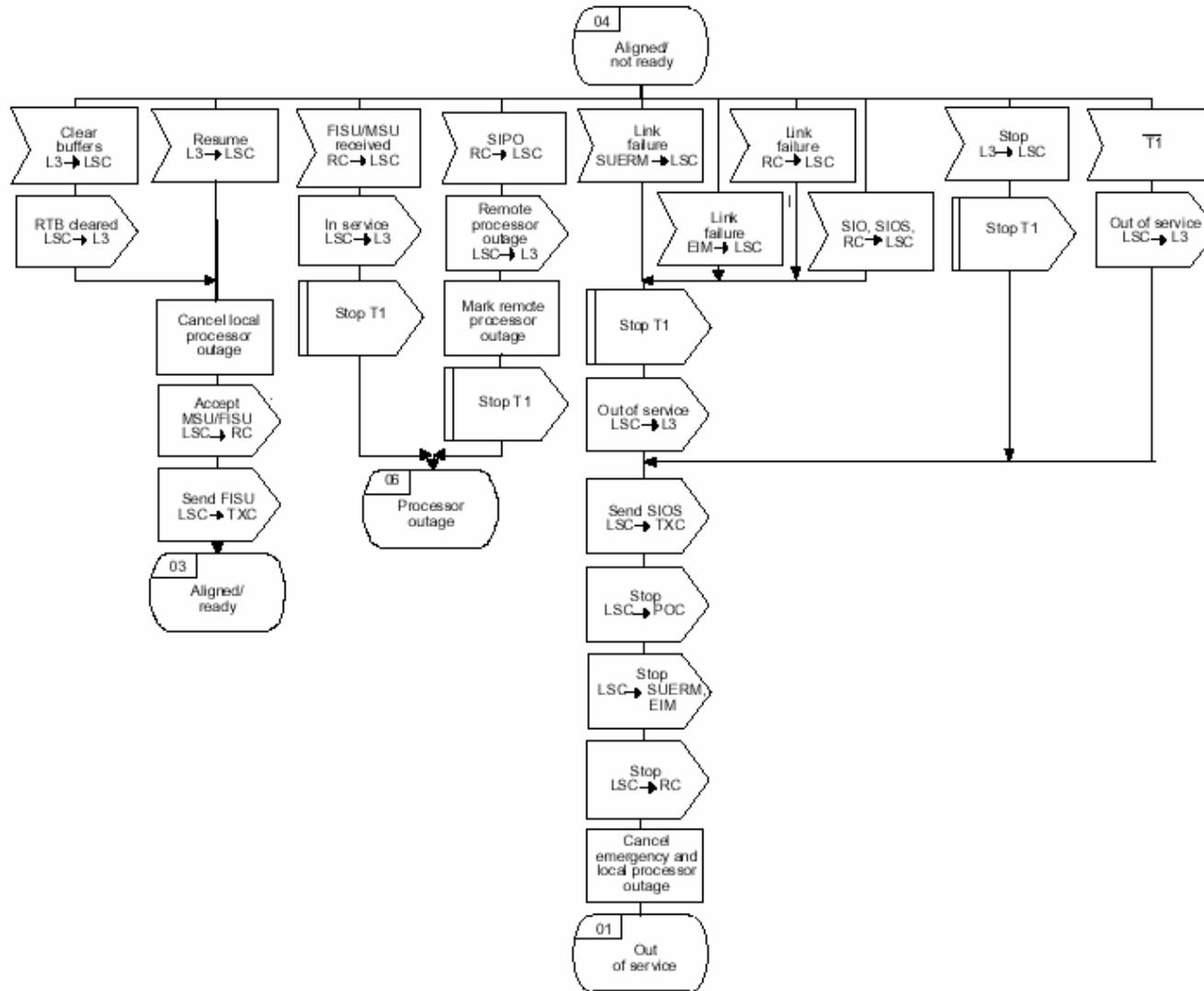


Figure 8/T1.111.3 Link State Control (Sheet 5 of 7)

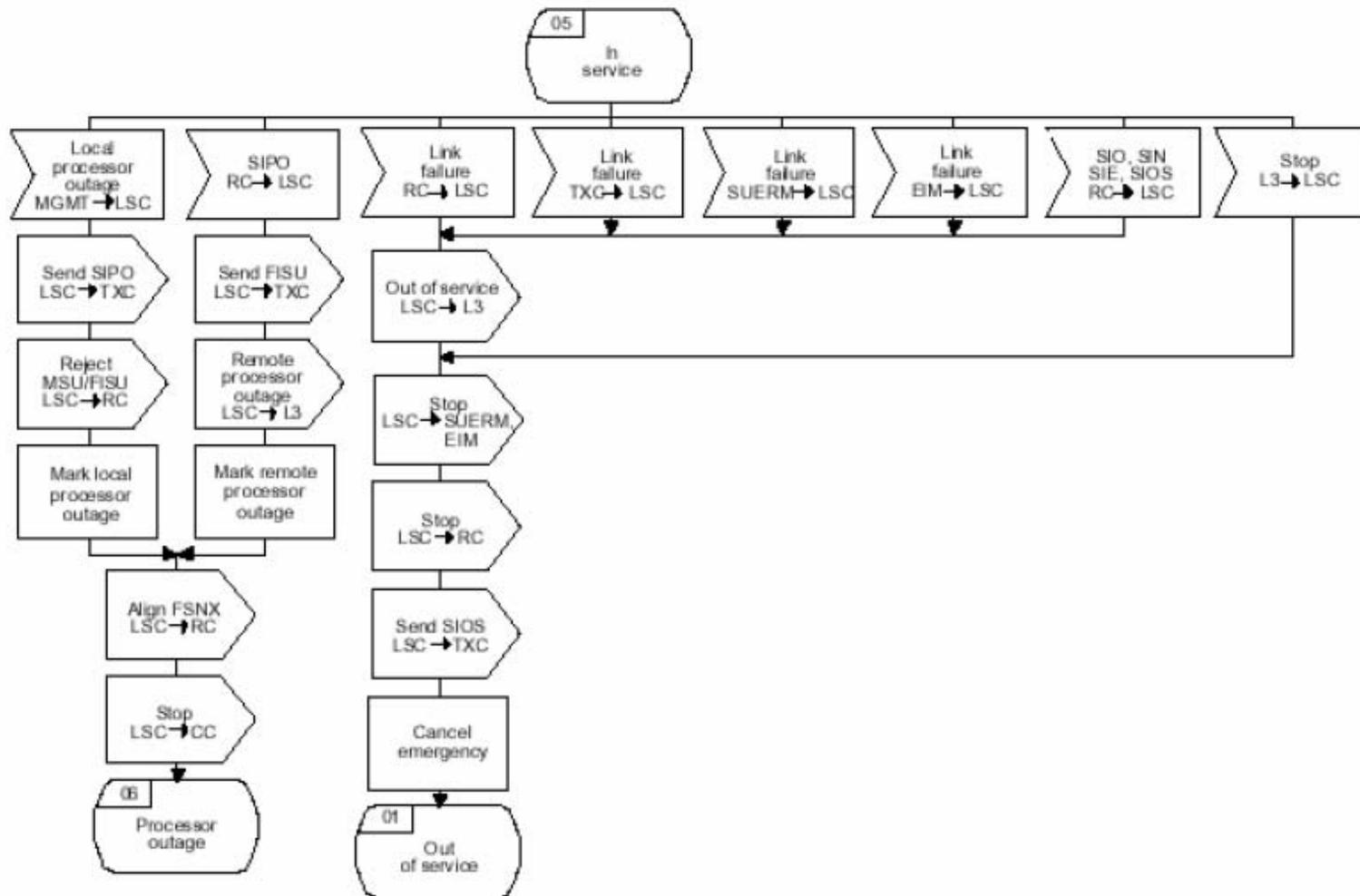


Figure 8/T1.111.3 Link State Control (Sheet 6 of 7)

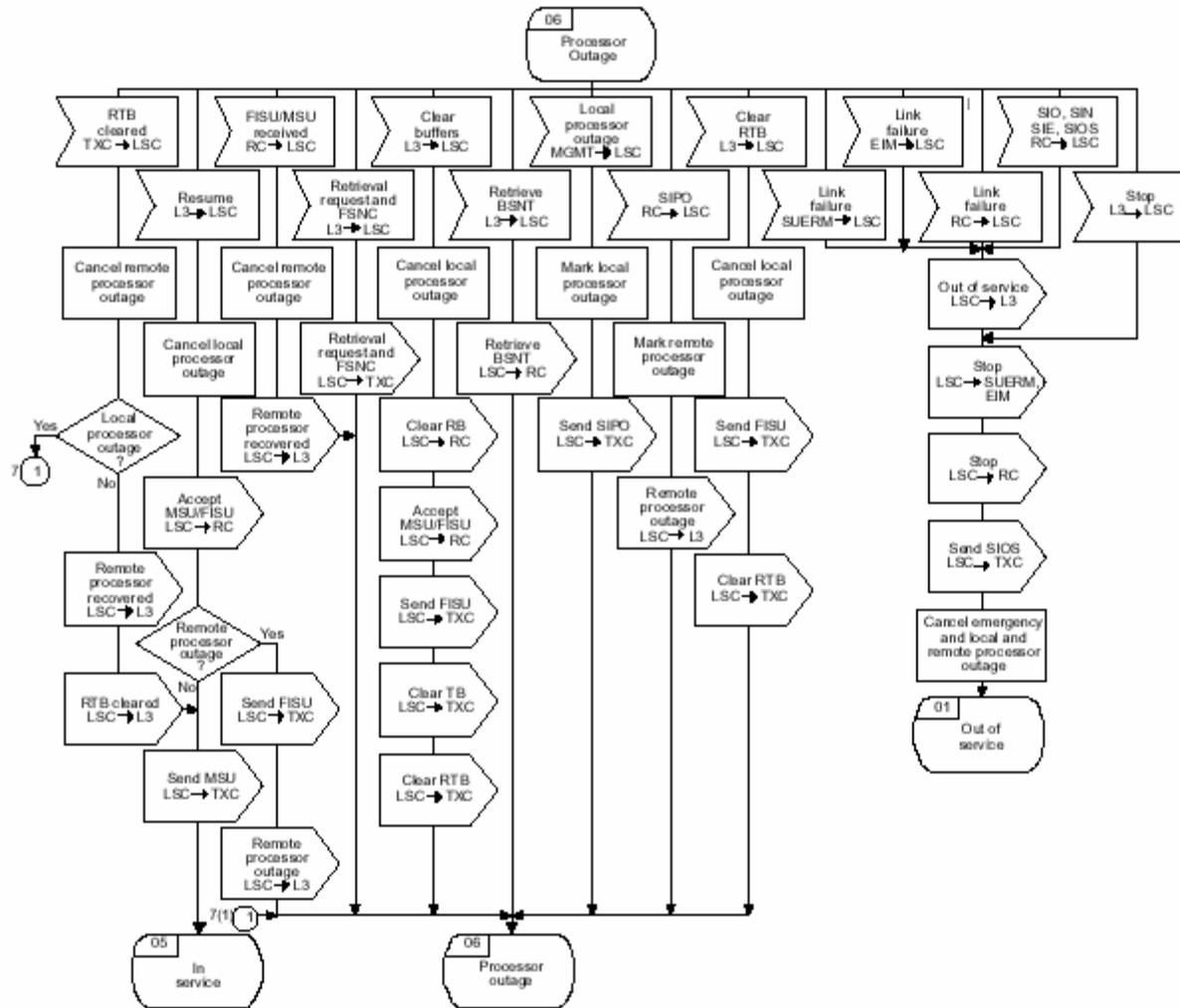


Figure 8/T1.111.3 Link State Control (Sheet 7 of 7)

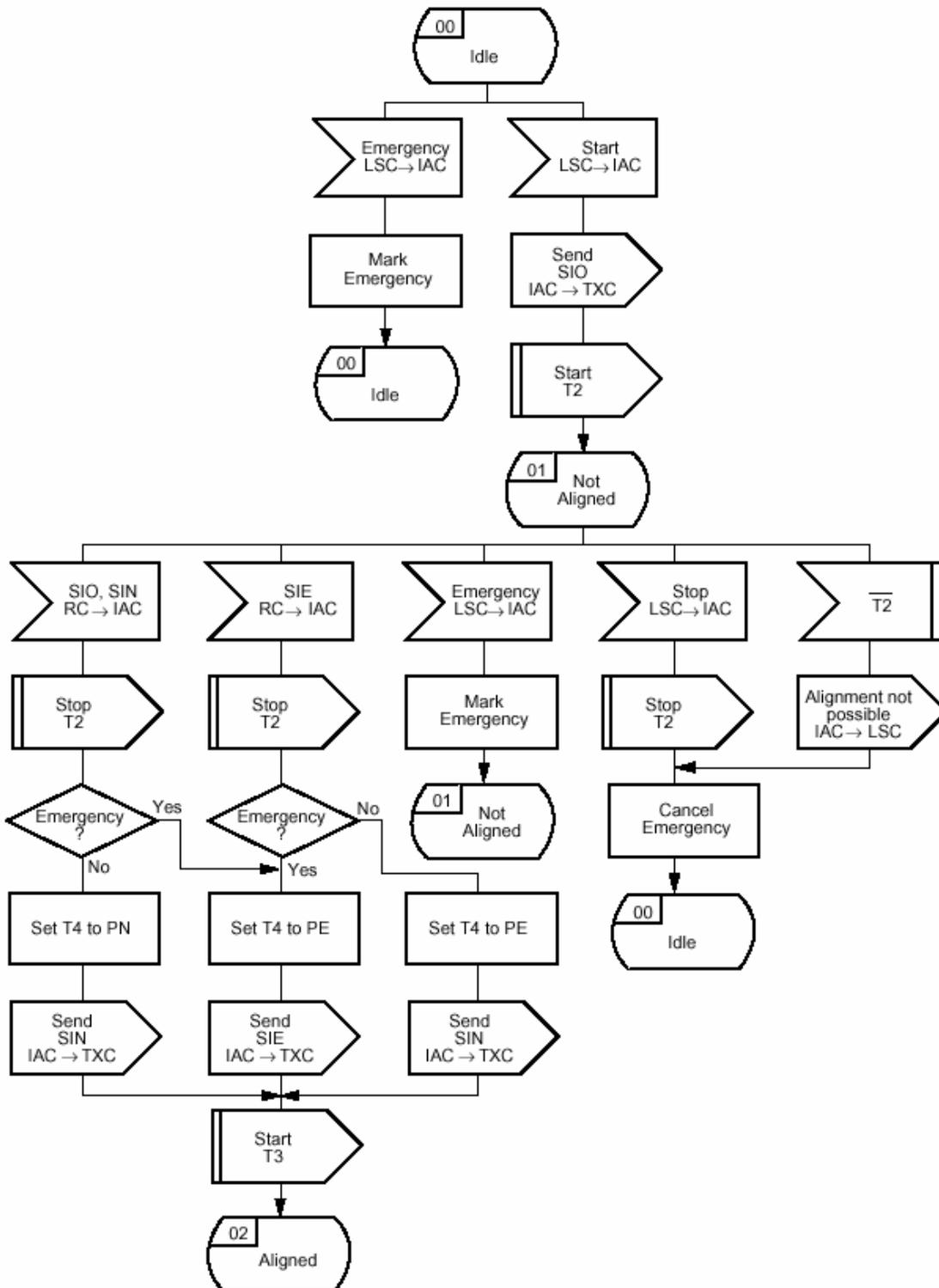


Figure 9/T1.111.3 Initial Alignment Control (Sheet 1 of 3)

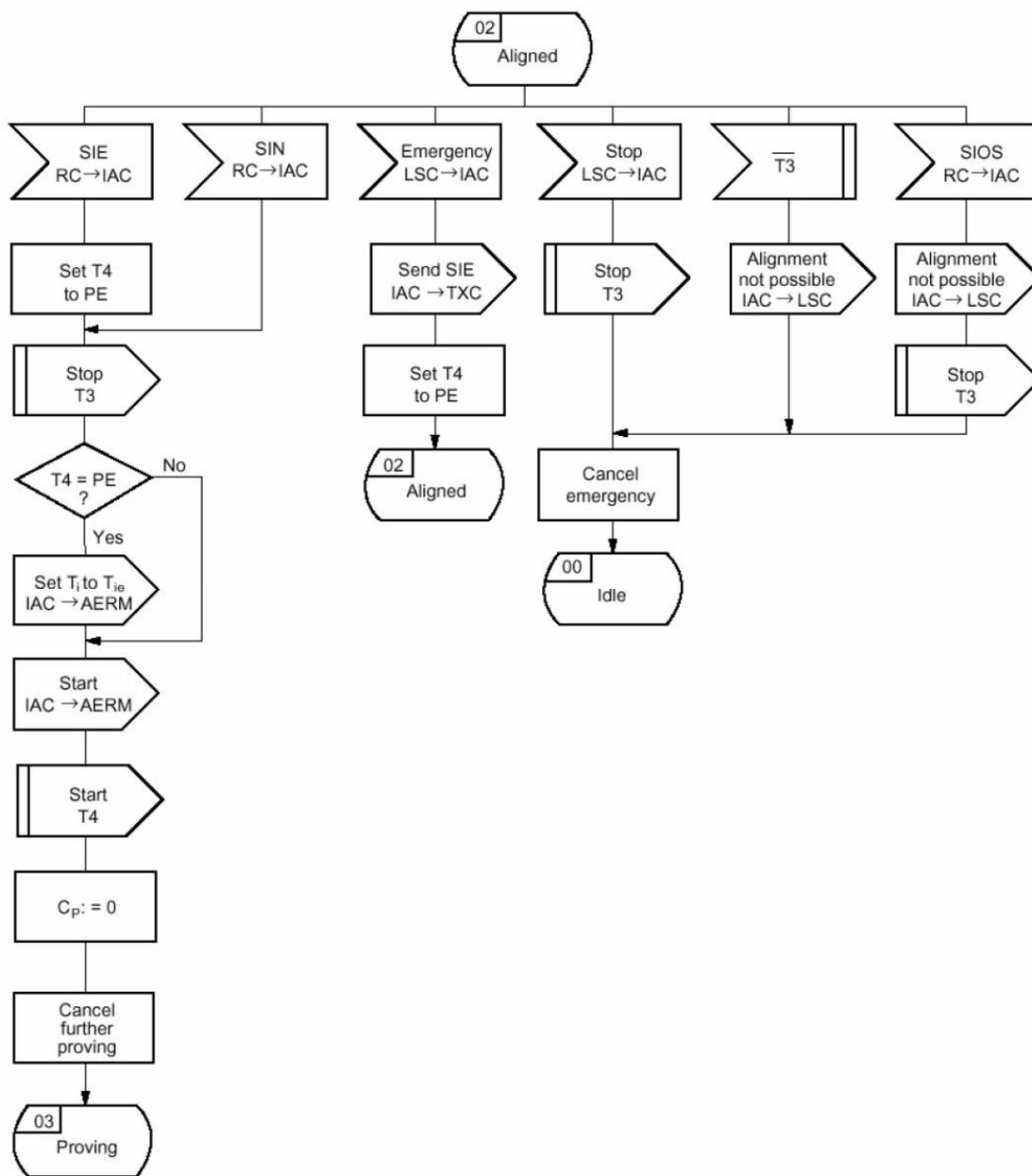


Figure 9/T1.111.3 Initial Alignment Control (Sheet 2 of 3)

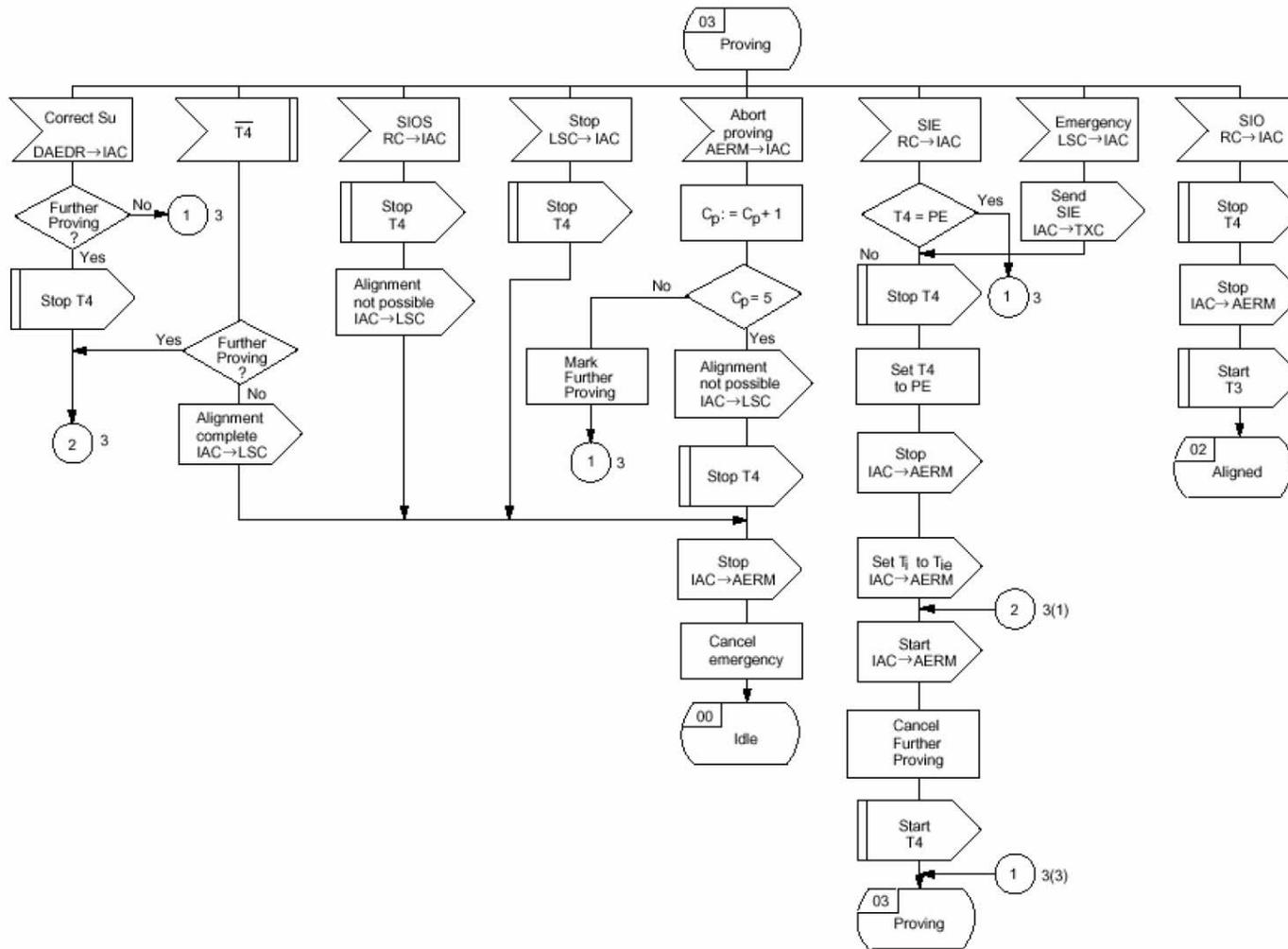


Figure 9/T1.111.3 Initial Alignment Control (Sheet 3 of 3)

The functions that were shown in Figure 10/T1.111.3 in a previous issue of this document have been included in Figure 8/T1.111.3.

Figure 10/T1.111.3 Processor Outage Control

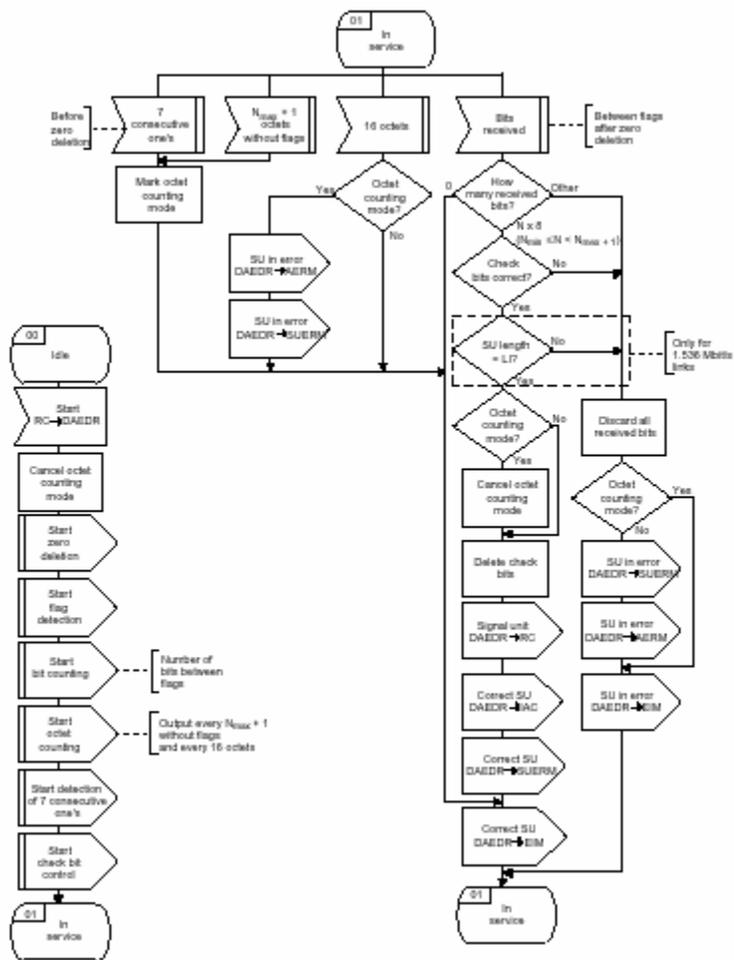


Figure 11/T1.111.3 Delimitation, Alignment, and Error Detection (Receiving)

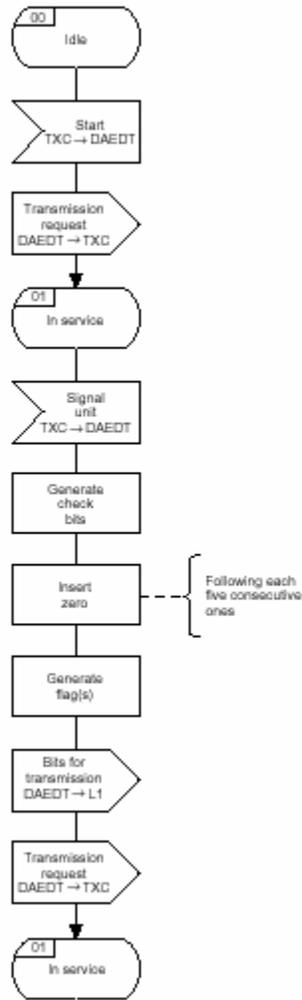


Figure 12/T1.111.3 Delimitation, Alignment, and Error Detection (Transmitting)

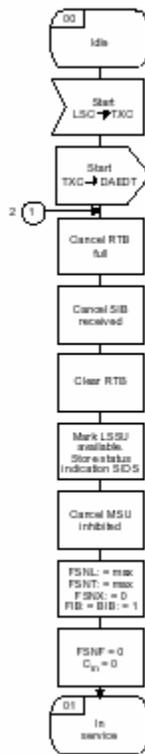


Figure 13/T1.111.3 Basic Transmission Control (Sheet 1 of 4)

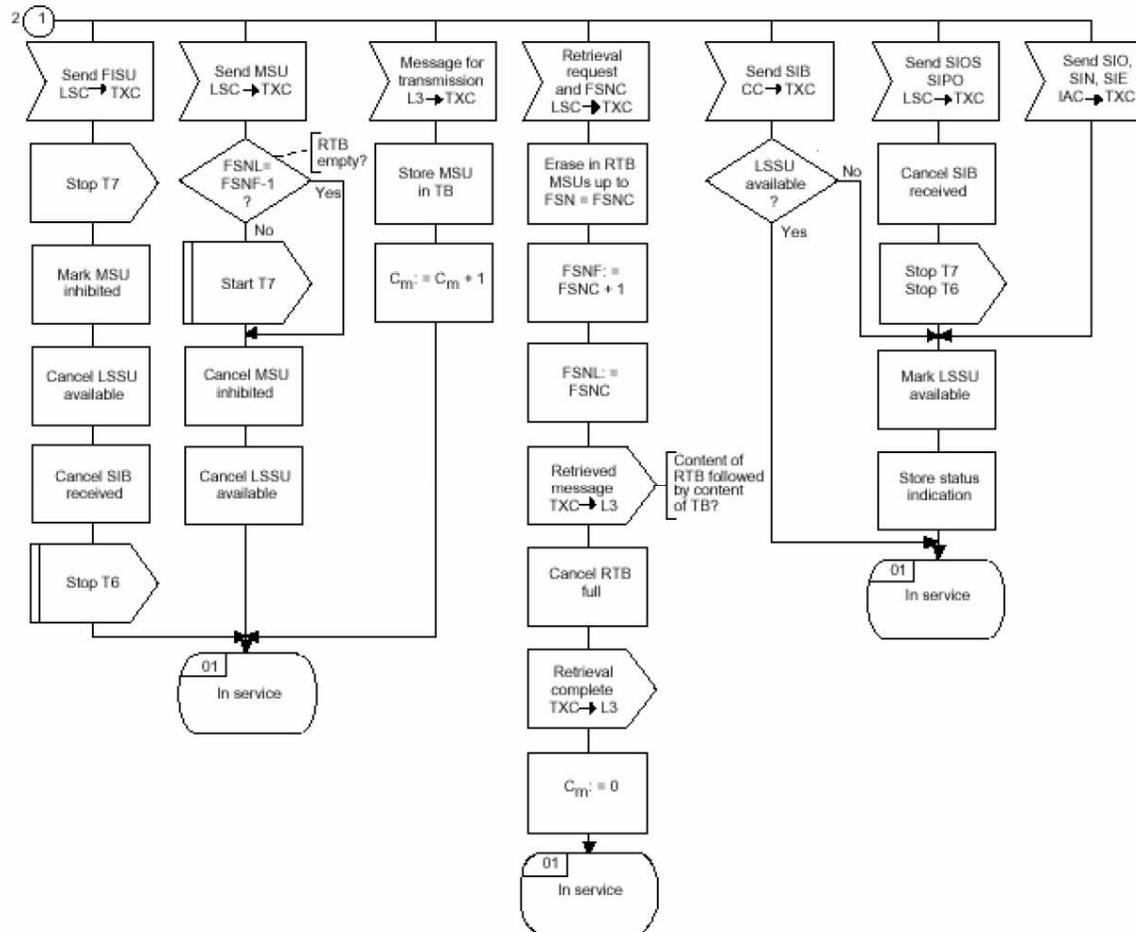


Figure 13/T1.111.3 Basic Transmission Control (Sheet 3 of 4)

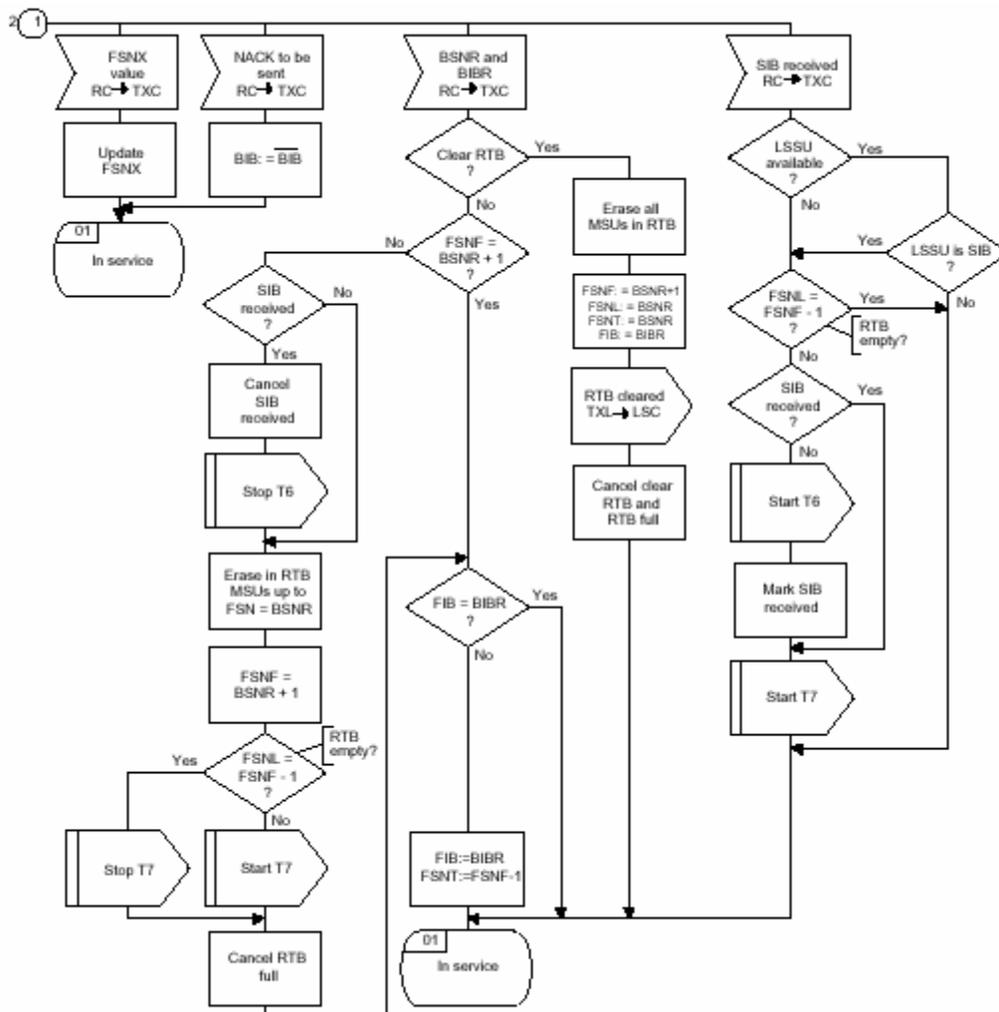


Figure 13/T1.111.3 Basic Transmission Control (Sheet 4 of 4)

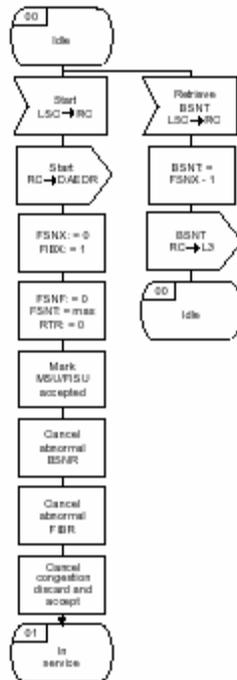


Figure 14/T1.111.3 Basic Reception Control (Sheet 1 of 4)

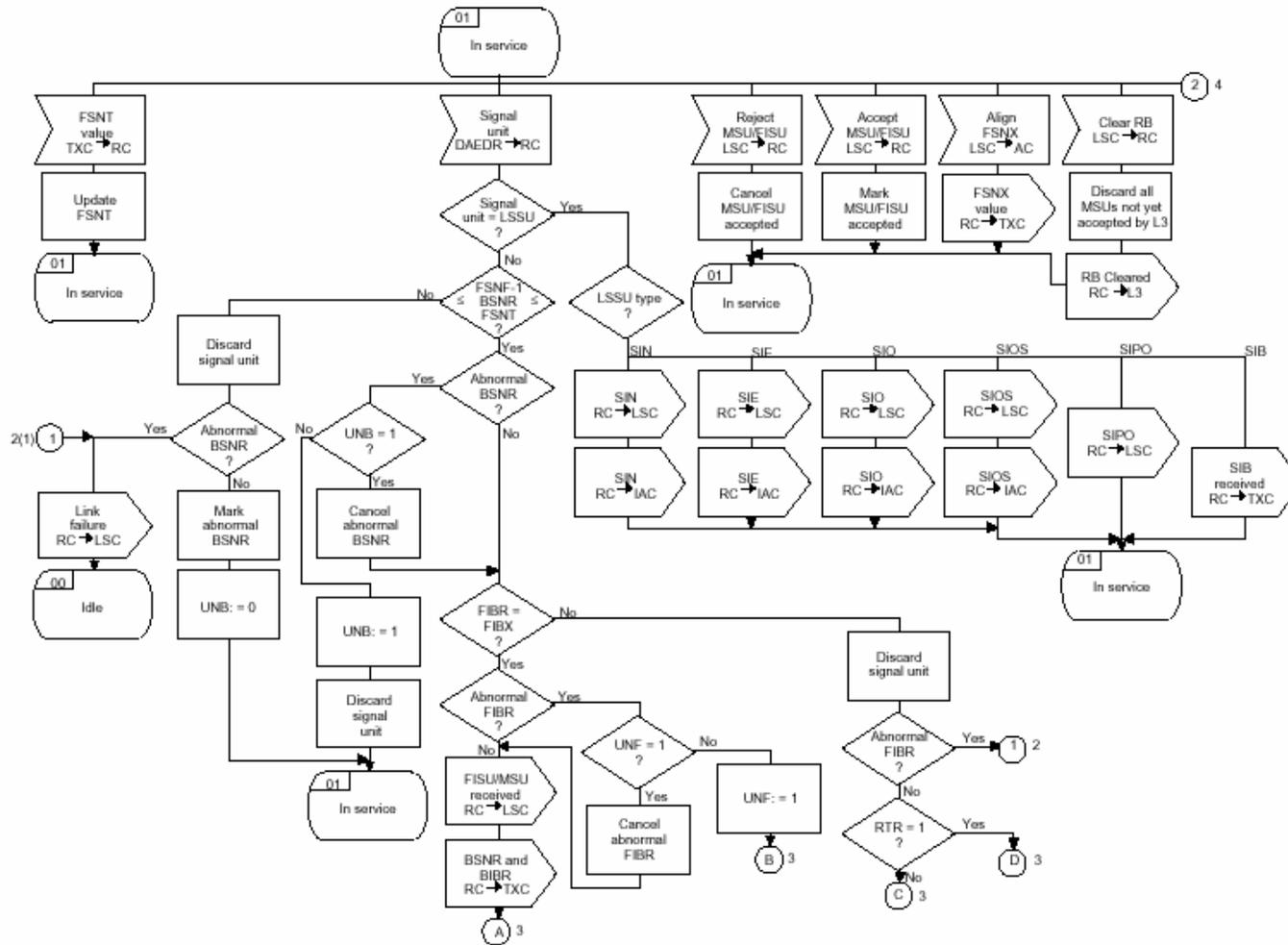


Figure 14/T1.111.3 Basic Reception Control (Sheet 2 of 4)

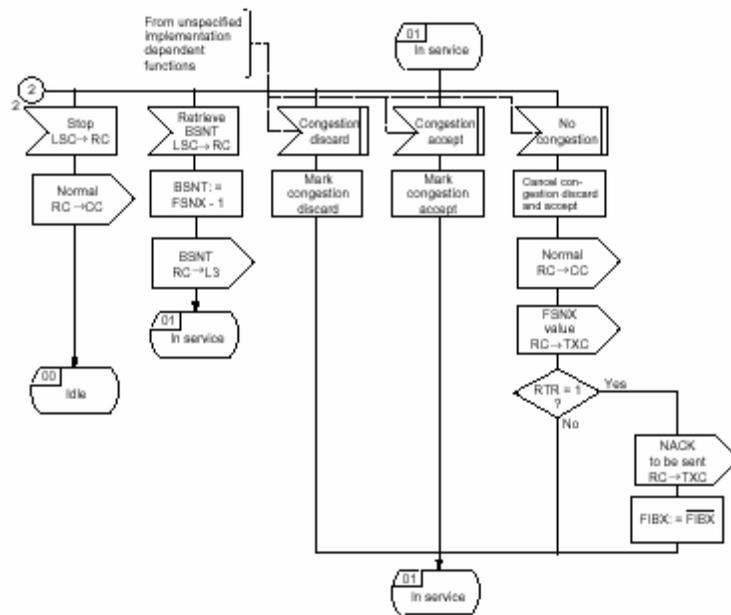


Figure 14/T1.111.3 Basic Reception Control (Sheet 4 of 4)

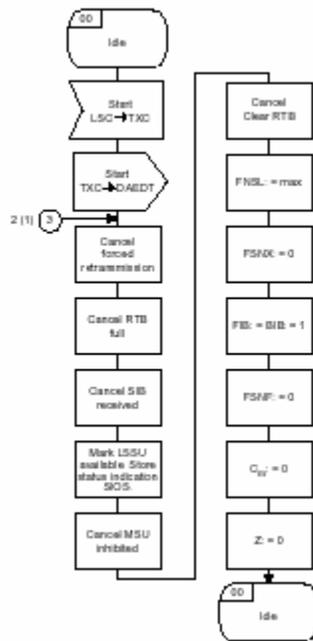


Figure 15/T1.111.3 Preventive Cyclic Retransmission - Transmission Control (Sheet 1 of 3)

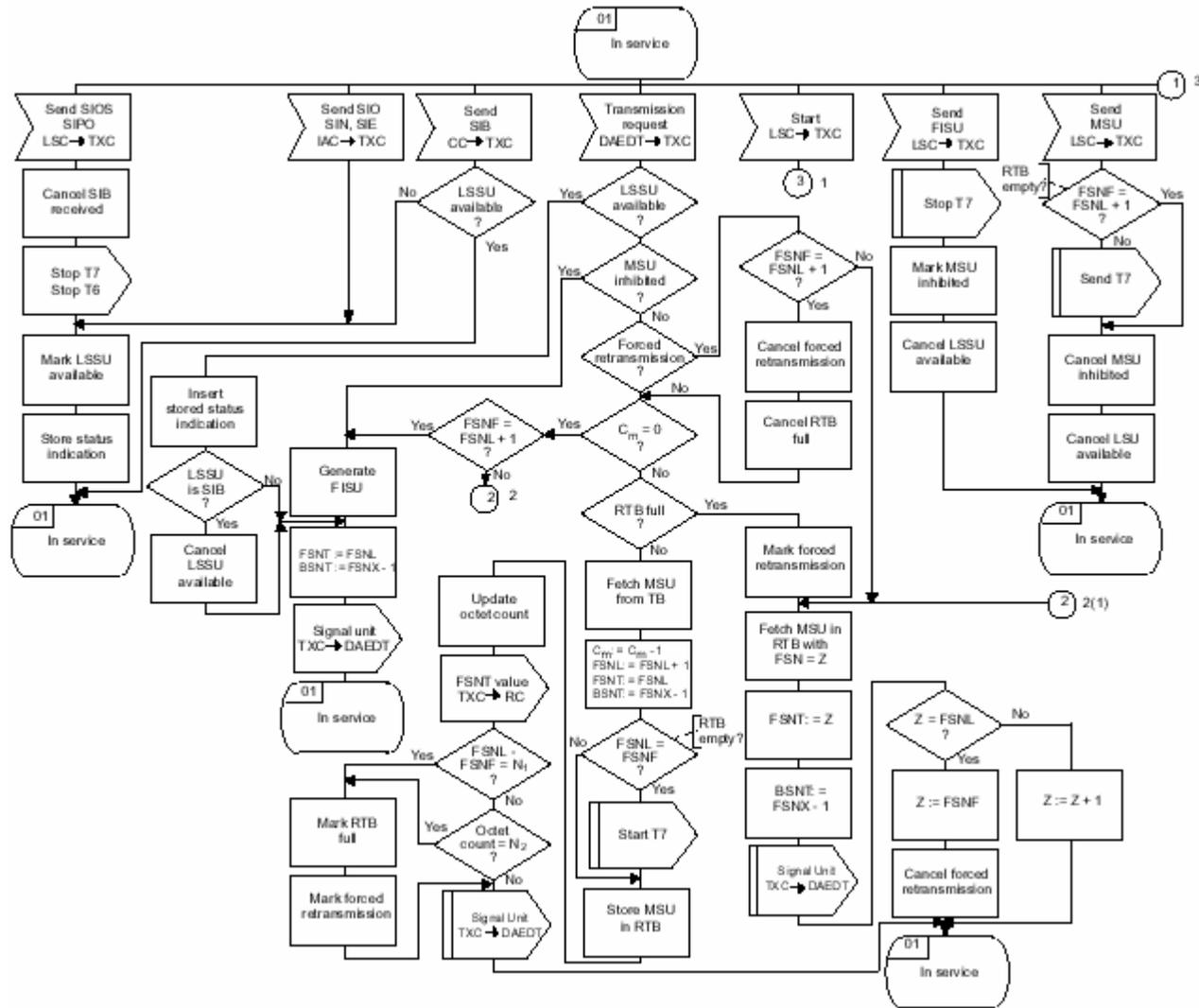


Figure 15/T1.111.3 Preventive Cyclic Retransmission - Transmission Control (Sheet 2 of 3)

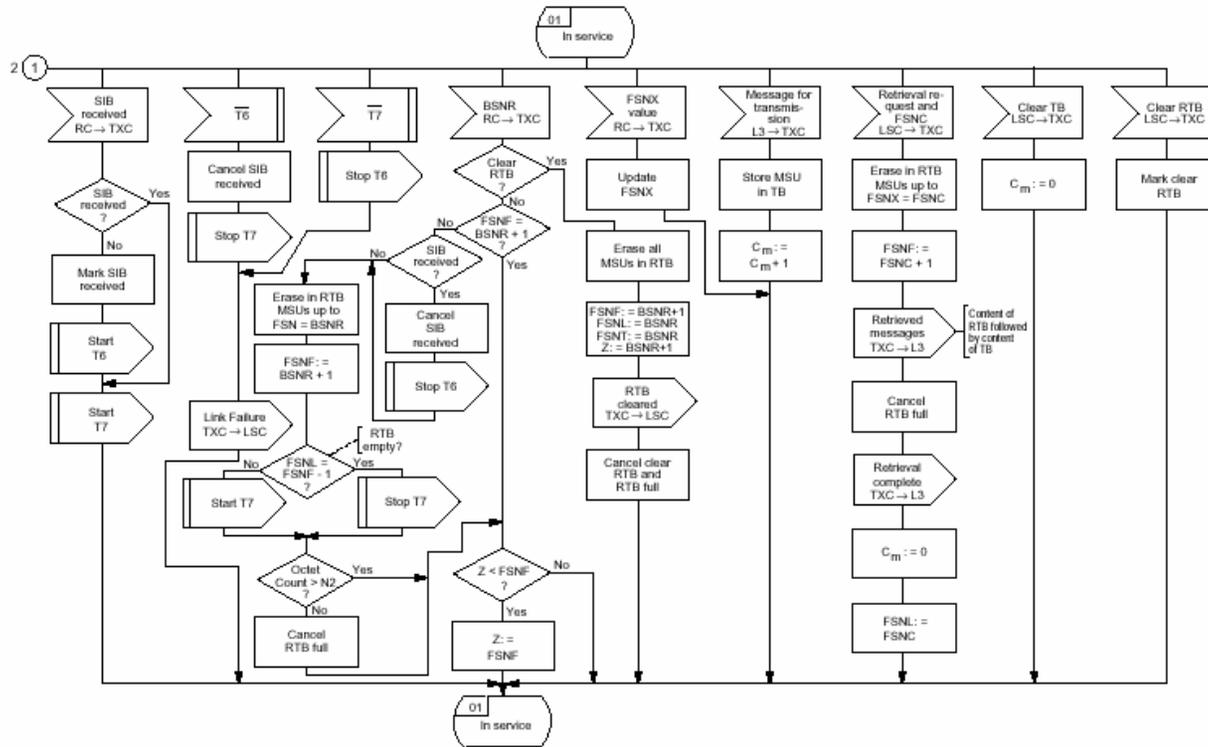


Figure 15/T1.111.3 Preventive Cyclic Retransmission - Transmission Control (Sheet 3 of 3)

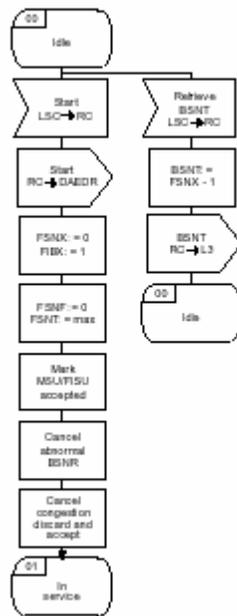


Figure 16/T1.111.3 Preventive Cyclic Retransmission - Reception Control (Sheet 1 of 3)

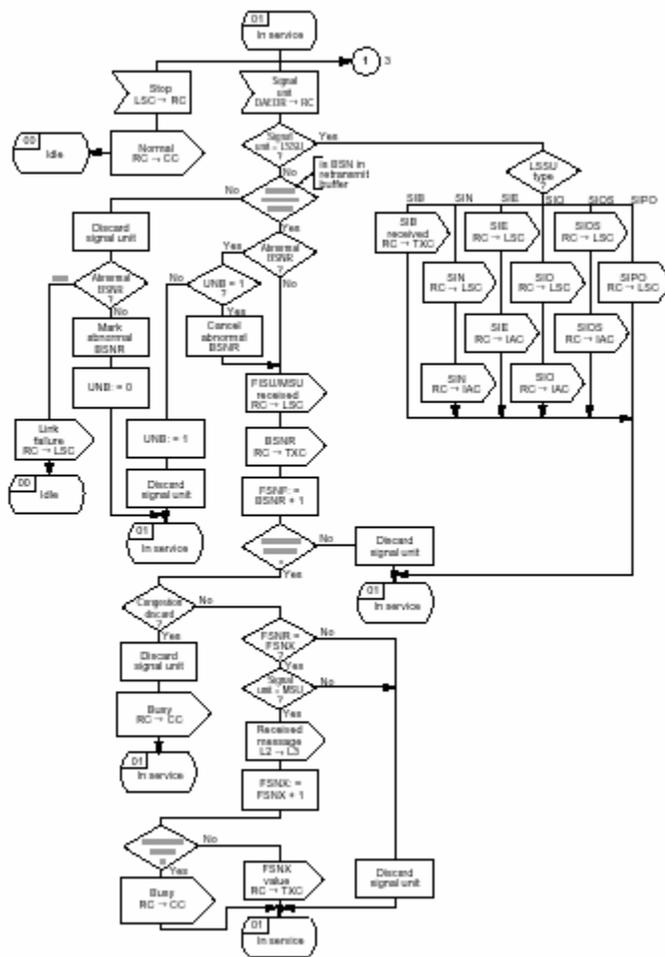


Figure 16/T1.111.3 Preventive Cyclic Retransmission - Reception Control (Sheet 2 of 3)

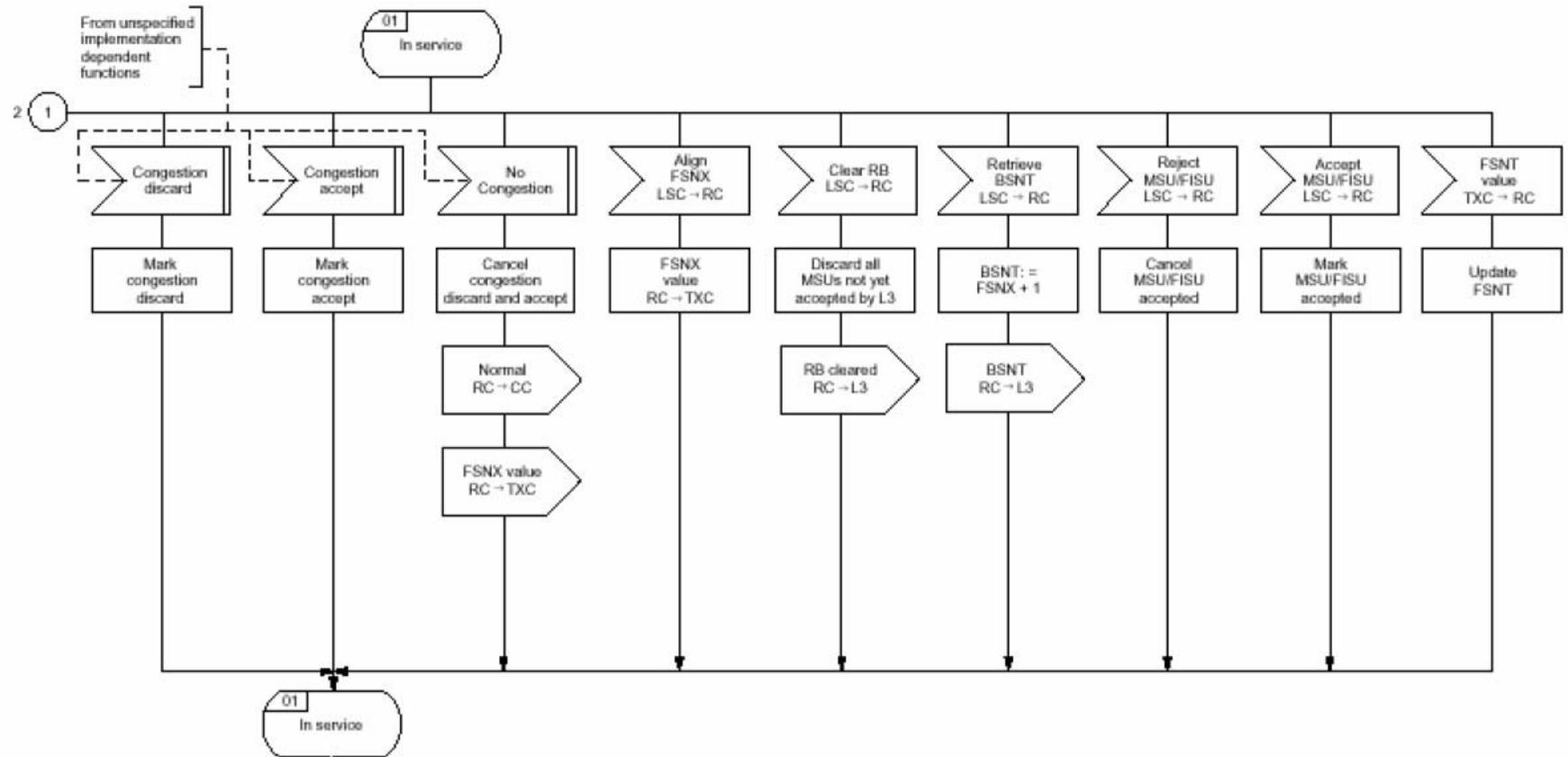


Figure 16/T1.111.3 Preventive Cyclic Retransmission - Reception Control (Sheet 3 of 3)

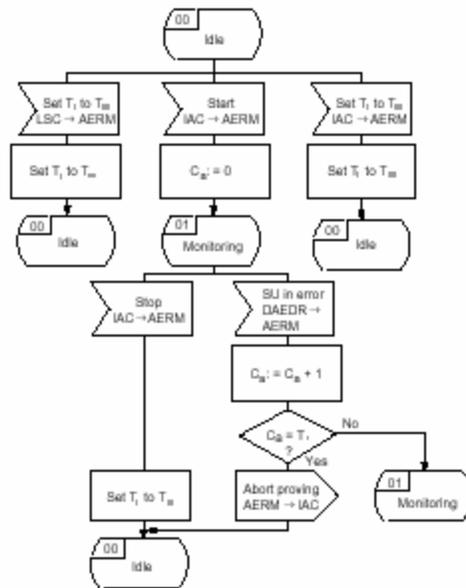


Figure 17/T1.111.3 Alignment Error Rate Monitor

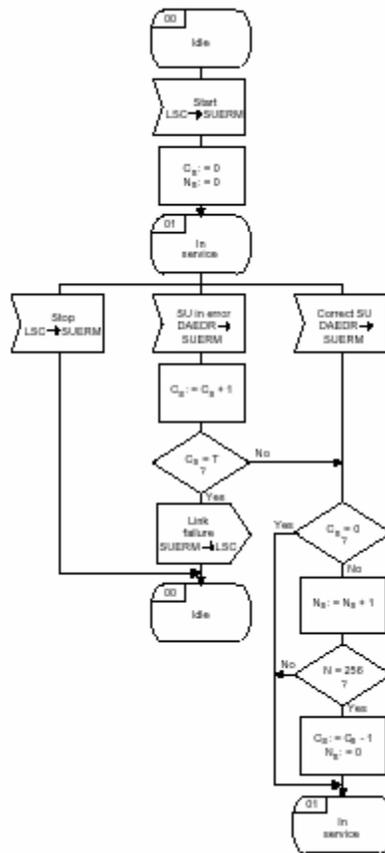


Figure 18/T1.111.3 Signal Unit Error Rate Monitor (for 56 kbit/s and 64 kbit/s Links)

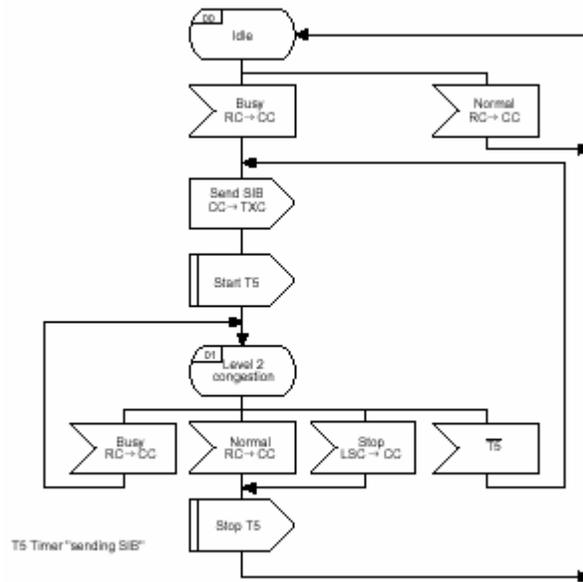


Figure 19/T1.111.3 Congestion Control

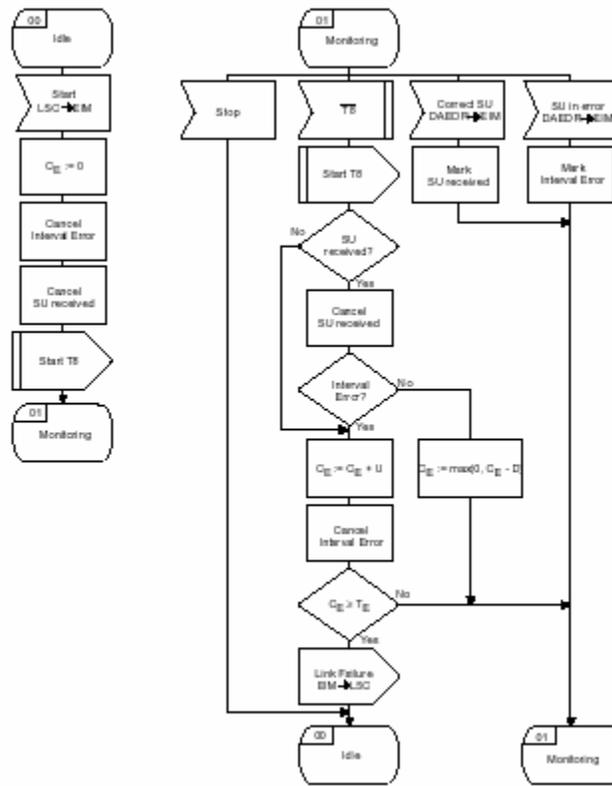


Figure 20/T1.111.3 Errorred Interval Monitor (for 1.536 Mbit/s Links)

Chapter T1.111.4

Signalling Network Functions and Messages

EDITORIAL NOTE – In this Chapter, all page numbers are in the format T1.111.4-#.

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Signalling System Number 7 (SS7) – Signalling Network Functions and Messages

1 SCOPE, PURPOSE, & APPLICATION¹

This chapter may contain requirements that reference other American National Standards. If so, when the American National Standards referenced in the requirements are superseded by revisions approved by the American National Standards Institute, Inc., the revisions shall apply.

1.1 *General Characteristics of the Signalling Network Functions*

1.1.1 Chapter T1.111.4 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 MTP Level 1 and MTP Level 2 protocols described in Chapters T1.111.2 and T1.111.3, respectively (called MTP Level 2 links), or the Signalling Asynchronous Transfer Mode (ATM) Adaptation Layer (SAAL), ATM Layer, and the physical layer, described in T1.636-1999 (R2005), T1.627-1993 (R2004), and T1.640-2001 (R2006) and T1.646-2003, respectively (called SAAL links). The signalling network functions must ensure a reliable transfer of the signalling messages, according to the requirements specified in Chapter T1.111.6, 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 1) signalling message handling; and 2) signalling network management.

The signalling message handling functions are briefly summarized in 1.2; the signalling network management functions in 1.3. The functional interrelations between these functions are indicated in Figure 1/T1.111.4.

1.1.2A The procedures specified in this chapter are the set of procedures with national options to be used in U. S. networks. International procedures that will only be used for signalling on international routes are so indicated.

¹ A "|" indicates a change from T1.111.

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 clause 2.

1.2.3 As illustrated in Figure 1/T1.111.4, the signalling message handling functions are divided into:

1. 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.
2. The message discrimination function, used at a signalling point to determine whether or not a received message is destined to the point itself. When the signalling point has the transfer capability and a message is not destined to it, that message has to be transferred to the message routing function.
3. 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 clause 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 and to control the traffic in case of congestion. Such a reconfiguration is effected by use of appropriate procedures to change the routing of signalling traffic in order to bypass 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 reestablish the normal configuration of the signalling network.

1.3.2 As illustrated in Figure 1/T1.111.4, the signalling network management functions are divided into:

1. Signalling traffic management;
2. Signalling link management; and
3. 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 clause 3.

1.3.3 Clauses 4 to 11 specify the procedures pertaining to signalling traffic management. In particular, the rules to be followed for the modification of signalling routing appear in clause 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", "controlled rerouting" and "MTP restart". They are specified in clauses 5 through 9, respectively. A signalling link may be made unavailable to User-Part-generated traffic by means of the "management inhibiting" procedures described in clause 10. 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 clause 11.

1.3.4 The different procedures pertaining to signalling link management are: "restoration", "activation", and "deactivation" of a signalling link; "link set activation"; and "automatic allocation" of signalling terminals and signalling data links. These procedures are specified in clause 12.

1.3.5 The different procedures pertaining to signalling route management are: the "transfer-prohibited", "transfer-allowed", "transfer-restricted",² "transfer-controlled", "signalling-route-set-test", and "signalling-route-set-congestion-test" procedures specified in clause 13.

1.3.6 The format characteristics common to all MTP Level 3 messages are specified in clause 14.

1.3.7 Labeling, formatting, and coding of the signalling network management messages are specified in clause 15.

² The transfer restricted procedure is a national option within the ITU-T specification; it is a standard procedure for U.S. networks.

1.3.8 The description of signalling network functions in the form of state transition diagrams according to the CCITT Specification and Description Language (SDL) is given in clause 16.

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 message to be sent, whereas message distribution and discrimination are functions concerning the received messages. The functional relations among message routing, distribution, and discrimination appear in Figure 2/T1.111.4.

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 another signalling point. When the signalling point has the transfer capability and the received message is not destined to it, the message has to be transmitted on an outgoing link according to the routing function.

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 network 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 network indicator are described in 14.2. 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 clause 15 for the signalling network management messages. The label used for signalling network management messages is also used for testing and maintenance messages (see Chapter T1.111.7). Moreover, the general characteristics of the routing label are described in 2.2.

A description of the detailed characteristics of the message routing function, including load sharing, appears in 2.3; principles concerning the number of load-shared links appear in Chapter T1.111.5.

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

2.1.7 In addition to the normal signalling message handling procedures it may, as an option, be possible to prevent the unauthorized use of the message transfer capability of a node. The procedures to be used are implementation-dependent and further information is given in clause 8 of Chapter T1.111.5.

2.2 *Routing Label*

2.2.1 The label contained in a signalling 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.³

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

The U. S. national label contained in a signalling message only contains 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 labels for use in U. S. networks are specified in the following subclauses.

2.2.2 The standard international routing label has a length of 32 bits and is placed at the beginning of the Signalling Information Field. Its structure appears in Figure 3/T1.111.4.

2.2.2A The U. S. national routing label has a length of 56 bits and is placed at the beginning of the signalling information field. Its structure appears in Figure 3A/T1.111.4.

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. In the international routing label the coding of these codes is pure binary. In the U. S. routing label each point code has the

³ Text from the CCITT Blue Book Vol. VI related to a modified label structure was deleted from this clause.

structure described in 2.2.3A. 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 any network, irrespective of the User Parts connected to each signalling point.

2.2.3A In the U. S. national routing label both the originating point code and the destination point code are constructed of fields as shown in Figure 3B/T1.111.4.

2.2.3B In many cases the value in the Network Identifier Field directly identifies the network to which a point code belongs; however, as specified in detail in Chapter T1.111.8, a number of values of that field have been reserved as escape codes so that more than 256 networks can be addressed. The appearance of one of these reserved values in the network identifier field of a point code indicates that the network cluster field should be used to identify the network to which the point code belongs.

2.2.3C Other values of the network identifier field are reserved to indicate that the point code identifies a signalling point belonging to a group of commonly administered signalling points that does not qualify for network status. Blocks of contiguous point codes are assigned to these groups of signalling points as specified in Chapter T1.111.8.

2.2.3D The cluster member code 00000000 is reserved for addressing points with signalling transfer point functionality and is not assigned to signalling points without the transfer function; however, a signalling transfer point is not required to have an address with a cluster member code of 00000000.

2.2.4 The Signalling Link Selection (SLS) Field is used, where appropriate, in performing load sharing, see 2.3. This field exists in all types of messages and always in the same position.⁴

In the case of circuit related messages of the Telephone User Part for international signalling only, the field contains the least significant bits of the circuit identification code, and these bits are not repeated elsewhere. In the case of all other users, SLS is an independent field in accordance with the criteria stated in 2.2.5.

2.2.5 From the rule stated in 2.2.4 above, it follows that the signalling link selection field of messages generated by any User Part 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

⁴ Some CCITT Blue Book text was deleted from this clause; it referred to the placement of the SLC in the SLS field in some MTP level 3 messages.

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... (This clause has been deleted as it is not applicable to U.S. networks).

2.3 *Message Routing Function*

2.3.1 The message routing function determines the signalling link over which each outgoing message is sent. For most messages an outgoing link set (or combined link set: see 2.3.2) is determined on the basis of the destination point code in the message's routing label,⁵ and a particular link within that link set is selected on the basis of the signalling link selection field. The load sharing of traffic over the links of a link set is described more fully in 2.3.2. Sometimes information beyond the routing label may be needed to route a message:⁶

1. Special link selection rules apply to some network management messages; see 2.3.4.
2. The network indicator may have to be examined to determine what label structure is used in a message; see 2.4.3.
3. The possibility of basing routing on the service indicator in addition to the routing label has been left open. For example, messages may be defined for signalling route test procedures (see Chapter T1.111.7) that require routing based on service indicator. The use of the service indicator for routing should be kept to a minimum in order to apply the same routing criteria to as many users as possible.

2.3.2 The purpose of load sharing is to distribute traffic evenly over the links of a link set (combined link set). Two basic cases of load sharing are defined, namely:

1. Load sharing between links belonging to the same link set; and
2. Load sharing between links not belonging to the same link set.

A load sharing collection of one or more link sets is called a *combined link set*.

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

In case (1), the traffic flow carried by a link set is shared (on the basis of the signalling link selection field) among 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 4/T1.111.4.

⁵ The link set (combined link set) may be determined on the basis of the whole DPC or part of the DPC; see examples in Annex C of T1.111.5.

⁶ In this clause the text of the CCITT Blue Book has been extensively revised for clarity.

NOTE - Figures 4/T1.111.4 and 5/T1.111.4 show the SLS values that are used to select a link. If SLS rotation is used, these values are rotated before the message is actually transmitted on the link; see clause 7 of Chapter T1.111.5.

In case (2), traffic relating to a given destination is shared (on the basis of the signalling link selection field) among different signalling links not belonging to the same link set, such as represented in Figure 5/T1.111.4. The load sharing rule used for a particular signalling relation may or may not apply to all the signalling relations that use one of the signalling links involved (in the example, traffic destined to B is shared among signalling links DE and DF with a given signalling link selection field assignment, whereas that destined to C is sent only on link DF, due to the failure of link EC). Another example is illustrated in Figure 5A/T1.111.4. In this example, traffic destined to B is shared among signalling links CD and CE, where as that destined to D is sent only on link CD, due to the use of direct routing between the adjacent STP (C) and the MTP user part (i.e., switching) of the combined node (D).

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 and examples of the use of the SLS field in load sharing appear in Chapter T1.111.5.

2.3.3 Routing information 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 clause 3) and to the signalling routing modification rules specified in clause 4.

When a signalling transfer point detects that a received message cannot be delivered to its destination point, or the message should not be delivered because the route might be circular [see 13.2.2(1)(c) or 13.2.2A(1)(c); see also clause 2.4 of T1.111.7], it sends in response a transfer-prohibited or transfer-cluster-prohibited message as specified in 13.2. The received message is discarded. In addition, if the destination point code does not exist according to the routing information, an indication is given to a management system.

NOTE - A signalling point "exists" according to the routing information if links over which to route messages to the signalling point can be determined, even though network failures may temporarily preclude the use of those links. The routing information may consist of a common routing for messages to some or all of the signalling points within the cluster or network to which the concerned signalling point belongs (see Annex B of Chapter T1.111.5).

2.3.4 Handling of Level 3 Messages

2.3.4.1 Messages not related to a signalling link may be assigned any SLS code where load sharing of the message is necessary, or a default code such as 00000000. They are handled in accordance with the normal routing function, using the SLS for load sharing.

2.3.4.2 Some messages relating to a signalling link require special routing. For example, a signalling link test message (Chapter T1.111.7) must be routed over the link to which it refers, and a changeover message (Chapter T1.111.4) must not be routed over the link to which it refers. Precise descriptions of special routing requirements are included in the descriptions of the procedures that use messages that require special routing. See also Figure 26/T1.111.4.

2.3.5 Handling of Messages under Signalling Link Congestion

2.3.5.1 In the international signalling network, congestion priorities of messages are only assigned and the decision to discard under congestion is only made within each User Part. Message discard will only occur in the MTP should there be an extreme resource limitation (for the MTP there is no congestion priority).⁷

2.3.5.2 In U. S. signalling networks, each message is assigned by its generating User Part a congestion priority. This is used by the MTP to determine whether or not a message should be discarded under signalling link congestion. Four levels-of-congestion priority levels are accommodated in the signalling network, with 0 being the lowest and 3 the highest. The highest priority is assigned to MTP and SCCP messages that are critical to the performance of the signalling network. See Annex A of Chapter T1.111.5 for message priority assignments.

When a signalling link has been selected for transmitting a message, comparisons of the congestion priority of the message are made with the congestion status of the selected signalling link (see 3.8). If the congestion priority is not less than the signalling link congestion status, that message is transmitted using the selected signalling link.

Otherwise, a transfer-controlled message is sent in response as specified in 13.7. In this case, the disposition of the concerned message is determined according to the following criteria:

1. If the congestion priority of the message is greater than or equal to the signalling link discard status, the message is transmitted.
2. If the congestion priority of the message is less than the signalling link discard status, the message is discarded.

2.3A Handling of Messages under Signalling Point or Signalling Transfer Point Congestion

If signalling message handling congestion is possible, the following procedures should be used to control the congestion. Clause 11.2.6 provides an overview to the signalling message handling congestion control procedures.

When a message is received at a signalling point or signalling transfer point, the congestion priority of the received message is compared to the internal signalling message handling congestion status of the signalling point/signalling transfer point.

⁷ Some text from the CCITT Blue Book dealing with multiple congestion priority levels has been moved from 2.3.5.1 to 2.3.5.2.

If the internal signalling message handling congestion status is equal to 0 (i.e., no congestion), then the message is handled normally.

If, in a signalling transfer point a message is received for destination X (or cluster CX) and sufficient internal resources have failed resulting in a capacity reduction such that signalling message handling congestion is possible,⁸ the procedures in clause 13.4.2(2) are performed. The destination X is considered restricted until sufficient signalling message handling resources become available (an implementation-specific determination) (see clause 3.3.2.3). The message is transmitted to the destination.

After the procedures in clause 13.4.2(2) are invoked (if applicable), the following procedures are performed if internal signalling message handling congestion is present. If the priority of the message is less than the internal signalling message handling congestion status n ($n=1, 2, 3$), a transfer-controlled message is sent by a signalling transfer point in response as specified in 13.7.2(ii) (the sending of a transfer-controlled message by a signalling point is optional). In this case the disposition of the concerned message is determined according to the following criteria:

1. If the congestion priority of the message is greater than or equal to the internal signalling message handling discard status, the received message is handled normally; or
2. If the congestion priority of the message is less than the internal signalling message handling discard status, the message is discarded. As specified in clause 13.7.2(ii), when a signalling transfer point discards a priority 3 message it does not send a transfer-controlled message to the originator of the discarded message.

2.4 Message Discrimination and Distribution Functions

2.4.1 The routing criteria and load sharing method described in 2.3 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.

A node performing the transfer function shall inspect the Originating Point Code (OPC) field of all received messages. For messages received over any link other than its C links, it should reject (at Level 3) any messages whose OPC is equal to the point code of its mate.

In instances where the STP receives a message with an Origination Point Code (OPC) equal to its own point code, the message should be discarded unless all the following criteria are met:

- ◆ The STP which has received the message has Circular Route Detection Test capability.
- ◆ The received message is a signaling route set congestion test message -- i.e., a Service Indicator value of 0000, a Heading Code (H0) value of 0011, and a Heading Code (H1) value of 0001.
- ◆ The received message has a priority level 3.

⁸ That is, signalling message handling congestion that is due to an internal failure, not due to received traffic volumes, and is unlikely to exist at the mate signalling transfer point.

In the event all of the preceding criteria are met, Circular Route Detection Test procedures outlined in T1.111.7, clause 2.4, should be followed.⁹

The destination point code field of the received messages is examined by the discrimination function in order to determine whether or not they are destined to the receiving signalling point. When the receiving signalling point has the transfer capability and the message is not destined to it, that message has to be directed to the routing function, as described in the previous clauses, in order to be sent on the appropriate outgoing link towards the message destination point.

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).

Should a User become unavailable (User unavailability is an implementation dependent notion), this is detected by the MTP. Whether the distribution function is marked accordingly is implementation dependent.

When the distribution function detects that a received message cannot be delivered to the required User (implementation dependent criteria), a user part unavailable message is returned to the originating signalling point on a response basis as specified in 11.2.7 and the message is discarded. In the originating signalling point, the relevant User is informed via an MTP-STATUS primitive. A mandatory parameter Cause is included in the MTP-STATUS indication with four possible values:

1. Signalling Network Congested (plus congestion status).
2. User Part Unavailability: unequipped remote User.
3. User Part Unavailability: inaccessible remote User.
4. User Part Unavailability: unknown.

The MTP User should reduce its traffic in an appropriate manner and take specific actions; see 5.2.2 and 5.2.4 of T1.112.4 and 2.11 of T1.113.4.

2.4.3 In the case of a signalling point handling both international and national signalling traffic (e.g., an international gateway exchange), the network 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 network indicator may be examined to discriminate between different label structures, or between different signalling point numbering if dependent on the network levels (see 14.2).

⁹ Messages discarded by this procedure may be evidence of an MTP circular route which otherwise might have triggered the Circular Route Detection Test (see T1.111.7, clause 2.4).

2.4.3A In the case of signalling network testing and maintenance messages there are two types of messages:

1. Regular messages that use all the normal message handling procedures; and
2. Special messages that use special message handling procedures which are invoked within message discrimination by inspection of the service indicator (see 14.2.1).

2.4.4 If the destination point code of the message contains an alias point code (see T1.111.5, clause 7.2.3) that identifies the receiving signalling point, then:

1. *If the local SCCP Global Title Translation function is available*, the message is directed to the message distribution function.
2. *If the local SCCP Global Title Translation function is unavailable*, the message is directed to the message routing function - a user part unavailable message is not returned to the originating signalling point.

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 links or at signalling points. The disruption may be in the form of complete loss of a signalling link or signalling point, or in reduced accessibility due to congestion. 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 or congestion 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 recognized as *failed*, *deactivated*, *blocked*,¹⁰ or *inhibited*, and it becomes once again available if it is recognized as "restored", "activated", "unblocked" or "uninhibited", respectively. A signalling route may be considered by level 3 as "available", "restricted", or "unavailable", too. A signalling point may be "available" or "unavailable". A signalling route set may be "congested" or "uncongested". The detailed criteria for the determination of the changes in the status of signalling links, routes, and points are described in 3.2, 3.4, and 3.6, respectively.

¹⁰ 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.

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:

1. 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:
 - a. Changeover (see clause 5);
 - b. Changeback (see clause 6);
 - c. Forced rerouting (see clause 7);
 - d. Controlled rerouting (see clause 8);
 - e. MTP restart (see clause 9);
 - f. Management inhibiting (see clause 10); and
 - g. Signalling traffic flow control (see clause 11).
2. The signalling link management function is used to restore failed signalling links, to activate idle (not yet aligned) links and to deactivate aligned signalling links it comprises the following procedures (see clause 12):
 - a. Signalling link activation, restoration, and deactivation;
 - b. Link set activation; and
 - c. Automatic allocation of signalling terminals and signalling data links.
3. 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:
 - a. Transfer-prohibited procedure (see 13.2);
 - b. Transfer-allowed procedure (see 13.3);
 - c. Transfer-restricted procedure (see 13.4);
 - d. Signalling-route-set-test procedure (see 13.5);
 - e. Transfer-controlled procedure (see 13.6, 13.7, and 13.8); and
 - f. Signalling-route-set-congestion-test procedure (see 13.9).

3.1.4 An overview of the use of the procedures relating to the different management functions on occurrence of the link, route, and point status changes is given in 3.3, 3.5, and 3.7, 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 seven possible cases as follows (see also Figure 6/T1.111.4):

1. Unavailable, failed or inactive;
2. Unavailable, blocked;
3. Unavailable, (failed or inactive) and blocked;
4. Unavailable, inhibited;
5. Unavailable, inhibited and (failed or inactive);
6. Unavailable, inhibited and blocked; or
7. Unavailable, (failed or inactive), blocked, and inhibited.

The concerned link can be used to carry signalling traffic only if it is available except test and management messages (e.g., SLT, TFX, TRA and TRW). Eight possible events can change the status of a link: signalling link failure, restoration, deactivation, activation, blocking, unblocking, inhibiting, and uninhibiting; they are described in 3.2.2 through 3.2.9.

3.2.2 Signalling Link Failure

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

1. A link failure indication is obtained from level 2. For MTP Level 2 links, the indication may be caused by:
 - a. Intolerably high signal unit error rate (see clause 10 of Chapter T1.111.3).
 - b. Excessive length of the realignment period (see 4.1 and clause 7 of Chapter T1.111.3).
 - c. Excessive delay of acknowledgments (see 5.3 and 6.3 of Chapter T1.111.3).
 - d. Excessive period of level 2 congestion (see clause 9 of Chapter T1.111.3).
 - e. Failure of signalling terminal equipment.
 - f. Two out of three unreasonable backward sequence numbers or forward indicator bits (see 5.3 and 6.3 of Chapter T1.111.3).
 - g. Reception of consecutive link status signal units indicating out-of-alignment, out-of-service, normal or emergency terminal status (see 1.7 of Chapter T1.111.3).

The first two conditions are detected by the signal unit error rate monitor (see clause 10 of Chapter T1.111.3).

For SAAL links, failure indications include:

- a. Intolerably high protocol data unit error rate -- see clause 8.1.1 of T1.652-1996 (R2006).
 - b. Excessive length of the realignment period-- see clause 6.2.2 of T1.645-1995 (R2008).
 - c. No receipt of a status (STAT) protocol data unit - timer No_Response expiration -- see clause 7.6 of T1.637-1999 (R2005).
 - d. Excessive period of no credit -- see clause 8.1.2 of T1.652-1996 (R2006).
 - e. Local or remote processor outage condition -- see clause 6.2.1 of T1.645-1995 (R2008).
2. A request (automatic or manual) is obtained from a management or maintenance system.

3. The signalling link test fails (see clause 2.2 of Chapter T1.111.7).
4. False link congestion is detected (see 3.8.2.2).

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

3.2.3 Signalling Link Restoration

A previously failed signalling link is restored when both ends of the signalling link have successfully completed an initial alignment procedure (see clause 7 of Chapter T1.111.3 or clause 6.2.2 of T1.645-1995 (R2008)).

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:

1. A request is obtained from the signalling link management function (see clause 12).
2. A request (automatic or manual) is obtained from an external management or maintenance system.

3.2.5 Signalling Link Activation

A previously inactive signalling link is recognized by level 3 as activated when both ends of the signalling link have successfully completed an initial alignment procedure (see clause 7 of Chapter T1.111.3 or clause 6.2.2 of T1.645-1995 (R2008)).

3.2.6 Signalling Link Blocking

A signalling link (in service, failed, or inactive) is recognized as blocked when 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 clause 8 of Chapter T1.111.3).

NOTE 1 -- A link becomes unavailable when it is failed or deactivated or ((failed or deactivated) and blocked) (see Figure 6/T1.111.4).

NOTE 2 -- For SAAL links, a processor outage condition causes the link to fail.

3.2.7 Signalling Link Unblocking

A signalling link previously blocked is unblocked when 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.)

NOTE - A link becomes available when it is restored, or activated, or unblocked, or [(restored or activated) and unblocked] -- see Figure 6/T1.111.4.

3.2.8 Signalling Link Inhibiting

In U. S. networks the standard for management control of signalling links is the management inhibit procedure. A signalling link is recognized as inhibited when:

1. An acknowledgment is received from a remote signalling point in response to an inhibit request sent to the remote end by the local signalling link management. Level 3 has marked the link locally inhibited.
2. Upon receipt of a request from a remote signalling point to inhibit a link and successful determination that no destination will become inaccessible by inhibiting the link, the link has been marked remotely inhibited by Level 3.

3.2.9 Signalling Link Uninhibiting

A signalling link previously inhibited is uninhibited when:

1. A request is received to uninhibit the link from a remote end or from a local routing function.
2. An acknowledgment is received from a remote signalling point in response to an uninhibit request sent to the remote end by the local signalling link management.

3.3 *Procedures Used in Connection with Link Status Changes*

In 3.3, the procedures relating to each signalling management function, which are applied in connection with link status changes, are listed. (See also Figures 6-8/T1.111.4.) Typical examples of the application of the procedures to the particular network cases appear in Chapter T1.111.5.

3.3.1 Signalling Link Failed

3.3.1.1 Signalling Traffic Management

The changeover procedure (see clause 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 to which the affected traffic can be transferred, and procedures to retrieve messages sent over the failed link but not received by the far end.

3.3.1.2 Signalling Link Management

The procedures described in clause 12 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.

3.3.1.3 Signalling Route Management

In the case when the failure of a signalling link causes a signalling route set to become unavailable or restricted, the signalling transfer point that can no longer route the concerned signalling traffic applies the transfer-prohibited or transfer-restricted procedures described in clause 13.

3.3.2 Signalling Link Restored

3.3.2.1 Signalling Traffic Management

The changeback procedure (see clause 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.

3.3.2.2 Signalling Link Management

The signalling link deactivation procedure (see clause 12) 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 be deactivated and considered no longer available for signalling.

3.3.2.3 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 or transfer-restricted procedures described in clause 13 as appropriate. When a "danger of congestion" situation subsides, which had restricted a normal route to a destination, the status of the route is changed to available, but the transfer-allowed procedure (broadcast method) is not invoked (transfer-allowed messages are sent according to clause 13.5.4).

3.3.3 Signalling Link Deactivated

3.3.3.1 Signalling Traffic Management

As specified in 3.3.1.1.

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

3.3.3.2 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 clause 12 may be used to activate another signalling link in the link set.

3.3.3.3 Signalling Route Management

As specified in 3.3.1.3.

3.3.4 Signalling Link Activated

3.3.4.1 Signalling Traffic Management

As specified in 3.3.2.1.

3.3.4.2 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 clause 12 may be used to deactivate another signalling link in the link set.

3.3.4.3 Signalling Route Management

As specified in 3.3.2.3.

3.3.5 Signalling Link Blocked

3.3.5.1 Signalling Traffic Management¹¹

As specified in 3.3.1.1.

3.3.5.2 Signalling Route Management

If the blocking of the link causes a signalling route set to become unavailable or restricted, the signalling transfer point which can no longer route the concerned signalling traffic applies the transfer-prohibited or transfer-restricted procedures described in clause 13.

¹¹ CCITT Blue Book text specifying an option to use local processor outage to stabilize the link state during traffic management actions has been deleted from this clause.

3.3.6 Signalling Link Unblocked

3.3.6.1 Signalling Traffic Management

As specified in 3.3.2.1.

3.3.6.2 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 or transfer-restricted procedures described in clause 13, as appropriate.

3.3.7 Signalling Link Inhibited

3.3.7.1 Signalling Traffic Management

As specified in 3.3.1.1.

3.3.7.2 Signalling Link Management

As specified in 3.3.3.2.

3.3.8 Signalling Link Uninhibited

3.3.8.1 Signalling Traffic Management

As specified in 3.3.2.1.

3.3.8.2 Signalling Link Management

As specified in 3.3.4.2.

3.3.8.3 Signalling Route Management

If the link uninhibited 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 or transfer-restricted procedures described in clause 13, as appropriate.

3.4 *Status of Signalling Routes*

A signalling route can be in three states for signalling traffic having the concerned destination; these are available, restricted, and unavailable. A route may become available or unavailable because of changes in the availability of the local links in that route; however, the procedures already given in 3.3 handle such cases. Subclauses 3.4 and 3.5 deal with route status changes caused by receipt of signalling route management messages.

3.4.1 **Signalling Route Unavailability**

A signalling route becomes unavailable when a transfer-prohibited message, indicating that signalling traffic towards a particular destination or cluster of destinations cannot be transferred via the signalling transfer point sending the concerned message, is received (see clause 13).

3.4.2 **Signalling Route Availability**

A signalling route becomes available when a transfer-allowed message, indicating that signalling traffic towards a particular destination or cluster of destinations can be transferred via the signalling transfer point sending the concerned message, is received (see clause 13).

3.4.3 **Signalling Route Restricted**

A signalling route becomes restricted when a transfer-restricted message, indicating that signalling traffic towards a particular destination or cluster of destinations is being transferred with some difficulty via the signalling transfer point sending the concerned message, is received (see clause 13).

3.5 *Procedures Used in Connection with Route Status Changes*

In 3.5, the procedures relating to each signalling management function, which in general are applied in connection with route status changes caused by receipt of signalling route management messages, are listed. (See also Figures 6/ and 8/T1.111.4.) Typical examples of the application of the procedures to particular network cases appear in Chapter T1.111.5.

3.5.1 **Signalling Route Unavailable**

3.5.1.1 **Signalling Traffic Management**

The forced rerouting procedure (see clause 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.

3.5.1.2 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 clause 13.

3.5.2 Signalling Route Available

3.5.2.1 Signalling Traffic Management

The controlled rerouting procedure (see clause 8) is applied; it is used to transfer signalling traffic to the newly available route. It includes the determination of which traffic should be diverted, and procedures for maintaining the correct message sequence.

3.5.2.2 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 clause 13.

3.5.3 Signalling Route Restricted

3.5.3.1 Signalling Traffic Management

The controlled rerouting procedures (see clause 8) is applied; it is used to transfer signalling traffic to the concerned destination from the link set belonging to the restricted route, to an alternative link set if one is available to give more, if possible, efficient routing. It includes actions to determine the alternative route.

3.5.3.2 Signalling Route Management

Because of the restricted availability of the signalling route, the network routing is, if possible, reconfigured; procedures described in clause 13 are used to advise adjacent signalling points.

3.6 Status of Signalling Points

A signalling point can be in one of two states: available or unavailable (see Figure 6/T1.111.4). However, implementation dependent congestion states may exist.

3.6.1 Signalling Point Unavailability

3.6.1.1 Unavailability of a Signalling Point Itself

A signalling point becomes unavailable when all connected signalling links are unavailable.

3.6.1.2 Unavailability of an Adjacent Signalling Point

A signalling point considers that an adjacent signalling point becomes unavailable when the adjacent point is inaccessible.

3.6.2 Signalling Point Availability

3.6.2.1 Availability of a Signalling Point Itself

A signalling point becomes available when at least one link connected to the signalling point becomes available.

3.6.2.2 Availability of an Adjacent Signalling Point

A signalling point considers that an adjacent signalling point becomes available when at least one signalling link connected to the adjacent signalling point becomes available and the signalling point has restarted, or when the adjacent signalling point becomes accessible on the reception of a transfer allowed message or a transfer restricted message (see 13.4).

3.7 Procedures Used in Connection with Point Status Changes

3.7.1 Signalling Point Unavailable

There is no specific procedure used when a signalling point becomes unavailable. The transfer prohibited and transfer restricted procedures are used to update the status of the affected routes in all nodes of the signalling network (see 13.2).

3.7.2 Signalling Point Available

3.7.2.1 Signalling Traffic Management

the MTP restart procedure (see clause 9) is applied; it is used to restart the traffic between the signalling network and the signalling point which becomes available. This restart is based on the following criteria:

1. Avoid loss of messages.
2. Limit the level 3 load due to the restart of the signalling point.
3. Restart, as much as possible, simultaneously in both directions of the signalling relations.

3.7.2.2 Signalling Link Management

The first step of the MTP restart procedure attempts to restore the signalling links of the point which becomes available; the signalling link restoration procedure is used (see clause 12).

3.7.2.3 Signalling Route Management

The second step of the MTP restart procedure consists of updating the signalling route states before carrying traffic to the point which becomes available and in all adjacent points; the transfer prohibited and transfer restricted procedures are used (see clause 13).

3.7.3 Signalling Point Congested

Procedures are implementation dependent (see 11.2.6).

3.8 *Signalling Network Congestion*

3.8.1 General

In 3.8, criteria for the determination of signalling link congestion status and signalling route set congestion status are specified. The procedures relating to each signalling network management function, which in general are applied in connection with congestion status changes, are listed.

3.8.2 Congestion Status of Signalling Links

3.8.2.1 When predetermined levels of MTP Level 3 messages fill in the transmission or retransmission buffer are crossed, an indication is given to level 3 advising of congestion/congestion abatement. The location and setting of the congestion thresholds are considered to be implementation dependent.

NOTE - The criterion for setting the congestion thresholds is based on: (1) the proportion of the total transmit and retransmit buffer capacity that is occupied and/or (2) the total number of messages in the transmit and retransmit buffers. (The buffer capacity below the threshold should be sufficient to overcome load peaks due to signalling network management functions and the remaining buffer capacity should allow User Parts time to react to congestion indications before message discard occurs.) The monitoring may be performed in different ways depending on the relative sizes of the transmit and retransmit buffers. In the case of a relatively small retransmit buffer, monitoring of the transmit buffer may be sufficient. In the case of a relatively large retransmit buffer, both the transmit buffer and retransmit buffer occupancies may need to be monitored.

1. In the international signalling network, one congestion onset and one congestion abatement threshold are provided. The congestion abatement threshold should be placed lower than the congestion onset threshold in order to provide hysteresis during the process of recovering from congestion.

2. In U. S. networks three separate thresholds are provided for detecting the onset of congestion. They are called congestion onset thresholds and are numbered 1, 2, and 3, respectively. Three separate thresholds are provided for monitoring the abatement of congestion. They are called congestion abatement thresholds and are numbered 1, 2, and 3, respectively.

Each congestion abatement threshold should be placed lower than the corresponding congestion onset threshold in order to provide hysteresis during the process of recovering from congestion.

Congestion abatement threshold n ($n=2$ or 3) should be placed higher than congestion onset threshold $n-1$ so as to allow for a precise determination of signalling link congestion status.

Congestion abatement threshold 1 should be placed higher than the normally engineered buffer occupancy of a signalling link.

Under normal operation, when the signalling link is uncongested, the signalling link congestion status is assigned the zero value.

At the onset of congestion, when the buffer occupancy is increasing, the signalling link congestion status is determined by the highest congestion onset threshold exceeded by the buffer occupancy. That is, if congestion onset threshold n ($n = 1, 2, \text{ or } 3$) is the highest congestion onset threshold exceeded by the current buffer occupancy, the current signalling link congestion status is assigned the value n (see Figure 8A/T1.111.4).

At the abatement of congestion, when the buffer occupancy is decreasing, the signalling link congestion status is determined by the lowest congestion abatement threshold below which the buffer occupancy has dropped. That is, if congestion abatement threshold n ($n=1, 2, \text{ or } 3$) is the lowest congestion abatement threshold below which the current buffer occupancy has dropped, the current signalling link congestion status is assigned the value $n-1$ (see Figure 8B/T1.111.4).

The use of the signalling link congestion status is specified in 2.3.5.2.

3.8.2.2 In U. S. networks three separate thresholds are provided for determining whether, under congestion conditions a message should be discarded or transmitted using the signalling link. They are called congestion discard thresholds and are numbered 1, 2, and 3, respectively.

Congestion discard threshold n ($n=1, 2, \text{ or } 3$) is placed higher than congestion onset threshold n in order to minimize message loss under congestion conditions.

Congestion discard threshold n ($n = 1$ or 2) should be placed at or lower than congestion onset threshold $n+1$ in order to make congestion control effective.

When the current buffer occupancy does not exceed congestion discard threshold 1, the current signalling link discard status is assigned the zero value.

When the current buffer occupancy exceeds congestion discard threshold n ($n = 1$ or 2), but does not exceed congestion discard threshold $n+1$, the current signalling link discard status is assigned the value n (see Figure 8C/T1.111.4).

When the current buffer occupancy exceeds congestion discard threshold 3, the current signalling link discard status is assigned the value 3.

The use of the signalling link discard status shall be as specified in 2.3.5.2.

If the link remains at a congestion level, as defined below, for greater than T31¹⁰ (a false link congestion condition), and it also remains in service, an audit should trigger the link to be restarted. T31 is started when buffer occupancy increases through onset level 1. Any change of congestion level [defined as a change of signalling link congestion status (see clause 3.8.2.1) and optionally including the first time the discard status is increased to n after signalling link congestion status is increased to n ($n=1, 2, 3$)] restarts the timer. T31 is stopped when the signalling link congestion status is zero. The management should be notified if the link is restarted due to false link congestion.

When the transmit buffer is full, all messages destined for the link should be discarded. Transfer-controlled messages indicating level 3 congestion should be sent to the originators of messages destined for the congested link when the messages are received, if the received messages are not priority 3. When priority 3 messages destined for a congested link are received and the transmit buffer is full, transfer-controlled messages are not sent to the originators of the received priority 3 messages.

3.8.2.3 In national signalling networks using... (This clause has been deleted as it is not applicable to U. S. networks.)

3.8.3 Procedures Used in Connection with Link Congestion Status Changes

In 3.8.3, the procedures relating to each signalling network management function, which in general are applied in connection with link congestion status changes, are listed.

Signalling Route Management: When the congestion of a signalling link causes a signalling route set to become congested, the transfer-controlled procedure (see 13.6 and 13.7) is used, if required, to notify originating signalling points that they should reduce the concerned signalling traffic towards the affected destination.

3.8.4 Congestion Status of Signalling Route Sets

At each originating signalling point, there is associated with each signalling route set a congestion status, which indicates the degree of congestion in the signalling route set.

1. In the international signalling network two states are provided, congested and uncongested.

If a link in a signalling route towards a given destination becomes congested, the congestion status of the signalling route set towards the affected destination is changed to congested.

When a transfer controlled message relating to a given destination is received, the congestion status of the signalling route set towards the affected destination is indicated to the level 4 User Parts in accordance with the transfer controlled procedure specified in clause 13. The congestion status is not retained by level 3 at the receiving signalling point.

2. In U. S. signalling networks, corresponding to the four levels of signalling link congestion, there are four values of signalling route set congestion status, with 0 being the lowest and 3 the highest. Normally the congestion status of a signalling route set is assigned the zero value, indicating that the signalling route set is uncongested. If a signalling link in the signalling route set to a given destination becomes congested, the congestion status of the signalling route set is assigned the value of the signalling link congestion status, if it is higher than the current signalling route set congestion status. When a transfer-controlled message relating to a given destination is received, the congestion status of the signalling route set towards that destination shall be updated in accordance with the transfer-controlled procedures as specified in 13.7. The congestion status of the signalling route set towards that destination may be decremented in accordance with the signalling-route-set-congestion-test procedure as specified in 13.9.
3. In national signalling networks using...(This clause has been deleted as not applicable to U. S. Networks.)

3.8.5 Procedures Used in Connection with Route Set Congestion Status Changes

In 3.8.5, the procedures relating to each signalling network management function, which in general are applied in connection with route set congestion status changes, are listed.

3.8.5.1 Signalling Traffic Management

The signalling traffic flow control procedure (see clause 11) is applied, it is used to regulate the input of signalling traffic from User parts to the concerned signalling route set.

3.8.5.2 Signalling Route Management

As a national option, the signalling-route-set-congestion-test procedure (see 13.9) is applied; it is used to update the congestion status of the concerned signalling route set until the congestion status is reduced to the zero value.

3.8.6 Signalling Point/Signalling Transfer Point Message Handling Congestion

3.8.6.1 Internal signalling message handling congestion occurs in a signalling point or signalling transfer point when the offered load exceeds the capacity or ability of the signalling message handling function of the signalling point or signalling transfer point.¹² Though implementation dependent, it is strongly recommended that signalling message handling congestion controls use multiple congestion thresholds if possible.¹³ These signalling message handling congestion thresholds are predetermined levels of signalling message handling capacity-and identify when the ability of the signalling message

¹² Determination of internal signalling message handling congestion is implementation dependent.

¹³ Signalling message handling thresholds may, for example, be based on internal bus occupancy, processor utilization, or any other implementation dependent means deemed to be suitable for measuring internal signalling message handling capacity.

handling function has been exceeded. The location, setting, and determination of the signalling message handling congestion thresholds are implementation dependent.

Three separate thresholds are provided if possible for detecting the onset of internal signalling message handling congestion. They are called *signalling message handling congestion onset thresholds* and are numbered 1, 2, and 3, respectively. Three separate thresholds are provided for monitoring the abatement of internal signalling message handling congestion. They are called *signalling message handling congestion abatement thresholds* and are numbered 1, 2, and 3, respectively. If three separate sets of onset and abatement thresholds are not used, a single set is provided.

Each signalling message handling congestion abatement threshold should be placed lower than the corresponding signalling message handling congestion onset threshold in order to provide hysteresis during the process of recovering from signalling message handling congestion.

Signalling message handling congestion abatement threshold n ($n = 2$ or 3) should be placed higher than signalling message handling congestion onset threshold $n-1$.

Under normal operation, when there is no internal signalling message handling congestion, the internal signalling message handling congestion status is assigned the zero value.

At the onset of congestion, the internal signalling message handling congestion status is determined by the highest signalling message handling congestion onset threshold exceeded. That is, if onset threshold n ($n = 1, 2,$ or 3) is the highest onset threshold exceeded, the current signalling message handling congestion status is assigned the value n . If one onset threshold is used, the presence of internal signalling message handling congestion corresponds to a congestion status of 3.

At the abatement of internal signalling message handling congestion, the internal signalling message handling congestion status is determined by the lowest congestion abatement threshold below which the internal signalling message handling congestion has dropped. That is, if congestion abatement threshold n ($n = 1, 2,$ or 3) is the lowest congestion abatement threshold below which the internal signalling message handling congestion has dropped, the current signalling message handling congestion status is assigned the value $n-1$. If one abatement threshold is used, the abatement of internal signalling message handling congestion corresponds to a congestion status of 0.

3.8.6.2 Four separate thresholds are provided if possible for determining whether, under internal signalling message handling congestion conditions a message should be discarded or transmitted using the signalling link. They are called signalling message handling congestion discard thresholds and are numbered 1, 2, 3, and 4, respectively. If four separate discard thresholds are not used, two discard thresholds are provided.

Signalling message handling congestion discard threshold n ($n = 1, 2,$ or 3) is placed at the same point as the signalling message handling congestion onset threshold n . If it can be ensured that multiple transfer-controlled messages will not be sent from the congested signalling transfer point/signalling point for the same message as a result of routing the message, and that the signalling transfer point/signalling point will not be adversely affected by routing the message, the discard threshold n may be placed higher than the onset threshold in order to minimize message loss during internal signalling message handling congestion conditions. Discard threshold 4 is placed higher than discard threshold 3.

Signalling message handling congestion discard threshold n ($n = 1$ or 2) should be placed at or lower than signalling message handling congestion onset threshold $n+1$.

When the current internal signalling message handling congestion does not exceed signalling message handling congestion discard threshold 1, the current signalling link discard status is assigned the zero value.

When the internal signalling message handling congestion exceeds congestion discard threshold n ($n = 1, 2,$ or 3), but does not exceed signalling message handling congestion discard threshold $n+1$, the current signalling message handling discard status is assigned the value n . If two discard thresholds are used, exceeding the first threshold corresponds to a discard status of 3.

When the internal signalling message handling congestion exceeds congestion discard threshold 4, the internal signalling message handling discard status is assigned the value 4.

When the internal signalling message handling congestion exceeds discard threshold 4, the internal signalling message handling discard status is assigned the value 4.

Clause 2.3.A specifies the message handling procedures during internal signalling message handling congestion.

3.9 Status of Local SCCP for Alias Point Code Routing

At a signalling transfer point identified by an alias point code, the status of the local SCCP determines signalling network management actions. The status of the local SCCP can be available or unavailable. The determination of these states is implementation-dependent.

3.A Procedures Used in Connection with Local SCCP Status Changes

3.A.1 Local SCCP Unavailable

3.A.1.1 Signalling Traffic Management

Forced rerouting as specified in clause 7 or controlled rerouting as specified in clause 8 is used to reroute traffic to alternate routes specified for the alias point code.

3.A.1.2 Signalling Route Management

Procedures for transfer-prohibited and transfer-restricted are applied as indicated in clauses 13.2 and 13.4.

3.A.2 Local SCCP Available

3.A.2.1 Signalling Traffic Management

Controlled rerouting as specified in clause 8 is used to reroute traffic to the local SCCP.

3.A.2.2 Signalling Route Management

Procedures for transfer-allowed and transfer-restricted are applied as indicated in clauses 13.3 and 13.4.

4 SIGNALLING TRAFFIC MANAGEMENT

4.1 General

4.1.1 The signalling traffic management function is used, as indicated in clause 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, availability or restriction of signalling links and routes is typically made by means of the following basic procedures included in the signalling traffic management function:

1. *Signalling Link Unavailability (Failure, Deactivation, Blocking, or Inhibiting)*. The changeover procedure (see clause 5) is used to divert signalling traffic to one or more alternative links (if any).
2. *Signalling Link Availability (Restoration, Activation, Unblocking, or Uninhibiting)*. The changeback procedure (see clause 6) is used to divert signalling traffic to the link made available.
3. *Signalling Route Unavailability*. The forced rerouting procedure (see clause 7) is used to divert signalling traffic to an alternative route (if any).
4. *Signalling Route Availability*. The controlled rerouting procedure (see clause 8) is used to divert signalling traffic to the route made available.
5. *Signalling Route Restricted*. The controlled rerouting procedure (see clause 8) is used to divert signalling traffic to an alternative route (if any).
6. *Signalling Point Availability*. The MTP restart procedure (see clause 9) is used to divert traffic to or via the point 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 clauses. Moreover, these procedures include a modification of the signalling routing, which is made in a systematic way, as described in 4.2 to 4.8.

4.1.3 The signalling traffic flow control procedures are used in the case of congestion in order to limit signalling traffic at its source. The procedures are specified in clause 11.

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 more link sets. A load sharing collection of one or more link sets is called a combined link set. Within a link set (combined link set), a further routing may be performed in order to load share the traffic over the available signalling links (see clause 2).

To accommodate the situations when signalling links or routes become unavailable, alternative routing data are defined.

For each destination that may be reached from a signalling point, one or more alternative link sets (combined link sets) are allocated. An alternative combined link set may consist of one or more (or all) of the remaining available link sets that may carry signalling traffic towards the concerned destination. The possible link sets (combined link sets) appear in a certain priority order. The link set (combined link set) having the highest priority is used whenever it is available. It is defined as the normal link set (combined link set) for traffic to the concerned destination. The link set (combined link set) which is in use at a given time is called the current link set (combined link set). The current link set (combined link set) consists either of the normal link set (combined link set) or an alternative link set (combined link set). In case of load sharing between link sets, a normal link set (combined link set) exists for each portion of the divided signalling traffic.

For each signalling link, the remaining signalling links in the link set (combined link set) are alternative links. The signalling links of a link set (combined 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 signalling links (but not carrying any signalling traffic at the time) or inactive signalling links, see clause 12.

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 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 (combined link set) to which the unavailable link belongs, the signalling traffic is transferred within the link set (combined link set). If there is one or more active and unblocked signalling links currently not carrying any traffic, the signalling traffic is transferred to the one having the highest priority. If no such signalling link exists, the signalling traffic is transferred to one or more signalling links currently carrying traffic. The traffic may be transferred to more than one link to load share the traffic as evenly as possible or to one link for simplicity.

4.3.3 In the case when there is no alternative signalling link within the link set (combined link set) to which the unavailable signalling link belongs, the signalling traffic is transferred to one or more alternative link sets (combined link sets) in accordance with the alternative routing defined for each destination. For a particular destination, the alternative link set (combined link set) is the link set (combined 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 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 4.3.2).

In the case that multiple links in the link set are unavailable, traffic in addition to that for which the newly available link is the normal one may be transferred to the newly available link in order to distribute traffic among available links as evenly as possible. If this option is implemented, implementation-dependent safeguards must be employed to prevent missequencing or excessive delay of messages when additional links within the link set become available while changeback is still in progress.

4.4.3 In the case when the link set (combined link set) to which the available signalling links belongs does not carry any signalling traffic (i.e., a link set [combined link set] has become available), the traffic to be transferred is the traffic for which the available link set (combined link set) has higher priority than the link set (combined link set) currently used. The traffic is transferred from one or more links sets (combined link set) and from one or more signalling links within each link set.

4.5 *Signalling Route Unavailability*

When a signalling route becomes unavailable (see 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 or link sets) is determined in accordance with the alternative routing defined for the concerned destination (see 4.3.2).

4.6 *Signalling Route Availability*

When a previously unavailable signalling route becomes available again (see 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 equal or higher priority than the route (link set) currently used for traffic to the concerned destination (see 4.4.2).

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

4.7 *Signalling Route Restriction*

When a previously unavailable signalling route becomes restricted, signalling traffic may be transferred to the newly restricted route by means of a controlled rerouting procedure if the newly restricted route has a higher priority than the currently used route.

When a previously available signalling route becomes restricted (see 3.4), signalling traffic carried by the restricted route is, if possible, transferred to an alternative route by means of the controlled rerouting procedure, if an equal priority alternative is available and not restricted. If an equal priority route is available and restricted and is not currently carrying traffic, controlled rerouting is performed to resume loadsharing (i.e., traffic will be carried by both link sets). The alternative route is determined in accordance with the alternate routing defined for the concerned destination (see 4.3).

4.8 *Signalling Point Availability*

When a previously unavailable signalling point becomes available (see 3.6), signalling traffic may be transferred to the available point by means of a MTP restart procedure (see clause 9).

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 updating 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, blocking, or inhibiting) 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 5.2.

The criteria for initiation of changeover, as well as the basic actions to be performed, are described in 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 clause 4. In summary, two alternative situations may arise (either for the whole diverted traffic or for traffic relating to each particular destination):

1. Traffic is diverted to one or more signalling links of the same link set; or
2. 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 clause 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:

1. The new signalling link is parallel to the unavailable one (see Figure 9/T1.111.4).
2. 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 10/T1.111.4).
3. 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 11/T1.111.4).

Only in case (3) does a possibility of message mis-sequencing exist; therefore, its use should take into account the overall service dependability requirements described in Chapter T1.111.6.

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 3.2.2 and 3.2.6.

The following actions are then performed:

1. Transmission and acceptance of messages on the concerned signalling link is terminated;
2. Transmission of link status signal units or fill-in signal units, as described in clauses 7 and 8 of Chapter T1.111.3-2001 takes place on MTP Level 2 links;
3. The alternative signalling link(s) are determined according to the rules specified in clause 4;
4. A procedure to update the content of the retransmission buffer of the unavailable signalling link is performed as specified in 5.4; and
5. Signalling traffic is diverted to the alternative signalling link(s) as specified in 5.5.

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 13.2.

5.3.2 In the case when there is no traffic to transfer from the unavailable signalling link, only item (2) of 5.3.1 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:

1. 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;¹⁴
2. A command is sent to the user(s) (if any) in order to stop generating the concerned signalling traffic;
3. The transfer-prohibited procedure is performed as specified in 13.2; and
4. The appropriate signalling link management procedures are performed as specified in clause 11.

¹⁴ The adequacy of this procedure to meet the acceptable dependability objective in terms of loss of messages requires further study.

NOTE - At points without the transfer function, if the destination(s) become(s) accessible again before the changeover procedure concludes, messages for the concerned destination(s) in the transmission and retransmission buffers need not be discarded.

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 5.6 apply.

Other procedures to cover possible abnormal cases appear in 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 3.2.2), a changeover acknowledgment is sent instead.

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

The changeover order or changeover acknowledgment does not preempt the normal traffic of the signalling link on which the message is sent.

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

1. The label, indicating the destination and originating signalling points.
2. The SLC, indicating the identity of the unavailable signalling link.
3. The changeover-order (or changeover-acknowledgment) signal.
4. The forward sequence number for MTP Level 2 links or the sequence number for SAAL links of the last message signal unit or Sequenced Data (SD) Protocol Data Unit (PDU), respectively, accepted from the unavailable signalling link.

Formats and codes of the changeover order and the changeover acknowledgment appear in clause 15.

5.4.3 Upon reception of a changeover order or changeover acknowledgment, the retransmission buffer of the unavailable signalling link is updated (except as noted in 5.6), according to the information contained in the message. The messages successive to that indicated by the changeover order or acknowledgment_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:

1. The routing of the signalling traffic to be diverted is changed.
2. 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 does not preempt the 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 (MTP Level 2 links) or sequence number (SAAL links) of the last message signal unit or sequenced data protocol data unit accepted over the unavailable link. In this case, the concerned end accomplishes, if possible, the buffer updating procedures described in 5.4, but it makes use of an emergency changeover order or an emergency changeover acknowledgment instead of the corresponding normal message; these emergency messages, the format of which appears in clause 15, do not contain the (forward) sequence number of the last accepted message. 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 clause 11 of Chapter T1.111.3).

When the other end of the unavailable signalling link receives the emergency changeover order or acknowledgment, it accomplishes the changeover procedures described in 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:

1. An emergency changeover order is acknowledged by a changeover acknowledgment if the local conditions are normal; and
2. A changeover order is acknowledged by an emergency changeover acknowledgment if there are local fault conditions.

5.6.2 Time controlled changeover is initiated when the exchange of changeover messages is not possible or not desirable -- i.e., if one or more of the following cases apply:

1. No signalling path exists between the two ends of the unavailable link, so that the exchange of changeover messages is impossible.

2. Processor outage indication is received on a link. In this case, if the remote processor outage condition is only transitory, sending of a changeover order could result in a failure of a link.
3. A signalling link currently carrying traffic has been marked (locally or remotely) inhibited. In this case, time controlled changeover is used to divert traffic from the inhibited link without causing the link to fail.

NOTE - Case (2) above does not apply for SAAL links since, in the case of processor outage for SAAL links, the link will fail [see clause 6.2.1 of T1.645-1995 (R2008)].

When the concerned signalling point decides to initiate changeover in such circumstances, after the expiry of a time $T1$,¹⁵ it starts traffic not yet transmitted on the unavailable link on the alternative link(s); the purpose of withholding traffic for the time $T1$ is to reduce the probability of message missequencing. If the unavailable link becomes available before expiry of $T1$, and the signalling point at the remote end of the link was not inaccessible while $T1$ was running, traffic is restarted on the link. If the point at the remote end of the link was inaccessible, however, the MTP restart procedure applies (see clause 9) as well as the procedures of 5.3.3. In the case of a remote processor outage condition, if $T1$ expires, messages available for retransmission are discarded and level 2 sequence numbers are set so that the link remains in service at level 2 when the processor outage terminates. The level 2 actions are explained in clause 8 of Chapter T1.111.3.

In some circumstances it may be possible to perform a time controlled changeover for a link that is transmitting processor outage indication. As the criteria for transmitting processor outage indication are implementation dependent, this option is not fully specified, nor is it included in the state transition diagrams. If it is used, any message signal units, incoming or outgoing, that remain in level 2 after $T1$ has expired and traffic has been diverted to alternative link(s) are discarded.

If during $T1$ a changeover order is received for the unavailable link, the concerned signalling point responds with a changeover acknowledgement or emergency changeover acknowledgement depending on local conditions (see 5.6.1). If the changeover order is normal, the concerned signalling point performs buffer updating and retrieval in accordance with 5.4 and 5.5, if possible.

If a changeover order is received for the unavailable link after the expiry of $T1$, the concerned signalling point responds with an emergency changeover acknowledgement.

An example of case (1) appears in Chapter T1.111.5.

In the abnormal case, when the concerned signalling point is not aware of the situation, it starts the normal procedure and sends a changeover order; in this case, it may receive no changeover message in response, and the procedure is completed as indicated in 5.7.2. Possible reception of a transfer-prohibited message (sent by an involved signalling transfer point on the reception of the changeover order (see 13.2), will not affect changeover procedures.

¹⁵ Recommended ranges for all timers are given in 16.7.

5.6.3 Due to failures, it may be impossible for a 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 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 clause allow the completion of the changeover procedures in abnormal cases other than those described in 5.6.

5.7.2 If no changeover order or changeover acknowledgement in response to a changeover order is received within a time-out T2,¹⁰ new traffic is started on the alternative signalling link(s).

5.7.3 If a changeover order or acknowledgment containing an unreasonable value of the forward sequence number (MTP Level 2 links) or sequence number (SAAL links) 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 acknowledgment 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 acknowledgment is sent in response, without any further action.

6 CHANGEBACK

6.1 General

6.1.1 The changeback procedure is used to initiate the routing of traffic over an available signalling link at the conclusion of the MTP restart procedure (see clause 9) or upon the restoration, unblocking, or uninhibiting of a link when the MTP restart procedure is not applicable. The objective of the changeback procedure is to ensure that signalling traffic is placed upon the available link 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 uninhibited, restored, or unblocked). The characteristics of the alternative signalling link(s) from which changeback can be made are described in 5.2. In all the cases mentioned

in 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.

NOTE - The term "alternative signalling link(s)" refers to signalling link(s) terminating in the signalling point at which a changeback is initiated (see clause 4).

6.2 *Changeback Initiation and Actions*

6.2.1 Changeback is initiated at a signalling point at the conclusion of the MTP restart procedure (see clause 9) or upon the restoration, unblocking, or uninhibiting of a link when the MTP restart procedure is not applicable. Unless superseded by actions specified in 6.2.2 or 6.2.3, the following actions are then performed:

1. 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);
2. Signalling traffic is diverted (if appropriate, according to the criteria specified in clause 4) to the concerned signalling link either by means of the sequence control procedure specified in 6.3 or by means of the time controlled diversion specified in 6.4; traffic diversion can be performed at the discretion of the signalling point initiating changeback, as follows:
 - a. Individually for each traffic flow (i.e., on destination basis).
 - b. Individually for each alternative signalling link (i.e., for all the destinations previously diverted on that alternative signalling link).
 - c. 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 5.3.1); in this case, a transfer-allowed procedure is performed, as specified in 13.3.

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 13.2.

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:

1. 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;

2. A command is sent to the User Part(s) (if any) in order to restart generating the concerned signalling traffic;
3. transfer-allowed or transfer-restricted procedure is performed, as specified in 13.3 or 13.4. However, in national networks when the recovered link is not on the normal route for this destination, the transfer-restricted procedure may be performed as specified in 13.4.
4. The transfer-prohibited procedure is performed as specified in 13.2.2 (1).

6.2.4 In the case that the signalling link made available is the first link to be used on the normal route towards a destination that was previously declared restricted, the status of the destination is changed to available, and a transfer allowed procedure is performed according to 13.3.2 (2), unless in danger of congestion as described in 13.4.2 (2).¹⁶

6.2.5 If the signalling point at the far end of the link made available is currently inaccessible from the signalling point initiating changeback (see clause 9 on MTP restart), the sequence control procedure specified in 6.3 (which requires communication between the two concerned signalling points) does not apply; instead, the time-controlled diversion specified in 6.4 is performed. This is performed also when the concerned signalling point 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. The time controlled diversion procedure may also be used for changeback between different link sets instead of the sequence control procedure in order to avoid possible message missequencing or problems with multiple parallel changebacks.

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 6.4).

1. Transmission of the concerned traffic on the alternative signalling link is stopped; such traffic is stored in a "changeback buffer".
2. 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 messages 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 acknowledgment from the far signalling point of the link made available; this message indicates that all signalling 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 acknowledgment to the signalling point initiating

¹⁶ CCITT Blue Book text specifying an immediate restart of traffic on the available link has been deleted from this clause.

changeback in response to the changeback declaration; any available signalling route between the two signalling points can be used to carry the changeback acknowledgment.

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

1. The label, indicating the destination and originating signalling points;
2. The SLC, indicating the identity of the signalling link to which traffic will be diverted;
3. The changeback-declaration (or changeback-acknowledgment) signal; and
4. The changeback code.

Formats and codes of the changeback declaration and changeback acknowledgment appear in clause 15.

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 acknowledgment by the acknowledging signalling point. This allows discrimination between different changeback declarations and acknowledgments 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 link, 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 acknowledgment 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 acknowledgments 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 acknowledgment is received, or only when all the changeback acknowledgments have been received.

6.4 Time-Controlled Diversion Procedure

6.4.1 The time-controlled diversion procedure is used at the end of the MTP restart procedure (see clause 9) when an adjacent signalling point becomes available as well as for the reasons given in 6.2.5. An example of such a use appears in Figure 12/T1.111.4.

In this example, on failure of signalling link AB, traffic towards the destination D was diverted to signalling link AC. When signalling link AB becomes available, the point A considers itself as the neighbor of a point which restarts and applies the MTP restart procedure (see clause 9).

6.4.2 When changeback is initiated after the MTP restart procedure, the adjacent signalling point to the point that is restarting stops traffic to be diverted from the alternative links for a time $T3^{10}$ after which it starts traffic on the links made available. The time delay minimizes the probability of out of sequence delivery to the destination point(s).

6.5 Procedures in Abnormal Conditions

6.5.1 If a changeback acknowledgment is received by a signalling point that 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 acknowledgment 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 acknowledgment is received in response to a changeback declaration within a time $T4^{10}$ the changeback declaration is repeated and a new time-out, $T5^{10}$ is started. If no changeback acknowledgment 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 acknowledgment message makes it possible to determine, in the case of parallel changebacks from more than one reserve path, 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 to 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 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 Chapter T1.111.6).

7.1.2 Forced rerouting is the basic procedure to be used in the case where a signalling route towards a given destination becomes unavailable (due to, e.g., 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:

1. 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".
2. The alternative route is determined according to the rules specified in clause 4.
3. As soon as action (2) 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.
4. If appropriate, a transfer-prohibited procedure is performed (see 13.2.2).

7.2.2 In the case when there is no signalling traffic to be diverted from the unavailable route, actions (2) and (4) 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 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 rerouting includes a time-controlled traffic diversion procedure, which is the same as that used in some cases of changeback (see 6.4).

8.1.2 Controlled rerouting is the basic procedure to be used in the following two cases:

1. When 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 or to an equal or higher priority signalling route outgoing from the concerned signalling point.

2. When a transfer-restricted message is received, or optionally when a transfer-prohibited message is received, after signalling traffic management has decided that rerouting is appropriate (e.g., because it would be more efficient than routing via the link set over which the transfer-restricted message was received).

Signalling links pertaining to the alternative signalling route can be carrying their own signalling traffic (relating to different routes), and this is not interrupted by the controlled rerouting procedure.

8.2 *Controlled Rerouting Initiation and Actions*

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

1. Transmission of signalling traffic towards the concerned destination on the link set belonging to the alternative route or the route over which the transfer-restricted message was received is stopped; such traffic is stored in a "controlled rerouting buffer." Timer T6¹⁰ is started.
2. The transfer-prohibited, transfer-restricted, and transfer-allowed procedures are performed as appropriate according to clause 13.
3. At the expiry of T6, the concerned signalling traffic is restarted on an outgoing link set corresponding to the new route to be used, 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 to the route made available, the actions in 8.2.1(1) through 8.2.1(3) 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 or restricted, when the route is made available, then the destination is declared accessible and actions specified in 6.2.3 and 6.2.4 apply (if appropriate).

9 MTP RESTART

The MTP restart procedure enables the MTP at a signalling point that has just become available (see 3.6) to bring sufficient signalling links into the available state to handle the expected traffic and to stabilize its routing before user traffic is restarted to the point. This procedure uses the traffic restart allowed (TRA) and traffic restart waiting (TRW) messages, which contain:

1. The label, indicating the originating signalling point and the adjacent destination signalling point
2. The traffic restart allowed or traffic restart waiting signal.

The format and coding of these messages appear in clause 15.

NOTE - In the following description of the MTP restart procedure, only the use of signalling route management messages referring to an individual destination (e.g. transfer-prohibited message) is described. If a point performs route management on a cluster basis, the corresponding cluster messages (e.g. transfer-cluster-prohibited message) can be used.

9.1 *Actions in a Signalling Point Having the Transfer Function Which Restarts*

During the period that the signalling point is unavailable, a management function determines if the point should initiate the full restart procedure when the first link(s) become available. The management function can take into account factors such as the cause and duration of the point's unavailability, the number of signalling links at the point, and the requirements of applications residing at that point for minimizing outage time.¹⁷

If the management function determines that a full restart procedure is not needed when the first signalling link(s) become available, then traffic restart allowed messages are sent to the adjacent points at the remote ends of the available links, MTP-RESUME primitives are given to users for all destinations accessible via the available links, and the procedure terminates. Any traffic restart allowed or traffic restart waiting messages received from adjacent points are considered unexpected; see 9.4. Messages that were buffered in level 2 (transmit buffer, retransmit buffer, or receive buffer) during the period of unavailability on links that were transmitting or receiving processor outage status units (MTP Level 2 links) are discarded unless it can be determined that they were buffered for a time of less than T1.

If the management function determines that a full restart procedure is needed, then it ensures, for example, by using local processor outage, that the period of unavailability persists for a time of at least T27. The purpose of remaining unavailable for time T27 is to increase the probability that adjacent points are aware of the unavailability of the restarting point and initiate the appropriate restart procedures (see 9.3).

As the first step in restarting, the signalling point attempts to bring a predetermined number of links into the available state in each of its link sets (see clause 12). Links that are transmitting or receiving processor outage status units become available when reception and transmission of the processor outage status units ceases. Messages that were buffered in level 2 (transmit buffer, retransmit buffer, or receive buffer) during the period of unavailability on links that were transmitting or receiving processor outage status units (MTP Level 2 links) are discarded unless it can be determined that they were buffered for a time of less than T1. Link activation procedures are carried out in parallel on as many other unavailable links as possible (see clause 12).

NOTE -- The process of activating signalling links should be organized so as to minimize the duration of the MTP restart procedure. Emergency alignment procedures should be used for at least the first link in each link set. Strategies such as rapidly aligning one link in every link set and processing route management messages from adjacent points in parallel with alignment attempts on additional links may be helpful.

¹⁷ No rules for this management decision are being standardized at this time, but it is suggested that if a point becomes available because of the termination of a remote processor outage, the newly available point at least initiate the procedures for being adjacent to a restarting point (see 9.3).

When the first signalling link goes into the in service state at level 2, the restarting signalling point begins taking into account any transfer-prohibited, transfer-restricted, transfer-allowed, traffic restart allowed, and traffic restart waiting messages received. The restarting point starts timers T22 and T26 either when the first signalling link goes into the in service state at level 2 or when the first signalling link becomes available at level 3. When a traffic restart waiting message is received before user traffic is restarted on the link(s) to the point that sent the traffic restart waiting message, timer T25 is started and user traffic is not restarted on that link set until a traffic restart allowed message is received or timer T25 expires (see 9.3).

When the first signalling link of a signalling link set is available, MTP message traffic terminating at the far end of the link set is immediately restarted (see also 9.5), and a traffic restart waiting message is sent to the point at the far end of the link set.

Whenever timer T26 expires, the restarting signalling point restarts timer T26 and broadcasts a traffic restart waiting message to those adjacent signalling points connected by an available link.

T22 is stopped when sufficient links are available to carry the expected signalling traffic: stopping T22 is a management decision that may take into account factors such as the known long term unavailability of certain signalling links because of equipment failures.

When T22 is stopped or expires, the signalling point starts a timer T23, during which it expects to receive additional transfer-prohibited, transfer-restricted, transfer-allowed (see clause 13), traffic restart waiting, and traffic restart allowed messages. When traffic restart allowed messages have been received for all available links or the management function determines that sufficient traffic restart allowed messages have been received that the expected traffic can be handled, T23 is stopped.

When T23 is stopped or expires, the signalling point starts a timer T24, during which it broadcasts transfer-prohibited and transfer-restricted messages (see clause 13), taking into account signalling links which are not available and at least those transfer-prohibited, transfer-restricted, and transfer-allowed messages that were received before T23 expired or was stopped. Before user traffic is restarted, preventive transfer-prohibited messages according to 13.2.2 (1) must be sent. Whether these preventive transfer-prohibited messages are sent for all routes or only for alternate routes is a network option. When the broadcast of transfer-prohibited and transfer-restricted messages is completed, timer T24 is stopped.

When T24 is stopped, timer T26 is also stopped, and the signalling point broadcasts traffic restart allowed messages to all adjacent signalling points and restarts the remaining traffic by giving MTP-RESUME primitives to users for all accessible destinations. It also starts timer T29 for those points to which it has sent a traffic restart allowed message.

If T24 expires, the sending of any transfer-prohibited messages required by 13.2.2 (1) is completed, timer T26 is stopped, and the signalling point broadcasts traffic restart allowed messages to all adjacent signalling points and restarts the remaining traffic by giving MTP-RESUME primitives to users for all accessible destinations. It also starts timer T29 for those points to which it has sent a traffic restart allowed message.

If the first link in a previously unavailable link set becomes available while T23 or T24 is running, a traffic restart waiting message is sent to the point at the far end of the link. The necessary transfer-

prohibited and transfer-restricted messages and a traffic restart allowed message are sent either during the restart procedure or thereafter. Whether user traffic is restarted on such available links when T24 stops or at some time thereafter is implementation dependent. If changes in the availability of links or the reception of signalling route management messages causes the status of a destination to change during T24, it is implementation dependent whether this status change is reflected in the broadcast of transfer-prohibited and transfer-restricted messages during T24 or is handled outside the restart procedure.

9.2 Actions in a Restarting Signalling Point Having no Transfer Function

Actions in a restarting signalling point having no transfer function are identical to those at a point having the transfer function (see 9.1) except that transfer-prohibited and transfer-restricted messages are not sent to adjacent points. Therefore, when timer T23 expires or is stopped, timer T26 is stopped, traffic restart allowed messages are broadcast to adjacent signalling points and user traffic is restarted by giving users MTP-RESUME primitives for all accessible destinations.

9.3 Actions in a Signalling Point X Adjacent to a Restarting Signalling Point Y

A signalling point X considers that the MTP of an inaccessible adjacent signalling point Y is restarting when:

1. The first link in a direct link set is in the in service state at level 2; or
2. A route other than a direct link set becomes available -- e.g., through receipt of a transfer allowed or traffic restart allowed message or the availability of the corresponding link set.

When the first link in a direct link set towards the restarting signalling point Y goes into the in service state at level 2, signalling point X begins taking into account any traffic restart waiting, traffic restart allowed, transfer-prohibited, transfer-restricted, and transfer-allowed messages from Y. Signalling point X starts timer T28 either when the first link goes into the in service state at level 2 or when the first signalling link becomes available at level 3. In addition it takes the following actions:

1. If a TRW message is received from Y while T28 is running or before it is started, X starts T25. X stops T28 if it is running.
2. If a TRW message is received from Y while T25 is running, X restarts T25.
3. When the first link in a link set to Y becomes available, signalling point X sends to Y a traffic restart allowed message or, if X has the transfer function, a traffic restart waiting message followed by transfer-prohibited (note that all transfer-prohibited messages according to 13.2.2 (1) must be sent) and transfer-restricted messages and a traffic restart allowed message.
4. If a destination becomes prohibited, restricted, or available at X, after X has sent a traffic restart allowed message to Y, X notifies Y of the status change by the normal procedures in clause 13.
5. When a traffic restart allowed message has been sent to Y and a traffic restart allowed message has been received from Y, X stops T25 or T28, whichever is running, and restarts traffic on the link set to Y. X gives MTP-RESUME primitives to users concerning Y and any destinations

made accessible via *Y*. If *X* has the transfer function it also broadcasts transfer-allowed or transfer-restricted messages concerning the same destinations.

6. If T28 expires, *X* restarts traffic on the link set to *Y* as in (5), unless a traffic restart allowed message has not been sent to *Y*. In that case, *X* starts T25 and completes the sending of transfer-prohibited and transfer-restricted messages, followed by a traffic restart allowed message. Then, unless a traffic restart waiting message has been received from *Y* without a subsequent traffic restart allowed message, *X* stops T25 and restarts traffic on the link set to *Y*.
7. If T25 expires, *X* restarts traffic on the link set towards *Y*. In the abnormal case when *X* has not completed sending transfer-prohibited and transfer-restricted messages to *Y*, *X* completes sending the transfer-prohibited messages required by 13.2.2 (1) and sends a traffic restart allowed message before restarting user traffic.
8. If no traffic restart allowed message has been received from *Y* when traffic is restarted to *Y*, timer T29 (see 9.4) is started.

When signalling point *Y* becomes accessible via a route other than a direct link set between *X* and *Y*, *X* sends an MTP-RESUME primitive concerning *Y* to all local MTP users. In addition, if signalling point *X* has the transfer function, *X* sends to *Y* any required transfer-prohibited and transfer-restricted messages by the available route and broadcasts transfer-allowed or transfer-restricted messages concerning *Y*.

9.4 *Actions in Signalling Point X on Receipt of an Unexpected TRA or TRW Message*

If an unexpected traffic restart allowed message or traffic restart waiting message is received from an adjacent point:

1. If the receiving point has no transfer function it returns a traffic restart allowed message to the adjacent point from which the unexpected traffic restart allowed or traffic restart waiting message was received and starts timer T29 concerning that point.
2. If the receiving point has the transfer function, it starts timer T30, sends a traffic restart waiting message followed by the necessary transfer-restricted and transfer-prohibited messages (preventive transfer-prohibited messages according to 13.2.2 (1) are required for traffic currently being routed via the point from which the unexpected traffic restart allowed or traffic restart waiting message was received), and a traffic restart allowed message. It then stops T30 and starts T29. In the abnormal case that T30 expires before the sending of transfer-prohibited and transfer-restricted messages is complete, it sends a traffic restart allowed message, starts T29, and then completes sending any preventive transfer-prohibited messages according to 13.2.2 (1) for traffic currently being routed via the point from which the unexpected traffic restart allowed or traffic restart waiting message was received.

NOTE - A received traffic restart waiting or traffic restart allowed message is not unexpected if T22, T23, or T24 is running and a direct link is in service at level 2 to the point from which the message is received or if T25, T28, T29, or T30 is running for the point from which the message is received.

9.5 *General Rules*

When a signalling point restarts, it considers, at the beginning of the restart procedure, all signalling routes to be allowed and all signalling links to be uninhibited. A signalling route set test message received in a restarting signalling point during the restart procedure is ignored.

Signalling route set test messages received in a signalling point adjacent to a restarting signalling point while T25 or T28 is running are handled, but the replies consider that all signalling routes using the restarting signalling point are prohibited. When T28 expires or T25 is stopped or expires, these signalling routes are allowed unless a transfer-prohibited or transfer-restricted message was received from the restarting signalling point while T28 or T25 was running.

While T25 or T28 is running, all traffic from local Level 4 or other signalling points destined to the adjacent restarting point is discarded.

When an adjacent signalling point restarts, all signalling links to the restarting point are marked as uninhibited.

In the case that an adjacent signalling point becomes inaccessible, but routing control initiates a successful uninhibiting (see 10.3), no restart procedure is performed on either side of the link.

If the inhibiting is unsuccessful because the link has failed or was blocked after it was inhibited, then MTP restart procedures should apply based on the criteria in clause 9.3.

Message traffic is restarted on newly available links by using the time controlled changeback procedure (see 6.4).

If a link becomes unavailable during MTP restart, after having been successfully activated during the restart, time controlled changeover is performed (see 5.6.2).

If a message concerning another destination is received at a restarting point before TRA messages have been sent out, the restarting point may discard the message or it may route the message if it is able according to the current routing data. If the restarting point discards the message, it sends a transfer-prohibited message to the adjacent signalling point from which the message was received. If a transfer-prohibited message is sent in these circumstances, and a signalling route is established to the concerned destination before traffic restart allowed messages are broadcast, then a transfer-allowed message is sent to the adjacent point after traffic restart allowed messages are broadcast.

NOTE - The state transition diagrams only show the option that the restarting point routes messages if it is able according to the current routing data during the MTP restart procedure. It is also possible for the restarting point not to handle traffic during the MTP restart. This option is not shown in the state transition diagrams.

A message concerning a local MTP user with service indicator (SI) of 0010 is handled normally when received in a restarting signalling point. Treatments for some messages with SI = 0000 received in a restarting signalling point have been specified already in 9.1 through 9.5; other messages with SI = 0000 may be treated normally or discarded when received in a restarting signalling point. Messages with other values of service indicator may be treated normally or discarded when received in the restarting point (appropriate treatment may depend on the applications resident at the particular restarting point).

10 MANAGEMENT INHIBITING¹⁸

10.1 General

Signalling link management inhibiting is requested by management when it becomes necessary -- e.g., for maintenance or testing purposes -- to make or keep a signalling link unavailable to user-generated signalling traffic. Management inhibiting is a signalling traffic management action, and does not cause any link status changes at Level 2. A signalling link is marked "inhibited" under the management inhibiting procedure. In particular, a signalling link that was active and in service prior to being inhibited will remain so, and will thus be able to transmit and receive maintenance and test messages.

Inhibiting of a signalling link may be requested by management functions at either end of the link. The request is granted, provided that the inhibiting action does not cause any previously accessible destinations to become inaccessible at either end of the signalling link. The request may also be refused under certain circumstances such as congestion.¹⁹

A signalling link normally remains inhibited until uninhibiting is invoked in the signalling point at which inhibiting was initiated. Uninhibiting is initiated either at the request of a management function or by routing functions at either end of the signalling link when it is found that a destination has become inaccessible for signalling traffic and the link sets associated with routes to that destination contain inhibited links. Unless the link is unavailable for other reasons, uninhibiting causes the signalling link to enter the available state and changeback to be initiated.

Throughout the time that a signalling point has marked a signalling link locally inhibited it periodically transmits a local inhibit test message to the signalling point at the far end of the link marked inhibited. If the signalling point that receives a local inhibit test message considers the link referred to in the message to be remotely inhibited, it takes no further action. If it does not consider the link remotely inhibited, it requires forced uninhibiting of the link in order to align the inhibiting status at the two ends of the link.

Throughout the time that a signalling point has marked a signalling link remotely inhibited, it periodically transmits a remote inhibit test message to the signalling point at the far end of the link marked inhibited. When a signalling point receives a remote inhibit test message, it checks if the concerned signalling link is marked locally inhibited. If the signalling link is marked locally inhibited, the receiving signalling point takes no further action. If the signalling link is not marked locally inhibited, the receiving signalling point initiates the uninhibiting procedure in order to align the inhibiting status at the two ends of the link.

¹⁸ Except for some additional options provided in 10.3.2 for signalling routing control uninhibiting, management inhibiting procedures are the same as those in the CCITT Blue Book, although text used to describe the procedures differs from Blue Book text at many points, because T1.111-1996 text is retained.

¹⁹ For further study under system management.

10.2 *Inhibiting Initiation and Actions*

When at signalling point *X*, a request is received from a management function to inhibit a signalling link to signalling point *Y*, the following actions take place:

1. A check is performed at signalling point *X* to determine whether, in the case of an available link, inhibiting will result in a destination becoming inaccessible, or in the case of an unavailable link, signalling point *Y* is inaccessible. If either is the case, management is informed that the inhibiting request is denied.
2. If inhibiting is permitted, signalling point *X* sends an inhibit message to signalling point *Y*, indicating that it wishes to inhibit the signalling link identified in the message.
3. Signalling point *Y*, on receiving the inhibit message from *X*, checks whether, in the case of an available link, inhibiting will result in a destination becoming inaccessible; and, if so, an inhibit denied message is returned to signalling point *X*. The latter then informs the management function which requested inhibiting that the request cannot be granted.
4. If signalling point *Y* finds that inhibiting of the concerned link is permissible, it sends an inhibit acknowledgment to signalling point *X*, marks the link remotely inhibited, and starts inhibit test procedure timer T21.¹⁰ If the link concerned is currently carrying traffic, signalling point *Y* sends the inhibit acknowledgement via that link and diverts subsequent traffic for it, using the time controlled changeover procedure.
5. On receiving an inhibit acknowledgment message, signalling point *X* marks the link locally inhibited, informs management that the link is inhibited, and starts inhibit test procedure timer T20.¹⁰ If the link concerned is currently carrying traffic, signalling point *X* diverts subsequent traffic for the link, using the time controlled changeover procedure.
6. When changeover has been completed, the link while inhibited, is unavailable for the transfer of user-generated traffic but still permits the exchange of test messages.
7. If, for any reason, the inhibit acknowledgment message is not received, a timer T14¹⁰ expires and the procedure is restarted including inspection of the status of the destination of the inhibit message. If the destination is not available, management is informed.

At most two consecutive automatic attempts may be made to inhibit a particular link.

10.3 *Uninhibiting Initiation and Actions*

Signalling link uninhibiting is initiated at the signalling point which originally caused the link to be inhibited, upon receipt of an uninhibit or forced uninhibit request.

In a given signalling point, an uninhibit request may be initiated for a locally inhibited link by the management or signalling routing control function, while a forced uninhibiting request may be initiated for a remotely inhibited link by the signalling routing control function only.

Signalling routing control will initiate signalling link uninhibiting if an inhibited link is found to be a member of a link set in a route to a destination which has become inaccessible.

If such signalling routing control uninhibiting is unsuccessful because of a failed or blocked inhibited link, and if that link recovers or becomes unblocked with the destination still unavailable, uninhibiting is reattempted.

10.3.1 Management Initiated Uninhibiting

Upon receipt of an uninhibiting request from the management function of signalling point X regarding an inhibited link to signalling point Y, the following actions take place:

1. A check is performed at signalling point X to determine whether an uninhibit message can be sent to signalling point Y, either over an available route, or, if all routes to signalling point Y are unavailable, over the concerned inhibited link. If all routes to signalling point Y are unavailable and the concerned inhibited link is marked failed or processor outage, management is informed that uninhibiting is not possible.
2. If uninhibiting is possible, signalling point X sends an uninhibit signalling link message to signalling point Y indicating that the link identified in the message should be uninhibited.
3. Upon receipt of the uninhibit signalling link message, signalling point Y returns an uninhibit acknowledgment message to signalling point X and cancels the remote inhibit indication. If no locally inhibited, failed or blocked condition exists on the link, it is put in the available state and changeback is initiated.
4. On receipt of the uninhibit acknowledgment message, signalling point X cancels the local inhibit indication, and informs management that the link has been uninhibited. If no remotely inhibited, failed or blocked condition exists on the link, it is put in the available state and changeback is initiated.
5. If, for any reason, the uninhibit acknowledgment message is not received, a timer T12¹⁰ expires and the procedure is restarted including inspection of the status of the destination of the inhibit message. If the destination is not available, or T12 has expired for the second time during the uninhibition attempt on this link, management is informed, and the uninhibition is abandoned.

10.3.2 Signalling Routing Control Initiated Uninhibiting

Upon receipt of an uninhibit request from signalling routing control at signalling point X regarding an inhibited link to signalling point Y, the following actions take place:

1. A check is performed at signalling point X to determine whether an uninhibit message can be sent to signalling point Y, either over an available route, or, if all routes to signalling point Y are unavailable, over the concerned inhibited link. If all routes to signalling point Y are unavailable and the concerned inhibited link is marked failed or processor outage, signalling routing control is informed that uninhibiting is not possible.
2. If uninhibiting is possible, a further check is performed by signalling point X to determine whether inhibiting initiated by X (local inhibiting) or inhibiting initiated by Y (remote inhibiting) is in effect.
3. If local inhibiting is in effect, then the actions described in 10.3.1(2) through 10.3.1(5) take place. If uninhibition is abandoned, step (6) below is taken.

4. If remote inhibiting is in effect, then the signalling point X requests forced uninhibiting of the signalling link by sending a force uninhibit signalling link message to signalling point Y, which will then initiate uninhibiting in accordance with the description given in 10.3.1(2) through 10.3.1(5) take place. The force uninhibit signalling link message is transmitted over the link to be uninhibited (As an implementation option, the force uninhibit signalling link message can be sent over an available route, if an available route exists.).
5. If for any reason, an uninhibit signalling link message is not received in response to the force uninhibit message, a timer T13¹⁰ expires. If this is the first expiry of T13 for this uninhibition attempt on this link, the procedure is restarted including inspection of the status of the inhibited link. If the link is marked failed or blocked, or timer T13 has expired for the second time during uninhibition of this link, management is informed and the uninhibition is abandoned.
6. If an attempt to uninhibit a signalling link is abandoned, signalling routing control attempts to uninhibit the next inhibited link to signalling point Y, starting from (1) above. The search continues until either a link is successfully uninhibited, or all possible links to Y in the routing table have been exhausted, or the destination has become available for other reasons. Optionally, when more signalling links than one are inhibited, uninhibiting attempts may proceed in parallel.

10.3A Inhibit Test Procedure Actions

When a signalling link becomes inhibited, either locally, remotely, or both, the following test procedure actions take place, as appropriate:

1. If timer T20 expires at signalling point X and the signalling link is locally inhibited at signalling point X, signalling point X transmits a local inhibit test message to the signalling point at the other end of the locally inhibited link and restarts timer T20.
2. If timer T20 expires at signalling point X and the signalling link is no longer locally inhibited, no action is taken.
3. If timer T21 expires at signalling point X and the signalling link is remotely inhibited at signalling point X, signalling point X transmits a remote inhibit test message to the signaling point at the other end of the remotely inhibited link and restarts timer T21.
4. If timer T21 expires at signalling point X and the signalling link is no longer remotely inhibited, no action is taken.
5. If signalling point Y receives a local inhibit test message from signalling point X and the concerned link is marked remotely inhibited, no action is taken.
6. If signalling point Y receives a local inhibit test message from signalling point X and the concerned signalling link is not marked remotely inhibited, the forced uninhibiting procedure is invoked at signalling point Y, beginning with the transmission of a force uninhibit signalling link message to signalling point X. As a result of this procedure, the local inhibit indicator is canceled at signalling point X.
7. If signalling point Y receives a remote inhibit test message from signalling point X and the concerned link is marked locally inhibited, no action is taken.
8. If signalling point Y receives a remote inhibit test message from signalling point X and the concerned signalling link is not marked locally inhibited, the uninhibiting procedure is invoked at signalling point Y, beginning with the transmission of a uninhibit signalling link message to

signalling point X. As a result of this procedure, the remote inhibit indicator is canceled at signalling point X.

10.3B Procedures for Abnormal Conditions

10.3B.1 An inhibit signalling link message concerning a remotely inhibited signalling link is answered with an inhibit acknowledgment message without taking any further action.

10.3B.2 An uninhibit signalling link message concerning an uninhibited link is answered with an uninhibit acknowledgment message without taking any further action.

10.3B.3A force uninhibit signalling link message concerning an uninhibited link is answered with an uninhibit signalling link message without taking any further action.

10.3B.4 If an inhibit acknowledgment message is received and no inhibit signalling link message is outstanding for the concerned link, no action is taken.

10.3B.5 If an uninhibit acknowledgment message is received and no uninhibit signalling link message is outstanding for the concerned link, no action is taken.

10.3B.6 After a local processor recovery that involves loss of inhibit status information, the signalling point will mark all the links as uninhibited, and the traffic will be restarted.

10.3B.7 The following rules apply when management or routing control requests uninhibiting of a signalling link for which an unacknowledged inhibit message is outstanding or when management requests the inhibiting of a signalling link for which an unacknowledged uninhibit message is outstanding.

1. If a signalling point transmits an inhibit signalling link message concerning a particular signalling link, it will not transmit an uninhibit signalling link message concerning the same signalling link until the inhibit signalling link message is acknowledged or the inhibit procedure is timed out.
2. If a signalling point transmits an uninhibit signalling link message concerning a particular signalling link, it will not transmit an inhibit signalling link message concerning the same signalling link until the uninhibit signalling link message is acknowledged or the uninhibit procedure is timed out.

10.3B.8 If traffic for Level 4 is received on an inhibited signalling link, the traffic will be discriminated and distributed. Reception of traffic on an inhibited signalling link is, however, considered an abnormal situation that occurs upon processor recovery.

11 SIGNALLING TRAFFIC FLOW CONTROL

11.1 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:

1. Failures in the signalling network (signalling links or signalling points) have resulted in route set unavailability. In this situation, flow control may provide a short-term remedy until more appropriate actions can be taken.
2. Congestion of a signalling link or signalling point has resulted in a situation where reconfiguration is not appropriate.
3. Failure 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.

11.2 Flow Control Indications

The need for the following indications has been identified.

11.2.1 Signalling Route Set Unavailability

In the case when no signalling route is available for traffic towards a particular destination (see 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.

11.2.2 Signalling Route Set Availability

In the case when a signalling route becomes available for traffic to a previously inaccessible destination (see 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.

11.2.3 Signalling Route Set Congestion (International Signalling Network)

11.2.3.1 When the congestion status of a signalling route set changes to congested, the following actions will be taken:

1. When a message from a local User Part is received for a congested route set the following actions are performed:
 - a. The message is passed to level 2 for transmission.
 - b. A congestion indication primitive will be returned to each level-4 User Part, for the initial message and for every n messages ($n = 8$ provisional value) received for the congested destination. The congestion indication primitive contains as a parameter the DPC of the affected destination.
2. When a message is received at an STP for a congested route set, the following actions take place:
 - a. The message is passed to level 2 for transmission.
 - b. A transfer-controlled message is sent to the originating point for the initial message and for every n messages ($n = 8$ provisional value) received for the congested route set.

11.2.3.2 At the reception of a transfer-controlled message the receiving signalling point informs each level-4 User Part of the affected destination by means of a congestion indication primitive specified in 11.2.3.1(1).

11.2.3.3 When the status of a signalling route set changes to uncongested normal operation is resumed. Resumption of message transmission towards the concerned destination is the responsibility of the level-4 User Parts.

11.2.4 Signalling Route Set Congestion (National Option with Congestion Priorities)

When the congestion status of a signalling route set changes as a result of either the receipt of a transfer-controlled message relating to a particular destination (see 13.7) or an indication of local signalling link congestion, or due to the signalling-route-set-congestion-test procedure (see 13.9) an indication is given from the Message Transfer Part to the local level 4 informing them about the current congestion status of the signalling route set. Each user then takes appropriate actions in order to stop generation of signalling messages destined for the affected signalling point with congestion priorities lower than the specified congestion status. Messages received from local level 4 with congestion priorities lower than the current signalling route set congestion status are discarded by the Message Transfer Part.

11.2.5 Signalling Route Set Congestion (National Option without Congestion Priorities)

(This clause has been deleted as it is not applicable to U. S. networks).

11.2.6 Signalling Point/Signalling Transfer Point Congestion

Signalling message handling congestion in a signalling point or signalling transfer point occurs when the offered load exceeds the capacity or ability of the signalling point's or signalling transfer point's signalling message handling function. The procedures used to control signalling point or signalling transfer point congestion are a combination of level 2 flow control procedures, MTP Level 3 congestion control procedures, and transfer-restricted procedures.

The level 2 flow control procedure is the first method that a signalling point or signalling transfer point uses to prevent internal congestion (i.e., when offered load exceeds the capacity or ability of the signalling point's or signalling transfer point's signalling message handling function). A signalling point or signalling transfer point shall rely upon the level 2 flow control procedure to match the level 2 acceptance rate of messages to the acceptance rate of the MTP Level 3 signalling message handling function.

If the congestion is not controlled by the level 2 flow control procedure, the signalling point or signalling transfer point applies MTP Level 3 congestion control procedures. Predetermined levels of signalling message handling capacity, known as signalling message handling thresholds, identify when the ability of the signalling message handling function has been exceeded. The location, setting, and determination of the signalling message handling congestion thresholds are implementation dependent (see clause 3.8.A). A signalling transfer point responds to signalling message handling congestion by discarding-messages based on message priority (see clause 2.3.A), sending transfer-controlled messages to originators of discarded messages (see clause 13.7.2 (ii)), and sending indications to its Message Transfer Part users or Message Transfer Part functions concerning messages generated by these users or functions which were discarded. (See clause 11.2.4) A signalling point acts similarly although the sending of transfer-controlled messages to originators of discarded messages is optional.

Furthermore, in the case of signalling transfer points, if sufficient resources associated with signalling message handling have failed, resulting in an internal signalling message handling capacity reduction such that congestion is possible but is unlikely to exist at the mate signalling transfer point (an implementation-specific determination), the signalling transfer point sends transfer-restricted messages to adjacent signalling points via the response method (see clause 13.4.2 (2)). In this case, transfer-restricted messages should be sent before transfer-controlled messages, if possible. The affected destinations are considered restricted until sufficient signalling message handling resources become available (an implementation-specific determination) (see clause 3.3.2.3).

11.2.7 MTP User Flow Control

11.2.7.1 If the Message Transfer Part is unable to distribute a received message to a local user because that user is unavailable (MTP user unavailability is an implementation dependent notion -- it can include unavailability for management reasons or nonexistence of the user at that signalling point), the Message Transfer Part sends a user part unavailable message to the Message Transfer Part at the

originating signalling point. The detailed information whether the User is unequipped or unavailable for management reasons is contained in the User Part Unavailability message.

11.2.7.2 When the originating signalling point's Message Transfer Part receives a user part unavailable message, it:

1. Informs the management process; and
2. Sends an indication (MTP-STATUS with parameters, identifying the signalling point containing the unavailable user part as well as the cause "unequipped remote User" (if no such user exists), or "inaccessible remote User" (if the User exists but the MTP cannot currently distribute messages to it)) to the local MTP user designated in the message, if it is available, informing it that the peer user is unavailable at the particular signalling point.

11.2.7.3 The user should then take appropriate action to stop generation of normal signalling information for the unavailable user.

11.2.7.4 If the unavailability cause is "inaccessible remote User" or "unknown", it is the responsibility of the MTP user to determine when the remote MTP user is again available (MTP user availability is an implementation dependent notion). The user may, for example, send test messages periodically, or use reception of a message from the remote user as an implicit indication of availability, or both. If the unavailability cause is "unequipped remote User" these actions should not be performed.

11.2.7.5 The user part unavailable (UPU) message contains:

1. The label, indicating the destination and originating points;
2. The user part unavailable signal;
3. The identity of the affected MTP user; and
4. The cause of the unavailability.

The format and coding of this message appear in clause 15.

11.2.7.6 When the Message Transfer Part is again able to distribute received messages to a previously unavailable local MTP user, it resumes normal distribution of messages to that user.

11.2.7.7 If a user part unavailable message is received by the Message Transfer Part referring to a remote MTP user whose local peer is unequipped, the Message Transfer Part informs the management process and discards the user part unavailable message.

12 SIGNALLING LINK MANAGEMENT

12.1 General

12.1.1 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 subclauses. Each set corresponds to a certain level of automation as regards allocation and reconfiguration of signalling equipment. The basic set includes the minimum number of functions that must be provided for national or 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.

12.1.2 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 clause 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 of 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 some 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 Chapter T1.111.2).

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 12.5 and 12.6, 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.

12.1.3 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 clause 7.3 of Chapter T1.111.3 or

clause 6.2.2 of T1.645-1995 (R2008)]. 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:

1. No automatic functions are provided for allocation of signalling terminals and signalling data links (see 12.2);
2. An automatic function is provided for allocation of signalling terminals (see 12.3); or
3. Automatic functions are provided for allocation of signalling terminals and signalling data links (see 12.4).

12.2 Basic Signalling Link Management Procedures

12.2.1 Signalling Link Activation

12.2.1.1 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 that 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.

12.2.1.2 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 the signalling link test is started. If the signalling link test is successful, the link becomes ready to convey signalling traffic. When initial alignment is not possible, as determined at level 2 [see clause 7 of Chapter T1.111.3 or clause 6.2.2 of T1.645-1995 (R2008)], new initial alignment procedures are started on the same signalling link, after a time T_{17}^{10} (delay to avoid the oscillation of initial alignment failure and link restart. The value of T_{17} should be greater than the loop delay and less than the value of timer T_2 (see clause 7.3 of Chapter T1.111.3 or clause 6.2.2 of T1.645-1995 (R2008)). If the signalling link test fails, link restoration starts until the signalling link is activated or a manual intervention is made. If after a time T_{19}^{10} the signalling link has not been activated, a management function is notified, and, optionally, T_{19} may be restarted.

12.2.2 Signalling Link Restoration. After a signalling link failure is detected, signalling link initial alignment will take place. When the initial alignment procedure is successful, a signalling link test is started. If the signalling link test is successful, the signalling link is regarded as restored and thus available for signalling.

If initial alignment is not possible, as determined at level 2 [see clause 7 of Chapter T1.111.3 or clause 6.2.2 of T1.645-1995 (R2008)], new initial alignment procedures may be started on the same signalling link after a time T17 until the signalling link is restored or a manual intervention is made; e.g., to replace the signalling data link or the signalling terminal. If after time T19 the signalling link has not activated, a management function is notified, and, optionally, T19 may be restarted.

If the signalling link test fails, the restoration procedure is repeated until the link is restored or a manual intervention is made.

In order to prevent links from oscillating rapidly between the in-service and out-of-service states, a link oscillation filtering procedure shall be provided. This procedure is applicable in all cases where automatic restoration and removal of signalling links to and from service is used. The procedure is not invoked if restoration to or removal from service is initiated manually.

Link oscillation filtering is a local procedure. One of the following procedures, A or B, is used:

- A. When restoration begins, the oscillation timer T32¹⁰ is started. If the link fails within T32, the link is placed in the "suspension" state until T32 expires.

When a link exits the "suspension" state, link restoration is to be started and T32 is restarted.

When a link is in "suspension," the link remains in the out-of-service state at level 2, restoration procedures to bring the link back into alignment are not invoked and realignment attempts initiated by the remote end are ignored.

The oscillation timer T32 value chosen in a given signalling point may be modified by management action. The expiration of the timer does not change the link status.

- B. When activation or restoration of a signalling link has been completed, it is put on probation for a period controlled by timer T33¹⁰ which starts running when the link enters the in-service state and is stopped either on time-out or on link failure.

If a link fails during probation, i.e. before expiration of timer T33, it is put on suspension. While suspended the link remains in the out-of-service state at level 2, restoration procedures to bring the link back into alignment are not invoked and realignment attempts initiated by the remote end are ignored. The suspension time period is controlled by timer T34¹⁰ which starts running when the link enters the out-of-service state. Link restoration is resumed, on expiry of timer T34.

The values chosen in a given network node for the probation and suspension time periods are dependent on the type and location of the node in the network and may be modified by management action.

12.2.3 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. The deactivation procedure is given in Figure 40/T1.111.4.

12.2.4 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:

1. Link set normal activation; and
2. Link set emergency restart.

12.2.4.1 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:

1. All signalling links in a link set are faulty;
2. A processor restart in a signalling point makes it necessary to re-establish a link set; or
3. 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 (see clause 12.2.4.2 for examples of emergency situations).

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 12.2.1 until the signalling links are made active.

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

12.2.4.2 Link Set Emergency Restart. Link set emergency restart should only be used when an immediate reestablishment 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.

A signalling point shall use link set emergency restart procedures when all the links in the restarting link set are unavailable (i.e., there are no other available links in the link set) and one or both of the following criteria are satisfied:

1. The signalling point at the remote end is inaccessible (i.e., it is not possible to communicate with the signalling point at the remote end of the link set via any available route).
2. The local signalling point is performing MTP Restart.

A signalling point may use link set emergency restart procedures when all the links in the restarting link_set are unavailable and one or both of the following criteria are satisfied provided that the signalling point is capable of determining these conditions at the time the link set restart is initiated:

1. One or more remote destination signalling points normally accessible via that link set are not accessible via any other route (i.e., the restarted link set would allow communication with one or more inaccessible destination signalling points).
2. The link set is a member of a signalling route set and the other (available) link sets in the route set are experiencing severe local transmit link congestion (congestion level ≥ 2).

A signalling point must use normal link set restart procedures when none of the above conditions are satisfied for an unavailable 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 clause 7 of Chapter T1.111.3 or clause 6.2.2 of T1.645-1995 (R2008)]. Furthermore, the signalling terminals employ the emergency proving procedure 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 procedures.

12.2.4.3 Time-out Values

The initial alignment procedure [see clause 7.3 of Chapter T1.111.3 or clause 6.2.2 of T1.645-1995 (R2008)] includes time-outs, the expiry of which indicates the failure of an activation or restoration attempt.

12.3 Signalling Link Management Procedures Based on Automatic Allocation of Signalling Terminals²⁰

12.3.1 Signalling Link Activation²¹

12.3.1.1 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 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 signalling links in a link set, should be identical at both ends of the link set.

12.3.1.2 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

²⁰ The use of automatic allocation of signalling data links and signalling terminals is for further study for SAAL-based signalling links.

²¹ The procedures to be used on initialization of a new link set or re-initialization of a signalling point are for further study.

example, when a link set is to be brought into service for the first time (see 12.3.4), or when a link failure occurs. In the latter case, activation starts when the restoration attempts on the faulty link are considered unsuccessful (see 12.3.2).

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. 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.

12.3.1.3 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 12.5.

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, shall be removed from its alternative use (e.g., as a speech circuit) before signalling link activation can start.

12.3.1.4 The chosen signalling terminal is then connected to the signalling data link, and the initial alignment starts (see clause 7 of Chapter T1.111.3).

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

If initial alignment is not possible, as determined at level 2 (see clause 7 of Chapter T1.111.3), or the test fails, 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 after a time T17 until it is restored, or its signalling terminal is disconnected (see 12.5). If after a time T19¹⁰ the signalling link has not been activated, a management function is notified, and, optionally, T19 may be restarted.

In view of the fact that if it is not possible to activate a signalling link an attempt is made to activate the next inactive signalling link in a link set, it may be that the two ends of a link set continuously attempt to activate different signalling links. By having different values of initial alignment time-out T2 at the two ends of the link set (see 12.3.4.3), it is ensured that eventually both ends of the link set will attempt to activate the same signalling link.

12.3.2 Signalling Link Restoration

12.3.2.1 After a signalling link failure is recognized, signalling link initial alignment will take place (see clause 7 of Chapter T1.111.3). When the initial alignment is successful, a signalling link test is started. If the signalling link test 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.

12.3.2.2 The signalling terminal may be automatically replaced in accordance with the principles defined for automatic allocation of signalling terminals (see 12.5). 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 after time T17 until a manual intervention is made, or the signalling terminal is disconnected (see 12.5). If after a time T19¹⁰ the signalling link has not been activated, a management function is notified, and, optionally, T19 may be restarted.

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.

12.3.3 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 12.5).

12.3.4 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:

1. Link set normal activation; or
2. Link set emergency restart.

12.3.4.1 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:

1. All signalling links in a link set are faulty;
2. A processor restart in a signalling point makes it necessary to re-establish a link set; or
3. A signalling point recognizes other irregularities concerning the interworking between the two signalling points; e.g., 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 (e.g., 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 links sets at the same time.

The signalling link activation procedures are performed as specified in 12.3.1.

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.²² According to the principles for automatic allocation of signalling terminals defined in 12.5, 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 12.3.1, 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.

12.3.4.2 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 (clause 7 of Chapter T1.111.3) are employed in order to accelerate the procedure (see further 12.2.4.2).

²² 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.

12.3.4.3 Time-Out Values. The values of the initial alignment time-outs T2 (see clause 7 of Chapter T1.111.3) will be different at the two ends of the link set, if automatic allocation of signalling terminals or signalling data links is applied at both ends of a signalling link set.

12.4 Signalling Link Management Procedures Based on Automatic Allocation of Signalling Data Links and Signalling Terminals²⁰

12.4.1 Signalling Link Activation

12.4.1.1 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.

12.4.1.2 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 12.4.4), or when a link failure occurs. In the latter case, activation starts when the restoration attempts on the faulty link are considered unsuccessful (see 12.4.2).

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.

12.4.1.3 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 12.5.

The signalling data link is allocated automatically by means of the function defined in 12.6. However, in conjunction with link set activation, the identity of the signalling data link to use may be predetermined (see 12.4.4). A signalling data link which is not connected to a signalling terminal may be utilized for other purposes, e.g., 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.

12.4.1.4 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 clause 7 of Chapter T1.111.3). If the initial alignment procedure is successful, the signalling link is active and a signalling link test is started. If the signalling link test is successful the link becomes ready to convey signalling traffic.

If the initial alignment is not possible, as determined at Message Transfer Part Level 2 (see clause 7 of Chapter T1.111.3), alternative signalling data links are automatically connected to the signalling terminal, until an initial alignment procedure is successfully completed. 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 12.4.1.2 above). Successive initial alignment attempts may continue on the previous signalling link after a time T17 until it is activated, or its signalling terminal is disconnected (see 12.5).

12.4.2 Signalling Link Restoration

12.4.2.1 After a signalling link failure is recognized, signalling link initial alignment will take place (see clause 7 of Chapter T1.111.3). In the case when the initial alignment is successful, a signalling link test is started. If the signalling link test is successful the link becomes restored, and thus available for signalling.

If the initial alignment is unsuccessful or the signalling link test fails, the signalling terminal and signalling data link may be faulty and require replacement.

12.4.2.2 The signalling data link may be automatically replaced by an alternative, in accordance with the principles defined in 12.6. 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 12.4.1.2). Successive initial alignment attempts may, however, continue on the previous (faulty) signalling link after a time T17 until it is restored or its signalling terminal is disconnected.

12.4.2.3 The signalling terminal may be automatically replaced in accordance with the principles defined in 12.5. 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 12.4.1.2).

Successive initial alignment attempts may, however, continue on the previous (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 12.4.2.2 and 12.4.2.3 above is taking place.

12.4.3 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 -- e.g., 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 12.5 and 12.6).

12.4.4 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 12.3.4). The link set activation procedure is performed as specified in 12.3.4, also as regards the allocation of signalling data links; i.e., 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 (see 12.6). 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 12.4.1).

12.5 Automatic Allocation of Signalling Terminals.

In conjunction with the signalling link activation and restoration procedures specified in 12.3 and 12.4, 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:

1. An idle signalling terminal (i.e., a signalling terminal not connected to a signalling data link) is chosen if possible; or
2. 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 12.3 and 12.4).

Measures should be employed to ensure that signalling terminals to be allocated to signalling links are able to function correctly (see Chapter T1.111.7).

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 (2) 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 Chapter T1.111.7).

12.6 Automatic Allocation of Signalling Data Links

12.6.1 In conjunction with the signalling link activation and restoration procedures specified in 12.4, 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 semipermanent 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).

12.6.2 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:

1. The label, indicating the destination and originating signalling points;
2. The SLC, indicating the identity of the signalling link being activated or restored;
3. The signalling-data-link-connection-order; and
4. The identity of the signalling data link.

Formats and codes for the signalling-data-link-connection-order message appear in clause 15.

12.6.3 Upon reception of the signalling-data-link-connection-order, the following applies:

1. When the signalling link to which a received signalling-data-link-connection-order message 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 acknowledgment is sent to the remote signalling point. 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 acknowledgment contains an indication informing the remote signalling point whether or not an alternative signalling data link should be allocated to the concerned signalling link.
2. When the signalling point receives a signalling data link connection order while waiting for an acknowledgment, 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.
3. 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-acknowledgment contains the label, indicating the destination and originating signalling points, and the SLC, indicating the identity of the signalling link to activate or restore, and one of the following signals:

1. Connection-successful signal, indicating that the signalling data link has been connected to a signalling terminal;
2. 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; or
3. 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-acknowledgment message appear in clause 15.

12.6.4 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 12.4).

In the case when the acknowledgment 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 acknowledgment 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-acknowledgment or -order is received from the remote signalling point within a time-out $T7^{10}$ the signalling-data-link-connection-order is repeated.

12.6.5 When a signalling data link is disconnected in conjunction with a signalling link restoration or deactivation, the signalling data link is made idle (and available -- e.g., as speech circuit).

12.7 Different Signalling Link Management Procedures at the Two Ends of a Link Set

Normally both ends of a link set use the same signalling link management procedures.

However, if one end uses the basic signalling link management procedures, the other end may use the signalling link management procedures based on automatic allocation of signalling terminals. In that case a signalling link includes a predetermined signalling terminal at one end; a predetermined signalling data link; and at the other end, any of the signalling terminals applicable to the concerned link group.

In the case when one end of a link set uses the basic signalling link management procedures and the other end uses the signalling link management procedures based on automatic allocation of signalling terminals, the values of initial alignment time-out T2 do not have to be different at the two ends of the link set.

13 SIGNALLING ROUTE MANAGEMENT²³

13.1 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, restriction, and availability of a signalling route is communicated by means of the transfer-prohibited, transfer-restricted, and transfer-allowed procedures, respectively, specified in 13.2, 13.4 and 13.3.

Recovery of signalling route status information is made by means of the signalling-route-set-test procedure specified in 13.5.

In the international signalling network congestion of a route set is communicated by means of the TFC message specified in 13.6.

In U. S. networks, congestion of a signalling route set is communicated by means of the TFC as specified in 13.7 and the signalling-route-set-congestion-test procedure specified in 13.9.

13.2 Transfer-Prohibited

13.2.1 The transfer-prohibited procedure is performed at a signalling transfer point when it has to notify one or more adjacent signalling points that they must no longer route messages to it for a concerned signalling point.

²³ The possibility of referring to networks as well as individual destinations and clusters in signalling route management messages is for further study.

The transfer-prohibited procedure makes use of the transfer-prohibited message, which contains:

- (1) The label, indicating the destination and originating points;
- (2) The transfer-prohibited signal or the transfer-cluster-prohibited signal; and
- (3) The destination, or cluster of destinations, for which traffic transfer is no longer possible.

The format and codes of this message appear in clause 15.

The transfer-prohibited messages are always addressed to an adjacent signalling point. They may use any available signalling route that leads to that signalling point.

13.2.2 A transfer-prohibited message relating to a given destination *X* is sent from a signalling transfer point *Y* in the following cases unless the optional transfer-cluster-prohibited message is sent instead according to the criteria in 13.2.2A (see also 13.5.4):

1. When signalling transfer point *Y* starts to route (at changeover, changeback, forced or controlled rerouting) signalling traffic destined to destination *X* via signalling transfer point *Z* not currently used by signalling transfer point *Y* for this traffic. In this case, the preventive²⁴ transfer-prohibited message is sent to the following signalling transfer points:
 - a. Signalling transfer point *Z*, and to other signalling transfer points that are on currently unavailable routes of equal priority,
 - b. Other adjacent signalling transfer points that are on alternate routes of higher priority,
 - c. And may be sent to any other selected adjacent signalling transfer points.

Optionally, timer T8¹⁰ may be started to inhibit sending additional transfer-prohibited messages concerning *X* to the same adjacent point by the response method.

2. When signalling transfer point *Y* recognizes that it is unable to transfer signalling traffic destined to destination *X* (see 5.3.3 and 7.2.3) and destination *X* has been designated (by the administration of the network to which *Y* belongs) as one for which signalling transfer point *Y* should broadcast transfer-prohibited messages. In this case transfer-prohibited message is sent to all accessible adjacent signalling points (Broadcast method), and timer T8 is started concerning destination *X*.

The broadcast method is optional.²⁵ It may be used at the network boundary only with bilateral agreement. If the broadcast method is suppressed, the response method is immediately activated.

3. When a message destined to destination *X* is received at signalling transfer point *Y* and signalling transfer point *Y* is unable to transfer the message and no corresponding timer T8 is running. In this case the transfer-prohibited message is sent to the accessible adjacent signalling point from which the concerned message was received (Response method). Optionally, timer T8 may be started to inhibit sending additional transfer-prohibited messages concerning *X* to the same adjacent point by the response method.

²⁴ A *preventive* transfer-prohibited message is a transfer-prohibited message used to prevent circular routes.

²⁵ As a network option, the signalling transfer point may stop the broadcast of transfer-prohibited messages during large failures and send transfer-prohibited messages using the response method to notify the adjacent nodes that the destination is inaccessible. When to stop the broadcast is network dependent.

4. When an adjacent signalling point Z becomes accessible, signalling transfer point Y sends to Z a transfer-prohibited message concerning X, if X is inaccessible from Y (see clause 9).
5. When signalling transfer point Y restarts, it broadcasts to all accessible adjacent signalling points transfer-prohibited messages concerning X, if X is inaccessible from Y (see clause 9).
6. When a signalling transfer point receives a message from an adjacent signalling transfer point and one of the following applies to the adjacent signalling transfer point:
 - a. It is on the currently used route to the destination of the message;
 - b. A preventive transfer-prohibited message has been sent to it and no corresponding timer T8 is running;
 - c. It is on the currently used route to the destination of the message and a preventive transfer-prohibited message has been sent to it and no corresponding timer T8 is running,
 the signalling transfer point (re)sends a transfer-prohibited message to that signalling transfer point.

Examples of the above situations appear in Chapter T1.111.5.

13.2.2A As a network option, a signalling transfer point Y that uses the same routing to transfer traffic to all destinations in a cluster CX may send transfer-cluster-prohibited messages relating to that cluster in the following cases (see also 13.5.4A):²⁶

1. When signalling transfer point Y starts to route (at changeover, changeback, forced or controlled rerouting) signalling traffic destined to cluster CX via a signalling transfer point Z not currently used by signalling transfer point Y for this traffic. In this case, the preventive transfer-cluster-prohibited message is sent to the following signalling transfer points:
 - a. Signalling transfer point Z, and to other signalling transfer points that are on currently unavailable routes of equal priority,
 - b. Other adjacent signalling transfer points that are on alternate routes of higher priority,
 - c. And may be sent to any other selected adjacent signalling transfer points.
 - d. Optionally, timer T8 may be started to inhibit sending additional transfer-cluster-prohibited messages concerning CX to the same adjacent point by the response method.
2. When signalling transfer point Y recognizes that it is unable to transfer traffic destined to a cluster CX (see 5.3.3 and 7.2.3) and the concerned cluster has been designated (by the administration of the network to which Y belongs) as one for which signalling transfer point Y should broadcast transfer-prohibited messages. In this case a transfer-cluster-prohibited message is sent to all accessible adjacent signalling points (Broadcast method), and timer T8 is started concerning cluster CX.

²⁶ These procedures are subject to further study

The broadcast method is optional.²⁷ It may be used at the network boundary only with bilateral agreement. If the broadcast method is suppressed, the response method is immediately activated.

3. When signalling transfer point *Y* is unable to transfer messages to any signalling point within the cluster *CX* and a message destined to a signalling point within that cluster is received and no corresponding timer *T8* is running. In this case a transfer-cluster-prohibited message referring to the inaccessible cluster is sent to the adjacent signalling point from which the concerned message was received (Response method). Optionally, timer *T8* may be started to inhibit sending additional transfer-cluster-prohibited messages concerning cluster *CX* to the same adjacent point by the response method.
4. When an adjacent signalling point *Z* becomes accessible, signalling transfer point *Y* sends to *Z* a transfer-cluster-prohibited message concerning *CX*, if *CX* is inaccessible from *Y* (see clause 9).
5. When signalling transfer point *Y* restarts, it broadcasts to all accessible adjacent signalling points transfer-cluster-prohibited messages concerning *CX*, if *CX* is inaccessible from *Y* (see clause 9).
6. When a signalling transfer point receives a message from an adjacent signalling transfer point and one of the following applies to the adjacent signalling transfer point:
 - a. It is on the currently used route to the destination of the message;
 - b. A preventive transfer-cluster-prohibited message has been sent to it and no corresponding timer *T8* is running;
 - c. It is on the currently used route to the destination of the message and a preventive transfer-cluster-prohibited message has been sent to it and no corresponding timer *T8* is running;

The signalling transfer point (re)sends a transfer-cluster-prohibited message to that signalling transfer point.

13.2.3 When a signalling point receives a transfer-prohibited or transfer-cluster-prohibited message from a signalling transfer point *Y* it performs the actions specified in clause 7 (since reception of transfer-prohibited or transfer-cluster-prohibited messages indicates the unavailability of the concerned signalling route, see 3.4.1). In other words, it may perform forced rerouting and, if appropriate, generate additional transfer-prohibited or transfer-cluster-prohibited messages.

Optionally, when a signalling transfer point must divert traffic to an alternate route because it receives a transfer-prohibited or transfer-cluster-prohibited message, depending on network architecture, it may perform the actions specified in clause 8. In other words, it may perform controlled rerouting to maintain the sequence of messages while diverting them to the alternate link set.

13.2.4 In some circumstances it may happen that a signalling point receives either a repeated transfer-prohibited or transfer-cluster-prohibited message, or a transfer-prohibited or transfer-cluster-prohibited message relating to a nonexistent route (i.e., there is no route from that signalling point to

²⁷ As a network option, the signalling transfer point may stop the broadcast of transfer-cluster-prohibited messages during large failures and send transfer-cluster-prohibited messages using the response method to notify the adjacent nodes that the destination is inaccessible. When to stop the broadcast is network dependent.

the concerned destination via signalling transfer point Y, according to signalling network configuration) or to a destination that is already inaccessible, due to previous failures; in this case, no action is taken.

13.3 *Transfer-Allowed*

13.3.1 The transfer-allowed procedure is performed at a signalling transfer point when it has to notify one or more adjacent signalling points that they may start to route to it, if appropriate, messages for a concerned signalling point.

The transfer-allowed procedure makes use of the transfer-allowed message, which contains:

1. The label, indicating the destination and originating points,
2. The transfer-allowed signal or the transfer-cluster-allowed signal, and
3. The destination or cluster of destinations for which transfer is now possible.

Formats and codes of this message appear in clause 15.

Transfer-allowed messages are always addressed to an adjacent signalling point. They may use any available signalling route that leads to that signalling point.

13.3.2 A transfer-allowed message relating to a given destination X is sent from signalling transfer point Y in the following cases unless the optional transfer-cluster-allowed message is sent instead according to the criteria in clause 13.3.2A (see also 13.5.4):

1. When signalling transfer point Y stops routing (at changeback or controlled rerouting) signalling traffic destined to destination X via a signalling transfer point Z (to which the concerned traffic was previously diverted as a consequence of changeover or forced rerouting) and begins routing via its normal route to destination X. In this case the transfer-allowed message is sent to signalling transfer point Z.
2. When signalling transfer point Y recognizes that it is again able to transfer via the normal route signalling traffic destined to destination X (see 6.2.3 and 8.2.3). In this case a transfer-allowed message is sent to all accessible adjacent signalling points (Broadcast method), except in the following cases:
 - a. Those signalling points that receive a transfer-prohibited message according to 13.2.2 (1).
 - b. Destination X if it is an adjacent point.
 - c. As specified in 3.3.2.3.
 - d. If a normal route becomes available after being unavailable and T11 has not expired.

As a network option, the rate that transfer-allowed messages are broadcast may be regulated²⁸ to minimize the burst of traffic that can occur due to controlled rerouting in adjacent nodes. This

²⁸ The decision to regulate the broadcasting of transfer-allowed (transfer-cluster-allowed) messages may be based on the number of adjacent nodes, the signalling transfer point's signalling route management load, and on alternate route capacity.

regulation is not performed for the broadcasting of transfer-allowed messages indicating that a previously isolated destination is accessible because of the urgency of this broadcast.

Examples of the above situations appear in Chapter T1.111.5.

13.3.2A As a network option, a transfer-cluster-allowed message relating to a given cluster of destinations CX is sent from a signalling transfer point Y in the following cases (see also 13.5.4A):

1. When signalling transfer point Y stops routing (at changeback or controlled rerouting) traffic destined to the cluster via a signalling transfer point Z (to which the concerned traffic was previously diverted as a consequence of changeover or forced rerouting) and begins routing via its normal route to the cluster. In this case the transfer-cluster-allowed message is sent to signalling transfer point Z.
2. When signalling transfer point Y recognizes that it is again able to transfer, via the normal route, signalling traffic to any signalling point in cluster CX. In this case a transfer-cluster-allowed message is sent to all accessible adjacent signalling points (Broadcast Method), except in the following cases:
 - a. Those signalling points that receive a transfer-cluster-prohibited message according to 13.2.2A (1);
 - b. As specified in 3.3.2.3; or
 - c. If a normal route becomes available after being unavailable and T11 has not expired.

As a network option, the rate that transfer-cluster-allowed messages are broadcast may be regulated²² to minimize the burst of traffic that can occur due to controlled rerouting in adjacent nodes. This regulation is not performed for the broadcasting of transfer-cluster-allowed messages indicating that a previously isolated cluster is accessible because of the urgency of this broadcast.

13.3.3 When a signalling point receives a transfer-allowed or transfer-cluster-allowed message from signalling transfer point Y, it performs the actions specified in clause 8 (since reception of a transfer-allowed or transfer-cluster-allowed message indicates the availability of the concerned signalling route, see 3.4.2). In other words, it may perform controlled rerouting and, if appropriate, generate additional transfer-allowed or transfer-cluster-allowed messages.

13.3.4 In some circumstances it may happen that a signalling point receives either a repeated transfer-allowed or transfer-cluster-allowed message, or a transfer-allowed or transfer-cluster-allowed message relating to a nonexistent 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, no action is taken.

13.4 *Transfer-Restricted*

13.4.1 The transfer-restricted procedure is performed at a signalling transfer point when it has to notify one or more adjacent signalling points that they should, if possible, no longer route messages to it for a concerned signalling point.

The transfer-restricted procedure makes use of the transfer-restricted message which contains:

1. The label, indicating the destination and originating points;
2. The transfer-restricted signal or transfer-cluster-restricted signal; and
3. The destination or cluster of destinations for which traffic transfer is no longer desirable.

Formats and codes of this message appear in clause 15.

Transfer-restricted messages are always addressed to an adjacent signalling point. They may use any available route that leads to that signalling point.

NOTE - Undesirable situations result in increased signalling delays, possibly overloading portions of the network. These inefficiencies could be avoided if the traffic can be appropriately diverted.

13.4.2 A transfer-restricted message relating to a given destination *X* is sent from a signalling transfer point *Y* in the following cases (all cases are related to the state of the normal, link set [combined link set] used by signalling point *Y* to route to destination *X*) unless the optional transfer-cluster-restricted message is sent instead according to the criteria in 13.4.2A (see also 13.5.4):

1. When the normal route(s) to destination *X* become unavailable and signalling transfer point *Y* begins using a lower priority route to destination *X*, timer T11 is started. When timer T11 expires or the lower priority route experiences danger of congestion (whichever occurs first), signalling transfer point *Y* notifies accessible adjacent signalling points using one of two possible methods:

- a. Broadcast Method

Signalling transfer point *Y* sends transfer-restricted messages concerning destination *X* to all accessible adjacent signalling points, except those signalling points that receive a transfer-prohibited message according to 13.2.2 (1) and except destination *X* if it is an adjacent point. Timer T18¹⁰ is started after the broadcast is complete. If the failure is still present and T18 expires, a transfer-restricted message is sent once per incoming link or link set by signalling transfer point *Y* in response to a message for destination *X*.

As a network option, the rate that transfer-restricted messages are broadcast may be regulated²⁹ to minimize the burst of traffic that can occur due to controlled rerouting in adjacent nodes. This regulation is not performed for the broadcasting of transfer-restricted messages indicating that a previously isolated destination is accessible.

- b. Response Method

²⁹ The decision to regulate the broadcasting of transfer-restricted (transfer-cluster-restricted) messages may be based on the number of adjacent nodes, the signalling transfer point's signalling route management load, and on alternate route capacity.

Signalling transfer point Y sends transfer-restricted messages concerning destination X to accessible adjacent signalling points once per incoming link or link set in response to messages received for destination X, except those signalling points that receive a transfer-prohibited message according to 13.2.2 (1). Timer T18¹⁰ is started after the first response method transfer-restricted message has been sent. While T18 is running, transfer-restricted messages are not sent in response to messages received for destination X if a transfer-restricted message has previously been sent to the adjacent signalling point concerning destination X. If the failure is still present and T18 expires, a transfer-restricted message is sent once per incoming link or link set by signalling transfer point Y in response to a message for destination X.

2. When sufficient links in the normal (combined) link set to destination X have failed, causing a noticeable capacity reduction, with danger of congestion. In this case, signalling transfer point Y sends transfer-restricted messages once per incoming link or link set to adjacent signalling points in response to messages destined to destination X (Response method). Timer T18¹⁰ is started after the first response method transfer-restricted message has been sent. While T18 is running, transfer-restricted messages are not sent in response to messages received for destination X if a transfer-restricted message has previously been sent to the adjacent signalling point concerning destination X. If the danger of congestion is still present and T18 expires, a transfer-restricted message is sent once per incoming link or link set by signalling transfer point Y in response to a message for destination X.

The detailed criteria for sending transfer-restricted messages in this case are considered to be implementation dependent. The intent of the specification is that the transfer-restricted procedure be used to divert traffic away from the link set with reduced capacity before the crossing of congestion thresholds for the links remaining in service triggers blockage of traffic.

When the normal (combined) link set to destination X is activated and sufficient links have not yet been restored in the (combined) link set, causing noticeable capacity reduction with danger of congestion, destination X is considered restricted via signalling transfer point Y and the transfer-allowed procedure is not performed. If the destination X was previously inaccessible, transfer-restricted messages are broadcast to all adjacent signalling points, except those signalling points that receive a transfer-prohibited message according to 13.2.2(1) and except destination X if it is an adjacent point.

Furthermore, if sufficient resources associated with signalling message handling have failed, resulting in an internal message handling capacity reduction which may cause congestion, and which is unlikely to exist at the mate STP³⁰ (an implementation specific determination), a signalling transfer point sends transfer-restricted messages once per incoming link or link set to adjacent signalling points via the response method. Transfer-restricted messages are sent before the onset of internal signalling message handling congestion, as described in clause 11.2.6 if possible. Timer T18¹⁰ is started after the first response method transfer-restricted message has been sent. While T18 is running, transfer-restricted messages are not sent in response to messages received for destination X if a transfer-restricted message has previously been sent to the adjacent signalling point concerning destination X. If the internal signalling transfer point capacity reduction condition is still present and T18 expires, a transfer-restricted message is sent

³⁰ That is, signalling message handling congestion is due to an internal failure, not due to received traffic volumes, and is therefore unlikely to exist at the mate signalling transfer point.

once per incoming link or link set by signalling transfer point Y in response to a message for destination X.

3. When routing to a previously inaccessible destination X becomes possible, but only through a route other than the normal one. In this case a transfer-restricted message is sent to all accessible adjacent signalling points, except those signalling points that receive a transfer-prohibited message according to 13.2.2 (1) and except signalling point X if it is an adjacent point (Broadcast method).
4. When an adjacent signalling point Z becomes accessible, signalling transfer point Y sends to Z a transfer-restricted message concerning X, if X is restricted from Y (see clause 9).
5. When signalling transfer point Y restarts and X is restricted from Y, Y broadcasts transfer-restricted messages concerning X to all accessible adjacent signalling points except those points that receive a transfer-prohibited message according to 13.2.2 (1) and except X, if X is an adjacent point.
6. When signalling transfer point Y receives a transfer-prohibited message associated with its normal route to destination X and must perform forced or controlled rerouting procedures to divert traffic from its normal route to X to a lower priority route, signalling transfer point Y sends transfer-restricted messages to adjacent signalling transfer points that are on its normal routes to destination X, unless preventive transfer-prohibited messages are to be sent to the adjacent signalling transfer points on its normal routes to destination X according to 13.2.2 (1c).
7. When signalling transfer point Y stops routing (at changeback or controlled rerouting) signalling traffic destined to destination X via an alternate route involving signalling transfer point Z (to which the concerned traffic was previously diverted as a consequence of changeover or forced rerouting) and begins routing via a higher priority alternate route to destination X. In this case the transfer-restricted message is sent to signalling transfer point Z.

13.4.2A As a network option, when a signalling transfer point Y uses the same normal link set (combined link set) to route to all destinations within a given cluster CX, it may send transfer-cluster-restricted messages relating to that cluster in the following cases (see also 13.5.4A):

1. When the normal route(s) to cluster CX become unavailable and signalling transfer point Y begins using a lower priority route to cluster CX, timer T11 is started. When timer T11 expires or the lower priority route experiences danger of congestion (whichever occurs first), signalling transfer point Y notifies accessible adjacent signalling points using one of two possible methods:

- a. Broadcast Method

Signalling transfer point Y sends transfer-cluster-restricted messages concerning cluster CX to all accessible adjacent signalling points, except those points that receive a transfer-cluster-prohibited message according to 13.2.2A (1). Timer T18 is started after the broadcast is complete. If the failure is still present and T18 expires, a transfer-cluster-restricted message is sent once per incoming link or link set by signalling transfer point Y in response to a message for cluster CX.

As a network option, the rate that transfer-cluster-restricted messages are broadcast may be regulated²³ to minimize the burst of traffic that can occur due to controlled rerouting in adjacent nodes. This regulation is not performed for the broadcasting of transfer-cluster-restricted messages indicating that a previously isolated destination is accessible.

b. Response Method

Signalling transfer point Y sends transfer-cluster-restricted messages concerning cluster CX to accessible adjacent signalling points once per incoming link or link set in response to messages received for cluster CX, except those points that receive a transfer-cluster-prohibited message according to 13.2.2A (1). Timer T18 is started after the first response method transfer-cluster-restricted message has been sent. While T18 is running, transfer-cluster-restricted messages are not sent in response to messages received for destination X if a transfer-cluster-restricted message has previously been sent to the adjacent signalling point concerning destination X. If the failure is still present and T18 expires, a transfer-cluster-restricted message is sent once per incoming link or link set by signalling transfer point Y in response to a message for cluster CX.

2. When sufficient links in the normal (combined) link set to cluster CX have failed, causing a noticeable capacity reduction, with danger of congestion. In this case, signalling transfer point Y sends transfer-cluster-restricted messages once per incoming link or link set to adjacent signalling points in response to messages destined to cluster CX (Response method). Timer T18 is started after the first response method transfer-cluster-restricted message has been sent. While T18 is running, transfer-cluster-restricted messages are not sent in response to messages received for destination X if a transfer-restricted message has previously been sent to the adjacent signalling point concerning destination X. If the danger of congestion is still present and T18 expires, a transfer-cluster-restricted message is sent once per incoming link or link set by signalling transfer point Y in response to a message for cluster CX.

The detailed criteria for sending transfer-cluster-restricted messages in this case are considered to be implementation dependent. The intent of the specification is that the transfer-cluster-restricted procedure be used to divert traffic away from the link set with reduced capacity before the crossing of congestion thresholds for the links remaining in service triggers blockage of traffic.

When the normal (combined) link set to cluster CX is activated and sufficient links have not yet been restored in the (combined) link set, causing noticeable capacity reduction with danger of congestion, cluster CX is considered restricted via signalling transfer point Y and the transfer-allowed procedure is not performed. If cluster CX was previously inaccessible, transfer-cluster-restricted messages are broadcast to all adjacent signalling points, except those signalling points that receive a transfer-cluster-prohibited message according to 13.2.2A(1).

Furthermore, if sufficient resources associated with signalling message handling have failed, resulting in an internal message handling capacity reduction which may cause congestion and which is unlikely to exist at the mate STP²⁸ (an implementation specific determination) a signalling transfer point sends transfer-cluster-restricted messages once per incoming link or link set to adjacent signalling points via the response method. Transfer-cluster-restricted messages are sent before the onset of internal signalling message handling congestion as described in clause 11.2.6 if possible. Timer T18 is started after the first response method transfer-cluster-restricted message has been sent. While T18 is running, transfer-cluster-restricted messages are not sent in response to messages received for destination X if a transfer-restricted message has previously been sent to the adjacent signalling point concerning destination X. If the internal signalling transfer point capacity reduction condition is still present and T18 expires, a transfer-cluster-restricted message is sent once per incoming link or link set by signalling transfer point Y in response to a message for cluster CX.

3. When routing to the previously inaccessible cluster CX becomes possible, but only through other than the normal link set (combined link set). In this case a transfer-cluster-restricted message is sent to all accessible adjacent signalling points, except those points that receive a transfer-cluster-prohibited message according to 13.2.2A (1) (Broadcast method).
4. When an adjacent signalling point Z becomes accessible, signalling transfer point Y sends to Z a transfer-cluster-restricted message concerning CX, if CX is restricted from Y (see clause 9).
5. When signalling transfer point Y restarts and cluster CX is restricted from Y, Y broadcasts transfer-cluster-restricted messages concerning CX to all accessible adjacent signalling points except those that receive a transfer-cluster-prohibited message according to 13.2.2A (1).
6. When signalling transfer point Y stops routing (at changeback or controlled rerouting) signalling traffic destined to cluster CX via an alternate route involving signalling transfer point Z (to which the concerned traffic was previously diverted as a consequence of changeover or forced rerouting) and begins routing via a higher priority alternate route to cluster CX. In this case the transfer-cluster-restricted message is sent to signalling transfer point Z.

13.4.3 When a signalling point receives a transfer-restricted or transfer-cluster-restricted message from signalling transfer point Y and has an alternative equal priority route available and not restricted to destination X, it performs the actions in 8.2. In other words, it performs controlled rerouting to maintain the sequence of messages while diverting them to the alternate equal priority route. If it cannot perform alternate routing to destination X because no alternate equal priority route is available, it may generate additional transfer-restricted or transfer-cluster-restricted messages.

When a signalling point receives a transfer-restricted or transfer-cluster-restricted message from signalling transfer point Y regarding an available and not restricted route to destination X and has an alternative equal priority route that is restricted, it performs the actions in 8.2 to resume load-sharing.

13.4.4 In some circumstances, it may happen that a signalling point receives either a repeated transfer-restricted or transfer-cluster-restricted message, or a transfer-restricted or transfer-cluster-restricted message relating to a nonexistent 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); in this case, no actions are taken.

13.4.5 When a transfer-restricted message is received updating a transfer-prohibited status:

1. If the destination referred to in the message is currently inaccessible, then traffic to that destination is restarted towards the signalling point from which the transfer-restricted message was received.
2. If the newly restricted route is of higher priority than the route(s) currently used for traffic to the concerned destination, then that traffic is diverted to the newly restricted route using the controlled rerouting procedure.
3. If the newly restricted route has priority equal to that of the route(s) currently used for traffic to the concerned destination and the currently used route(s) is (are) also restricted, then controlled rerouting is performed to resume loadsharing among the equal priority routes.

4. Otherwise, no other actions are taken.

13.4.5A When a transfer-cluster-restricted message is received concerning a cluster for which a transfer-cluster-prohibited message has previously been received for the same route the status of the route is updated and:

1. If one or more destinations in the cluster are currently inaccessible, then traffic to those destinations is restarted towards the signalling point from which the transfer-cluster-restricted message was received.
2. If the newly restricted route is of higher priority than the route(s) currently used for traffic to one or more destinations within the cluster, then that traffic is diverted to the newly restricted route using the controlled rerouting procedure.
3. If the newly restricted route has priority equal to that of the route(s) currently used for traffic to one or more destinations in the cluster, and the currently used route(s) is (are) also restricted, then controlled rerouting is performed to resume loadsharing among the equal priority routes.
4. Otherwise, no other actions are taken.

If no intervening transfer-cluster-prohibited message has been received, the receipt of a transfer-cluster-restricted message does not change the prohibited status of any individual signalling point for which a specific transfer-prohibited message has been received. Implementation of the procedures in 13.4.5A is a network option.

13.5 Signalling-Route-Set-Test

13.5.1 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.³¹

The procedure makes use of the signalling-route-set-test message, and the transfer-allowed, the transfer-prohibited, and the transfer-restricted procedures.

The signalling-route-set-test message contains:

1. The label, indicating the destination and originating points.
2. The signalling-route-set-test signal.
3. The destination or, optionally, cluster of destinations, the accessibility of which is to be tested.
4. The current route status of the destination being tested.

Format and coding of this message appear in clause 15.

13.5.2 A signalling-route-set-test message is sent from a signalling point in the following cases:

³¹ At the discretion of the management system, the signalling-route-set-test may be deactivated and activated on particular point codes.

1. When a transfer-prohibited or transfer-restricted 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 or restricted by the transfer-prohibited or transfer-restricted message, at the expiration of T10¹⁰ and the expiration of every subsequent T10 until a transfer-allowed message, indicating that the destination has become accessible, is received.
2. When a previously unavailable link set, directly connecting the signalling point with a signalling transfer point, becomes available and the signalling transfer point is not restarting. 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. Implementation of this item is a network option.

In case (1), 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 case (2), the positive, negative, or restriction response to the test messages (i.e., the reception of transfer-allowed transfer-prohibited, or transfer-restricted messages) are used to update route status in the signalling point.

In the case of a processor reinitialization, all destinations will be initialized as "accessible." The response mechanism in the transfer-prohibited procedure will correct the status of the destinations which are not "accessible."

NOTE - As long as the route being tested by the signalling-route-set-test procedure is not currently used or needed (e.g., because it is lower priority than the route being used), the test timing as an option may be less frequent or suspended at the discretion of the management system. However, if the route being tested or for which the test has been suspended is needed to route messages to their destinations, the time between tests returns to the value of T10.

13.5.2A As a network option, when a signalling point receives a transfer-cluster-prohibited or transfer-cluster-restricted message from an adjacent signalling transfer point, it may send a cluster signalling-route-set-test message referring to the cluster declared inaccessible or restricted to the adjacent signalling transfer point at the expiration of T10 and the expiration of every subsequent T10 until a transfer-cluster-allowed message indicating that the cluster has become accessible is received.

In response to a received transfer-cluster-prohibited or transfer-cluster-restricted message, as a network option, a signalling point initiates either a cluster signalling-route-set-test for the concerned cluster (preferred) or individual route set tests for equipped members within the concerned cluster for which routing data is maintained.

As a network option, when a previously unavailable link set, directly connecting the signalling point with a signalling transfer point, becomes available and the signalling point is not restarting, the signalling point may send a cluster signalling-route-set-test message referring to the cluster which in the absence of failures is accessible via the signalling transfer point.

13.5.3 A signalling-route-set-test message is sent to the adjacent signalling transfer point as an ordinary signalling network management message.

13.5.4 At the reception of a signalling-route-set-test message, a signalling transfer point will compare the status of the destination in the received message with the actual status of the destination. If they are the same no further action is taken. If they are different, one of the following messages is sent in response, dictated by the actual status of the destination:

1. 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 via normal routing.
2. A transfer-restricted message where access to the destination is possible via the normal route which is in danger of congestion or via an alternate to the normal routing which is less efficient, and the originator of the route set test message is not a signalling transfer point to which a transfer-prohibited message was sent according to 13.2.2 (1) when traffic was diverted to the current route.
3. A transfer-prohibited message in the remaining cases (including the inaccessibility of that destination).

13.5.4A At the reception of a cluster signalling-route-set-test message, a signalling transfer point will compare the status of the cluster in the received message with the actual status of the cluster. If they are the same, no further action is taken. If they are different, one of the following messages is sent in response:

1. A transfer-cluster-allowed message if any destination in the cluster is accessible via its normal routing and that normal routing is not via the signalling point that originated the test.
2. A transfer-cluster-restricted message if a transfer-cluster-allowed message is not sent and any destination in the cluster is in danger of congestion or is accessible through an alternate to its normal routing that does not involve the originating signalling point of the test.
3. A transfer-cluster-prohibited message in the remaining cases.

13.5.5 At the reception of the transfer-prohibited, transfer-allowed or transfer-restricted message, the signalling point will perform the procedures specified in 13.2, 13.3, or 13.4 respectively.

13.6 Transfer-Controlled (International Network)

The only use made of the transfer-controlled procedure in the international signalling network is to convey the congestion indication from the signalling point where congestion was detected to the originating signalling point (see 11.2.3) in a transfer-controlled message.

The transfer-controlled message contains:

1. The label, indicating the destination and origination points
2. The transfer-controlled signal
3. The identity of the congested destination

13.7 *Transfer Controlled (U. S. Networks)*

13.7.1 The transfer-controlled procedure is performed at a signalling transfer point, and optionally at a signalling point (see clause 13.7.7), when it must notify one or more originating signalling points that they should no longer send to the concerned destination messages with a given priority or lower.

The transfer-controlled procedure makes use of the transfer-controlled message which contains:

1. The label, indicating the destination and originating points.
2. The transfer-controlled signal.
3. The destination for which messages with a message priority lower than the specified congestion status should no longer be sent.
4. The current congestion status encountered in routing a particular message towards the concerned destination.

Format and coding of this message appear in clause 15.

13.7.2 A transfer-controlled message relating to a given destination *X* is sent from a signalling transfer point *Y* in response to a received message originating from signalling point *Z* destined to destination *X* when either of the following occur:

1. The message priority of the concerned message is less than the current congestion status of the signalling link selected to transmit the concerned message from *Y* to *X*. The transfer-controlled message is sent to the originating signalling point *Z* with the congestion status field set to the current congestion status of the signalling link.
2. The message priority of the concerned message is less than the current internal signalling message handling congestion status of the signalling transfer point. The sending of transfer-controlled messages by a signalling point is optional. The transfer-controlled message is sent to the originating signalling point *Z* with the congestion status field set to the current internal signalling message handling congestion status of the signalling transfer point/signalling point.

If a signalling transfer point/signalling point discards a priority 3 message, it does not send a transfer-controlled message to the originator of the discarded priority 3 message.

13.7.3 When the originating signalling point *Z* receives a transfer-controlled message relating to destination *X* and if the current congestion status of the signalling route set towards destination *X* is not greater than the congestion status in the transfer-controlled message, it assigns the congestion status of the signalling route set towards destination *X* with the value of the congestion status carried in the transfer-controlled message.

13.7.4 If within T15¹⁰ after the receipt of the last transfer-controlled message relating to destination *X*, signalling point *Z* receives another transfer-controlled message relating to the same destination, the

following action is taken. If the value of the congestion status carried in the new transfer-controlled message is not less than the current value of the congestion status of the signalling route set towards destination X, then the current value is updated by the new value.

13.7.5 If T15 expires after the last update of the congestion status of the signalling route set towards destination X by a transfer-controlled message relating to the same destination, the signalling-route-set-congestion-test procedure is invoked (see 13.9).

13.7.6 In some circumstances it may happen that a signalling point receives a transfer-controlled message relating to a destination that is already inaccessible due to previous failures; in this case the transfer-controlled message is ignored.

13.7.7 (Deleted.)

13.8 Transfer Controlled (National Option without Congestion Priorities)

(Deleted.....not applicable to U. S. networks.)

13.9 Signalling-Route-Set-Congestion-Test

13.9.1 The signalling-route-set-congestion-test procedure is used at an originating signalling point to update the congestion status associated with a route set towards a certain destination. The purpose is to test whether or not signalling messages destined towards that destination with a given message priority or higher may be sent.

In the case of a processor restart, the congestion status of all signalling route sets will be initialized to the zero value. Response mechanism within the transfer-controlled procedure will correct signalling route sets whose congestion status does not have the zero value.

The procedure makes use of the signalling-route-set-congestion-test message, and the transfer-controlled procedure.

The signalling-route-set-congestion-test message contains:

1. The label, indicating the destination and originating points.
2. The signalling-route-set-congestion-test signal.

Format and coding of this message appear in clause 15.

13.9.2 The signalling-route-set-congestion-test message differs from the other signalling network management messages in that it is not assigned the highest congestion priority. Instead, the congestion

priority assigned to a signalling-route-set-congestion-test message to be sent to a given destination is equal to one less than the current congestion status associated with the signalling route set towards that destination.

13.9.3 If within T16¹⁰ after sending a signalling-route-set-congestion-test message, a transfer-controlled message relating to the concerned destination is received, the signalling point assigns the congestion status of the signalling route set towards the concerned destination with the value of the congestion status carried in the transfer-controlled message. Following this, the procedures specified in 13.9.4 are performed.

If T16 expires after sending a signalling-route-set-congestion-test message without a transfer-controlled message relating to the concerned destination having been received, the signalling point changes the congestion status associated with the signalling route set towards the concerned destination to the next lower status.

13.9.4 Provided that the signalling route set toward destination X is not in the "unavailable" state, a signalling-route-set-congestion-test message is sent from an originating signalling point to destination X in the following cases:

1. When T15 expires after the last update of the congestion status of the signalling route set towards destination X by a transfer-controlled message relating to the same destination.
2. When T16 expires after sending a signalling-route-set-congestion-test message to destination X without a transfer-controlled message relating to the same destination having been received. After the congestion status has decremented by one, the test is repeated, unless the congestion status is zero.

13.9.5 At the reception of the signalling-route-set-congestion-test message, a signalling transfer point will route it as an ordinary message, i.e., according to the procedure specified in 2.3.5.

13.9.6 When a signalling-route-set-congestion-test message reaches its destination, it is discarded.

14 COMMON CHARACTERISTICS OF MTP LEVEL 3 MESSAGE FORMATS

14.1 *General*

For MTP Level 2 signalling links, the message formats are based on octet transmission order, as given in the Figures of T1.111.4 and T1.111.3, and the basic signal unit format which is common to all message signal units is described in clause 2 of Chapter T1.111.3. The following coding conventions shall be used when a message is generated for a SAAL signalling link:

1. When a field of a message is contained within a single octet, the lowest bit number of the field represents the least significant bit.

2. When a field of a message spans more than one octet, the order of bit values within each octet progressively increases as the octet number increases; the lowest bit number associated with the field represents the least significant bit.

Figures 13A/T1.111.4 and 13B/T1.111.4 show the general format and coding conventions of messages conveying peer-to-peer information for SAAL links in international and U. S. networks, respectively.

From the point of view of the Message Transfer Part Level 3 functions, common characteristics of messages are the presence of:

1. The service information octet.
2. The label, contained in the signalling information field (MTP Level 2) and, in particular, the routing label.

14.2 Service Information Octet

The Service Information Octet of the messages contains the service indicator and the subservice field. The structure of the service information octet is shown in Figure 13/T1.111.4.

14.2.1 Service Indicator

The service indicator is used by signalling handling functions to perform message distribution (see 2.4) and, in some special applications, to perform message routing (see 2.3).

The service indicator codes are allocated as follows in U. S. networks:

| bits | D | C | B | A | |
|------|---|---|---|---|---|
| | 0 | 0 | 0 | 0 | Signalling network management messages |
| | 0 | 0 | 0 | 1 | Signalling network testing and maintenance regular messages |
| | 0 | 0 | 1 | 0 | Signalling network testing and maintenance special messages |
| | 0 | 0 | 1 | 1 | SCCP |
| | 0 | 1 | 0 | 0 | Telephone User Part |
| | 0 | 1 | 0 | 1 | ISDN User Part |
| | 0 | 1 | 1 | 0 | Reserved (Used in ITU-T for Data User Part) |
| | 0 | 1 | 1 | 1 | Reserved (Used in ITU-T for Data User Part) |
| | 1 | 0 | 0 | 0 | MTP Testing User Part |
| | 1 | 0 | 0 | 1 | Broadband ISDN User Part |
| | 1 | 0 | 1 | 0 | Satellite ISDN User Part |
| | 1 | 0 | 1 | 1 | Reserved (Used in ITU-T for SPNE User Part) |
| | 1 | 1 | 0 | 0 | Reserved (Used in ITU-T for AAL Type 2 STC) |
| | 1 | 1 | 0 | 1 | Bearer-Independent Call Control (BICC) |
| | 1 | 1 | 1 | 0 | Reserved for Gateway Control Protocol (GCP) |
| | 1 | 1 | 1 | 1 | Reserved for Extension |

The allocation of the service indicator codes for national signalling networks is a national matter. However, the above allocation of service indicator codes agrees with the allocation for international

signalling given in the CCITT Blue Book Recommendation Q.704, except that in the Blue Book codes 0010, 1101, and 1110 are spare.

A mechanism to extend the Service Indicator field is defined in normative Annex B. This mechanism allows identification of 240 additional User Parts.

14.2.2 Subservice Field

The subservice field contains the network indicator (bits C and D) and two spare bits (bits A and B). The network indicator is used by signalling message handling functions (e.g., to determine the relevant version of a User Part) (see 2.3 and 2.4).

If the network indicator is set to 00 or 01, the two spare bits coded 00 are available for possible future needs that may require a common solution for all international User Parts.

If the network indicator is set to 10 or 11, the two spare bits are for national use. They may be used, for example, to indicate message priority, which is used in the optional flow control procedure in national applications.

The network indicator provides for discrimination between international and national messages. It can also be used, for example, for the discrimination between functionally two national signalling networks, each having different routing label structures and up to 16 User Parts defined by the 16 possible codes of the service indicator.

In the case of only one national signalling network the spare code of the network indicator reserved for national use can be used, for example, to define an additional 16 users (making a total of 32 User Parts) for that national signalling network.

The network indicator codes are allocated as follows:

| bits | D | C | |
|------|---|---|------------------------------------|
| | 0 | 0 | International message |
| | 0 | 1 | Spare (for international use only) |
| | 1 | 0 | National network |
| | 1 | 1 | Reserved for national use. |

The international spare code (01) should not be used for implementing features that are to be provided both internationally and nationally.

In national applications, when the discrimination provided by the network indication between international and national messages is not used, i.e., in a closed national signalling network seen from the signalling point of view, the whole subservice field can be used independently for different User Parts.

In U. S. networks the message priority codes are allocated as follows:

| bits | B | A | |
|------|---|---|------------|
| | 0 | 0 | priority 0 |
| | 0 | 1 | priority 1 |
| | 1 | 0 | priority 2 |
| | 1 | 1 | priority 3 |

Priority 3 is assigned to MTP and SCCP messages that are critical to the performance of the signalling network; see Annex A of Chapter T1.111.5 for message priority assignments.

14.3 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 2.2.

15 FORMAT AND CODES OF SIGNALLING NETWORK MANAGEMENT MESSAGES

15.1 General

15.1.1 The signalling network management messages are carried on the signalling channel in message signal units for MTP Level 2 links and sequenced data protocol data units for SAAL links, the format of which is described in clause 14 and in clause 2 of T1.111.3. In particular, as indicated in 14.2, these messages are distinguished by the configuration of the Service Indicator (SI). The Network Indicator (NI) field of the messages is used according with the rules also indicated in 14.2.

15.1.2 The signalling information (MTP Level 2 links) 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 15.2 and 15.3, respectively; the detailed message formats are described in the following clauses. 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). Within each field, the information is transmitted least significant bit first for MTP Level 2 based signalling links.

For SAAL links, the coding conventions as given in clause 14.1 apply to signalling network management messages. Figure 13C/T1.111.4 and 13D/T1.111.4 show the general format and coding conventions of signalling network management messages for SAAL links in international and U. S. networks, respectively.

Spare bits are coded 0 unless otherwise indicated.

15.1.2A The formats shown are those for signalling network management messages in U. S. networks. The formats for use in the international international signalling network are generally similar, but ITU-T Rec. Q.704 should be consulted for details.

15.2 *Label*^{β2}

For signalling network management messages, the label coincides with the routing label.

15.3 *Heading Code (H0)*

The heading code (H0) is the 4-bit field following the label, and identifies the message group.

The different heading codes are allocated as follows:

| | |
|------|---|
| 0000 | Spare |
| 0001 | Changeover and changeback messages |
| 0010 | Emergency changeover message |
| 0011 | Transfer-controlled and signalling-route-set-congestion-test messages |
| 0100 | Transfer-prohibited, -allowed, -restricted messages |
| 0101 | Signalling-route-set-test messages |
| 0110 | Management inhibiting messages |
| 0111 | Traffic restart messages |
| 1000 | Signalling-data-link-connection messages |
| 1001 | Spare |
| 1010 | MTP user flow control messages |

The remaining codings are spare.

The synopsis of signalling network management messages is given in Table 1/T1.111.4.

15.4 *Changeover Message*

15.4.1 The format of the changeover message is shown in Figure 15/T1.111.4.

15.4.2 The changeover message is made up of the following fields:

1. Label (56 bits): see 15.2;
2. Heading code H0 (4 bits): see 15.3;
3. Heading code H1 (4 bits): see 15.4.3;
4. SLC (4 bits) indicating the identity of the unavailable signalling link;

³² Text from CCITT Blue Book referring to the use of the SLS field to carry the SLC was deleted from this clause.

5. Forward sequence number (MTP Level 2 links) or sequence number (SAAL links) of last accepted message (7 bits for 56 kbit/s links and 12 bits for 1.536 Mbit/s links using MTP Level 2 (see T1.111.3-2001); 24 bits for links using the SAAL); and
6. Spare (5 bits) coded 00000 for 56 kbit/s links and no spare for 1.536 Mbit/s links using MTP Level 2; spare (4bits) coded 0000 for links using the SAAL.

15.4.3 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 acknowledgment signal |
| | 0 | 0 | 1 | 1 | Extended changeover order signal (SAAL links) |
| | 0 | 1 | 0 | 0 | Extended changeover acknowledgment signal (SAAL links) |

15.5 *Changeback Message*

15.5.1 The format of the changeback message is shown in Figure 16/T1.111.4.

15.5.2 The changeback message is made up of the following fields:

1. Label (56 bits): see 15.2;
2. Heading code H0 (4 bits): see 15.3;
3. Heading code H1 (4 bits): see 15.5.3;
4. SLC (4 bits) indicating the identity of link to which traffic will be diverted;
5. Changeback code (8 bits): see 15.5.4; and
6. spare (4 bits) coded 0000.

15.5.3 The heading code H1 contains signal codes as follows:

| bit | D | C | B | A | |
|-----|---|---|---|---|-----------------------------------|
| | 0 | 1 | 0 | 1 | Changeback declaration signal; |
| | 0 | 1 | 1 | 0 | Changeback acknowledgment signal. |

15.5.4 The changeback code is an 8-bit code assigned by the signalling point that sends the message according to the criteria described in clause 6.

15.6 *Emergency Changeover Message*

15.6.1 The format of the emergency changeover message is shown in Figure 17/T1.111.4.

15.6.2 The emergency changeover message is made up of the following fields:

1. Label (56 bits): see 15.2;
2. Heading code H0 (4 bits): see 15.3;
3. Heading code H1 (4 bits): see 15.6.3;
4. SLC (4 bits), indicating the identity of the unavailable signalling link; and
5. Spare (4 bits) coded 0000.

15.6.3 The heading code H1 contains signal codes as follows:

| bit | D | C | B | A | |
|-----|---|---|---|---|---|
| | 0 | 0 | 0 | 1 | Emergency changeover order signal; |
| | 0 | 0 | 1 | 0 | Emergency changeover acknowledgment signal. |

15.7 *Transfer-Prohibited Message*

15.7.1 The format of the transfer-prohibited message is shown in Figure 18/T1.111.4.

15.7.2 The transfer-prohibited message is made up of the following fields:

1. Label (56 bits): see 15.2;
2. Heading code H0 (4 bits): see 15.3;
3. Heading coding H1 (4 bits): see 15.7.3; and
4. Destination (24 bits): see 15.7.4.

15.7.3 The heading code H1 contains the signal codes as follows:

| bit | D | C | B | A | |
|-----|---|---|---|---|-------------------------------------|
| | 0 | 0 | 0 | 1 | Transfer-prohibited signal. |
| | 0 | 0 | 1 | 0 | Transfer-cluster-prohibited signal. |

15.7.4 The destination field contains the identity of the signalling point to which the transfer-prohibited message refers and the identity of the cluster for the transfer-cluster-prohibited message. The Network Cluster Member field for the destination field in the transfer-cluster-prohibited message is encoded as 00000000.

15.8 *Transfer-Allowed Message*

15.8.1 The format of the transfer-allowed message is shown in Figure 19/T1.111.4.

15.8.2 The transfer-allowed message is made up of the following fields:

1. Label (56 bits): see 15.2,
2. Heading code H0 (4 bits): see 15.3,
3. Heading code H1 (4 bits): see 15.8.3, and
4. Destination (24 bits): see 15.8.3A.

15.8.3 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-cluster-allowed signal. |

15.8.4 The destination field contains the identity of the signalling point to which the transfer-allowed message refers and the identity of the cluster for the transfer-cluster-allowed message. The Network Cluster Member field for the destination field in the transfer-cluster-allowed message is encoded as 00000000.

15.9 Transfer-Restricted Message

15.9.1 The format of the transfer-restricted is shown in Figure 18/T1.111.4.

15.9.2 The transfer-restricted message is made up of the following fields:

1. Label (56 bits): see 15.2,
2. Heading code H0 (4 bits): see 15.3,
3. Heading code H1 (4 bits): see 15.9.3, and
4. Destination (24 bits): see 15.9.4.

15.9.3 The heading code H1 contains signal codes as follows:

| bit | D | C | B | A | |
|-----|---|---|---|---|-------------------------------------|
| | 0 | 0 | 1 | 1 | Transfer-restricted signal; |
| | 0 | 1 | 0 | 0 | Transfer-cluster-restricted signal. |

15.9.4 The destination field contains the identity of the signalling point to which the transfer-restricted message refers and the identity of the cluster for the transfer-cluster-restricted message. The Network Cluster Member field for the destination field in the transfer-cluster-restricted message is encoded as 00000000.

15.10 Signalling-Route-Set-Test Message

15.10.1 The format of the signalling-route-set-test message is shown in Figure 20/T1.111.4.

15.10.2 This message is made up of the following fields:

1. Label (56 bits): see 15.2,
2. Heading code H0 (4 bits): see 15.3,
3. Heading code H1 (4 bits): see 15.10.3, and
4. Destination (24 bits): see 15.7.4.

15.10.3 The heading H1 codes are allocated as follows:

| bit | D | C | B | A | |
|-----|---|---|---|---|--|
| | 0 | 0 | 0 | 1 | Signalling-route-set-test signal for prohibited destination; |
| | 0 | 0 | 1 | 0 | Signalling-route-set-test signal for restricted destination; |
| | 0 | 0 | 1 | 1 | Signalling-route-set-test signal for prohibited cluster; |
| | 0 | 1 | 0 | 0 | Signalling-route-set-test signal for restricted cluster. |

15.10.4 The destination field contains the identity of the signalling point to which the signalling-route-set-test message refers and the identity of the cluster for the signalling-route-set-test message. The Network Cluster Member field for the destination field in the transfer-cluster-restricted message is encoded as 00000000.

15.11 Management Inhibit Message

15.11.1 The format of the management inhibit message is shown in Figure 20A/T1.111.4.

15.11.2 The management inhibit message is made up of the following fields:

1. Label (56 bits): see 15.2;
2. Heading code H0 (4 bits): see 15.3;
3. Heading code H1 (4 bits): see 15.11.3;
4. SLC (4 bits) indicating the identity of the signalling link to be inhibited; and
5. Spare (4 bits): Coded 0 0 0 0.

15.11.3 The heading code H1 contains signal codes as follows:

| bit | D | C | B | A | |
|-----|---|---|---|---|--------------------------------------|
| | 0 | 0 | 0 | 1 | Link inhibit signal |
| | 0 | 0 | 1 | 0 | Link uninhibit signal |
| | 0 | 0 | 1 | 1 | Link inhibit acknowledgment signal |
| | 0 | 1 | 0 | 0 | Link uninhibit acknowledgment signal |
| | 0 | 1 | 0 | 1 | Link inhibit denied signal |
| | 0 | 1 | 1 | 0 | Link force uninhibit signal |
| | 0 | 1 | 1 | 1 | Link local inhibit test signal |
| | 1 | 0 | 0 | 0 | Link remote inhibit test signal |

15.12 Signalling-Data-Link-Connection-Order Message

15.12.1 The format of the signalling-data-link-connection-order message is shown in Figure 21/T1.111.4.

15.12.2 The signalling-data-link-connection-order message is made up of the following fields:

1. Label (56 bits): see 15.2,
2. Heading code H0 (4 bits): see 15.3,
3. Heading code H1 (4 bits): see 15.12.3,
4. SLC (4 bits), indicating the identity of the signalling link being activated or restored,
5. Signalling data link identity (14 bits): see 15.12.4, and
6. Spare (6 bits) coded 000000.

15.12.3 The heading code H1 contains one signal code as follows:

| bit | D | C | B | A | |
|-----|---|---|---|---|---|
| | 0 | 0 | 0 | 1 | Signalling-data-link-connection-order signal. |

15.12.4 The signalling data link identity field contains the Circuit Identification Code (CIC), or the Bearer Identification Code (BIC) in case of a 56 kbit/s channel used to carry submultiplexed data streams of the transmission link corresponding to the signalling data link.

15.13 Signalling-Data-Link-Connection-Acknowledgment Message

15.13.1 The format of the signalling-data-link-connection-acknowledgment message is shown in Figure 22/T1.111.4.

15.13.2 The signalling-data-link-connection-acknowledgment message is made up of the following fields:

1. Label (56 bits): see 15.2,
2. Heading code H0 (4 bits): see 15.3,
3. Heading code H1 (4 bits): see 15.13.3,
4. SLC (4 bits), indicating the identity of the signalling link being activated or restored, and
5. Spare (4 bits), coded 0000.

15.13.3 The heading code H1 contains signalling codes as follows:

| bit | 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. |

15.14 Transfer-Controlled Message

15.14.1 The format of the TFC message is shown in Figure 22A/T1.111.4.

15.14.2 The transfer-controlled message is made up of the following fields:

1. Label (56 bits): see 15.2;
2. Heading Code H0 (4 bits): see 15.3;
3. Heading Code H1 (4 bits): see 15.14.3;
4. Destination (24 bits): see 15.14.4;
5. Status (2 bits): see 15.14.5; and
6. Spare (6 bit): justifies to integral number of octets.

15.14.3 The heading code H1 contains one signal code as follows:

| bit | D | C | B | A | |
|-----|---|---|---|---|-----------------------------|
| | 0 | 0 | 1 | 0 | Transfer-controlled signal. |

15.14.4 The destination field carries the address of the destination to which the message refers.

15.14.5 The status field in the transfer-controlled message is used to carry the congestion status associated with the destination.

15.15 Signalling-Route-Set-Congestion-Test Message

15.15.1 The format of the signalling-route-set-congestion-test message is shown in Figure 22B/T1.111.4.

15.15.2 The signalling-route-set-congestion-test message is made up of the following fields:

1. Label (56 bits): see 15.2,
2. Heading code H0 (4 bits): see 15.3, and
3. Heading code H1 (4 bits): see 15.15.3.

15.15.3 The heading code H1 contains one signal code as follows:

| | | | | | |
|-----|---|---|---|---|--|
| bit | D | C | B | A | |
| | 0 | 0 | 0 | 1 | Signalling-route-set-congestion-test signal. |

15.16 Traffic Restart Message³³

15.16.1 The format of the traffic restart message is shown in Figure 22C/T1.111.4.

15.16.2 The traffic restart message is made up of the following fields:

1. Label (56 bits): see 15.2;
2. Heading code H0 (4 bits): see 15.3; and
3. Heading code H1 (4 bits): see 15.16.3.

15.16.3 The heading code H1 contains signal codes as follows:

| | | | | | |
|-----|---|---|---|---|---------------------------------|
| bit | D | C | B | A | |
| | 0 | 0 | 0 | 1 | Traffic restart allowed signal; |
| | 0 | 0 | 1 | 0 | Traffic restart waiting signal. |

15.17 User Part Unavailable Message

15.17.1 The format of the user part unavailable message is shown in Figure 22D/T1.111.4.

15.17.2 The user part unavailable message is made up of the following fields:

1. Label (56 bits): see 15.2,
2. Heading code H0 (4 bits): see 15.3,

³³ The CCITT Blue Book contains only a traffic restart allowed message.

3. Heading code H1 (4 bits): see 15.17.3,
4. Destination (24 bits): see 15.14.4,
5. MTP user identity (4 bits): see 15.17.4, and
6. Unavailability cause (4 bits): see 15.17.5.

15.17.3 The heading code H1 contains signal codes as follows:

| bit | D | C | B | A | |
|-----|---|---|---|---|-------------------------------|
| | 0 | 0 | 0 | 1 | User part unavailable signal. |

15.17.4 The MTP user identity is coded as follows (codes agree with those used for the service indicator):

| bit | D | C | B | A | |
|-----|---|---|---|---|--|
| | 0 | 0 | 0 | 0 | Reserved; |
| | 0 | 0 | 0 | 1 | Reserved; |
| | 0 | 0 | 1 | 0 | Reserved; |
| | 0 | 0 | 1 | 1 | SCCP; |
| | 0 | 1 | 0 | 0 | Telephone User Part; |
| | 0 | 1 | 0 | 1 | ISDN User Part; |
| | 0 | 1 | 1 | 0 | Reserved (Used in ITU-T for Data User Part); |
| | 0 | 1 | 1 | 1 | Reserved (Used in ITU-T for Data User Part); |
| | 1 | 0 | 0 | 0 | MTP Testing User Part; |
| | 1 | 0 | 0 | 1 | Broadband ISDN User Part; |
| | 1 | 0 | 1 | 0 | Satellite ISDN User Part; |
| | 1 | 0 | 1 | 1 | Reserved (Used in ITU-T for SPNE User Part); |
| | 1 | 1 | 0 | 0 | Reserved (Used in ITU-T for AAL Type 2 STC); |
| | 1 | 1 | 0 | 1 | Bear Independent Call Control (BICC); |
| | 1 | 1 | 1 | 0 | Reserved for Gateway Control Protocol (GCP); |
| | 1 | 1 | 1 | 1 | Reserved for Extension. |

A mechanism to extend the Service Indicator field is defined in normative Annex B. The format of the User Part Unavailable Message for extended User Part ID is defined in normative Annex B.

15.17.5 The unavailability cause is coded as follows:

| bit | D | C | B | A | |
|-----|----|---|---|---|---------------------------|
| | 0 | 0 | 0 | 0 | Unknown; |
| | 0 | 0 | 0 | 1 | Unequipped remote user; |
| | 0 | 0 | 1 | 0 | Inaccessible remote user; |
| | 0 | 0 | 1 | 1 | |
| | to | | | | Spare. |
| | 1 | 1 | 1 | 1 | |

Table 1/T1.111.4 Heading Code Allocation of Signalling Network Management Messages

| Message Group | H1 | 0000 | 0001 | 0010 | 0011 | 0100 | 0101 | 0110 | 0111 | 1000 | 1001 | 1010 | 1011 | 1100 | 1101 | 1110 | 1111 |
|---------------|------|------|------|------|------|------|------|------|------|------|------|------|------|------|------|------|------|
| | H0 | | | | | | | | | | | | | | | | |
| | 0000 | | | | | | | | | | | | | | | | |
| CHM | 0001 | | COO | COA | XCO | XCA | CBD | CBA | | | | | | | | | |
| ECM | 0010 | | ECO | ECA | | | | | | | | | | | | | |
| FCM | 0011 | | RCT | TFC | | | | | | | | | | | | | |
| TFM | 0100 | | TFP | TCP | TFR | TCR | TFA | TCA | | | | | | | | | |
| RSM | 0101 | | RSP | RSR | RCP | RCR | | | | | | | | | | | |
| MIM | 0110 | | LIN | LUN | LIA | LUA | LID | LFU | LLI | LRI | | | | | | | |
| TRM | 0111 | | TRA | TRW | | | | | | | | | | | | | |
| DLM | 1000 | | DLC | CSS | CNS | CNP | | | | | | | | | | | |
| | 1001 | | | | | | | | | | | | | | | | |
| UFC | 1010 | | UPU | | | | | | | | | | | | | | |
| | 1011 | | | | | | | | | | | | | | | | |
| | 1100 | | | | | | | | | | | | | | | | |
| | 1101 | | | | | | | | | | | | | | | | |
| | 1110 | | | | | | | | | | | | | | | | |
| | 1111 | | | | | | | | | | | | | | | | |

15.18 Abbreviations Used in Table 1/T1.111.4

| | |
|-----|---|
| CBA | Changeback-acknowledgment signal |
| CBD | Changeback-declaration signal |
| CHM | Changeover and changeback messages |
| CNP | Connection-not-possible signal |
| CNS | Connection-not-successful signal |
| COA | Changeover-acknowledgment signal |
| COO | Changeover-order signal |
| CSS | Connection-successful signal |
| DLC | Signalling-data-link-connection-order signal |
| DLM | Signalling-data-link-connection-order messages |
| ECA | Emergency-changeover-acknowledgment signal |
| ECM | Emergency-changeover messages |
| ECO | Emergency-changeover-order signal |
| FCM | Signalling-traffic-flow control messages |
| LFU | Link forced uninhibit message |
| LIA | Link inhibit acknowledgment message |
| LID | Link inhibit denied message |
| LIN | Link inhibit message |
| LLI | Link local inhibit test signal |
| LRI | Link remote inhibit test signal |
| LUA | Link uninhibit acknowledgment |
| LUN | Link uninhibit message |
| MIM | Management inhibiting messages |
| RCP | Signaling-route-set-test cluster-prohibited signal |
| RCR | Signalling-route-set-test cluster-restricted signal |
| RCT | Signalling-route-set-congestion-test signal |
| RSM | Signalling-route-set-test messages |
| RSP | Signalling-route-set-test prohibited signal |
| RSR | Signalling-route-set-test restricted signal |
| TCA | Transfer-cluster-allowed signal |
| TCP | Transfer-cluster-prohibited signal |
| TCR | Transfer-cluster-restricted signal |
| TFA | Transfer-allowed signal |
| TFC | Transfer-controlled signal |

| | |
|-----|---|
| TFM | Transfer-prohibited, transfer-allowed, transfer-restricted messages |
| TFP | Transfer-prohibited signal |
| TFR | Transfer-restricted signal |
| TRA | Traffic restart allowed signal |
| TRM | Traffic restart messages |
| TRW | Traffic restart waiting signal |
| UFC | MTP user flow control messages |
| UPU | User part unavailable signal |

16 STATE TRANSITION DIAGRAMS

16.1 General

For each major function, a figure illustrates a subdivision into 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 clauses. The state transition diagrams are intended to show precisely the behavior 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 to facilitate understanding of the system behavior, and is not intended to specify the functional partitioning to be adopted in a practical implementation of the signalling system.

16.2 Drafting Conventions

16.2.1 Each major function is designated by its acronym (e.g., SMH = signalling message handling).

16.2.2 Each functional block is designated by an acronym that 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).

16.2.3 External input 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.

16.2.4 Internal inputs and outputs are only used to indicate control of time-outs.

16.2.5 Notation for national options (deleted...not used in this specification).

16.3 Signalling Message Handling

Figure 23/T1.111.4 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:

1. Message discrimination (HMDC) is shown in Figure 24/T1.111.4
2. Message distribution (HMDT) is shown in Figure 25/T1.111.4
3. Message routing (HMRT) is shown in Figure 26/T1.111.4
4. Handling of messages under signalling link congestion (HMCG) is shown in Figure 26A/T1.111.4

16.4 Signalling Traffic Management

Figure 27/T1.111.4 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:

1. Link availability control (TLAC) is shown in Figure 28/T1.111.4
2. Signalling routing control (TSRC) is shown in Figure 29/T1.111.4
3. Changeover control (TCOC) is shown in Figure 30/T1.111.4
4. Changeback control (TCBC) is shown in Figure 31/T1.111.4
5. Forced rerouting control (TFRC) is shown in Figure 32/T1.111.4
6. Controlled rerouting control (TCRC) is shown in Figure 33/T1.111.4
7. Signalling traffic flow control (TSFC) is shown in Figure 34/T1.111.4
8. Signalling route set congestion control (TRCC) is shown in Figure 29A/T1.111.4.

9. MTP restart control (TPRC) is shown in Figure 34A/T1.111.4.

16.5 Signalling Link Management

Figure 35/T1.111.4 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:

1. Link set control (LLSC) is shown in Figure 36/T1.111.4
2. Signalling link activity control (LSAC) is shown in Figure 37/T1.111.4
3. Signalling link activation (LSLA) is shown in Figure 38/T1.111.4
4. Signalling link restoration (LSLR) is shown in Figure 39/T1.111.4
5. Signalling link deactivation (LSLD) is shown in Figure 40/T1.111.4
6. Signalling terminal allocation (LSTA) is shown in Figure 41/T1.111.4
7. Signalling data link allocation (LSDA) is shown in Figure 42/T1.111.4

16.6 Signalling Route Management

Figure 43/T1.111.4 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:

1. Transfer-prohibited control (RTPC) is shown in Figure 44/T1.111.4
2. Transfer-allowed control (RTAC) is shown in Figure 45/T1.111.4
3. Transfer-restricted control (RTRC) is shown in Figure 46C/T1.111.4
4. Transfer-controlled control (RTCC) is shown in Figure 46A/T1.111.4
5. Signalling-route-set-test control (RSRT) is shown in Figure 46/T1.111.4
6. Signalling-route-set-congestion-test control (RCAT) is shown in Figure 46B/T1.111.4

16.7 Abbreviations and Timers Used in Figures 23 to 46C/T1.111.4.

| | |
|------|--|
| 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 |
| HMCG | Signalling link congestion |
| 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 |
| RCAT | Signalling-route-set-congestion-test control |
| RSRT | Signalling-route-set-test-control |
| RTAC | Transfer-allowed control |
| RTCC | Transfer-controlled control |
| RTPC | Transfer-prohibited control |
| RTRC | Transfer-restricted control |
| SLM | Signalling link management |
| SLS | Signalling link selection |
| SMH | Signalling message handling |
| SRM | Signalling route management |
| SLTC | Signalling link test control |
| STM | Signalling traffic management |
| TCBC | Changeback control |
| TCOC | Changeover control |
| TCRC | Controlled rerouting control |
| TFRC | Forced rerouting control |
| TLAC | Link availability control |
| TPRC | MTP restart control |
| TRCC | Signalling route congestion control |
| TSFC | Signalling traffic flow control |
| TSRC | Signalling routing control |

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| Timer | Description | Recommended Range³⁴ (seconds) |
|--------------|---|---|
| T1 | Delay to avoid message mis-sequencing on changeover | 0.5 (0.8) to 1.2 |
| T2 | Waiting for changeover acknowledgment | 0.7 (1.4) to 2.0 |
| T3 | Time controlled diversion -- delay to avoid mis-sequencing on changeback | 0.5 (0.8) to 1.2 |
| T4 | Waiting for changeback acknowledgment (first attempt) | 0.5 (0.8) to 1.2 |
| T5 | Waiting for changeback acknowledgment (second attempt) | 0.5 (0.8) to 1.2 |
| T6 | Delay to avoid message mis-sequencing on controlled rerouting | 0.5 (0.8) to 1.2 |
| T7 | Waiting for signalling data link connection acknowledgment | 1 to 2 |
| T8 | Transfer-prohibited inhibited timer (transient solution) | 0.8 to 1.2 |
| T9 | not used | |
| T10 | Waiting to repeat signalling-route-set-test message | 30 to 60 ³⁵ |
| T11 | Transfer-restricted timer | 30 to 90 |
| T12 | Waiting for uninhibit acknowledgment | 0.8 to 1.5 |
| T13 | Waiting for force uninhibit | 0.8 to 1.5 |
| T14 | Waiting for inhibition acknowledgment | 2 to 3 |
| T15 | Waiting to repeat signalling route set congestion test | 2 to 3 |
| T16 | Waiting for route set congestion status update | 1.4 to 2.0 |
| T17 | Delay to avoid oscillation of initial alignment failure and link restart | 0.8 to 1.5 |
| T18 | Repeat TFR once by response method | 2 to 20 |
| T19 | Failed link craft referral timer | 480 to 600 |
| T20 | Waiting to repeat local inhibit test | 90 to 120 |
| T21 | Waiting to repeat remote inhibit test | 90 to 120 |
| T22 | Timer at restarting SP waiting for signalling links to become available | network dependent |
| T23 | Timer at restarting SP, started after T22, waiting to receive all traffic restart allowed messages | network dependent |
| T24 | Timer at restarting SP with transfer function, started after T23, waiting to broadcast all traffic restart allowed messages | network dependent |
| T25 | Timer at restarting SP and SP adjacent to restarting SP, waiting for traffic restart allowed message | 30 to 35 |
| T26 | Timer at restarting SP waiting to repeat traffic restart waiting message | 12 to 15 |
| T27 | Minimum duration of unavailability for full restart | 2 (3) to 5 |
| T28 | Timer at SP adjacent to restarting SP waiting for traffic restart waiting message | 3 to 35 |
| T29 | Timer started when TRA sent in response to unexpected TRA or TRW | 60 to 65 |
| T30 | Timer to limit sending of TFPs and TFRs in response to unexpected TRA or TRW | 30 to 35 |
| T31 | False link congestion detection timer | 10 to 120 |
| T32 | Link oscillation timer - Procedure A | 5 to 120 |
| T33 | Probation timer for link oscillation - Procedure B | 60 to 600 |
| T34 | Suspension timer for link oscillation - Procedure B | 5 to 120 |

³⁴ The values in parentheses are the lower bounds to be used for long propagation delay signalling routes, e.g., routes using satellite clauses.

³⁵ The maximum value can be temporarily extended at the discretion of the management system if many point codes are being tested simultaneously.

17 REFERENCES

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T1.627-1993 (R2004), *Broadband ISDN - ATM Layer Functionality and Specification*.³⁷

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T1.652-1996 (R2006), *B-ISDN Signaling ATM Adaptation Layer - Layer Management for the SAAL at the NNI*.³⁷

T1.645-1995 (R2008), *B-ISDN Signaling ATM Adaptation Layer - Service Specific Coordination Function for Support of Signaling at the Network Node Interface (SSCF at the NNI)*.³⁷

³⁶ This document is available from the International Telecommunications Union. < <http://www.itu.int/ITU-T/> >.

³⁷ This document is available from the Alliance for Telecommunications Industry Solutions (ATIS), 1200 G Street N.W., Suite 500, Washington, DC 20005. < <https://www.atis.org/docstore/default.aspx> >.

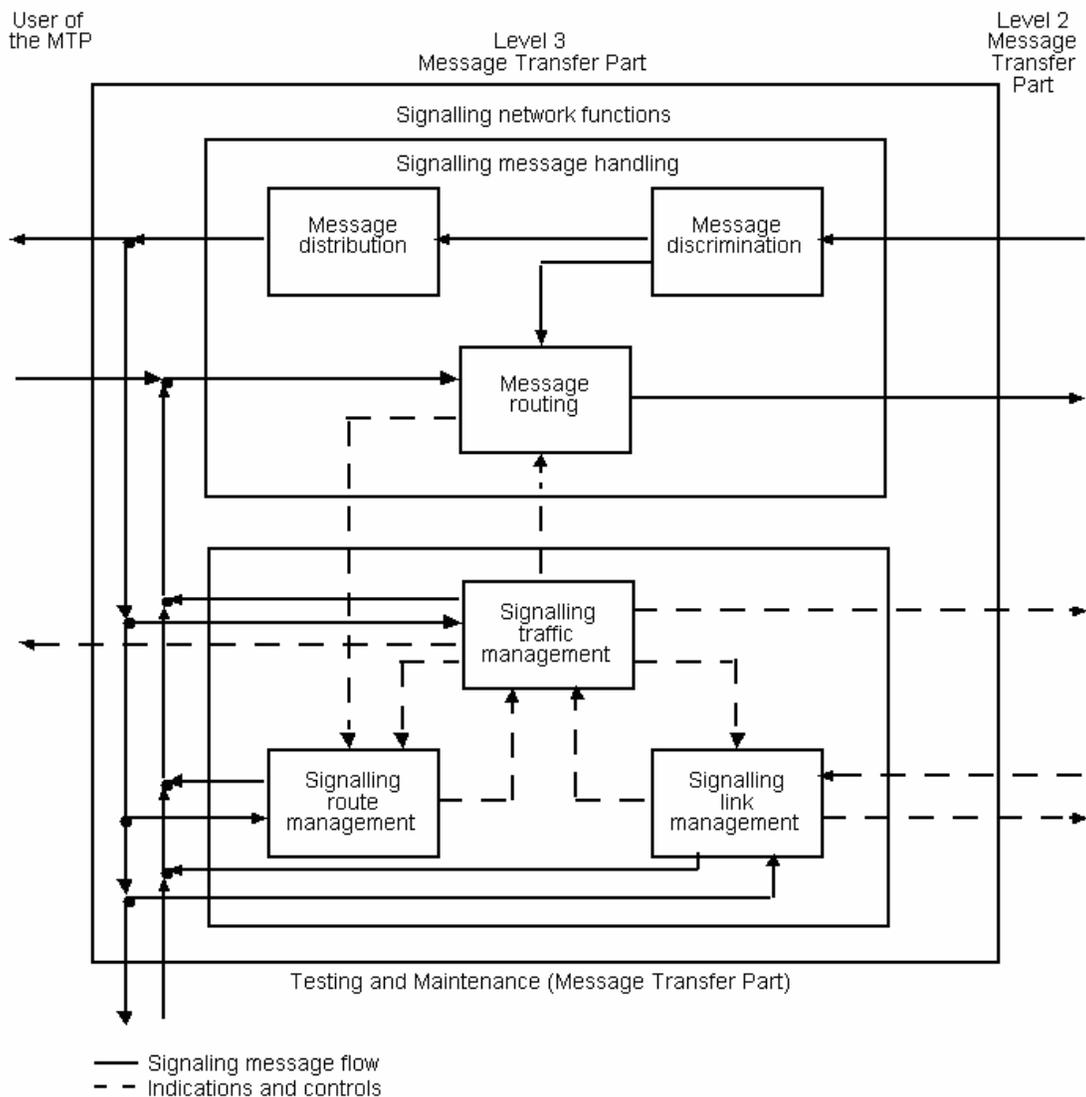


Figure 1/T1.111.4 Signalling Network Functions

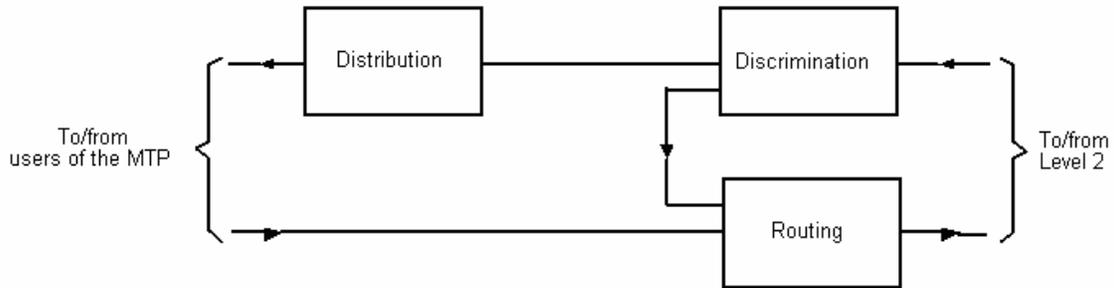


Figure 2/T1.111.4 Message Routing, Discrimination, and Distribution

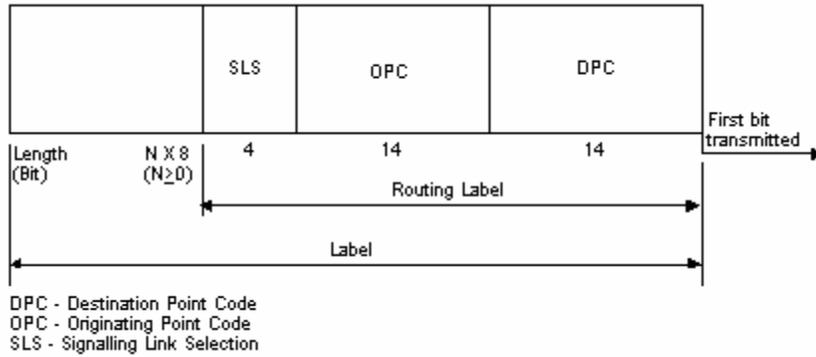


Figure 3/T1.111.4 International Routing Label Structure

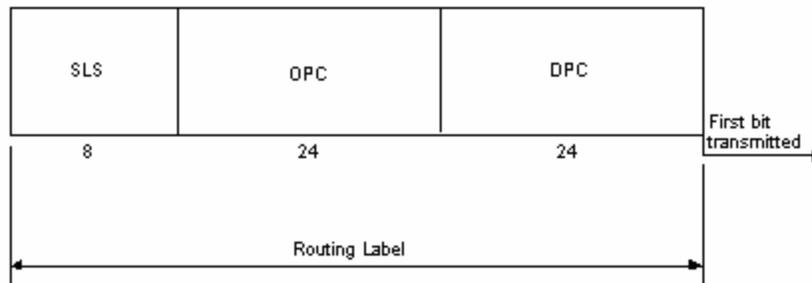


Figure 3A/T1.111.4 Routing Label Structure for U. S. Networks

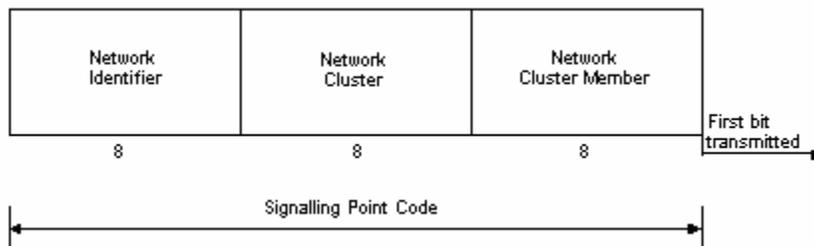


Figure 3B/T1.111.4 Signalling Point Code Structure

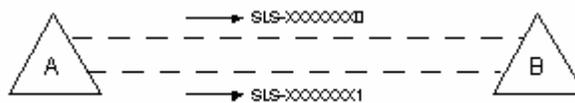


Figure 4/T1.111.4 Example of Load Sharing within a Link Set

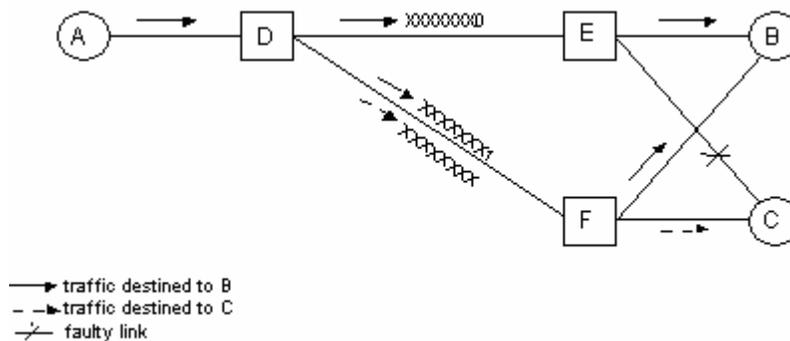


Figure 5/T1.111.4 Example of Load Sharing between Link Sets

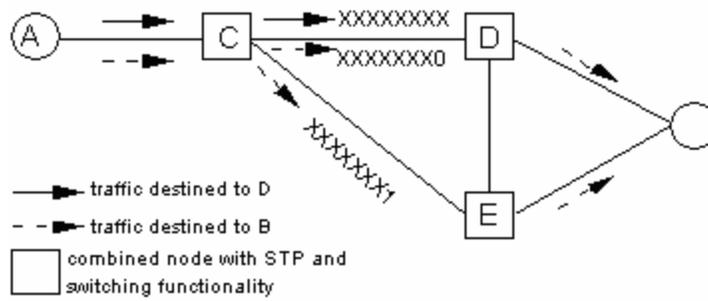
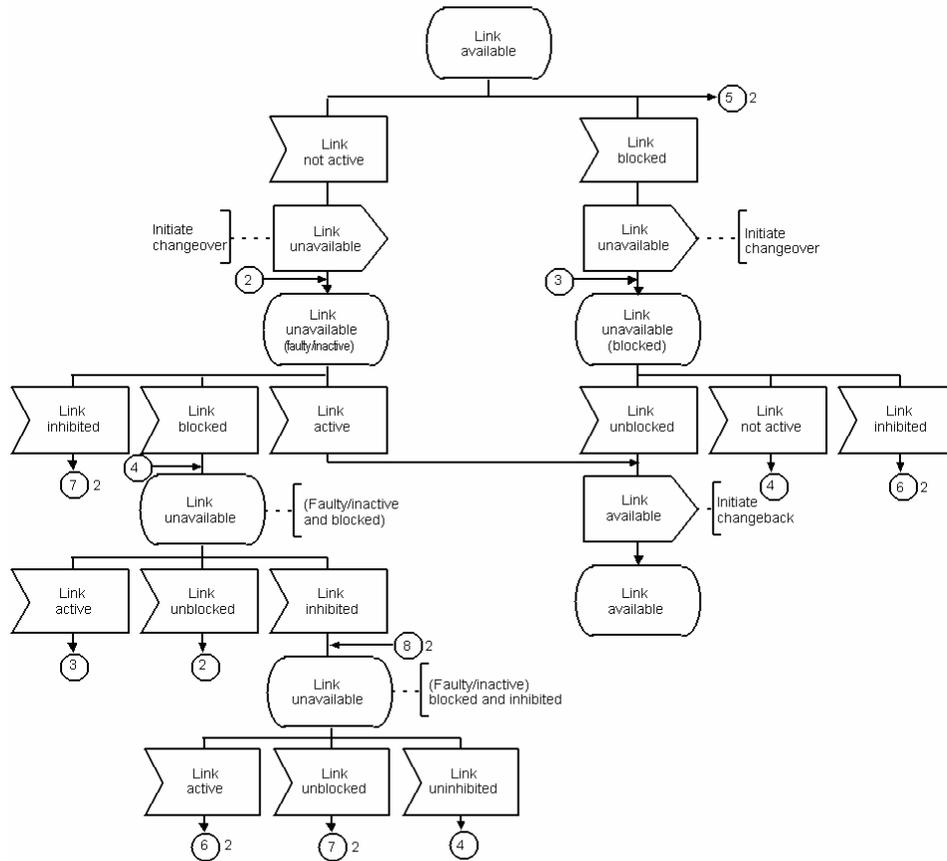


Figure 5A/T1.111.4 Example of Load Sharing with a Combined STP/Switch Node



Note - link not active signal represents both link failure and link deactivation.
 - link active signal represents both link restoration and link activation.

Figure 6/T1.111.4 Signalling Traffic Management Overview Diagram: Signalling Link Availability (Sheet 1 of 4)

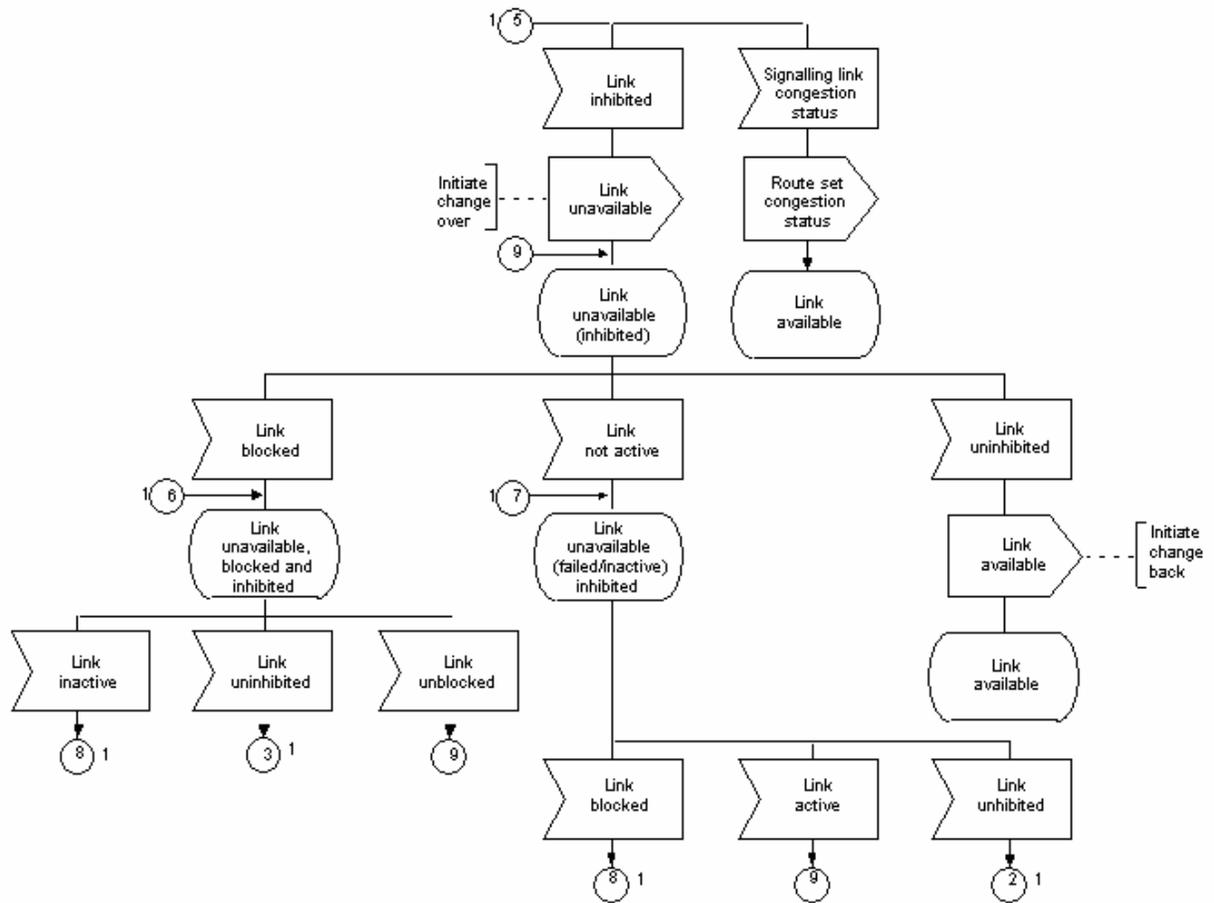


Figure 6/T1.111.4 Signalling Traffic Management Overview Diagram: Signalling Link Availability (Sheet 2 of 4)

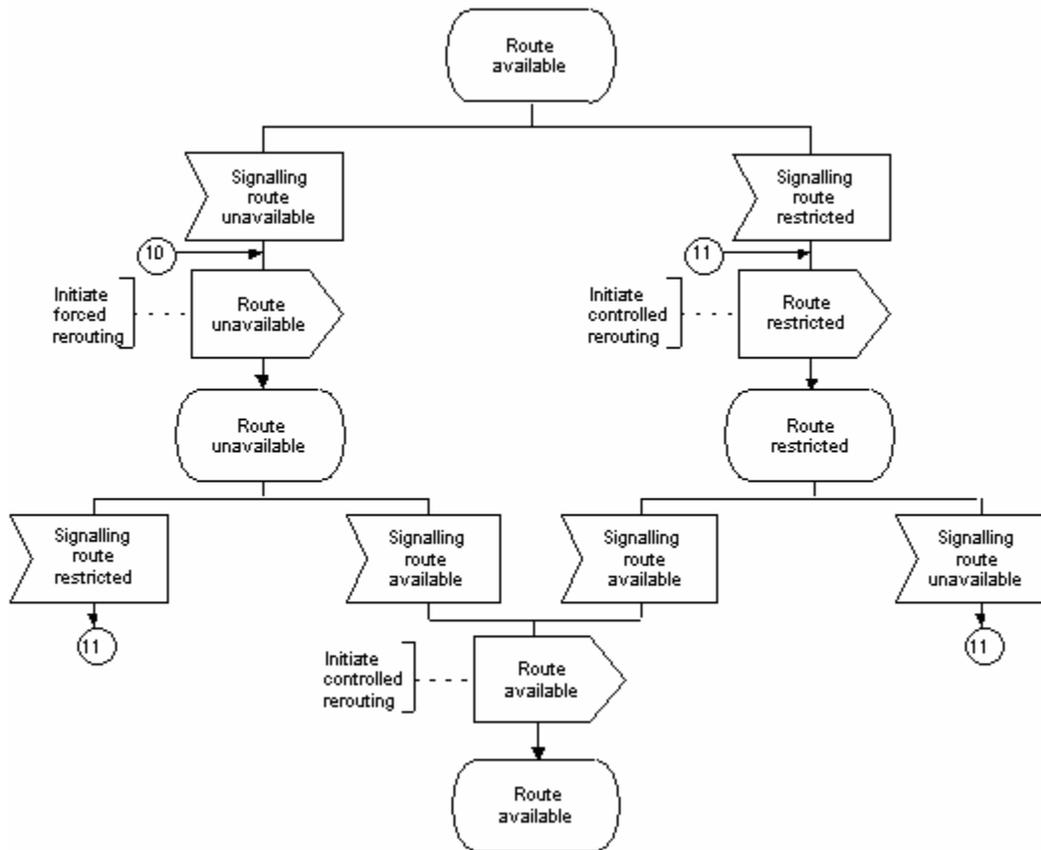


Figure 6/T1.111.4 Signalling Traffic Management Overview Diagram: Signalling Link Availability Status (Sheet 3 of 4)

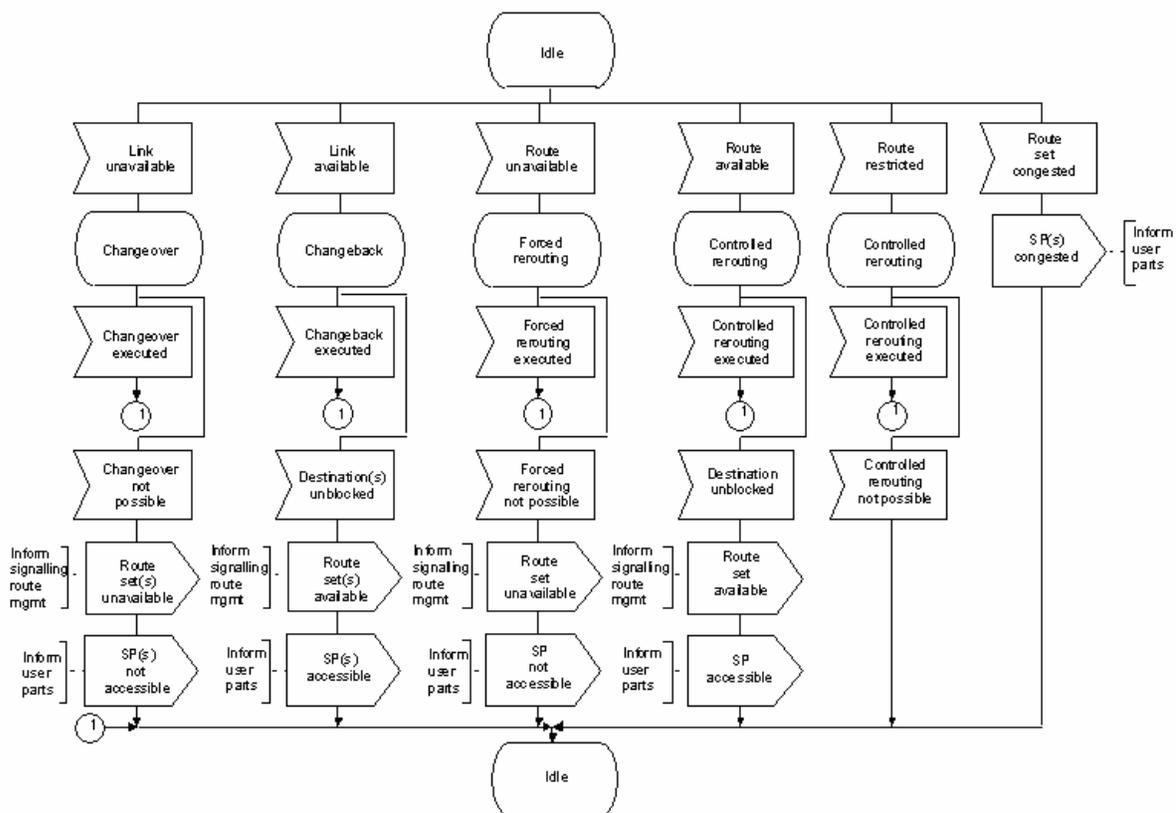


Figure 6/T1.111.4 Signalling Traffic Management Overview Diagram: Signalling Traffic Reconfiguration and Flow Control (Sheet 4 of 4)

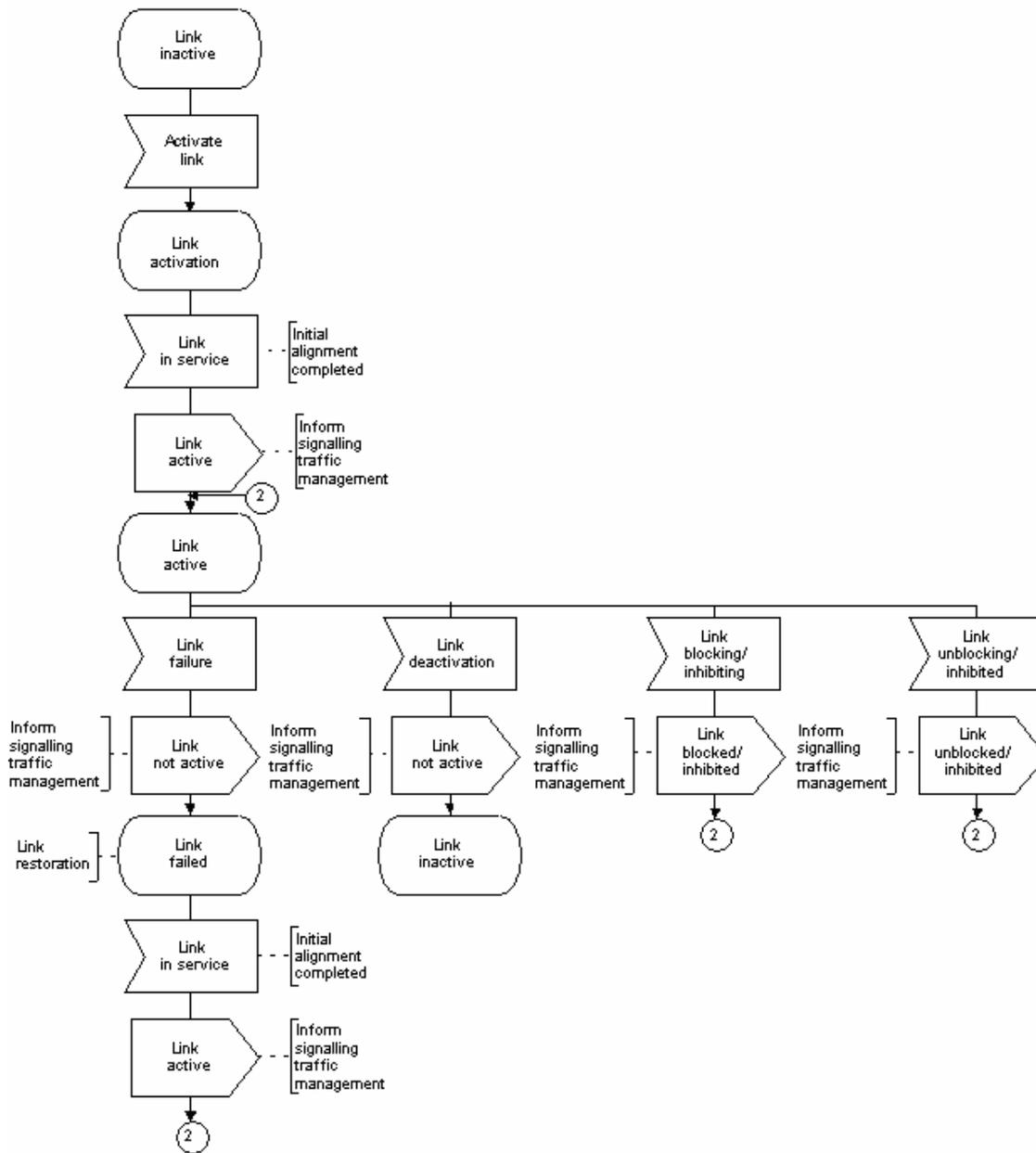


Figure 7/T1.111.4 Signalling Link Management Overview Diagram

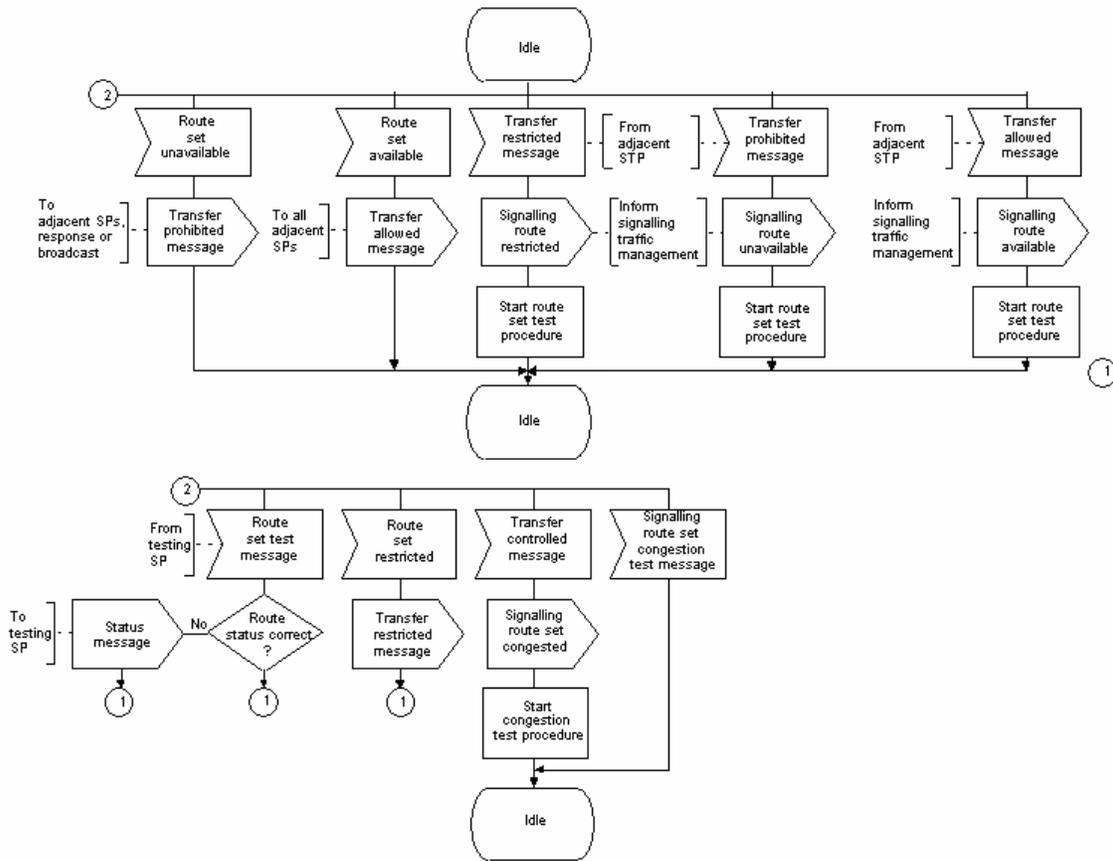


Figure 8/T1.111.4 Signalling Route Management Overview Diagram

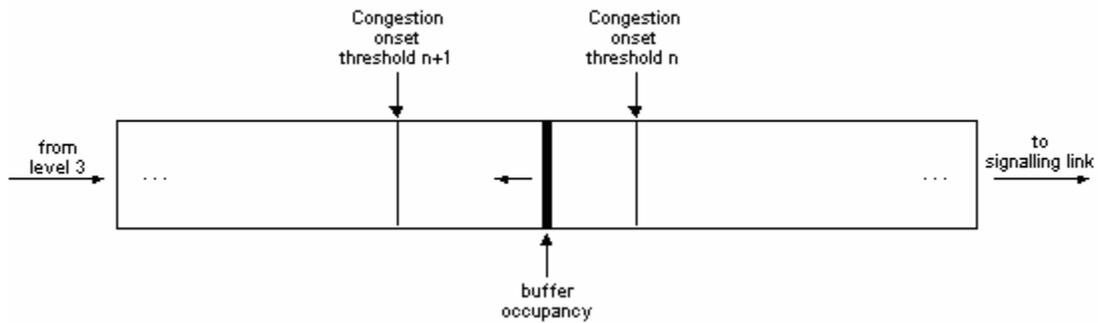


Figure 8A/T1.111.4 Signalling Link Congestion Status = n(Congestion Onset)

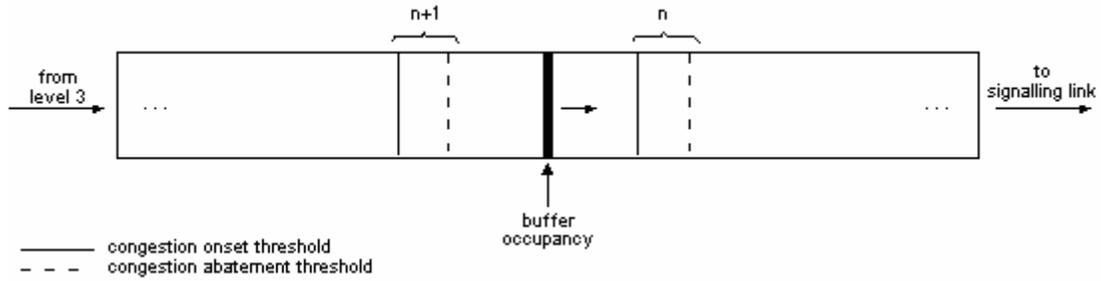


Figure 8B/T1.111.4 Signalling Link Congestion Status = n(Congestion Abatement)

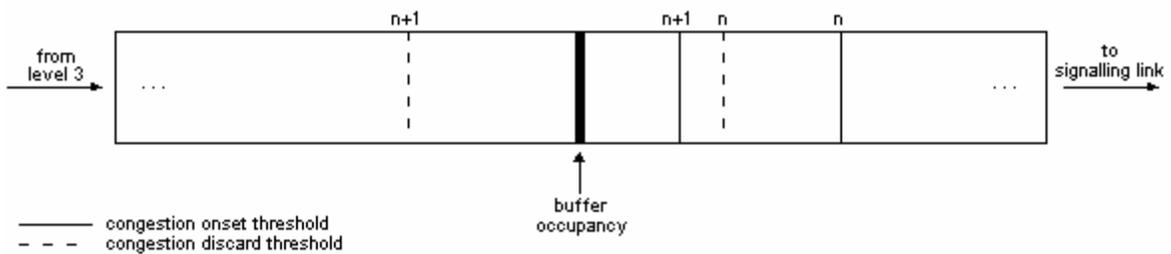


Figure 8C/T1.111.4 Signalling Link Discard Status = n

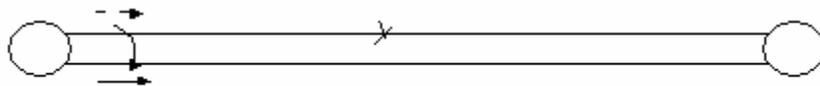


Figure 9/T1.111.4 Example of Changeover to a Parallel Link

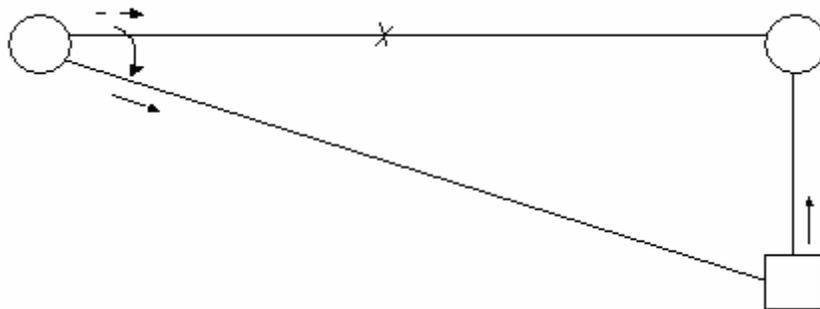


Figure 10/T1.111.4 Example of Changeover to a Signalling Route not Passing through the Remote Signalling Point

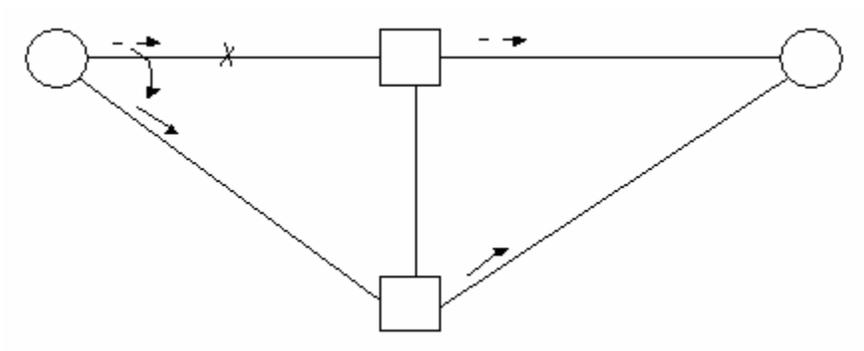


Figure 11/T1.111.4 Example of Changeover to a Signalling Route not Passing through the Remote Signalling Point

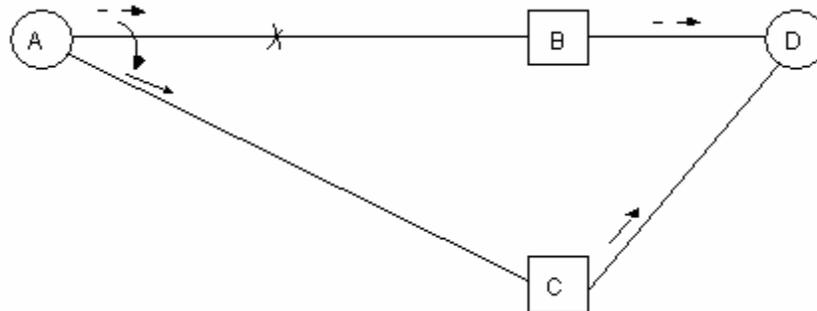


Figure 12/T1.111.4 Example of Time-controlled Diversion Procedure

| DCBA | DCBA |
|-------------------|-------------------|
| Sub-service Field | Service Indicator |
| 4 | 4 |

First bit Transmitted

Figure 13/T1.111.4 Service Information Octet

| 8 | 7 | 6 | 5 | 4 | 3 | 2 | 1 | Bit | Octet | | |
|-----|---|-------------------|-----|-----|-----|-----|---|-------------------|-------|-----|---|
| MSB | | Sub-service field | | | LSB | MSB | | Service indicator | | LSB | 1 |
| | | | | DPC | | | | LSB | | 2 | |
| OPC | | LSB | MSB | DPC | | | | | | 3 | |
| | | | | OPC | | | | | | 4 | |
| MSB | | SLS | | | LSB | MSB | | OPC | | LSB | 5 |
| | | | | | | | | | 6 | | |
| | | | | | | | | | ... | | |
| | | | | | | | | | n | | |

Figure 13A/T1.111.4 General Format and Coding Conventions of Messages Conveying Peer-to-peer Information (SAAL Links) for International Networks

| 8 | 7 | 6 | 5 | 4 | 3 | 2 | 1 | Bit | Octet | | |
|-----|---|-------------------|---|------------------------------|-----|-----|---|-------------------|-------|-----|---|
| MSB | | Sub-service field | | | LSB | MSB | | Service indicator | | LSB | 1 |
| | | | | DPC - Network Cluster Member | | | | LSB | | 2 | |
| | | | | DPC - Network Cluster | | | | LSB | | 3 | |
| | | | | DPC - Network Identifier | | | | LSB | | 4 | |
| | | | | OPC - Network Cluster Member | | | | LSB | | 5 | |
| | | | | OPC - Network Cluster | | | | LSB | | 6 | |
| | | | | OPC - Network Identifier | | | | LSB | | 7 | |
| | | | | SLS | | | | LSB | | 8 | |
| | | | | | | | | | 9 | | |
| | | | | | | | | | .. | | |
| | | | | | | | | | n | | |

Figure 13B/T1.111.4 General Format and Coding Conventions of Messages Conveying Peer-to-peer Information (SAAL Links) for U. S. Networks

| 8 | 7 | 6 | 5 | 4 | 3 | 2 | 1 | Bit | Octet | | |
|-----------|---|-------------------|-----|-----|-----|-----|---|-------------------|-----------|-----|---|
| MSB | | Sub-service field | | | LSB | MSB | | Service indicator | | LSB | 1 |
| | | | | DPC | | | | LSB | | 2 | |
| OPC | | LSB | MSB | DPC | | | | | | 3 | |
| | | | | OPC | | | | | | 4 | |
| MSB | | SLC | | | LSB | MSB | | OPC | | LSB | 5 |
| MSB | | Heading Code H1 | | | LSB | MSB | | Heading Code H0 | | LSB | 6 |
| | | | | | | | | | (Note) 7 | | |
| | | | | | | | | | (Note) .. | | |
| | | | | | | | | | (Note) m | | |
| User Data | | | | | | | | | n | | |

Figure 13C/T1.111.4 General Format and Coding Conventions of Signalling network Management Messages (SAAL Links) for International Networks

NOTE - The octets numbered from 7 to m may not be present, or consist of one or more than one octet depending on the type of signalling network management message.

| 8 | 7 | 6 | 5 | 4 | 3 | 2 | 1 | Bit | Octet |
|------------------------------|-------------------|---|---|--------------------------|-----|-------------------|---|-----|-----------|
| MSB | Sub-service field | | | LSB | MSB | Service indicator | | LSB | 1 |
| DPC - Network Cluster Member | | | | DPC - Network Cluster | | | | LSB | 2 |
| DPC - Network Identifier | | | | DPC - Network Identifier | | | | LSB | 3 |
| DPC - Network Cluster Member | | | | DPC - Network Cluster | | | | LSB | 4 |
| DPC - Network Identifier | | | | DPC - Network Identifier | | | | LSB | 5 |
| DPC - Network Cluster Member | | | | DPC - Network Cluster | | | | LSB | 6 |
| DPC - Network Identifier | | | | DPC - Network Identifier | | | | LSB | 7 |
| SLS | | | | SLS | | | | LSB | 8 |
| Heading Code H1 | | | | LSB | MSB | Heading Code H0 | | LSB | 9 |
| | | | | | | | | LSB | (Note) 10 |
| | | | | | | | | | (Note) .. |
| MSB | | | | | | | | | (Note) n |

Figure 13D/T1.111.4 General Format and Coding Conventions of Signalling network Management Messages (SAAL Links) for U. S. Networks

NOTE -- The octets numbered from 7 to m may not be present, or consist of one or more than one octet depending on the type of signalling network management message.

The functions that were shown in Figure 14/T1.111.4 in a previous issue of this document are not applicable to U.S. networks.

Figure 14/T1.111.4 Deleted - Not applicable to U. S. Networks

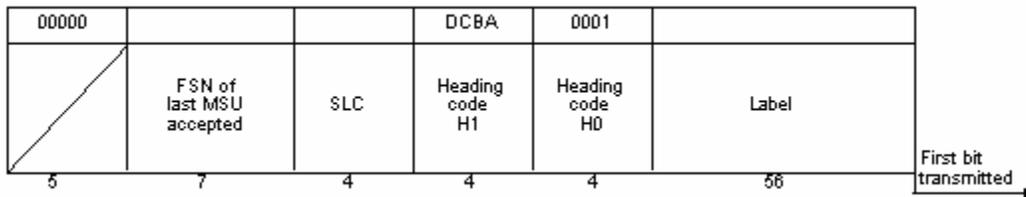


Figure 15/T1.111.4 Changeover Message for 56 kbit/s and 64 kbit/s Links using MTP Level 2

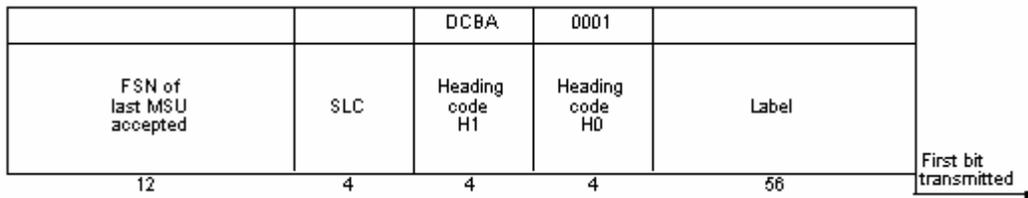


Figure 15A/T1.111.4 Changeover Message for 1.536 Mbit/s Links using MTP Level 2

| 8 | 7 | 6 | 5 | 4 | 3 | 2 | 1 | Bit | Octet |
|--|---|---|---|--|---|---|---|-----|-------|
| Sub-service field | | | | Service indicator | | | | | 1 |
| DPC - Network Cluster Member | | | | | | | | | 2 |
| DPC - Network Cluster | | | | | | | | | 3 |
| DPC - Network Identifier | | | | | | | | | 4 |
| OPC - Network Cluster Member | | | | | | | | | 5 |
| OPC - Network Cluster | | | | | | | | | 6 |
| OPC - Network Identifier | | | | | | | | | 7 |
| SLS | | | | | | | | | 8 |
| D | C | B | A | 0 | 0 | 0 | 1 | | 9 |
| Heading Code H1 | | | | Heading Code H0 | | | | | |
| Sequence Number of Last Accepted Message | | | | SLC | | | | | 10 |
| Sequence Number of Last Accepted Message | | | | | | | | | 11 |
| Sequence Number of Last Accepted Message | | | | | | | | | 12 |
| 0 | 0 | 0 | 0 | Sequence Number of Last Accepted Message | | | | | 13 |

Figure 15B/T1.111.4 Format of the Changeover Message Containing the Extended Changeover Signals

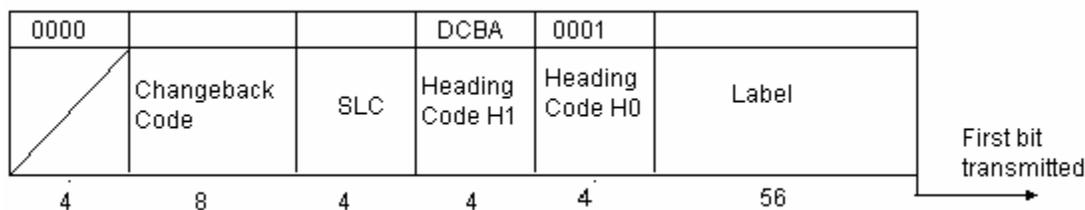


Figure 16/T1.111.4 Changeback Message

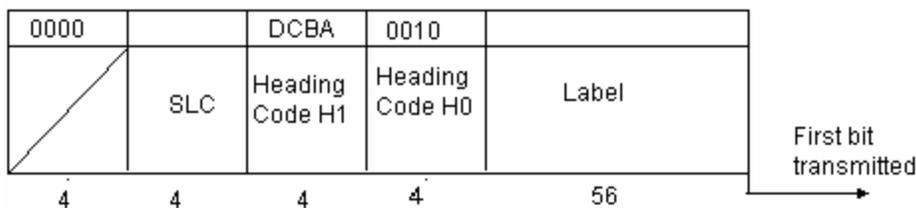


Figure 17/T1.111.4 Emergency Changeover Message

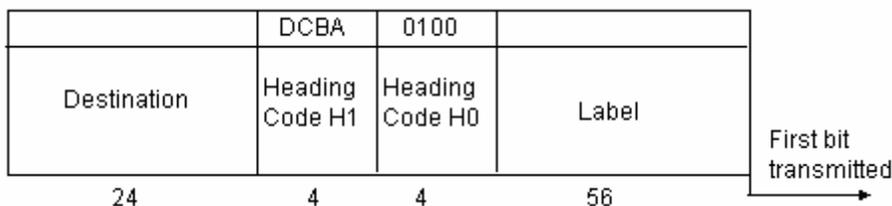


Figure 18/T1.111.4 Transfer-Prohibited/Transfer-Restricted Message

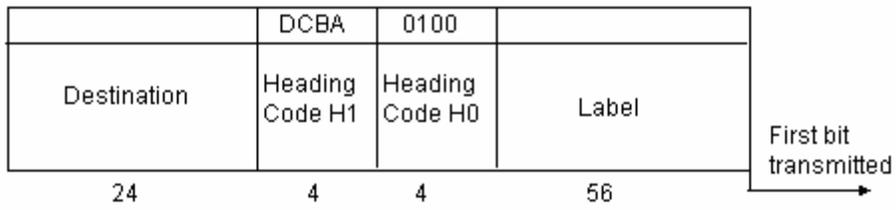


Figure 19/T1.111.4 Transfer Allowed Message

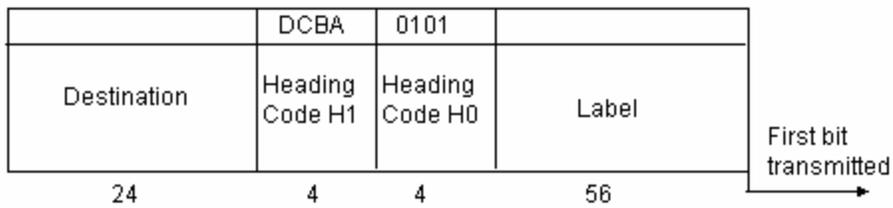


Figure 20/T1.111.4 Signalling-Route-Set-Test Message

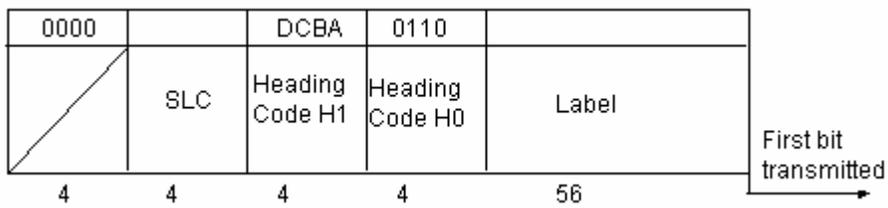


Figure 20A/T1.111.4 Management Inhibit Message

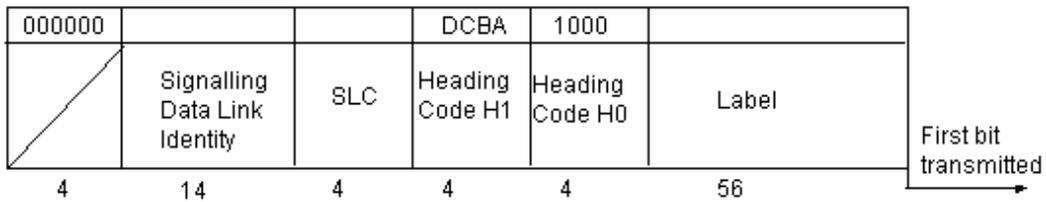


Figure 21/T1.111.4 Signalling-Data-Link-Connection-Order Message

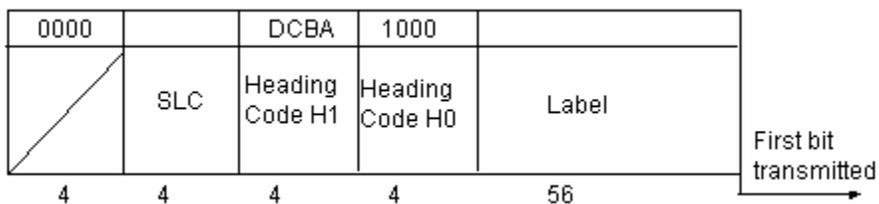


Figure 22/T1.111.4 Signalling-Data-Link-Connection-Acknowledgement Message

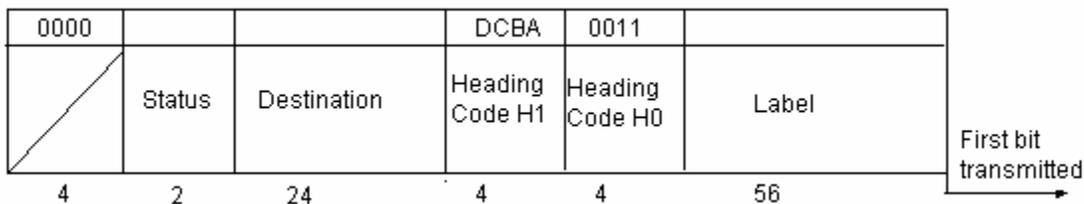


Figure 22A/T1.111.4 Transfer-Controlled Message

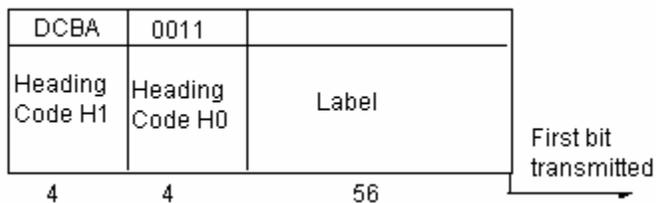


Figure 22B/T1.111.4 Signalling-Route-Set-Congestion-Test Message

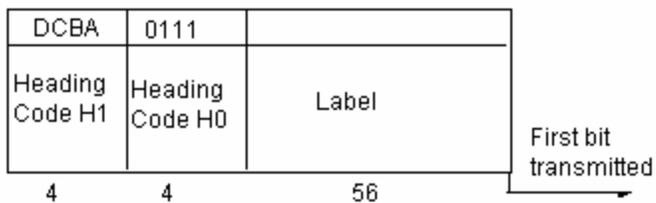


Figure 22C/T1.111.4 Traffic Restart Message

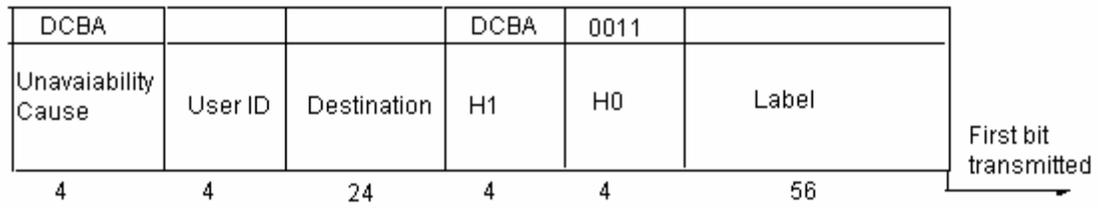
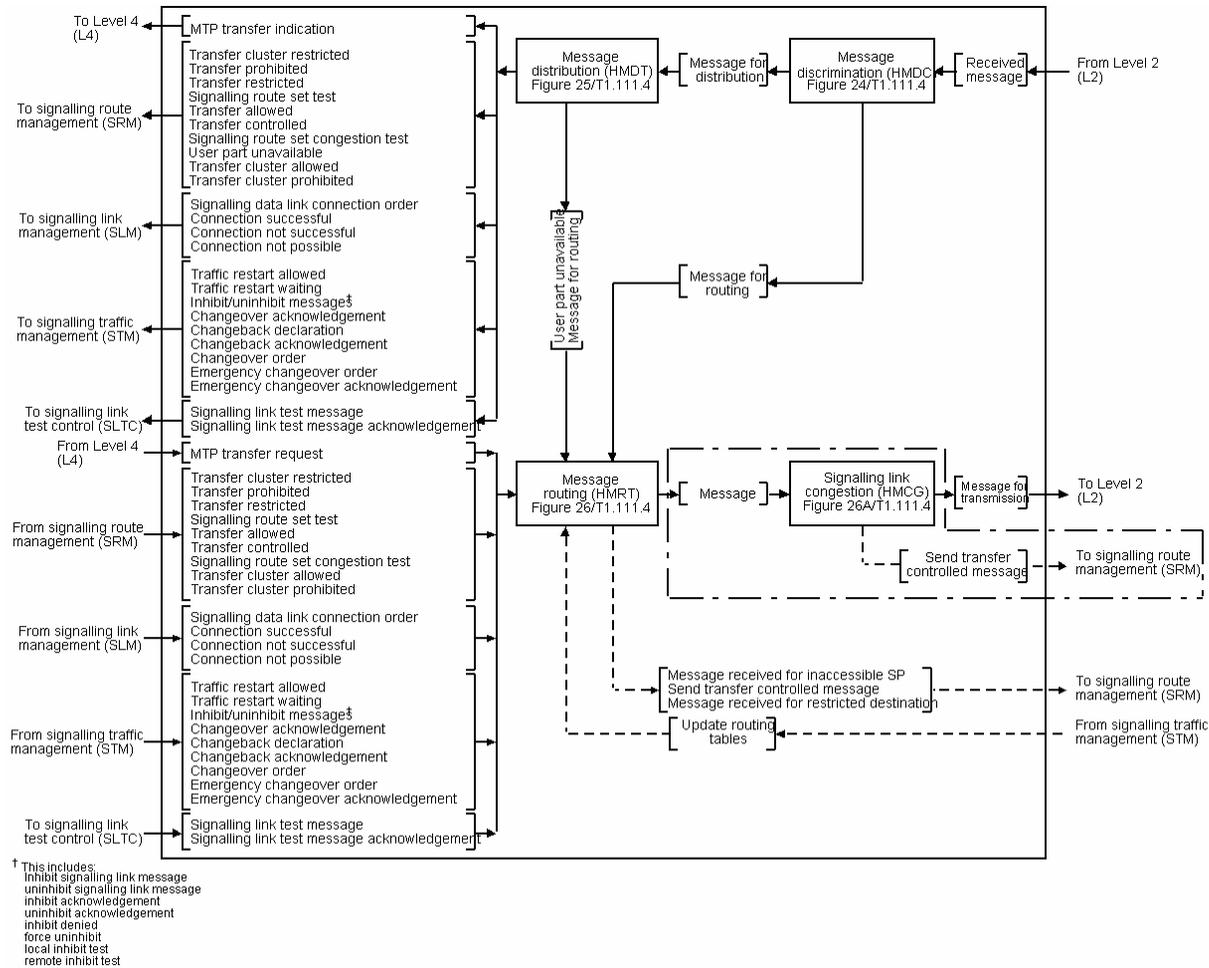


Figure 22D/T1.111.4 User Part Unavailable Message



**Figure 23/T1.111.4 Level 3 - Signalling Message Handling (SMH);
 Functional Block Interactions**

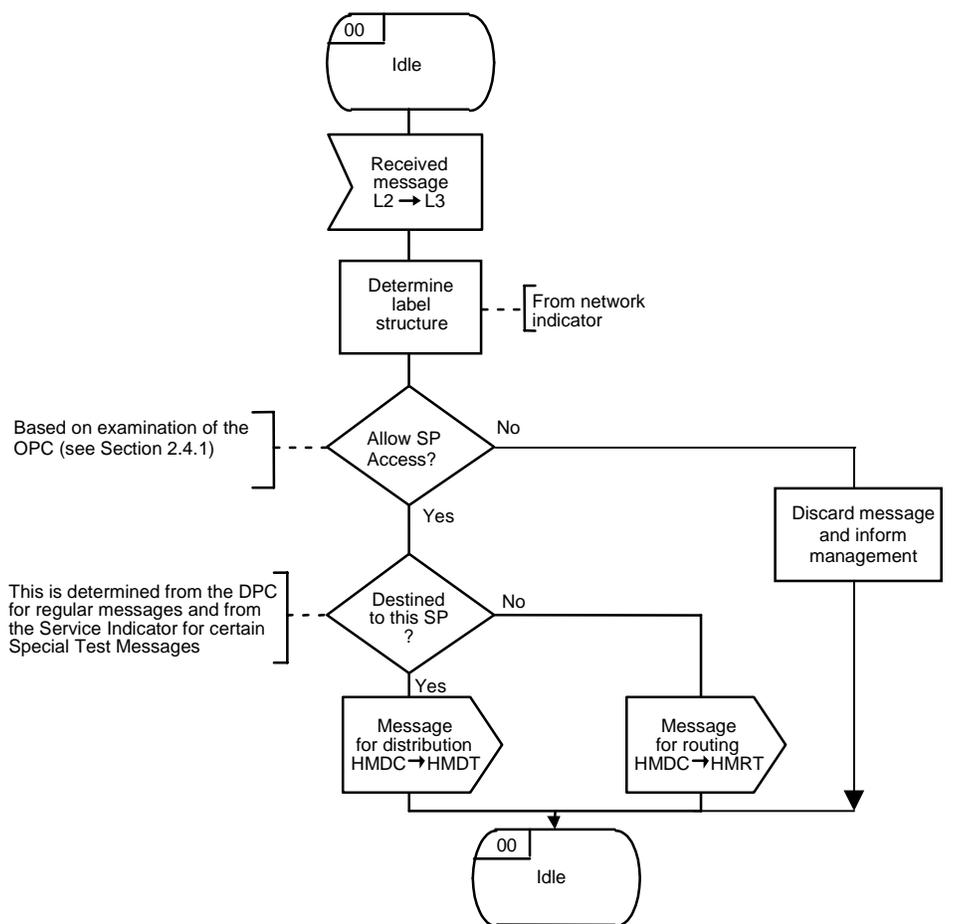


Figure 24/T1.111.4 Signalling Message Handling; Message Discrimination (HMDC)

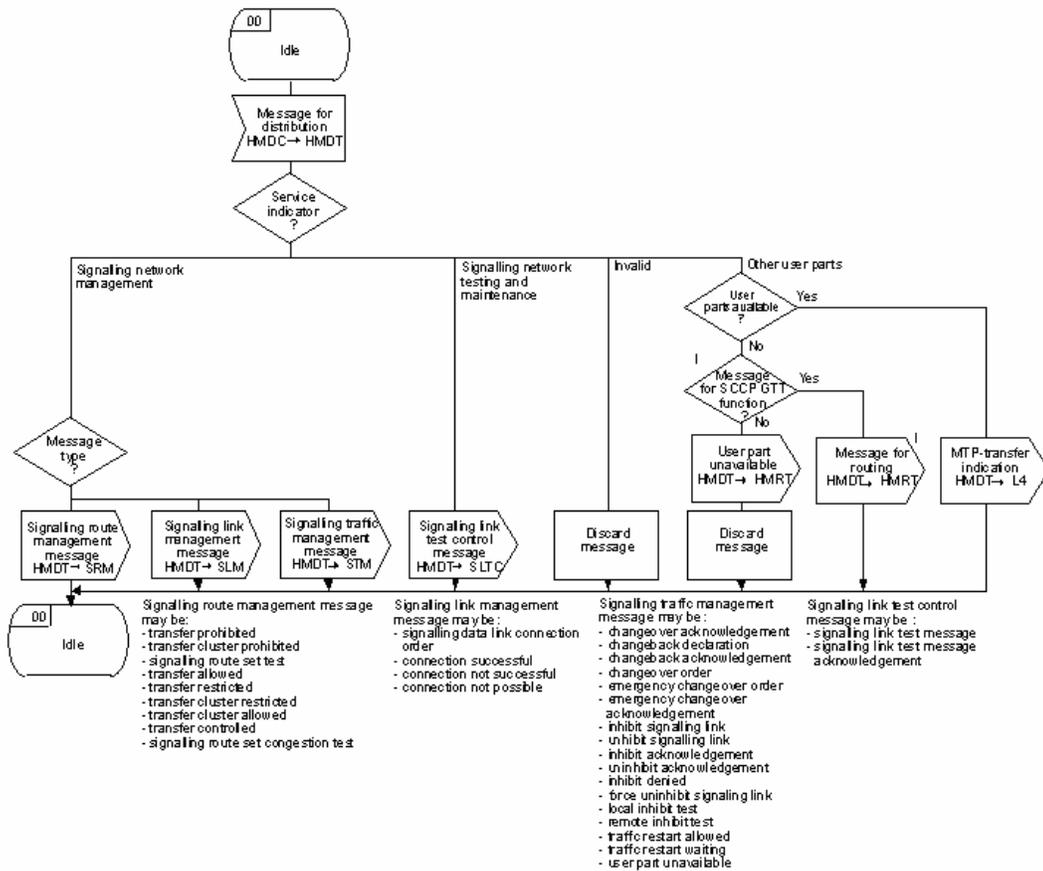


Figure 25/T1.111.4 Signalling Message Handling; Message Distribution (HMDT)

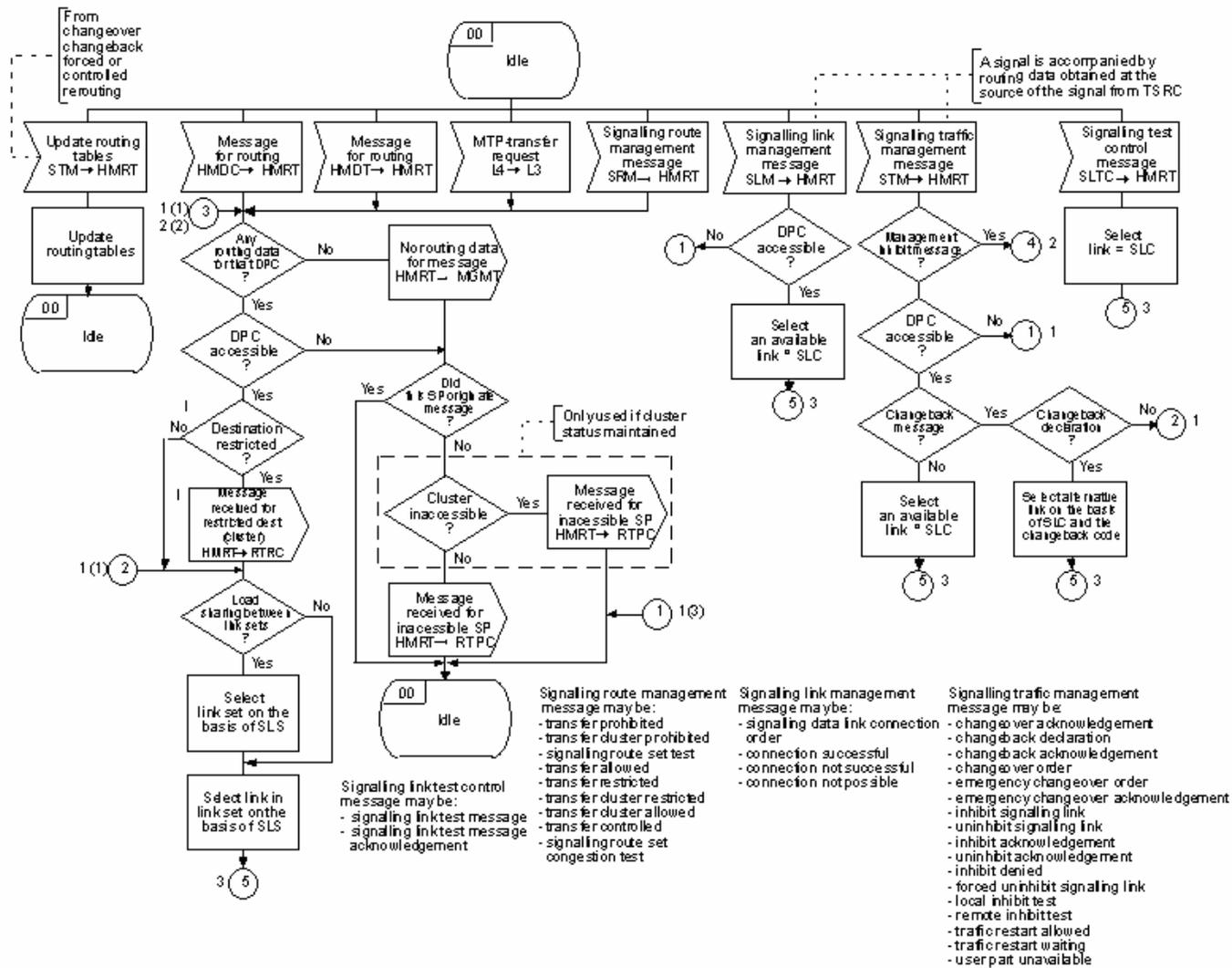


Figure 26/T1.111.4 Signalling Message Handling - Message Routing (Sheet 1 of 3)

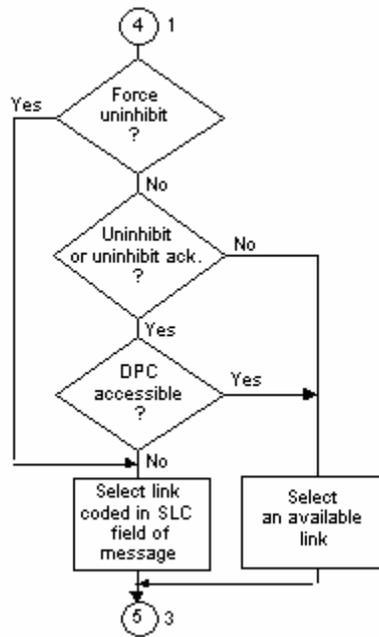


Figure 26/T1.111.4 Signalling Message Handling - Message Routing (HMRT) (Sheet 2 of 3)

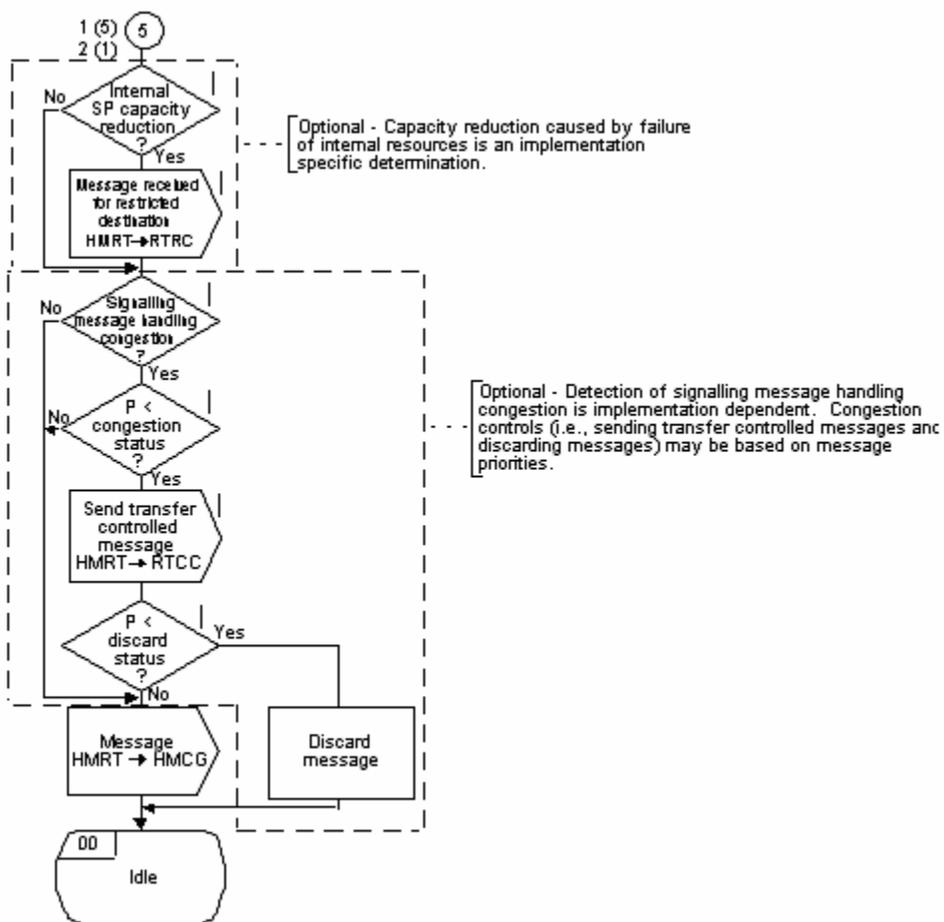


Figure 26/T1.111.4 Signalling Message Handling - Message Routing (HMRT) (Sheet 3 of 3)

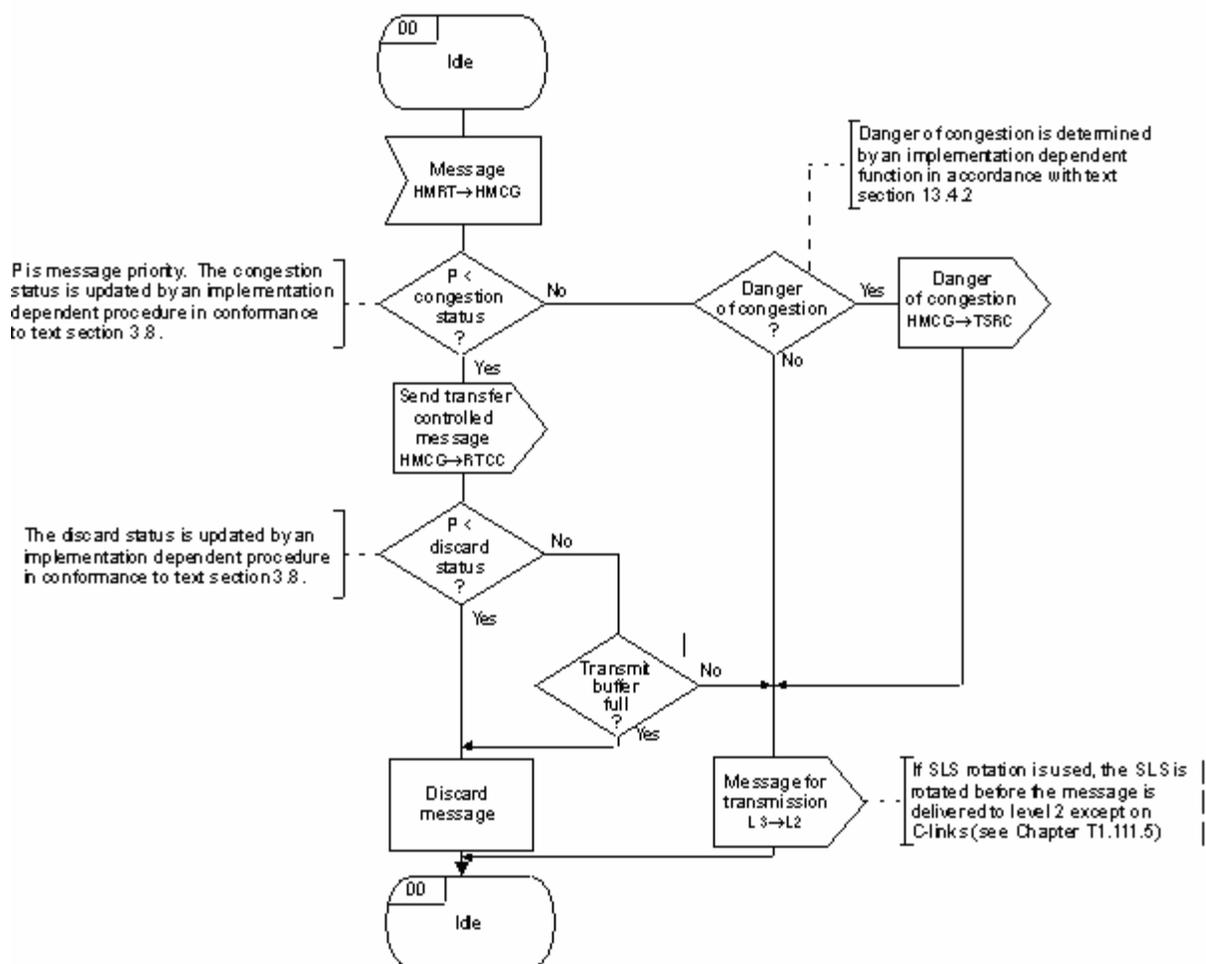


Figure 26A/T1.111.4 Signalling Message Handling - Signalling Link Congestion (HMCG)

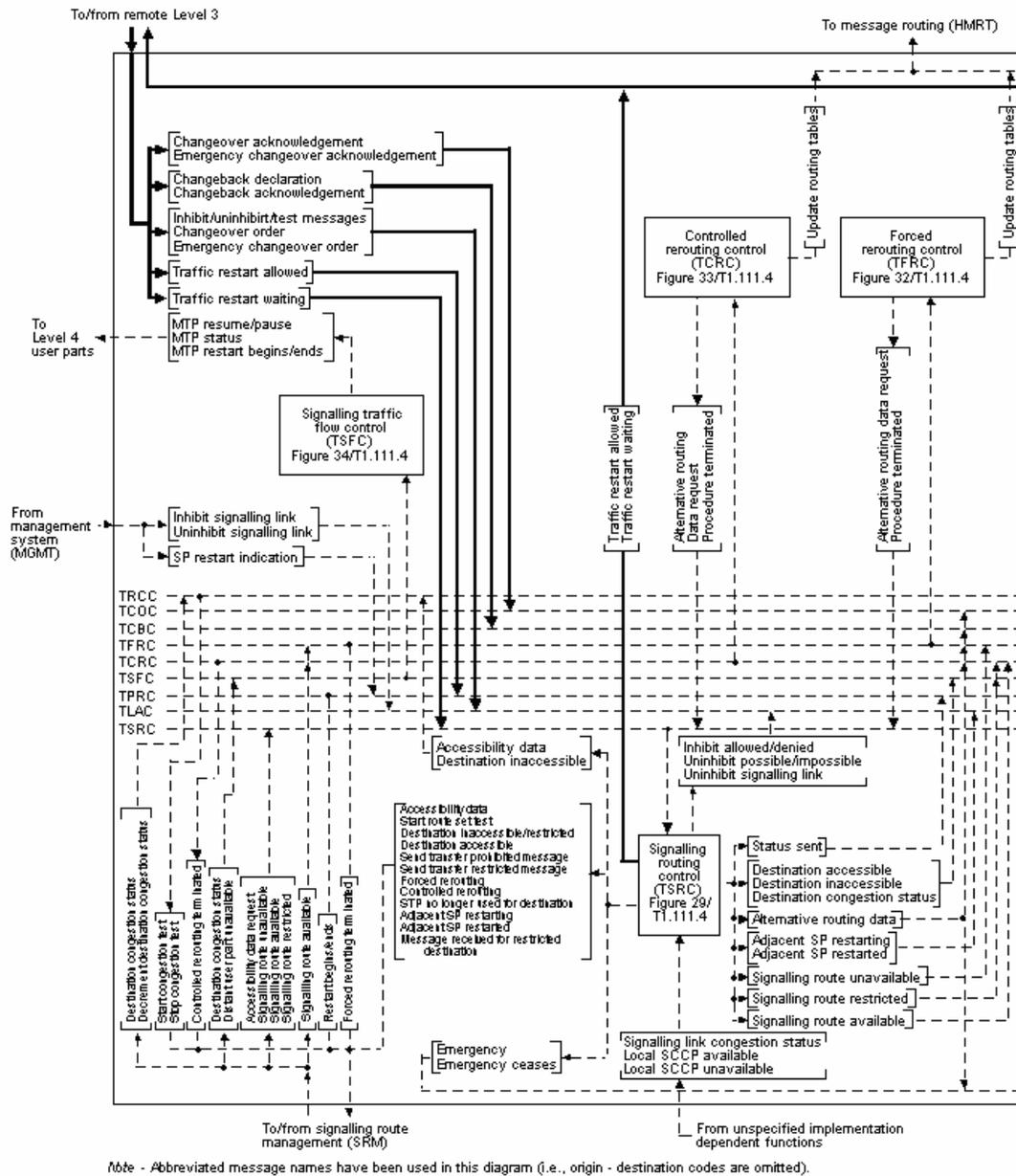
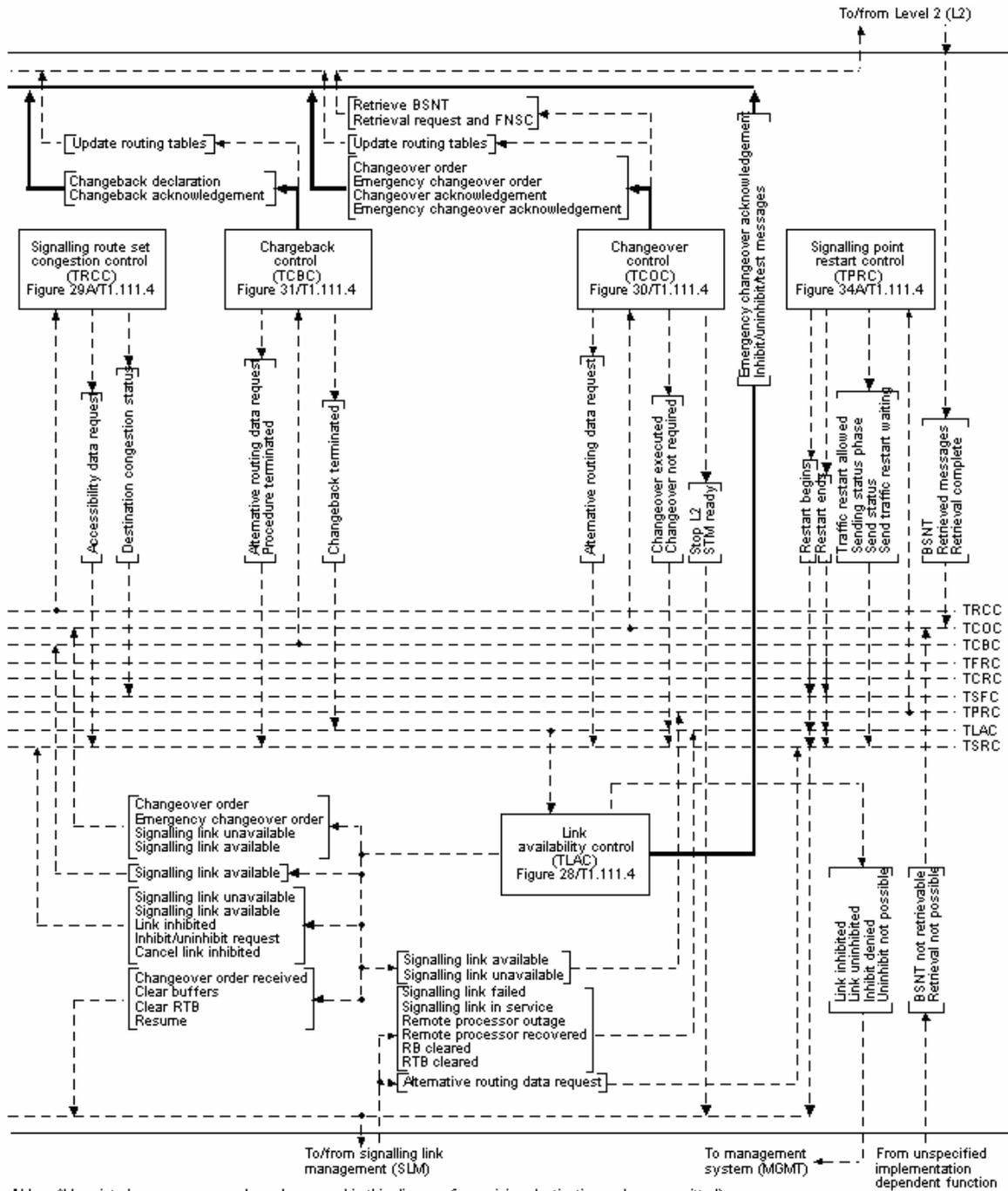


Figure 27/T1.111.4 Level 3 - Signalling Traffic Management (STM);
 Functions/Block Interactions (Sheet 1 of 2)



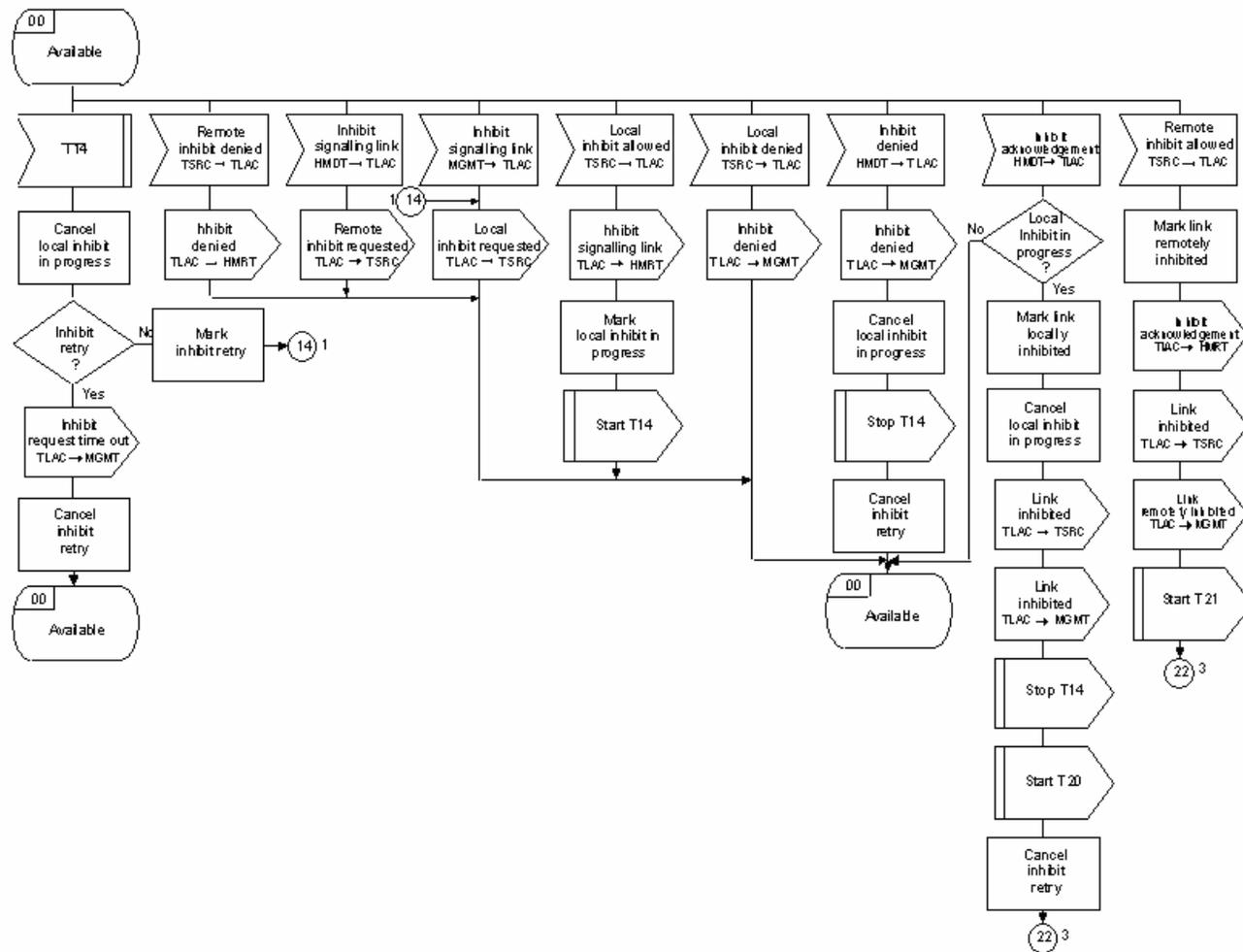


Figure 28/T1.111.4 Signalling Traffic Management - Link Availability Control (TLAC) (Sheet 1 of 11)

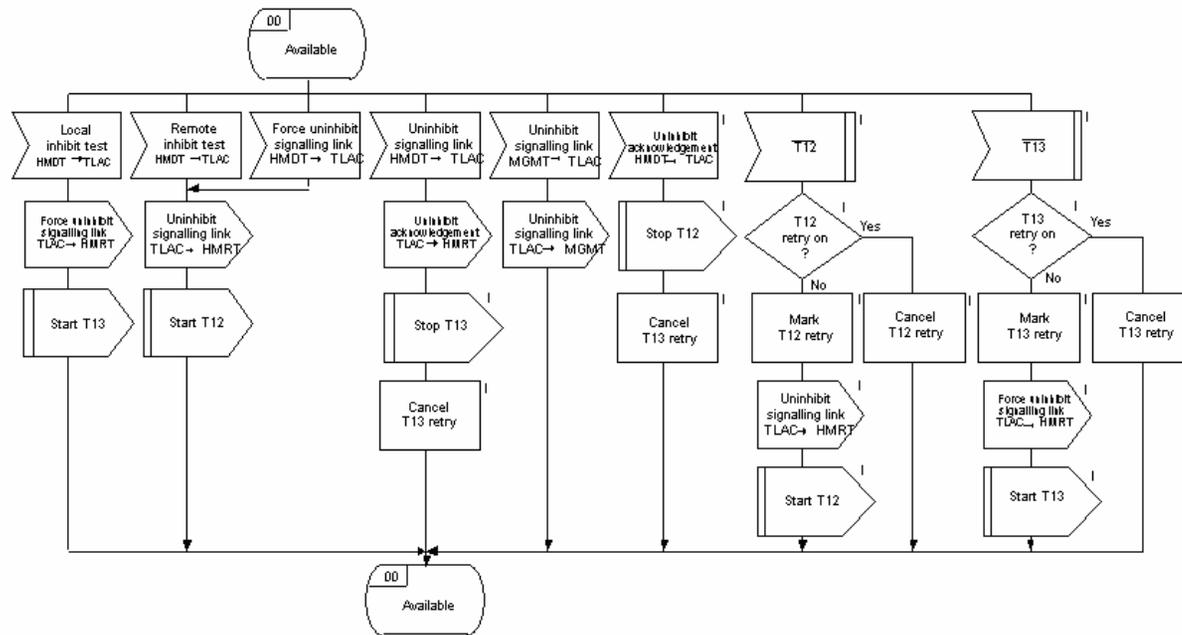


Figure 28/T1.111.4 Signalling Traffic Management - Link Availability Control (TLAC) (Sheet 2 of 11)

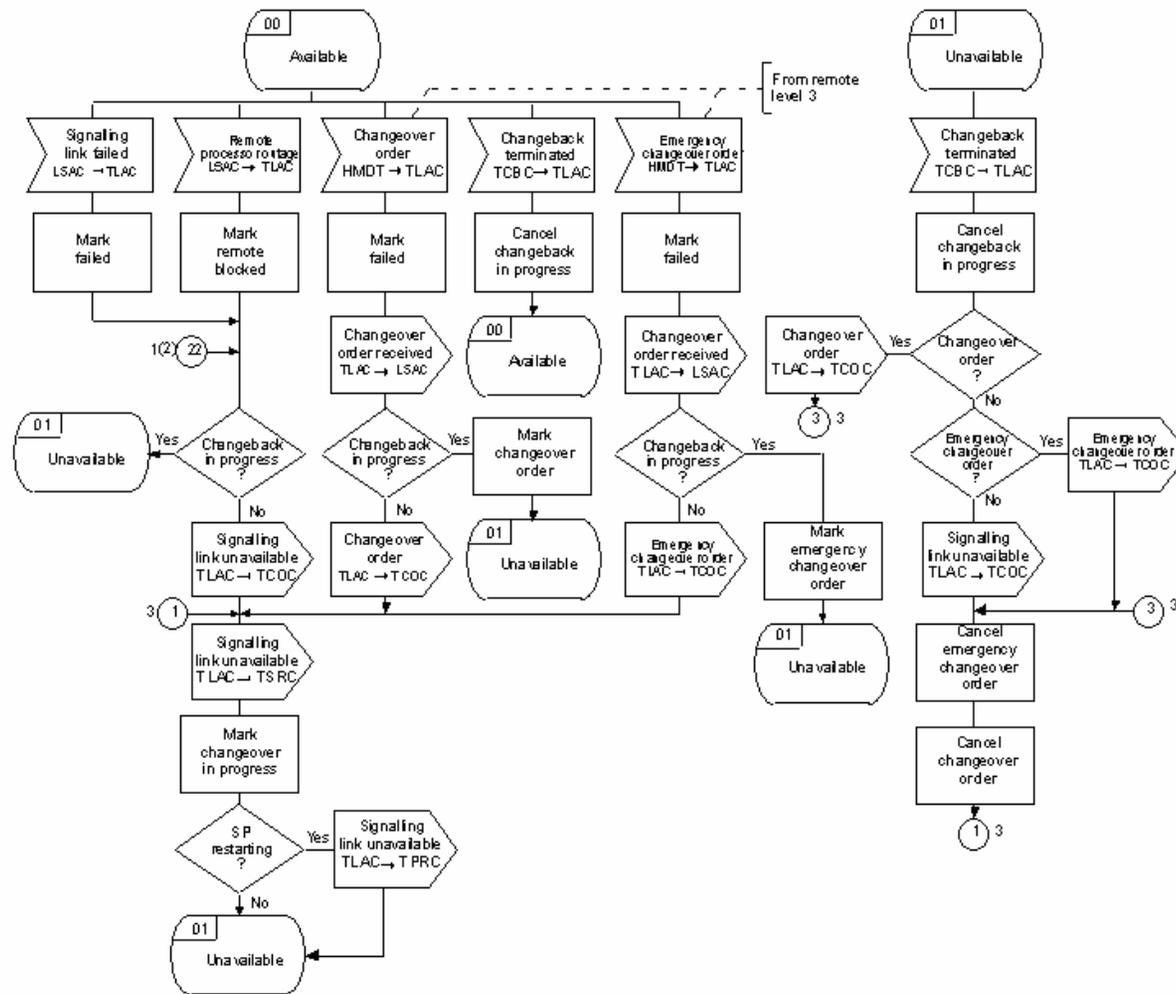


Figure 28/T1.111.4 Signalling Traffic Management - Link Availability Control (TLAC) (Sheet 3 of 11)

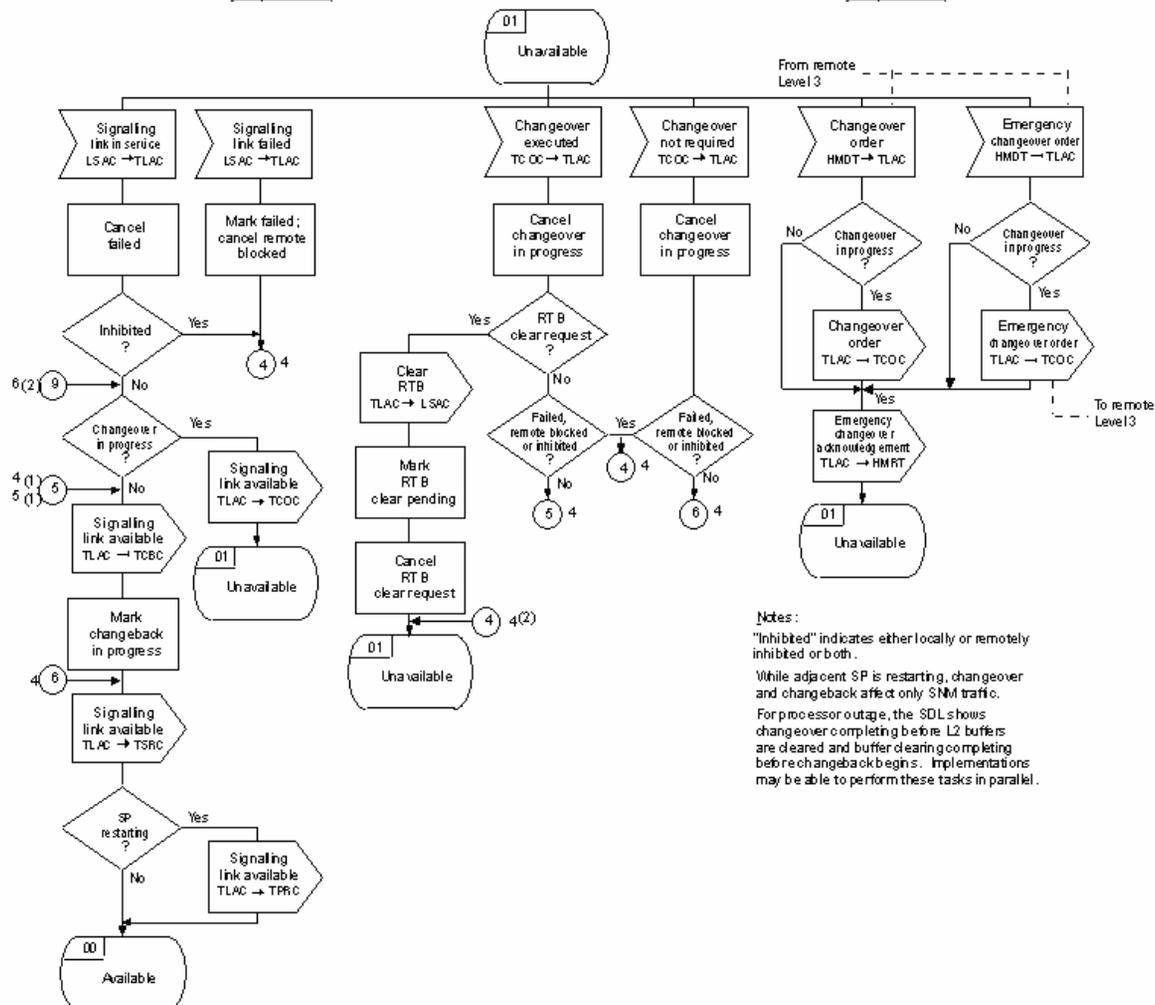


Figure 28/T1.111.4 Signalling Traffic Management - Link Availability Control (TLAC) (Sheet 4 of 11)

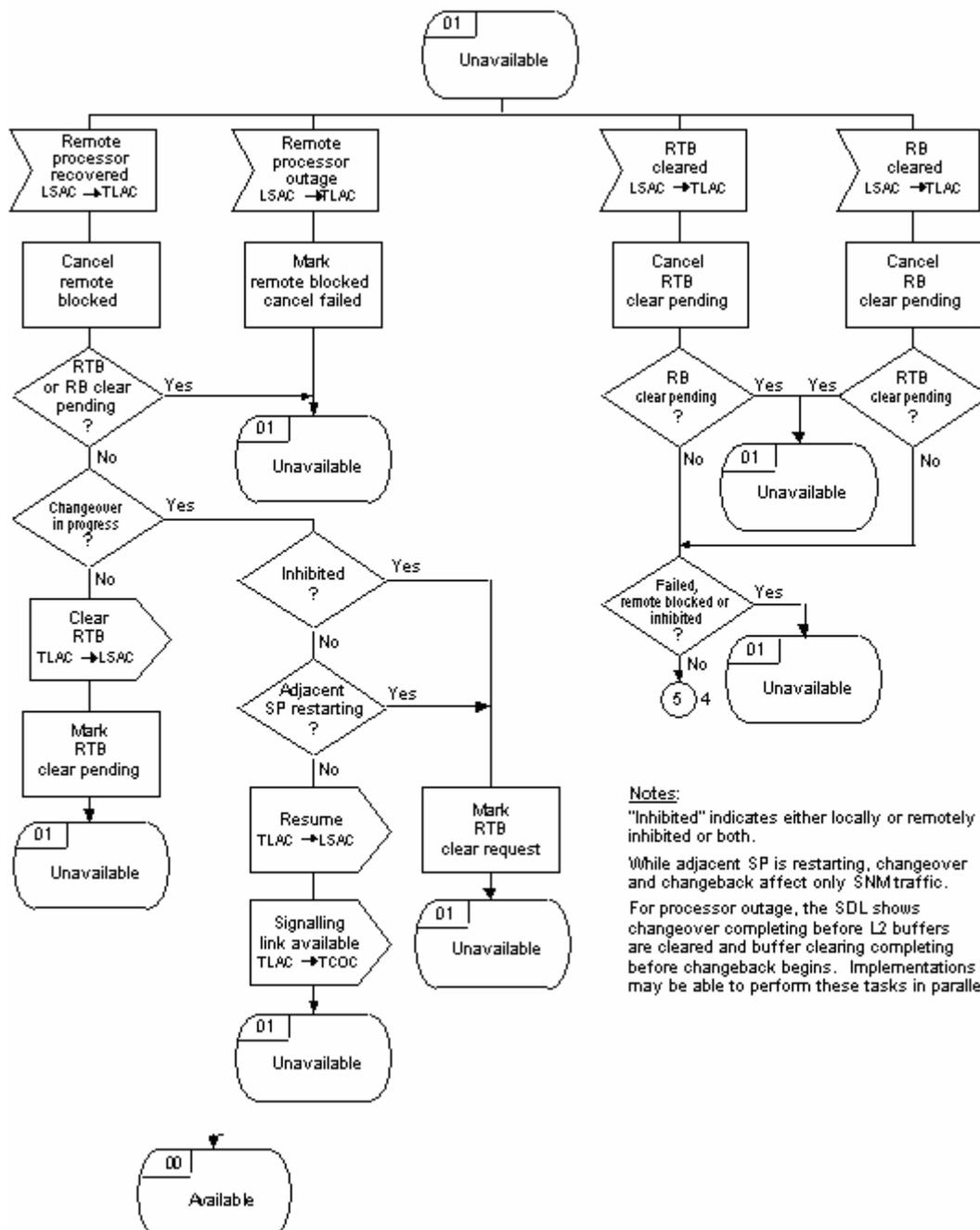


Figure 28/T1.111.4 Signalling Traffic Management - Link Availability Control (TLAC) (Sheet 5 of 11)

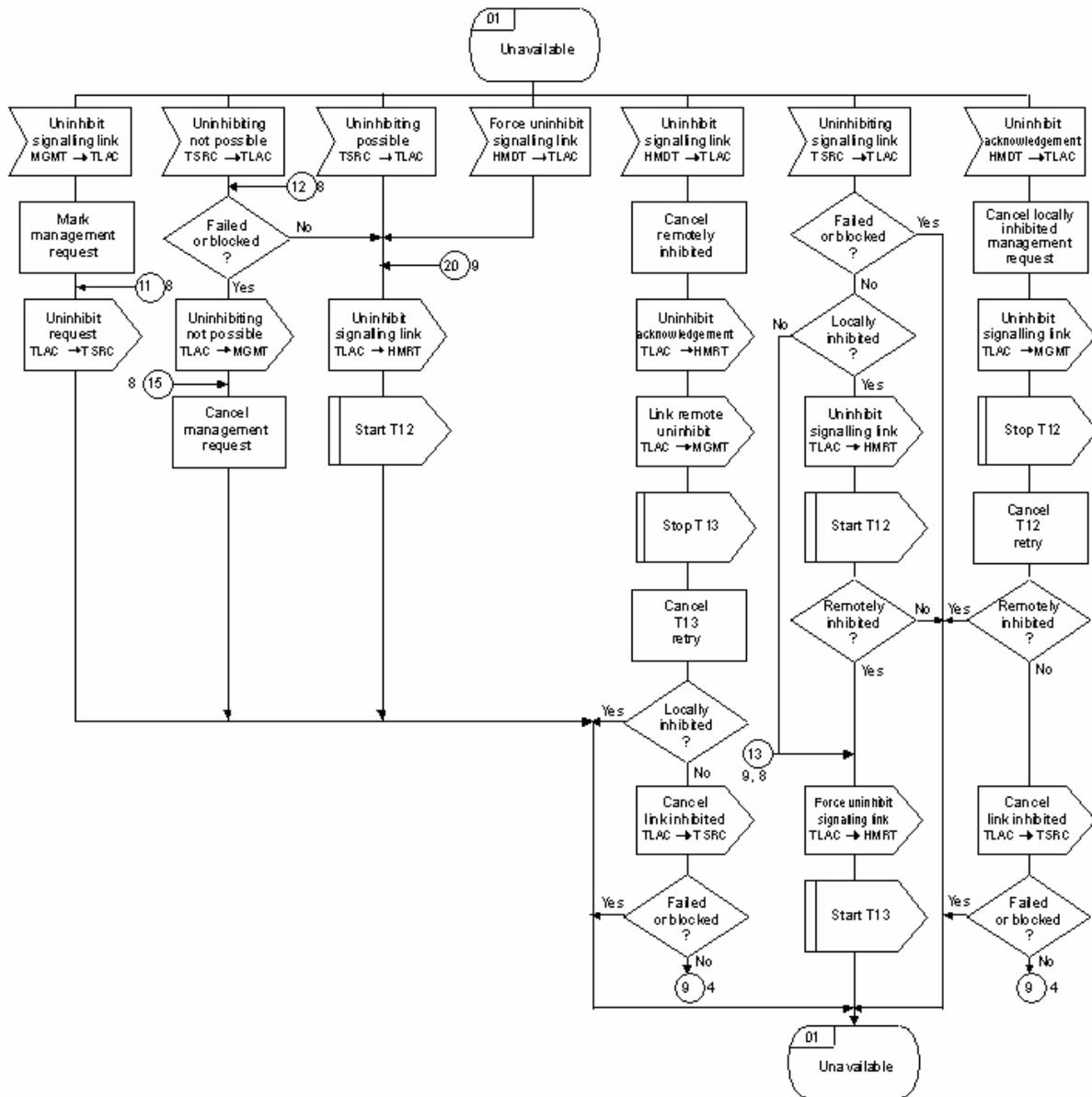


Figure 28/T1.111.4 Signalling Traffic Management - Link Availability Control (TLAC) (Sheet 6 of 11)

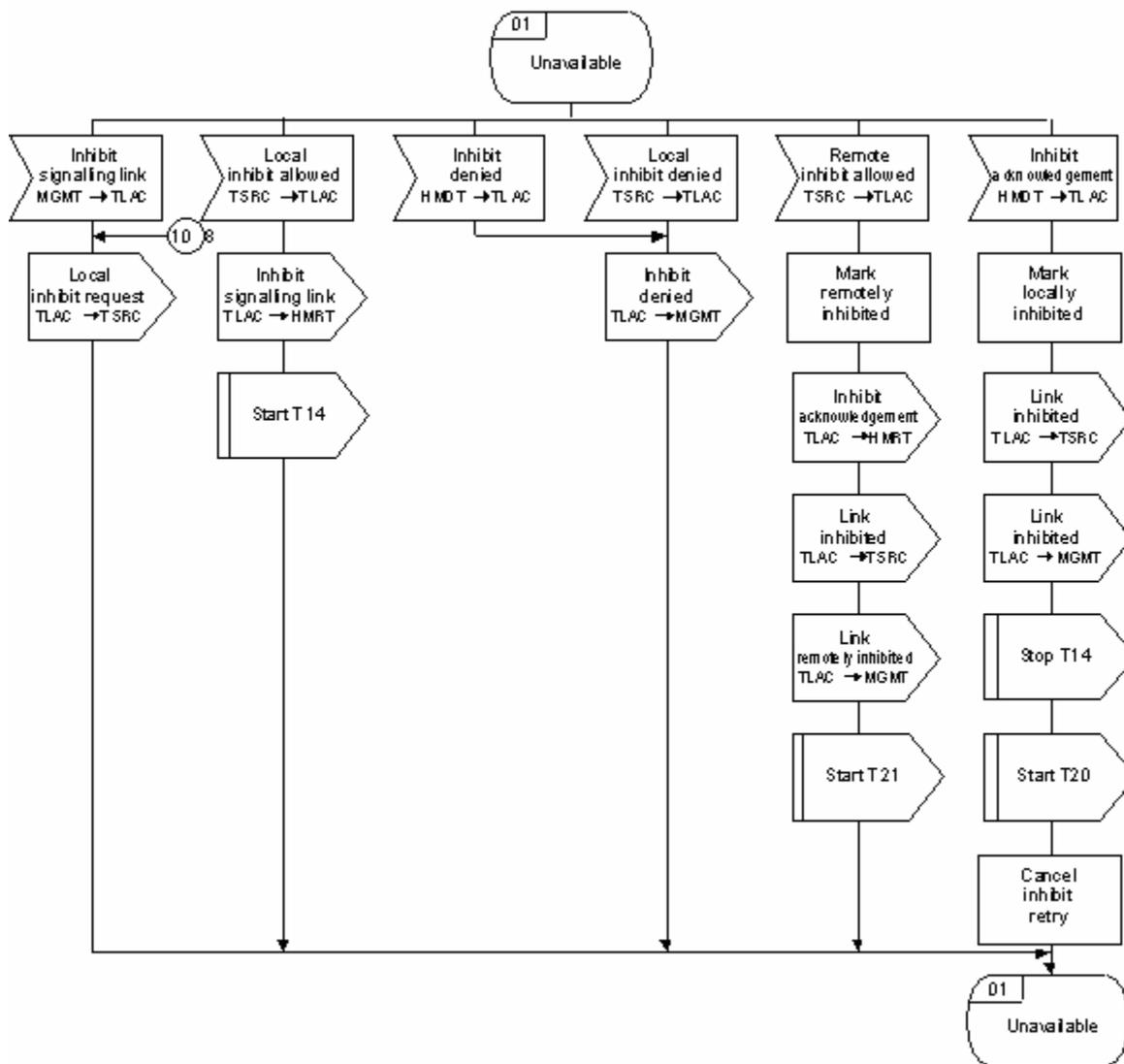


Figure 28/T1.111.4 Signalling Traffic Management - Link Availability Control (TLAC) (Sheet 7 of 11)

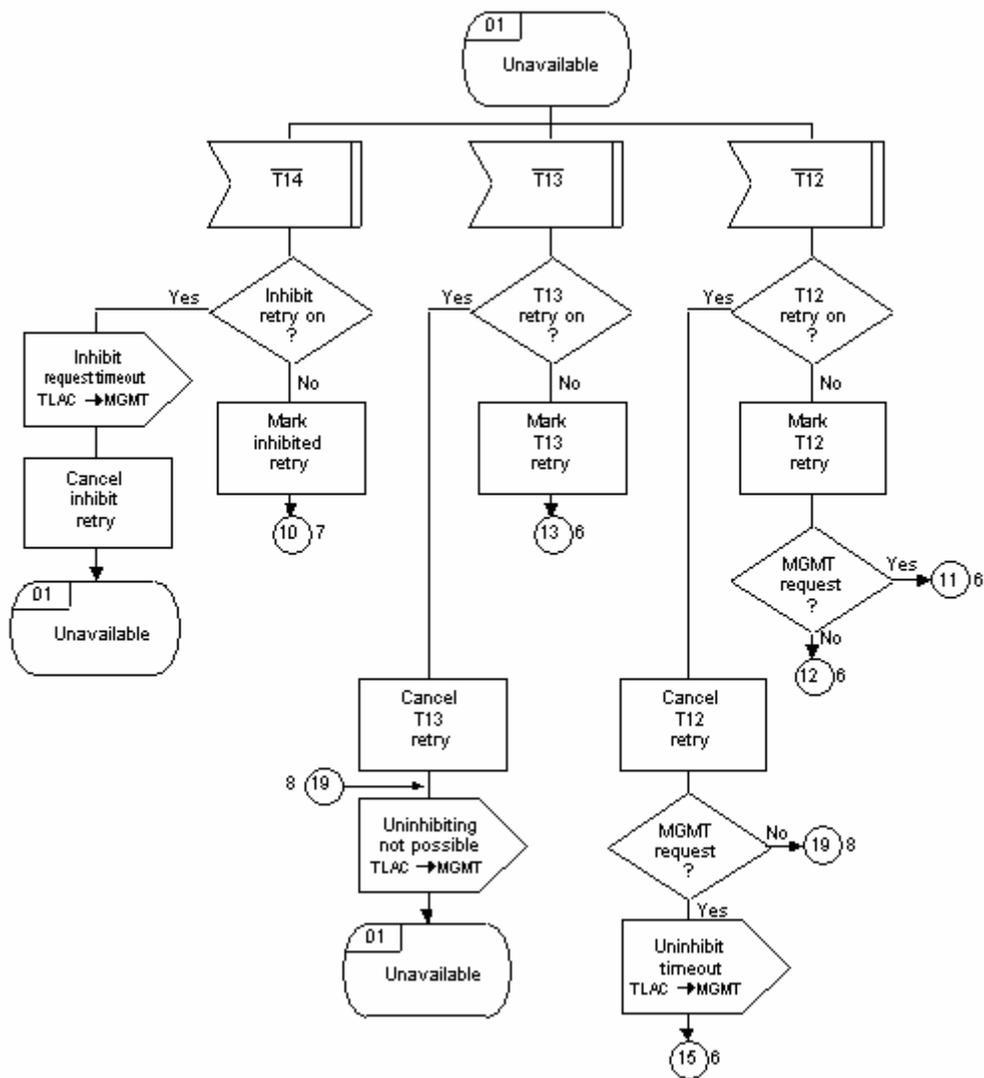


Figure 28/T1.111.4 Signalling Traffic Management - Link Availability Control (TLAC) (Sheet 8 of 11)

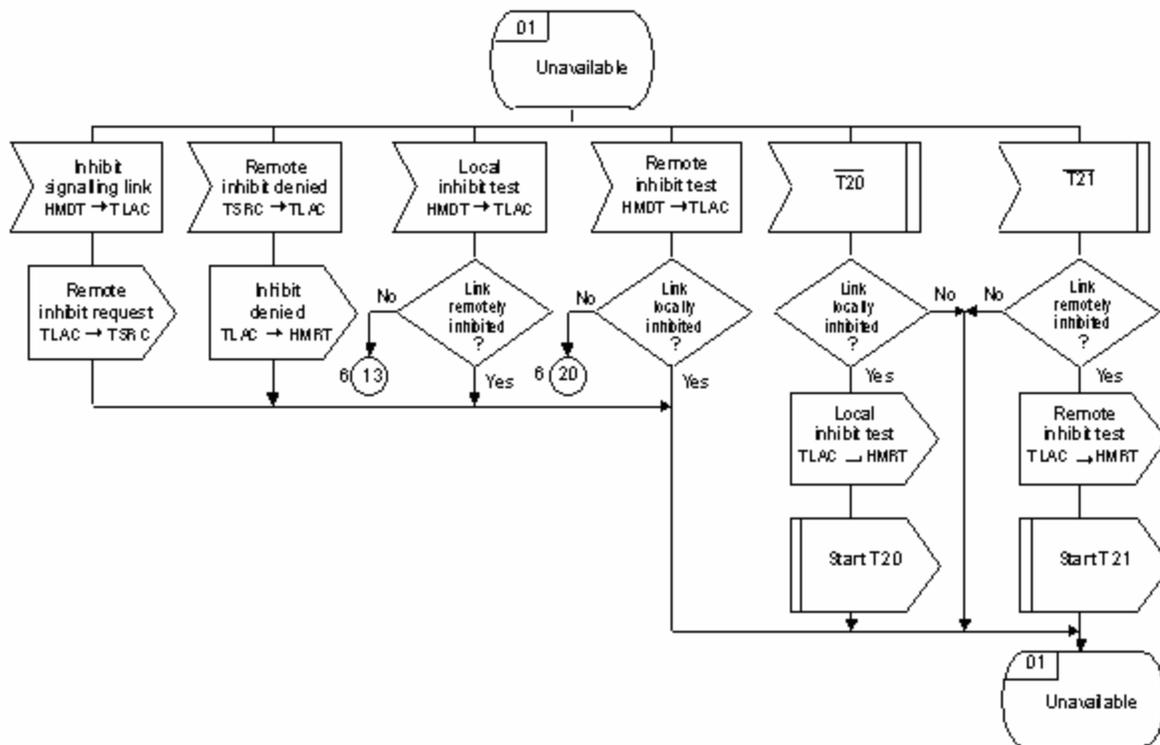


Figure 28/T1.111.4 Signalling Traffic Management - Link Availability Control (TLAC) (Sheet 9 of 11)

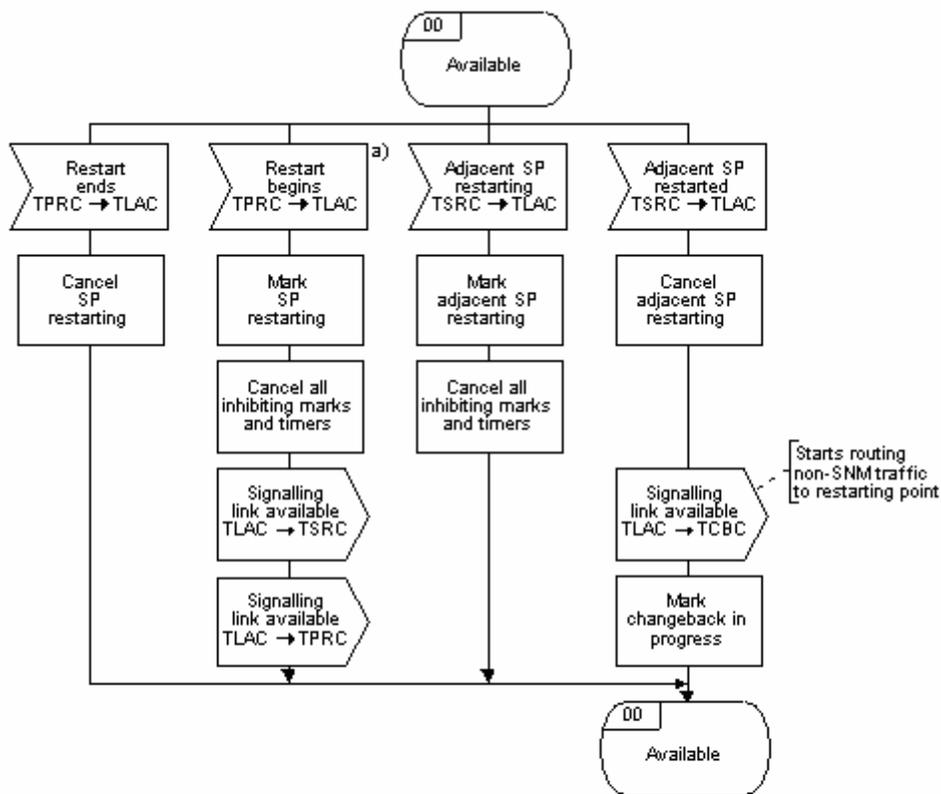


Figure 28/T1.111.4 Signalling Traffic Management - Link Availability Control (TLAC) (Sheet 10 of 11)

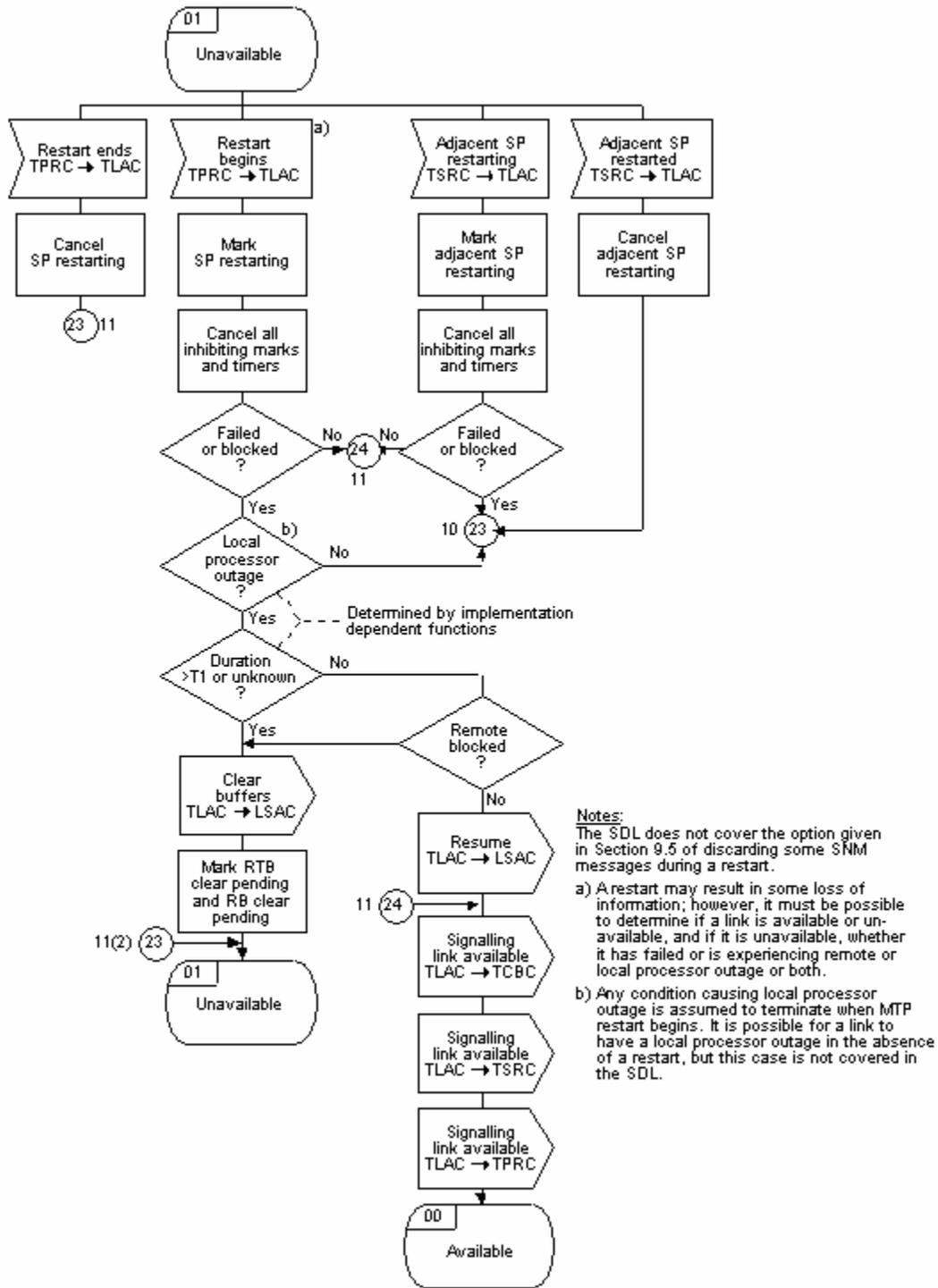


Figure 28/T1.111.4 Signalling Traffic Management - Link Availability Control (TLAC) (Sheet 11 of 11)

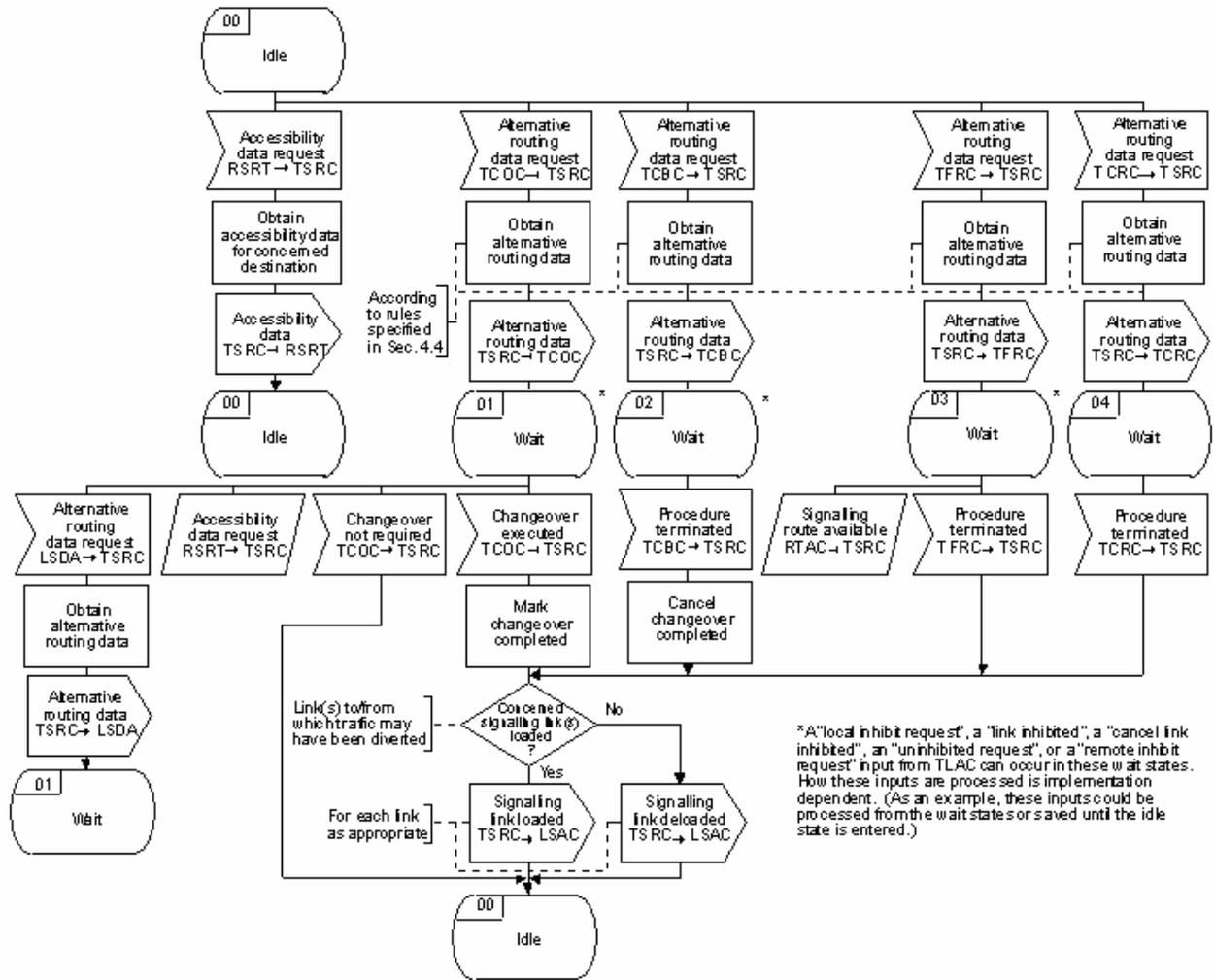


Figure 29/T1.111.4 Signalling Traffic Management - Signalling Routing Control (TSRC) (Sheet 1 of 15)

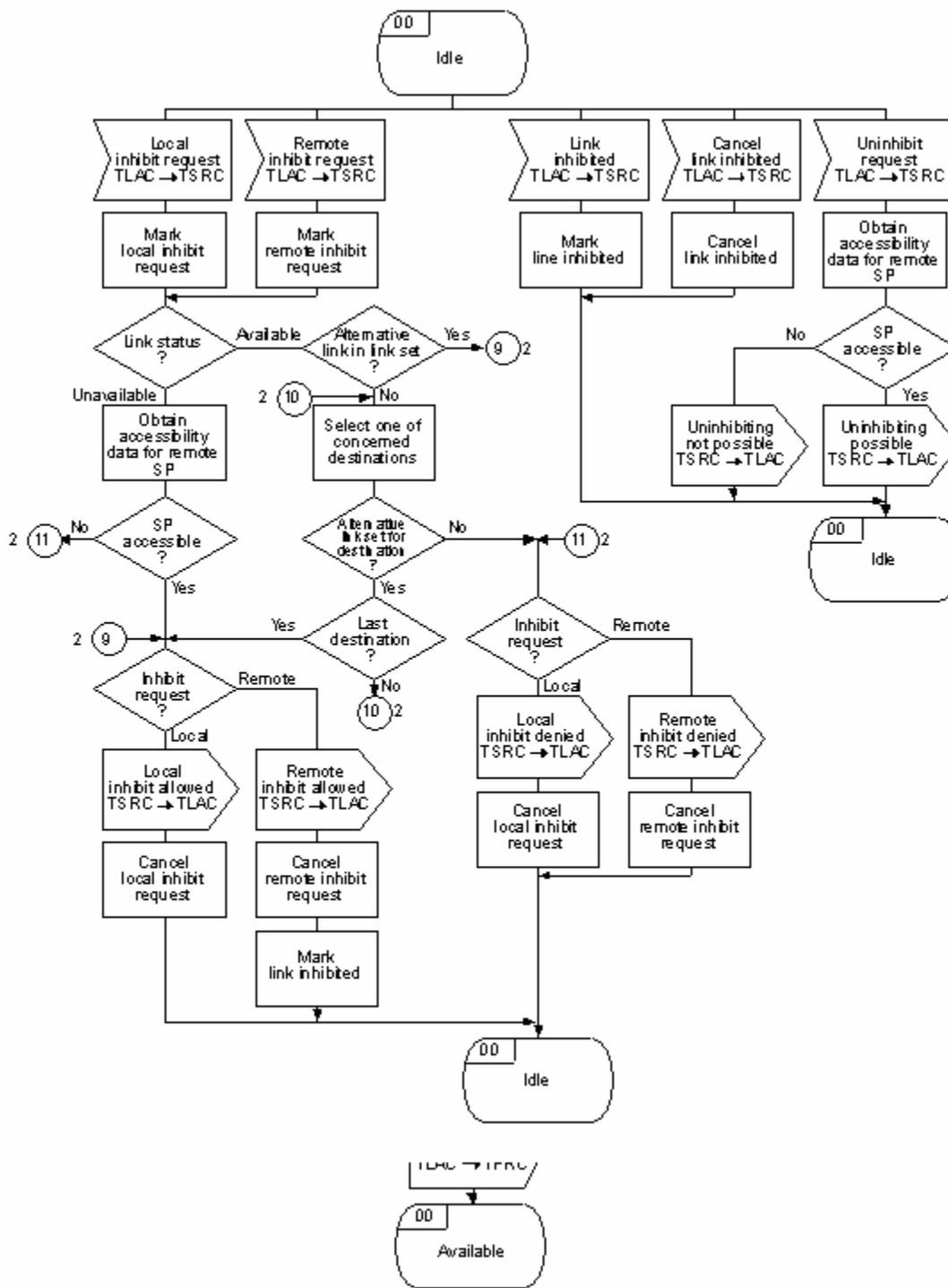


Figure 29/T1.111.4 Signalling Traffic Management - Signalling Routing Control (TSRC) (Sheet 2 of 15)

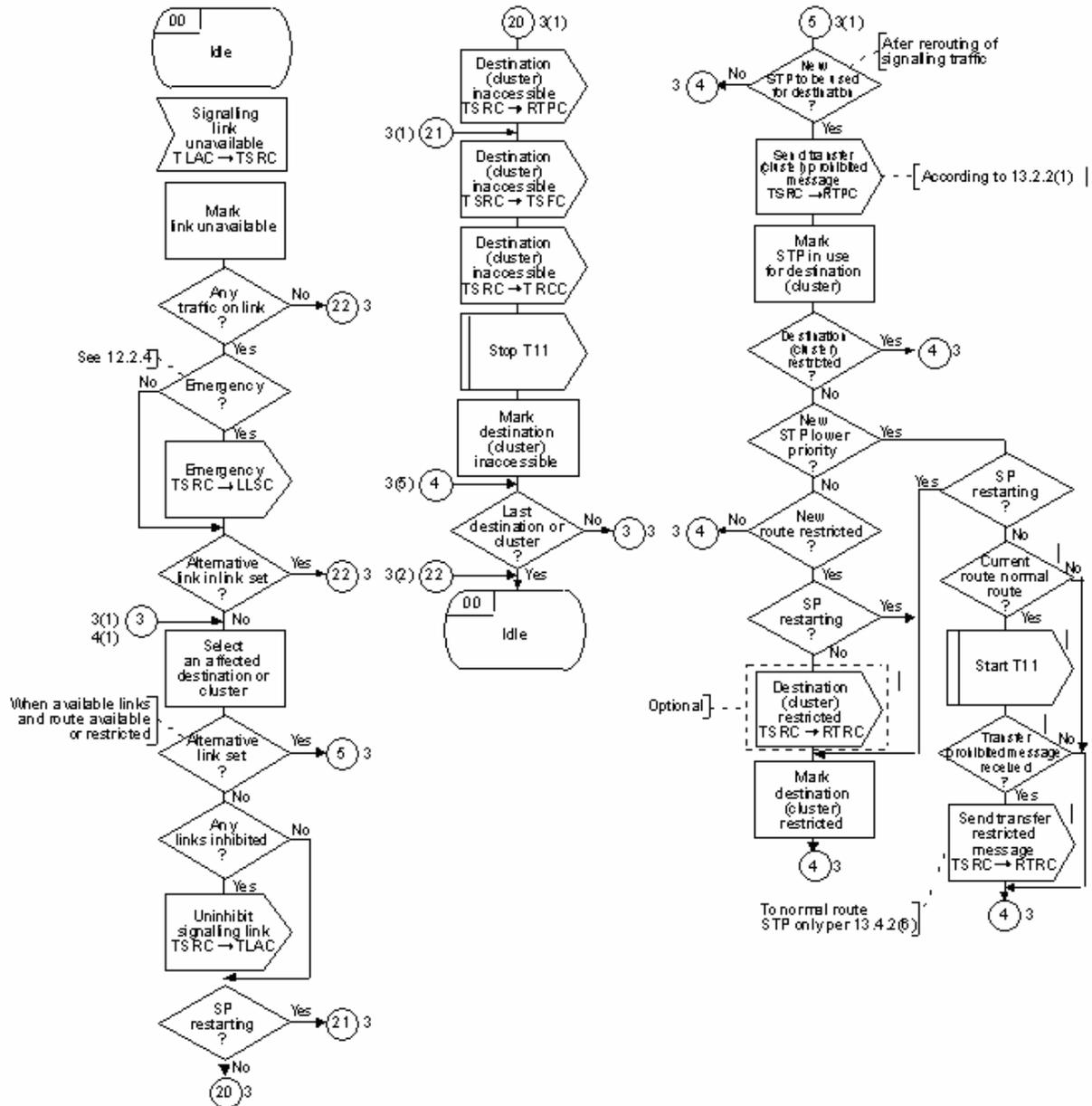


Figure 29/T1.111.4 Signalling Traffic Management - Signalling Routing Control (TSRC) (Sheet 3 of 15)

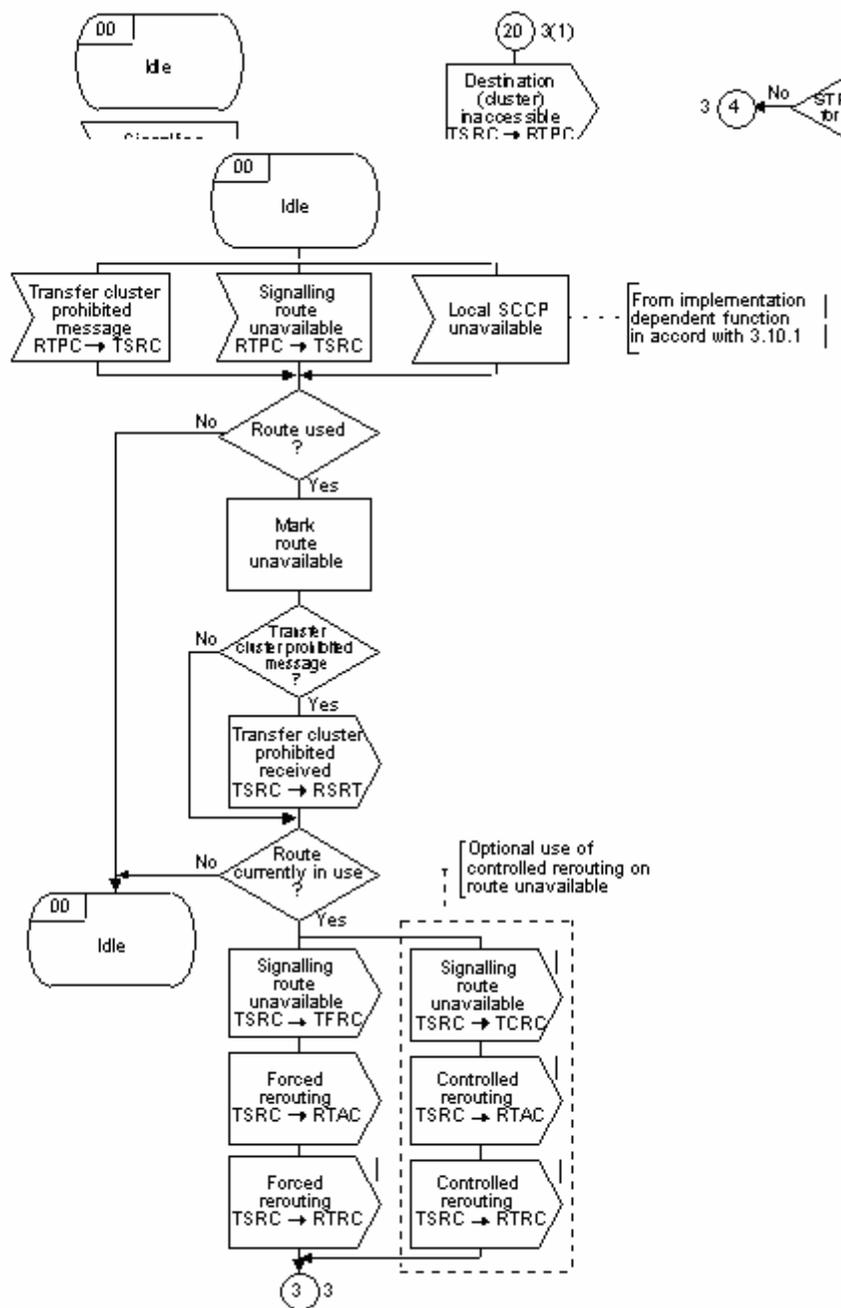


Figure 29/T1.111.4 Signalling Traffic Management - Signalling Routing Control (TSRC) (Sheet 4 of 15)

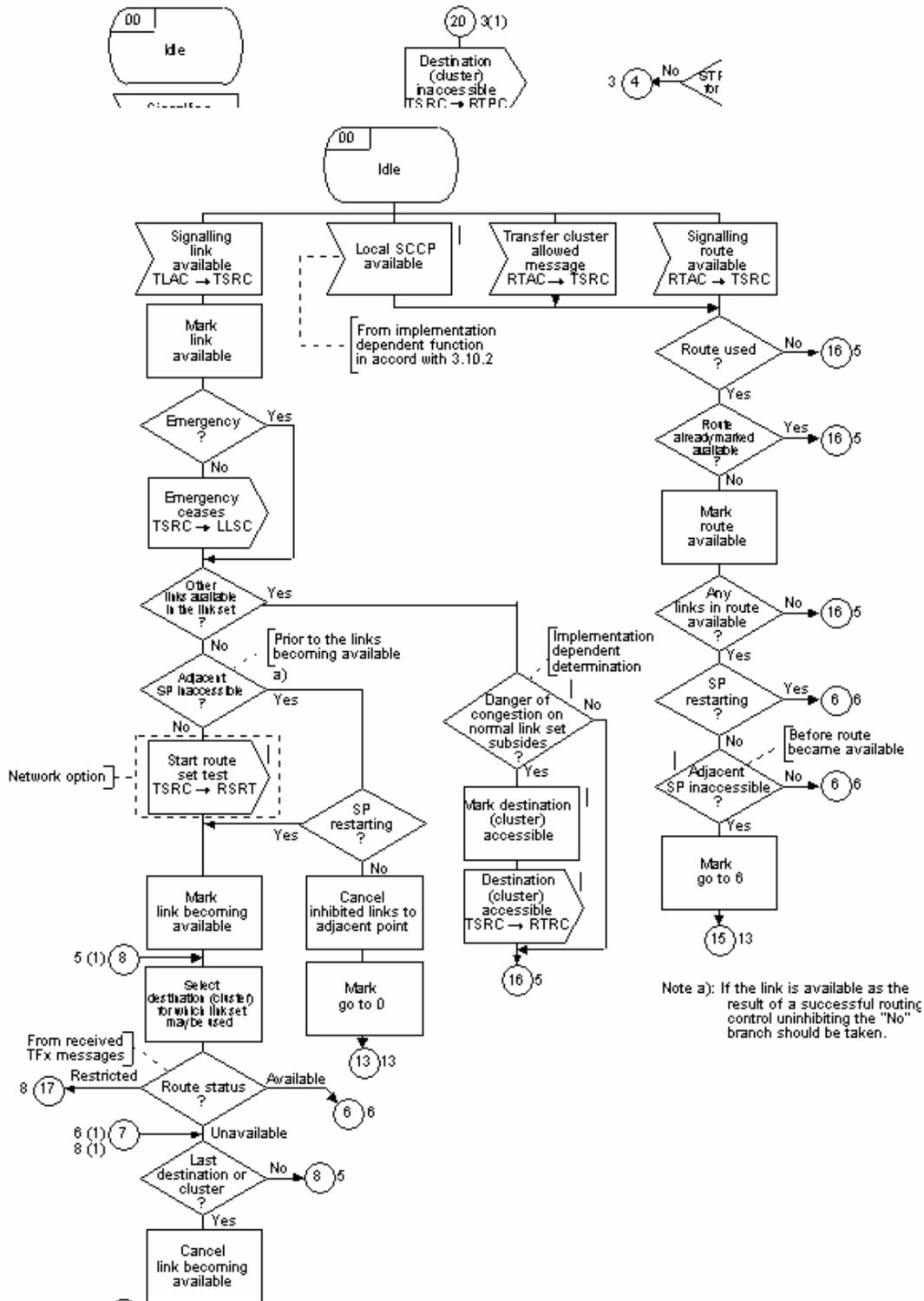


Figure 29/T1.111.4 Signalling Traffic Management - Signalling Routing Control (TSRC) (Sheet 5 of 15)

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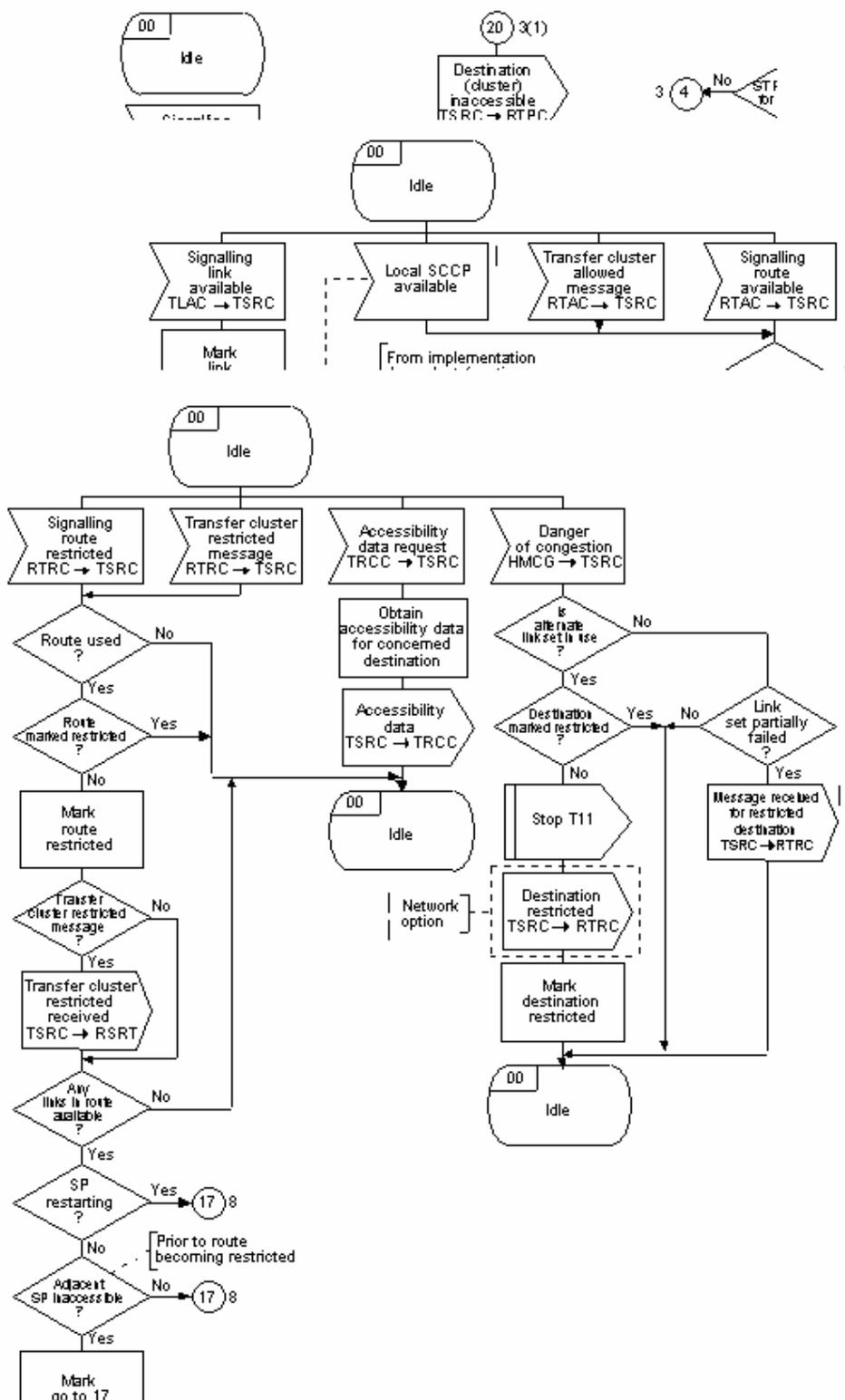


Figure 29/T1.111.4 Signalling Traffic Management - Signalling Routing Control (TSRC) (Sheet 7 of 15)

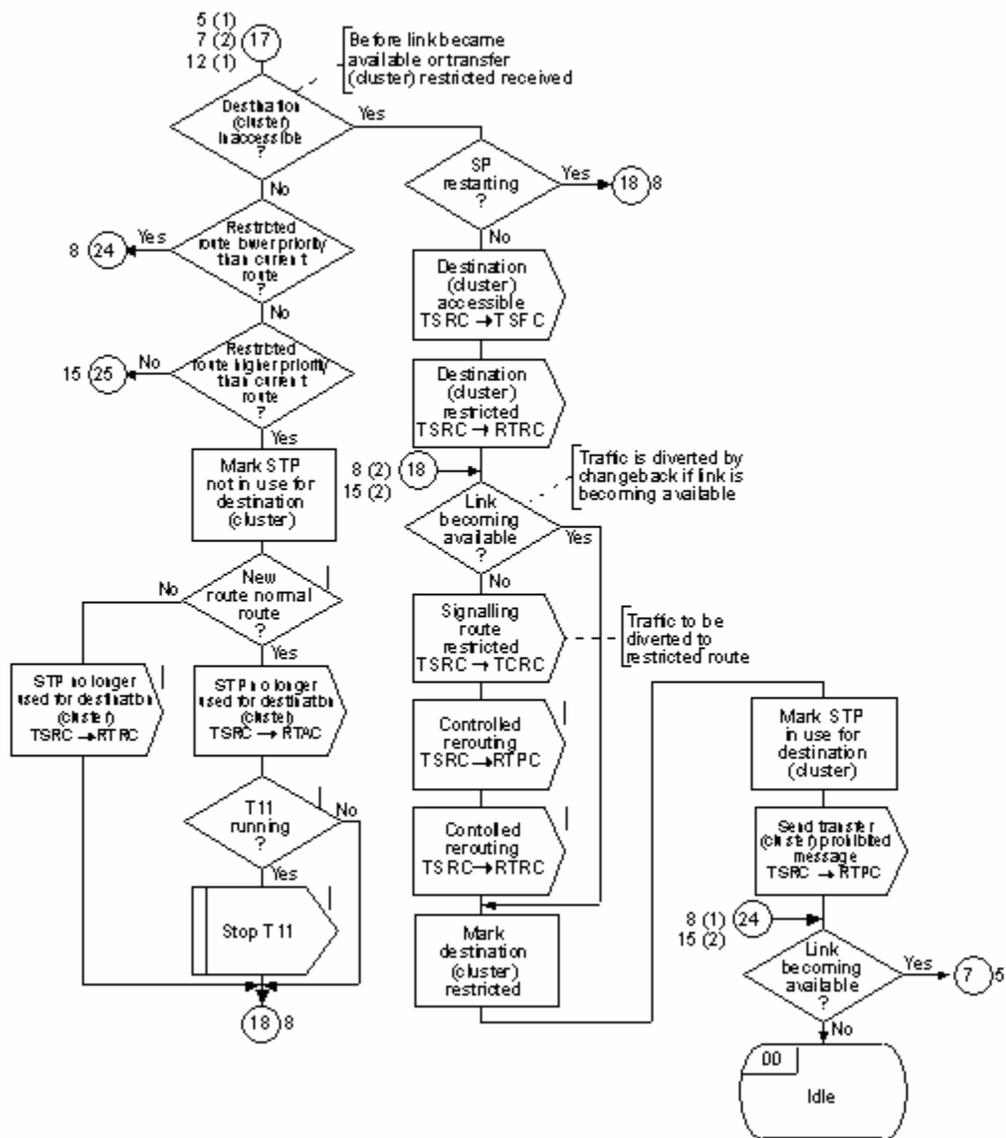


Figure 29/T1.111.4 Signalling Traffic Management - Signalling Routing Control (TSRC) (Sheet 8 of 15)

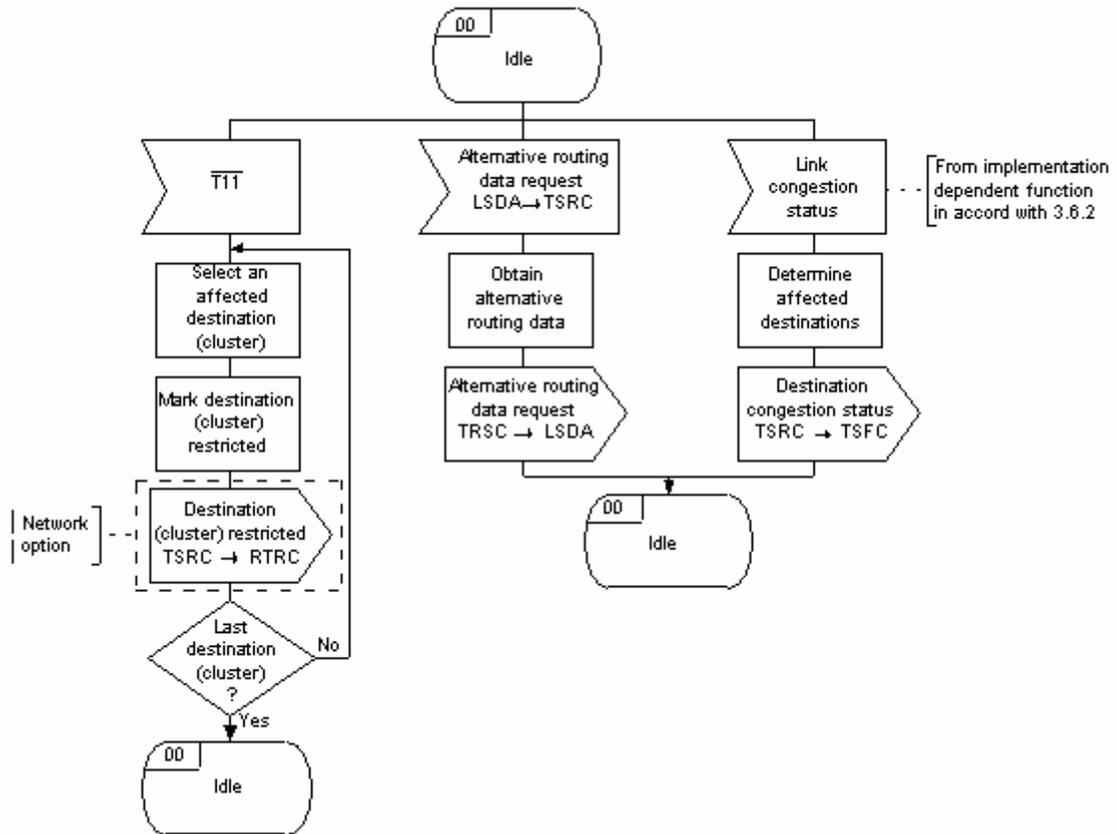


Figure 29/T1.111.4 Signalling Traffic Management - Signalling Routing Control (TSRC) (Sheet 9 of 15)

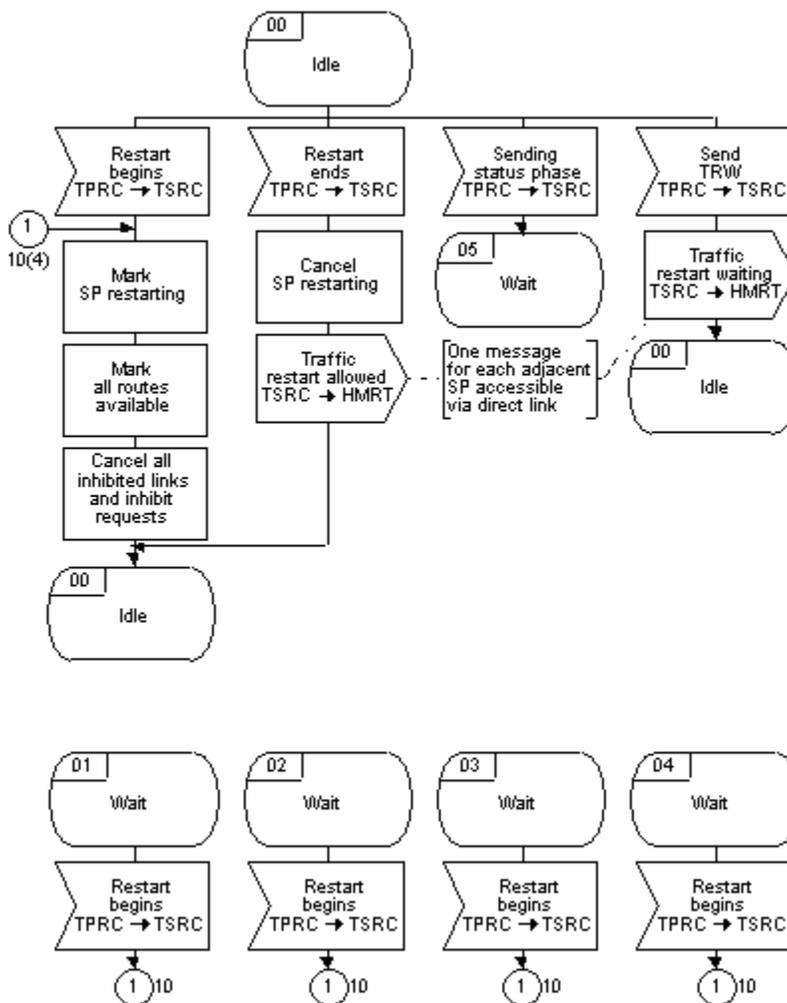
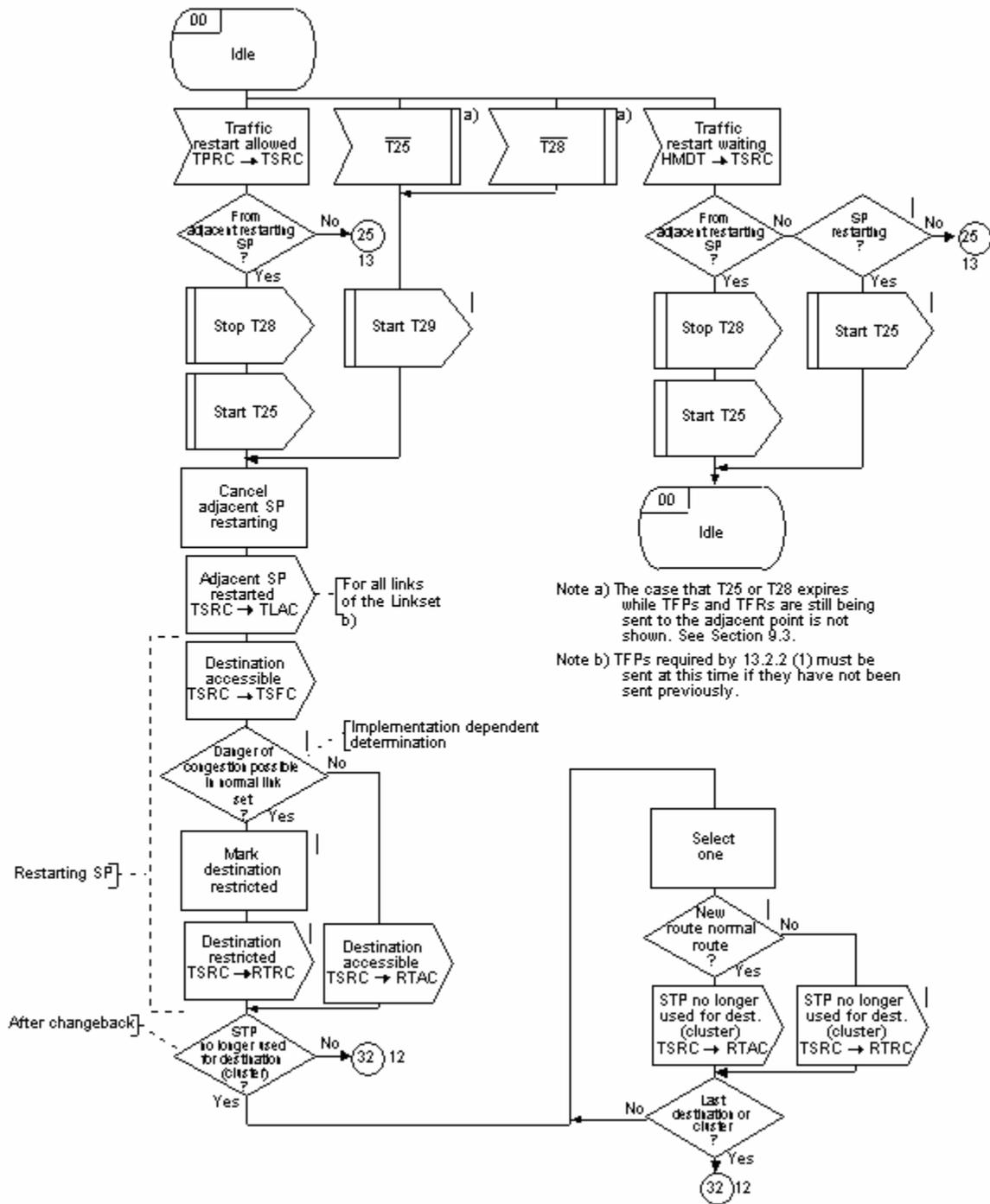


Figure 29/T1.111.4 Signalling Traffic Management - Signalling Routing Control (TSRC) (Sheet 10 of 15)



Note a) The case that T25 or T28 expires while TFPs and TFRs are still being sent to the adjacent point is not shown. See Section 9.3.

Note b) TFPs required by 13.2.2 (1) must be sent at this time if they have not been sent previously.

Figure 29/T1.111.4 Signalling Traffic Management - Signalling Routing Control (TSRC) (Sheet 11 of 15)

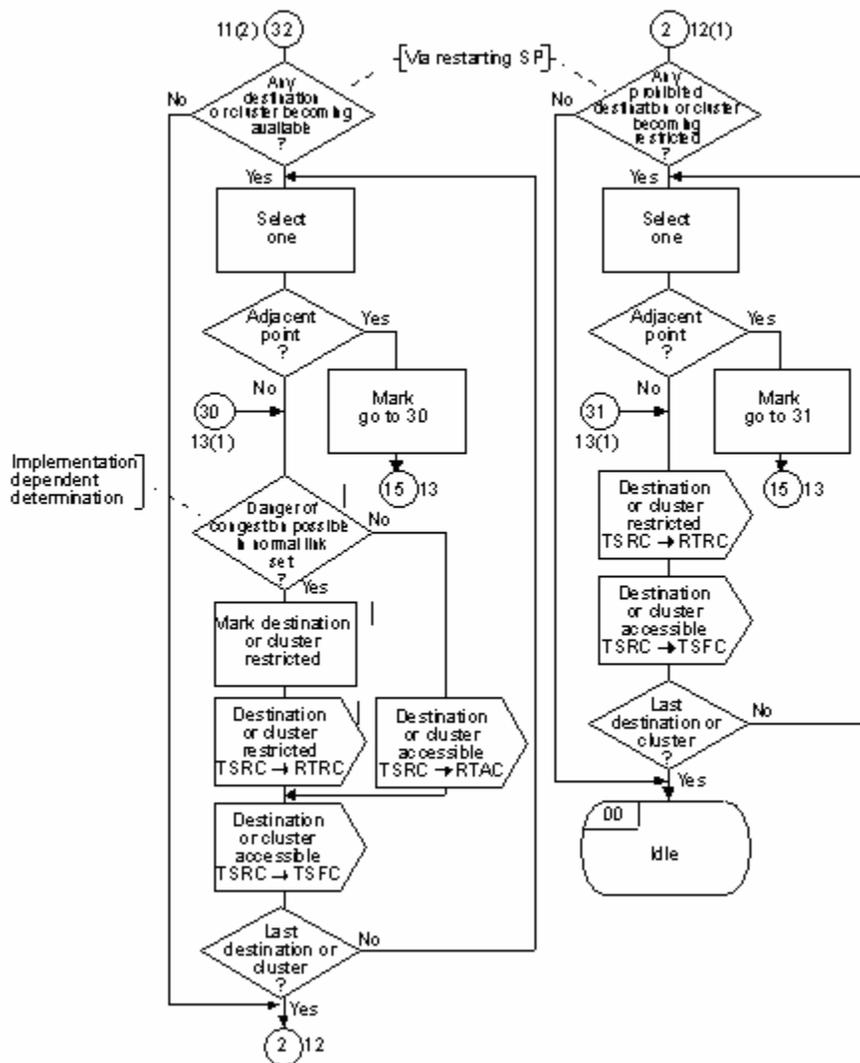


Figure 29/T1.111.4 Signalling Traffic Management - Signalling Routing Control (TSRC) (Sheet 12 of 15)

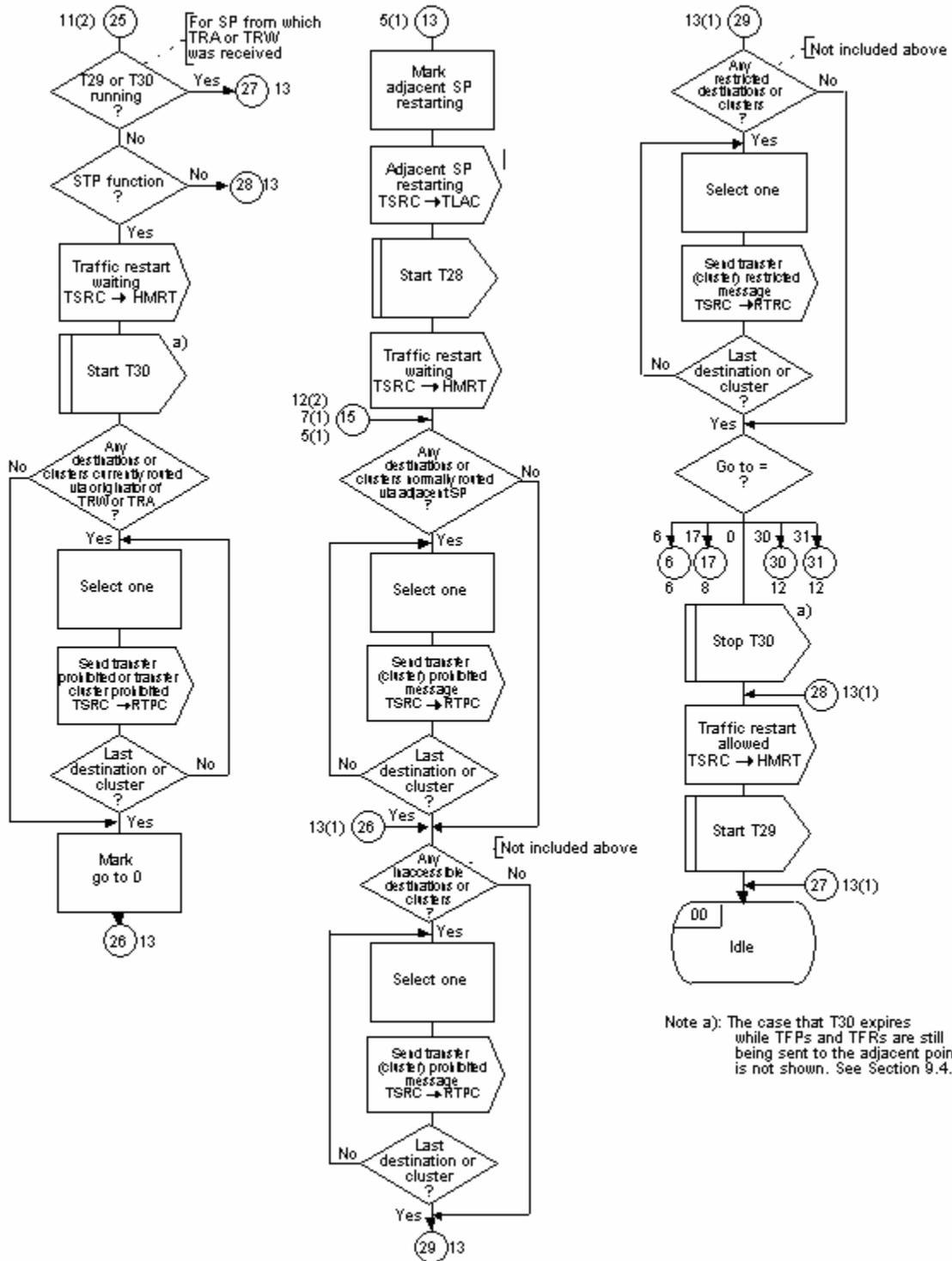


Figure 29/T1.111.4 Signalling Traffic Management - Signalling Routing Control (TSRC) (Sheet 13 of 15)

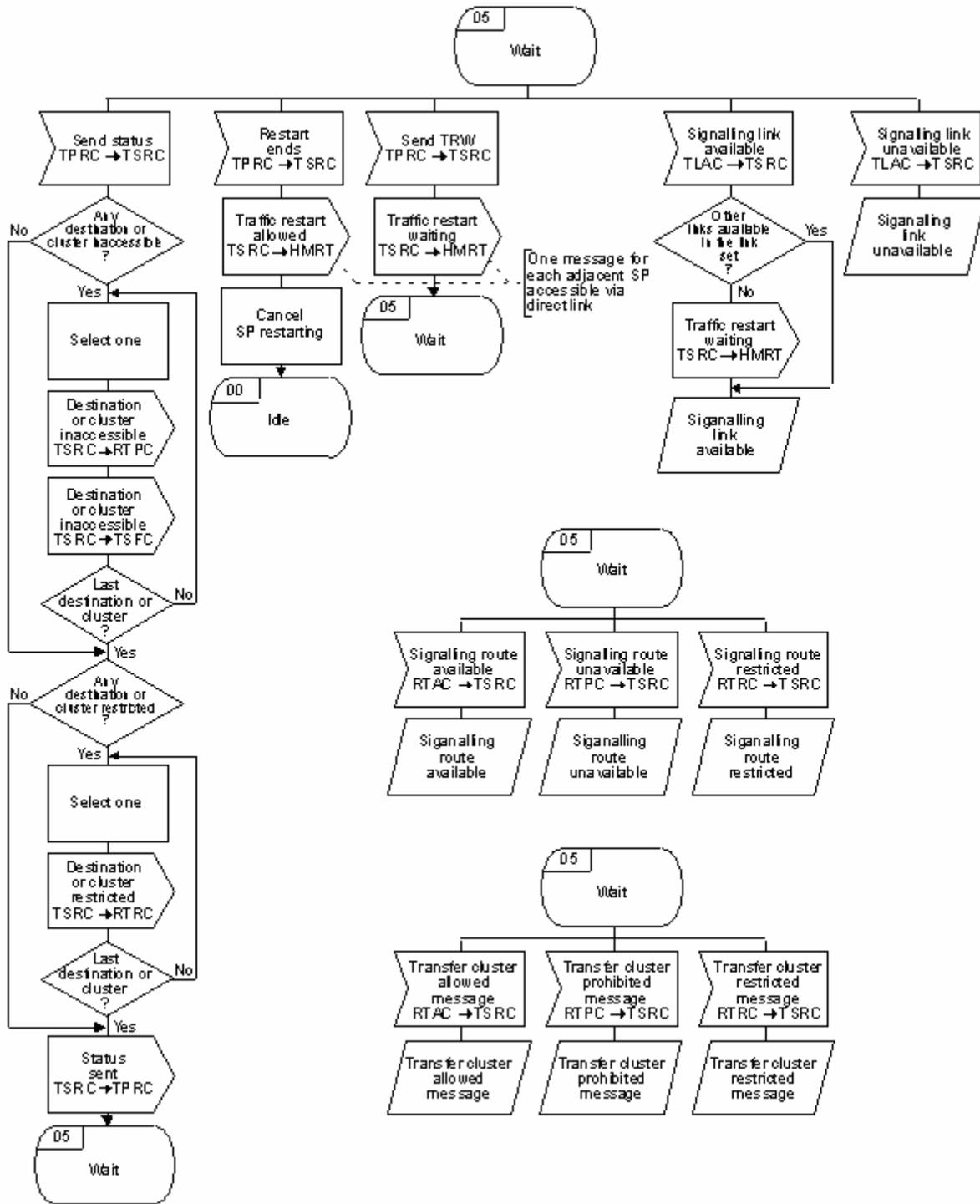


Figure 29/T1.111.4

Signalling Traffic Management - Signalling Routing Control (TSRC)
(Sheet 14 of 15)

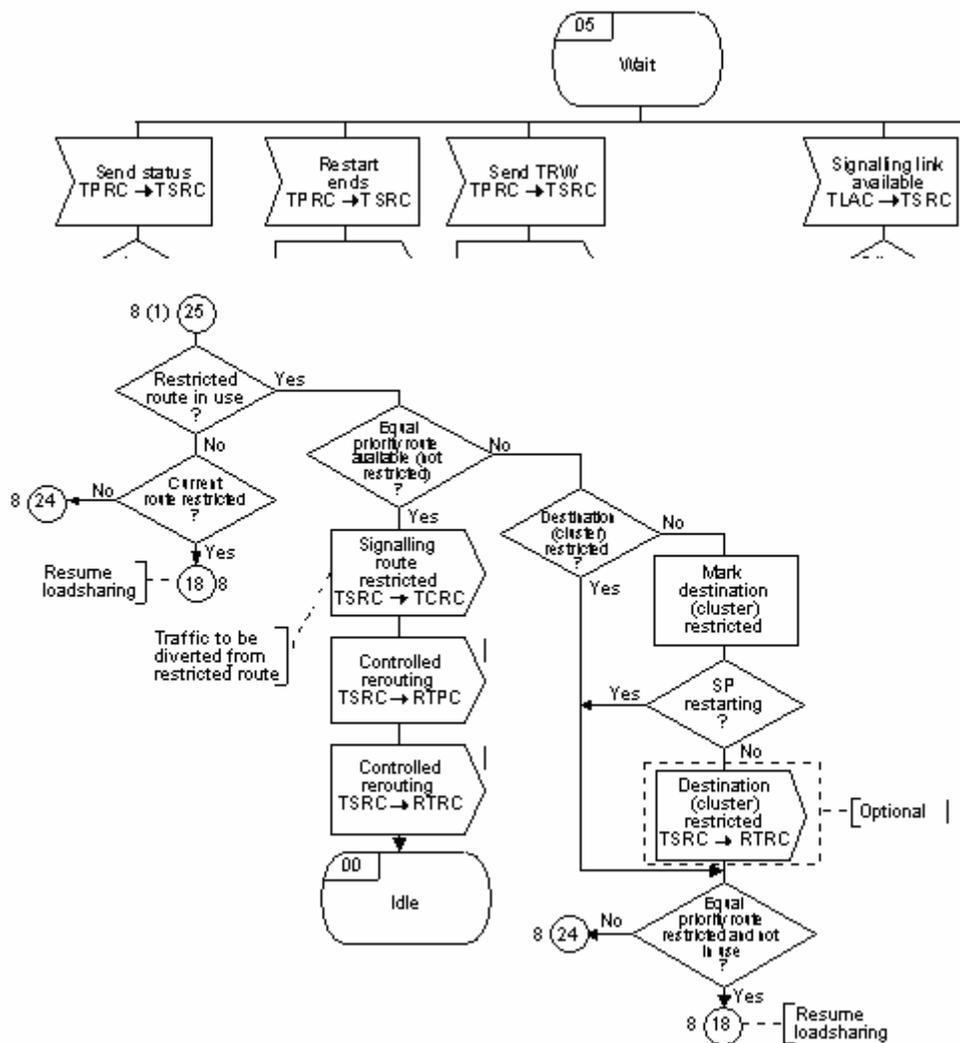


Figure 29/T1.111.4 Signalling Traffic Management - Signalling Routing Control (TSRC) (Sheet 15 of 15)

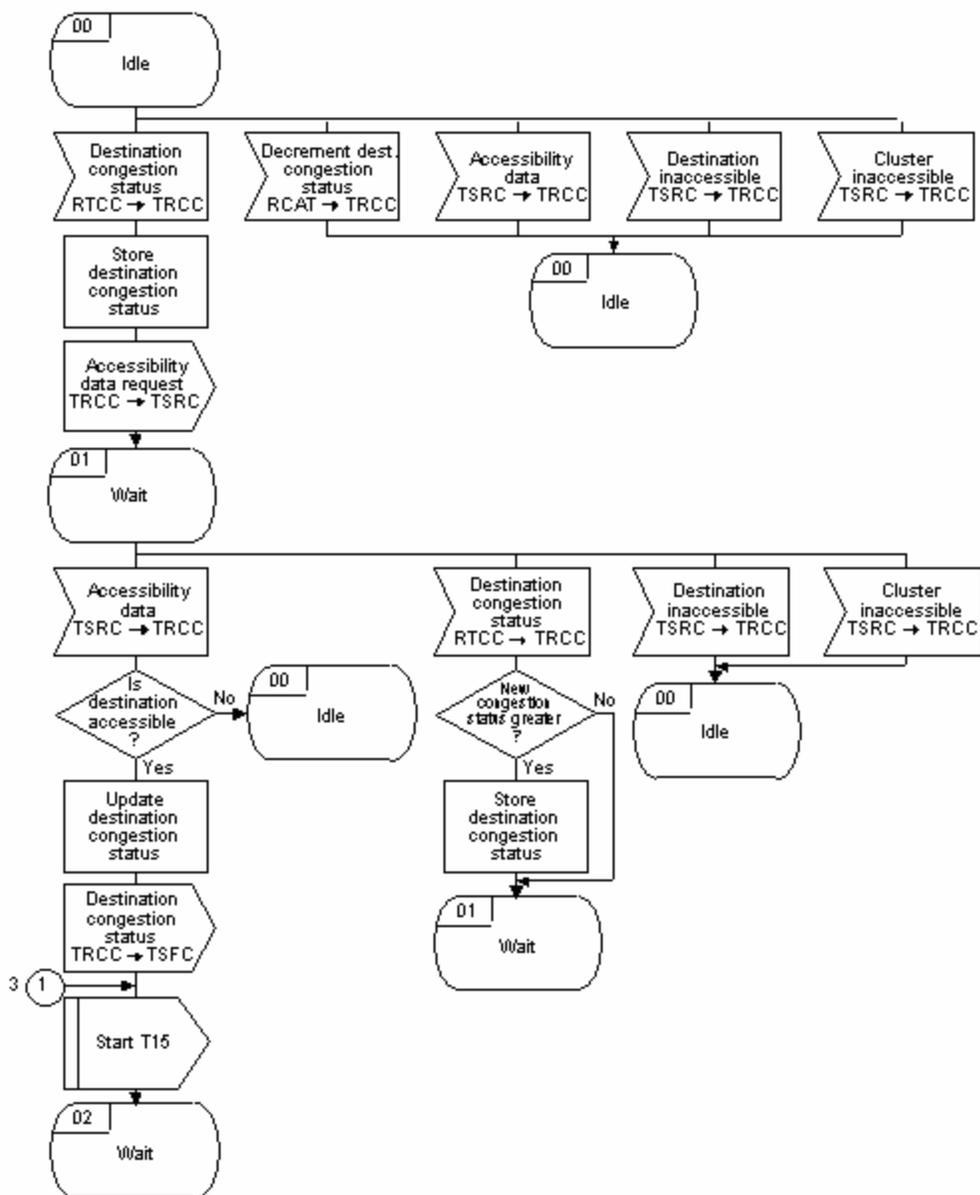


Figure 29A/T1.111.4 Signalling Traffic Management - Signalling Route Congestion Control (TRCC) (Sheet 1 of 3)

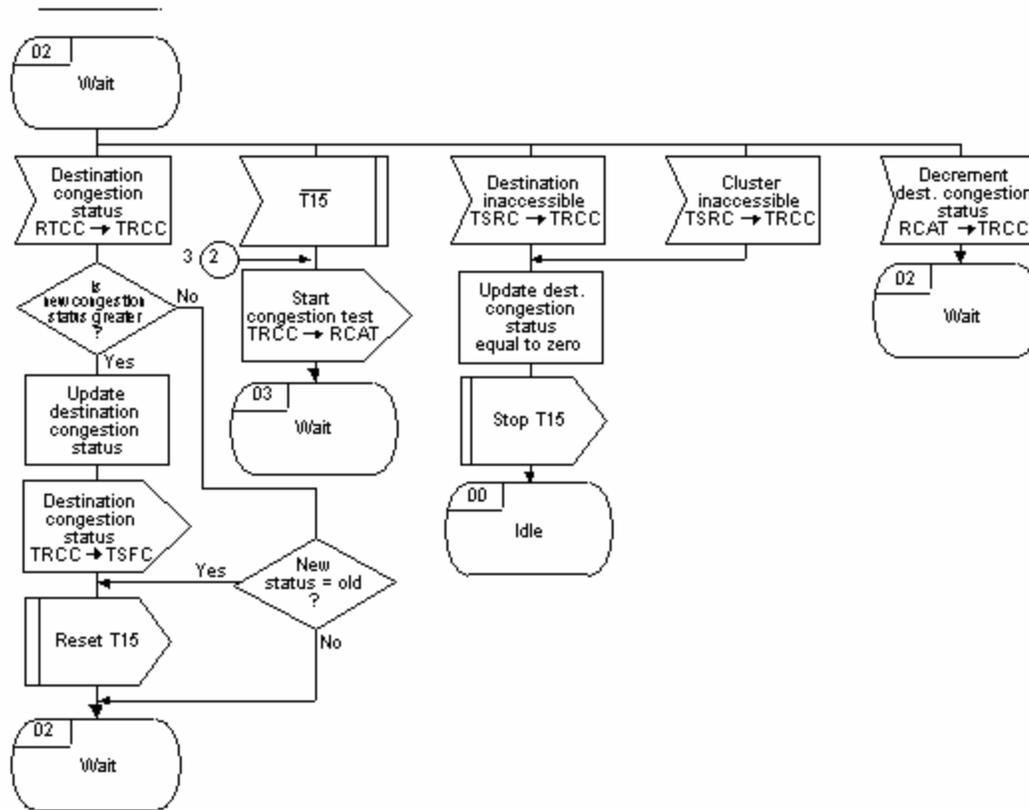


Figure 29A/T1.111.4 Signalling Traffic Management - Signalling Route Congestion Control (TRCC) (Sheet 2 of 3)

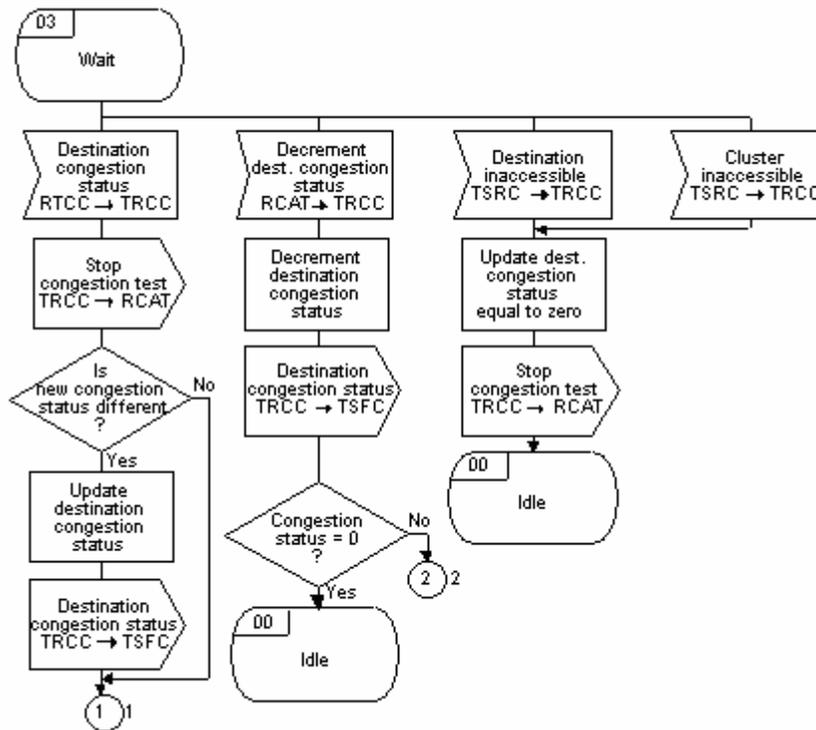


Figure 29A/T1.111.4 Signalling Traffic Management - Signalling Route Congestion Control (TRCC) (Sheet 3 of 3)

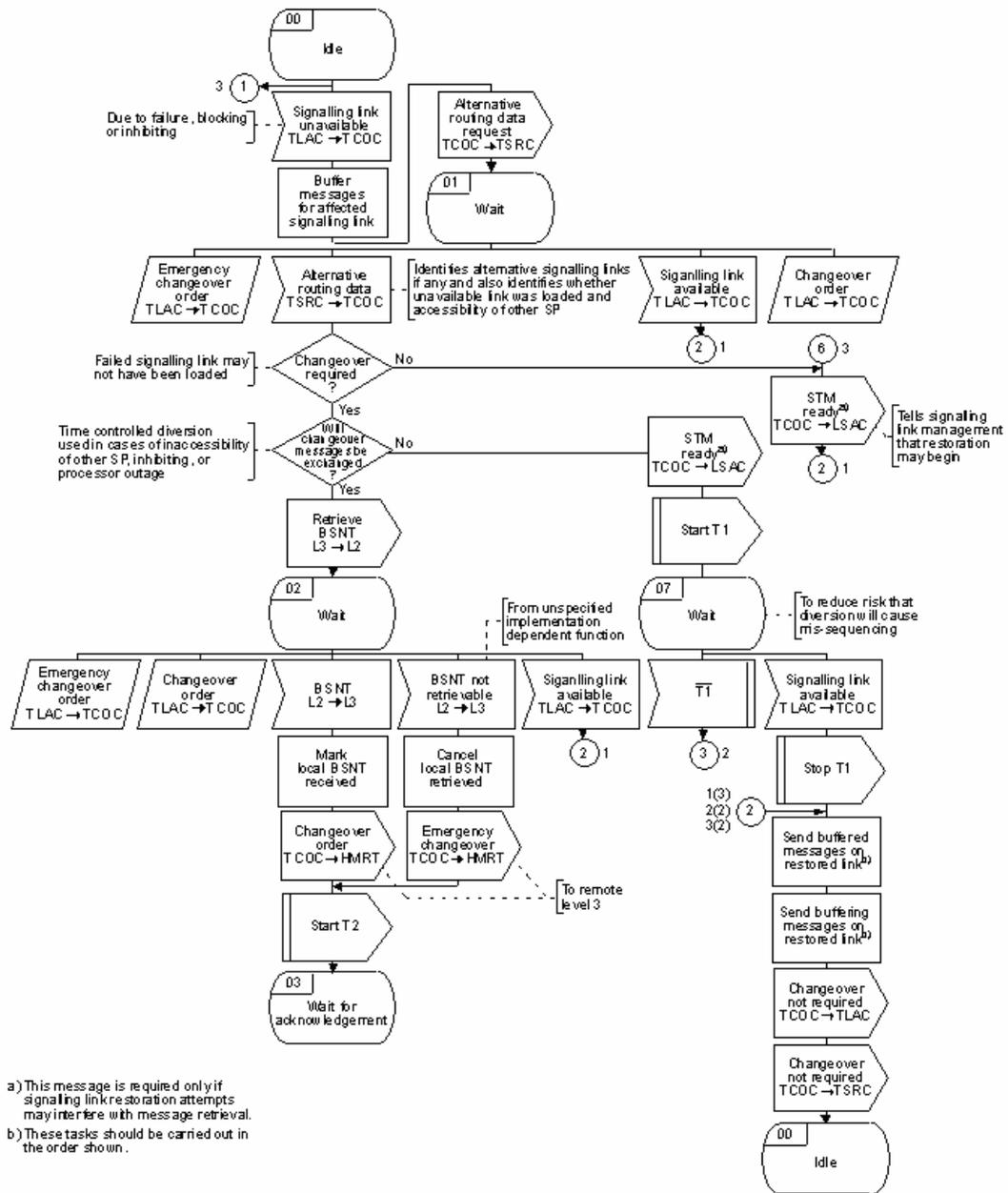


Figure 30/T1.111.4 Signalling Traffic Management - Changeover Control (TCOC) (Sheet 1 of 4)

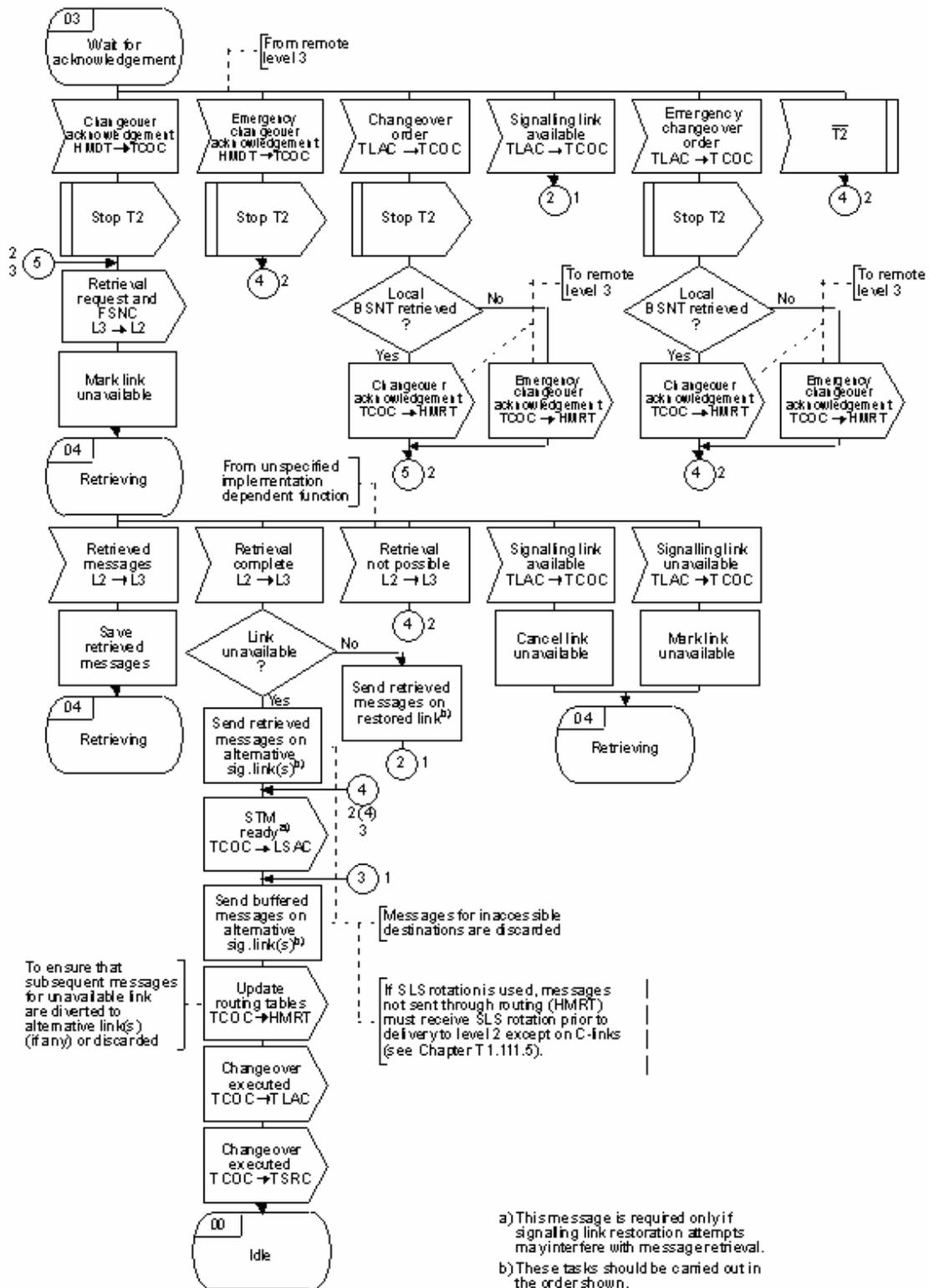


Figure 30/T1.111.4 Signalling Traffic Management - Changeover Control (TCOC) (Sheet 2 of 4)

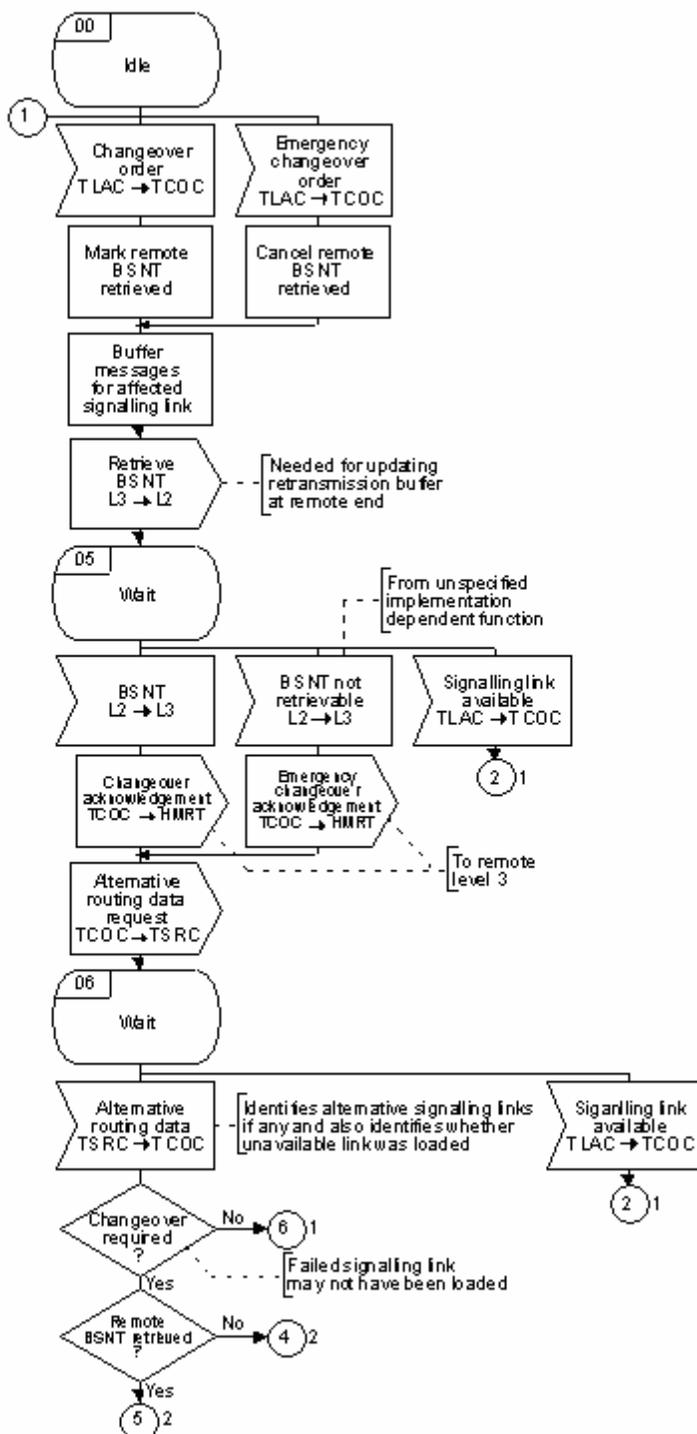


Figure 30/T1.111.4 Signalling Traffic Management - Changeover Control (TCOC)
(Sheet 3 of 4)

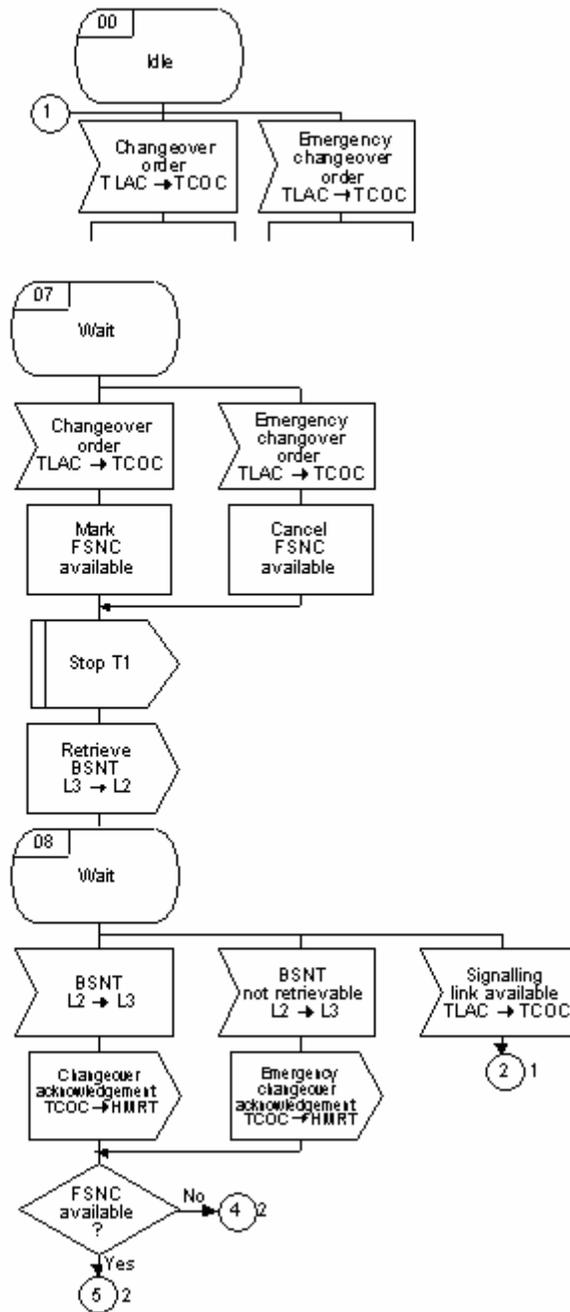


Figure 30/T1.111.4 Signalling Traffic Management - Changeover Control (TCOC) (Sheet 4 of 4)

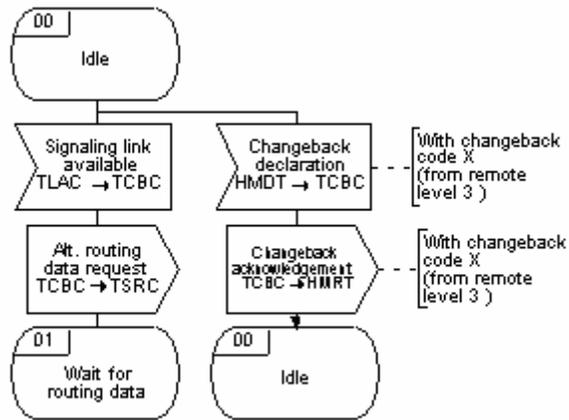


Figure 31/T1.111.4 Signalling Traffic Management - Changeback Control (TCBC) (Sheet 1 of 2)

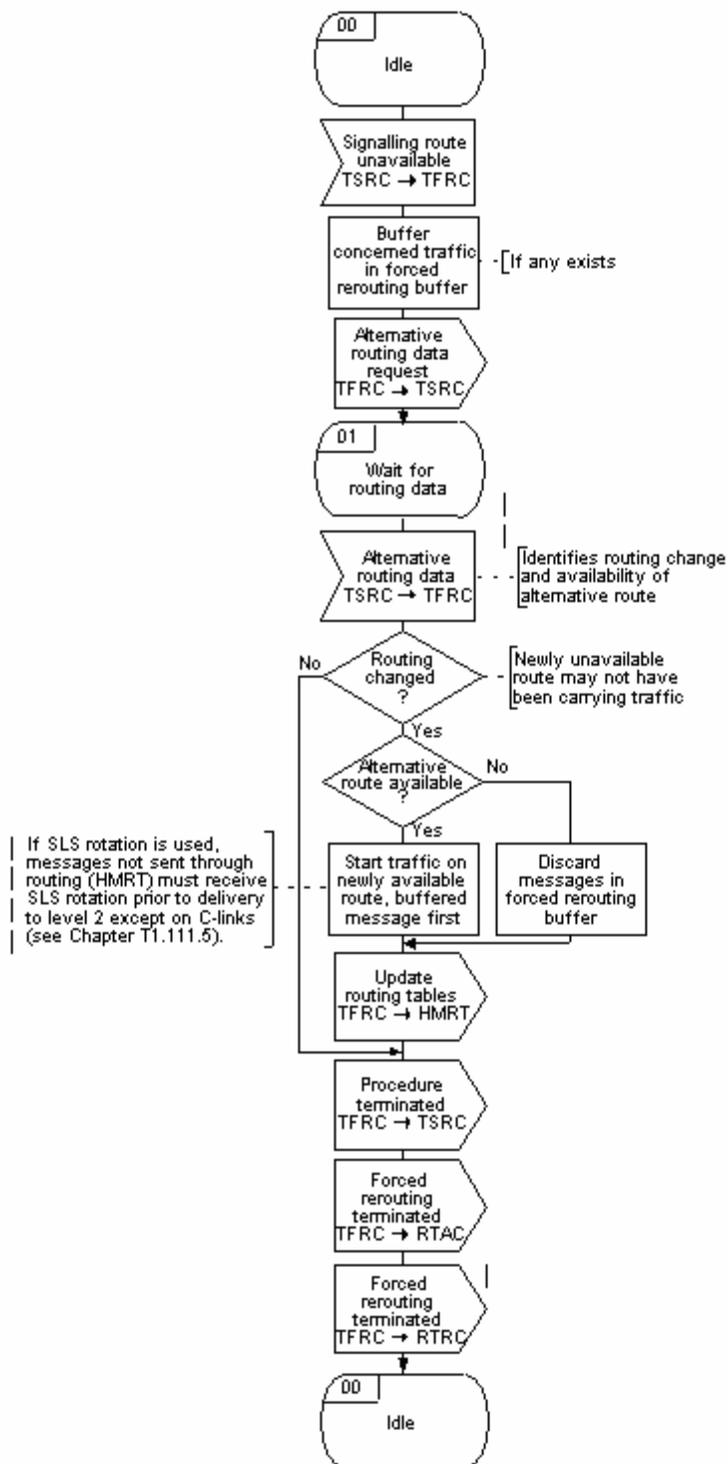


Figure 32/T1.111.4 Signalling Traffic Management - Forced Rerouting Control (TFRC)

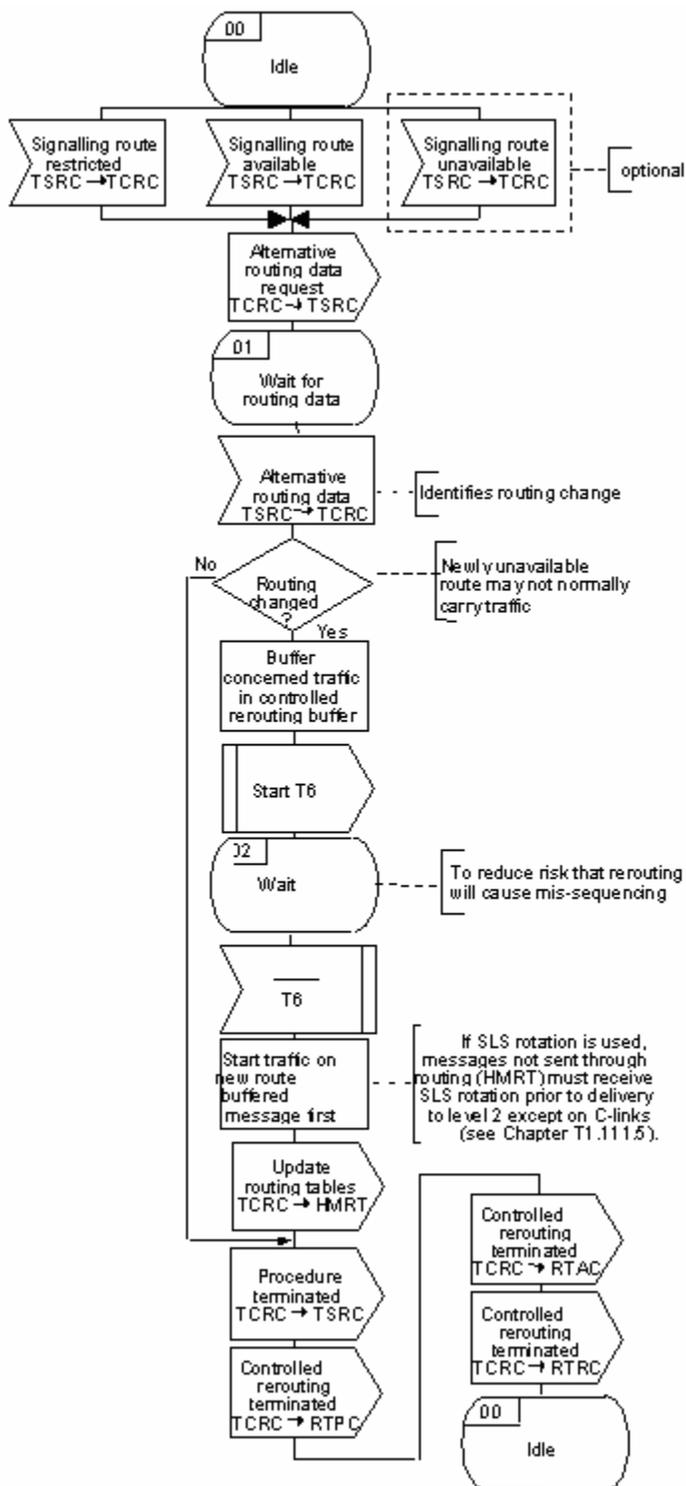


Figure 33/T1.111.4 Signalling Traffic Management - Controlled Rerouting Control (TCRC)

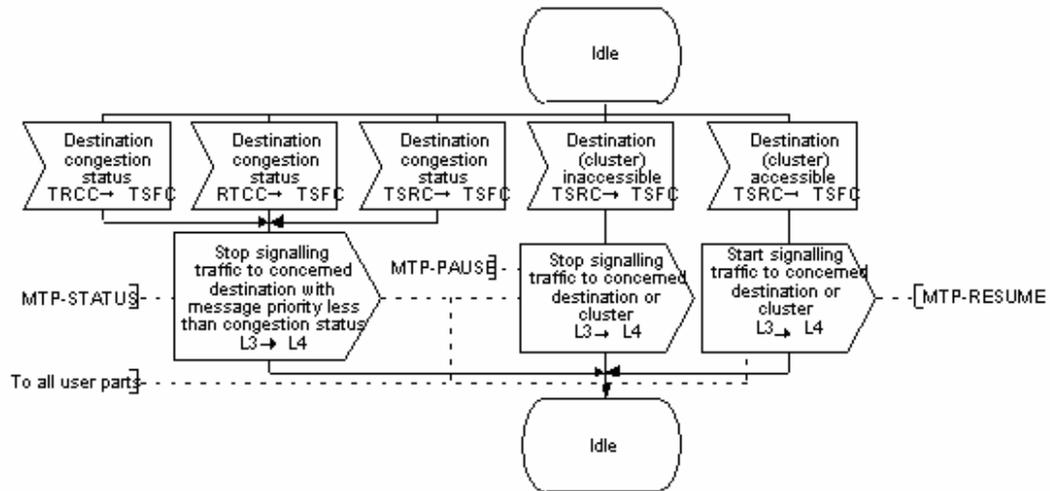


Figure 34/T1.111.4 Signalling Traffic Management - Signalling Traffic Flow Control (TSFC) (Sheet 1 of 2)

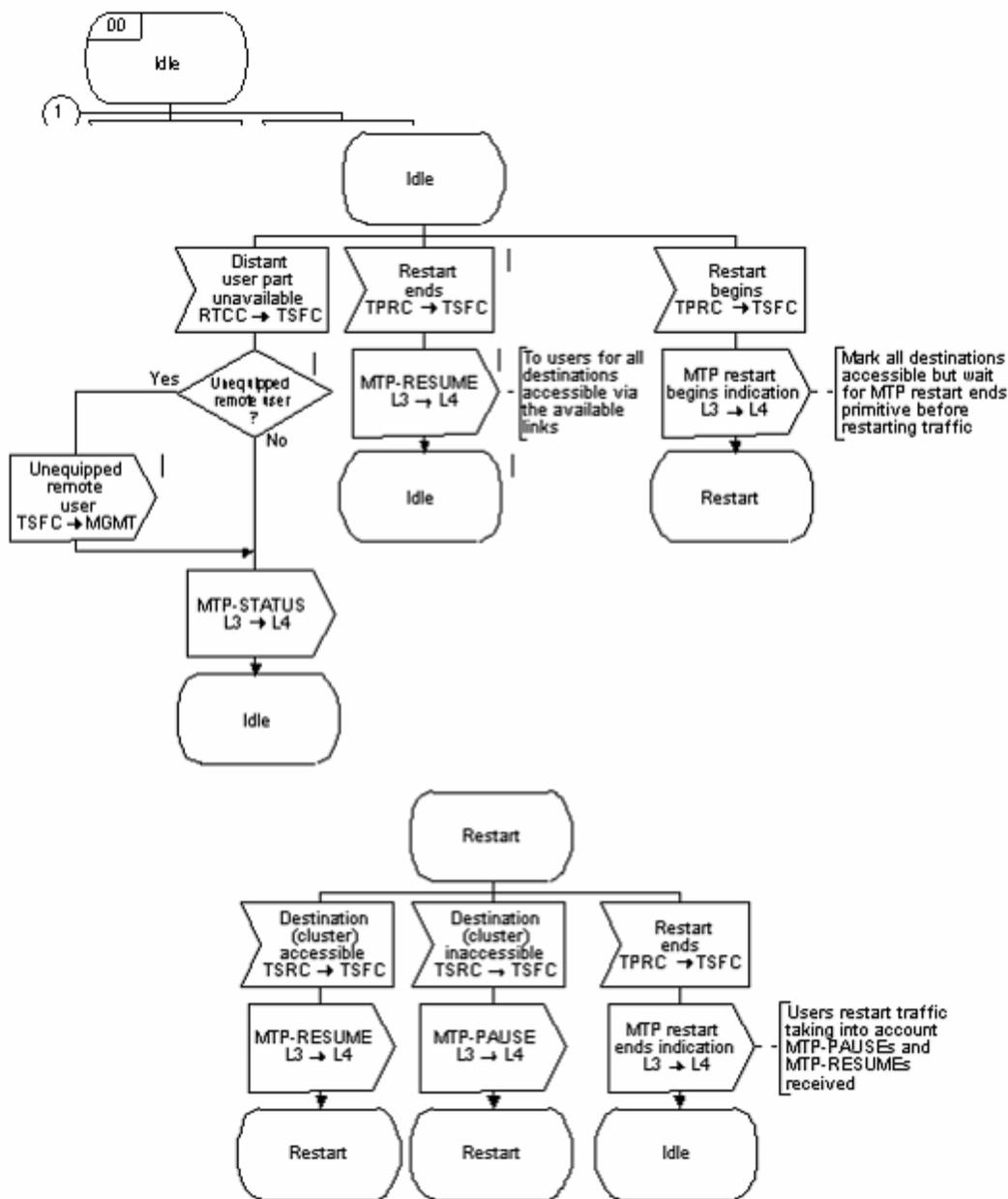


Figure 34/T1.111.4 Signalling Traffic Management - Signalling Traffic Flow Control (TSFC) (Sheet 2 of 2)

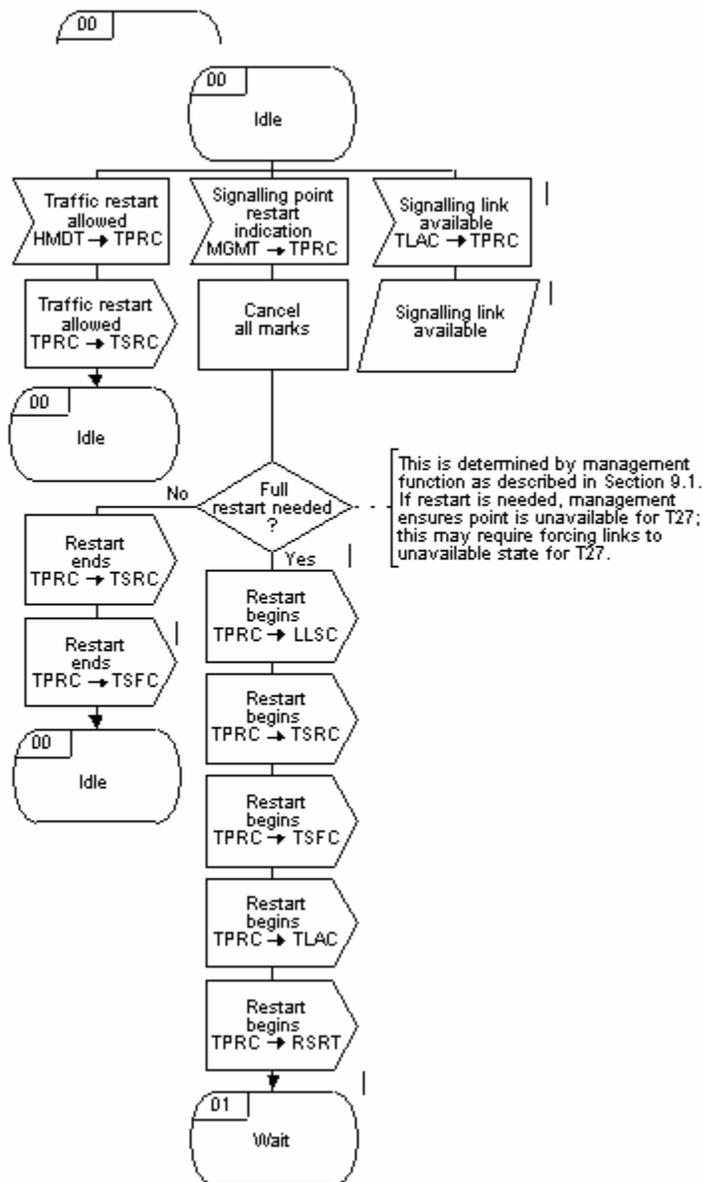


Figure 34A/T1.111.4 Signalling Traffic Management - MTP Restart Control (TPRC)
(Sheet 1 of 4)

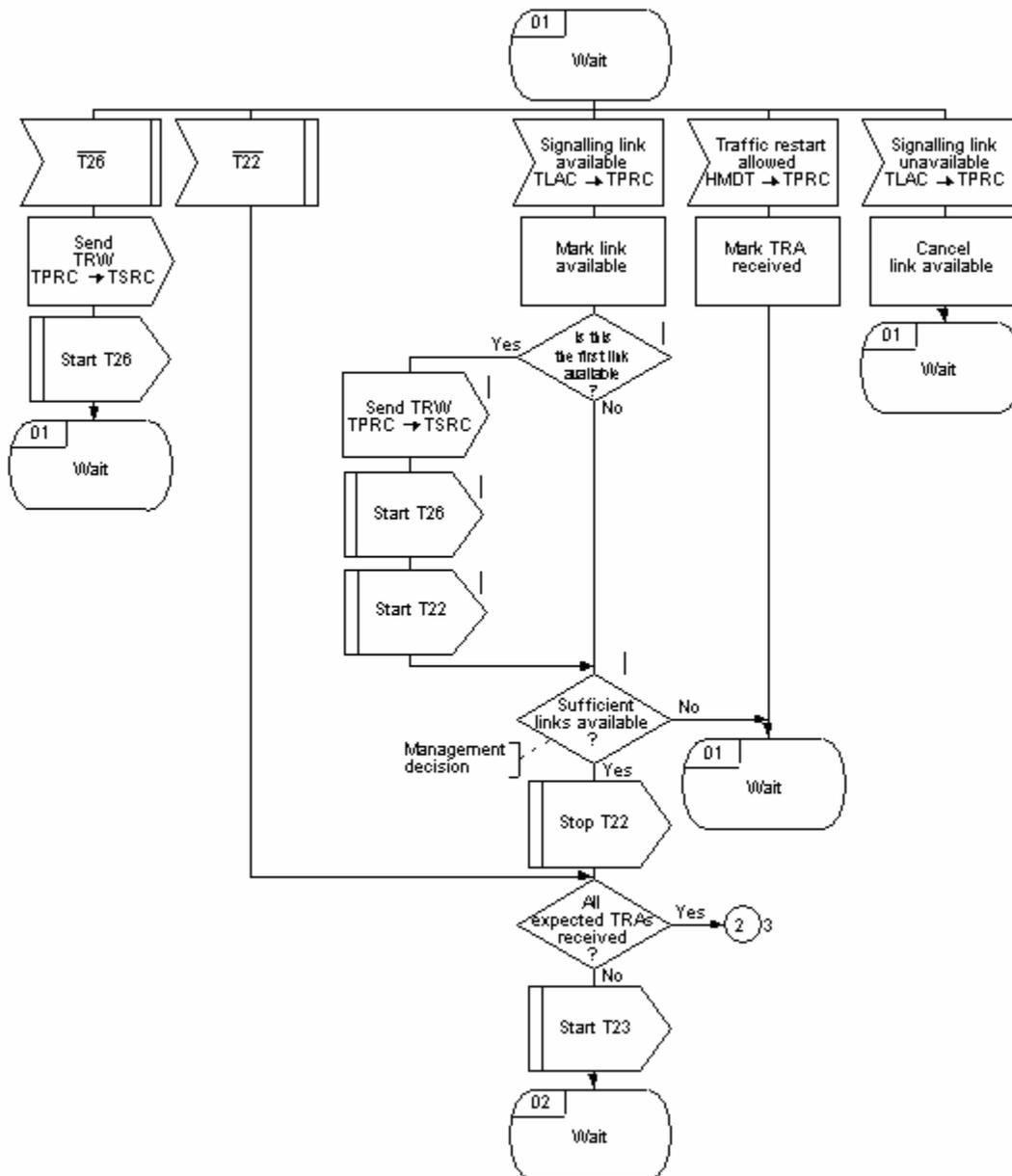


Figure 34A/T1.111.4 Signalling Traffic Management - MTP Restart Control (TPRC)
(Sheet 2 of 4)

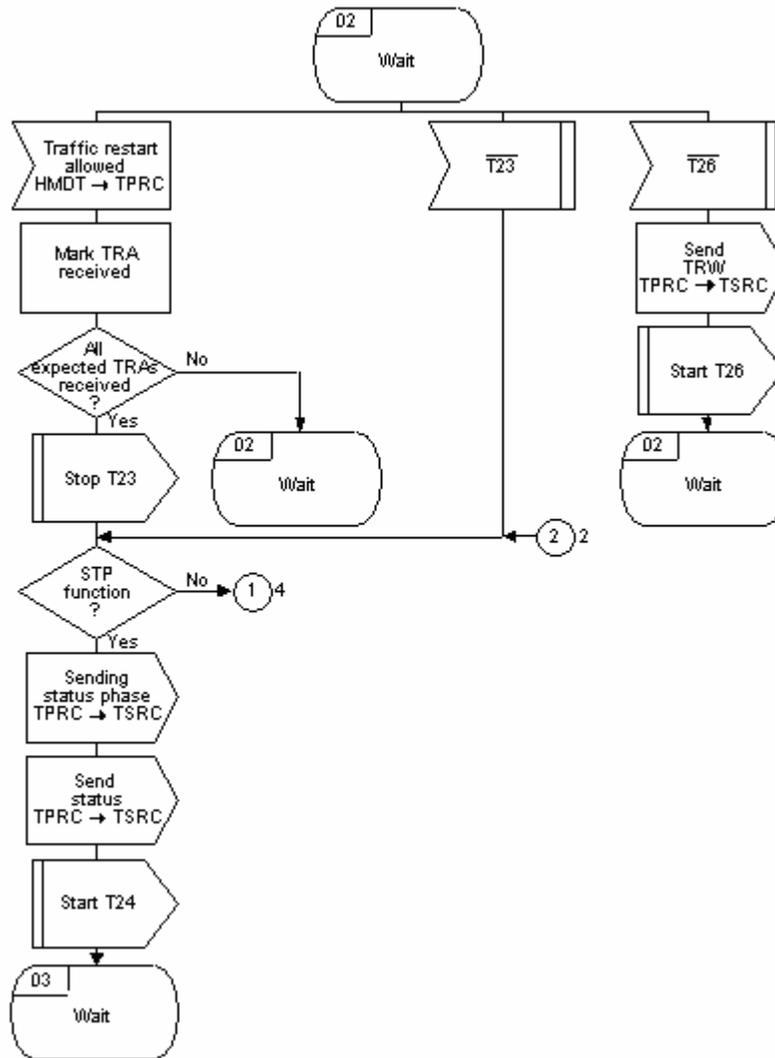


Figure 34A/T1.111.4 Signalling Traffic Management - MTP Restart Control (TPRC)
(Sheet 3 of 4)

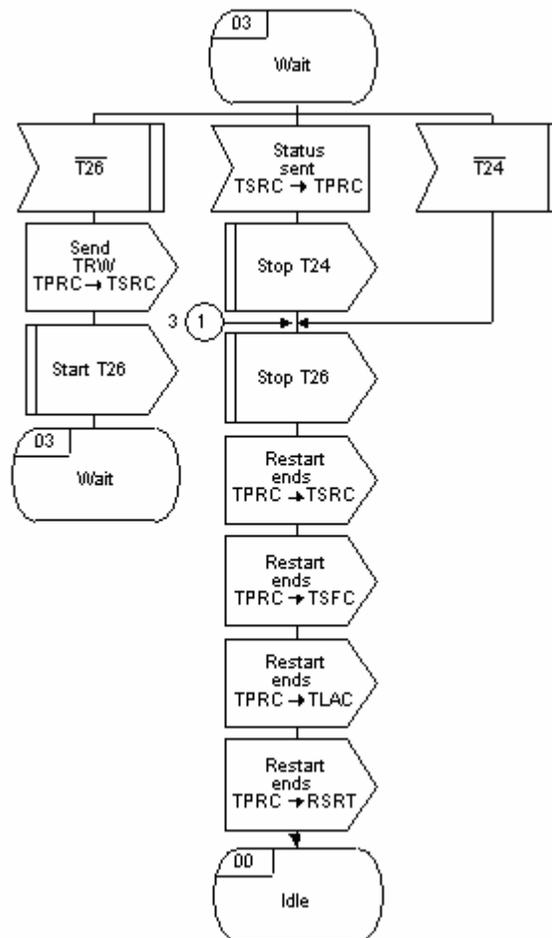


Figure 34A/T1.111.4 Signalling Traffic Management - MTP Restart Control (TPRC)
(Sheet 4 of 4)

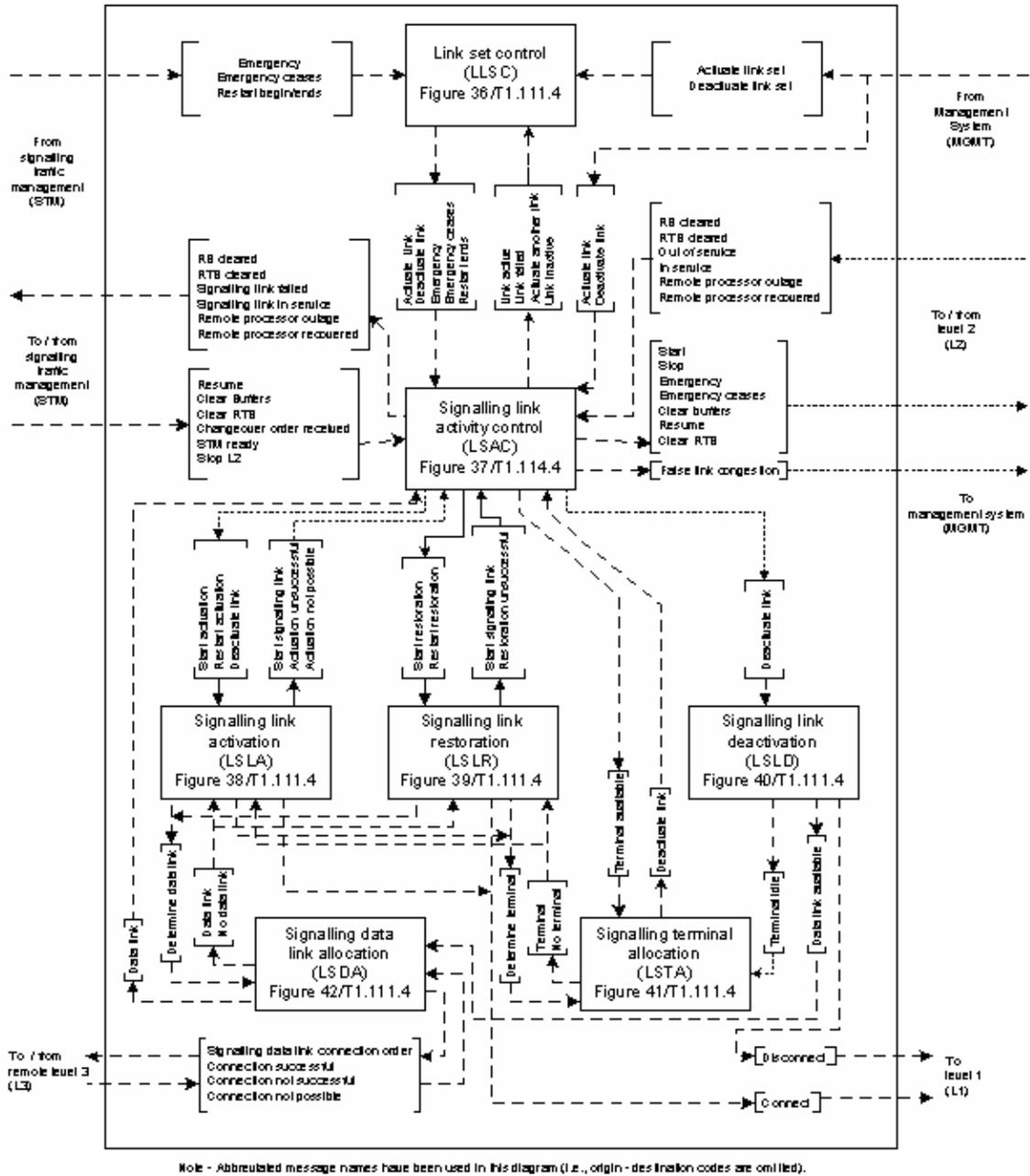
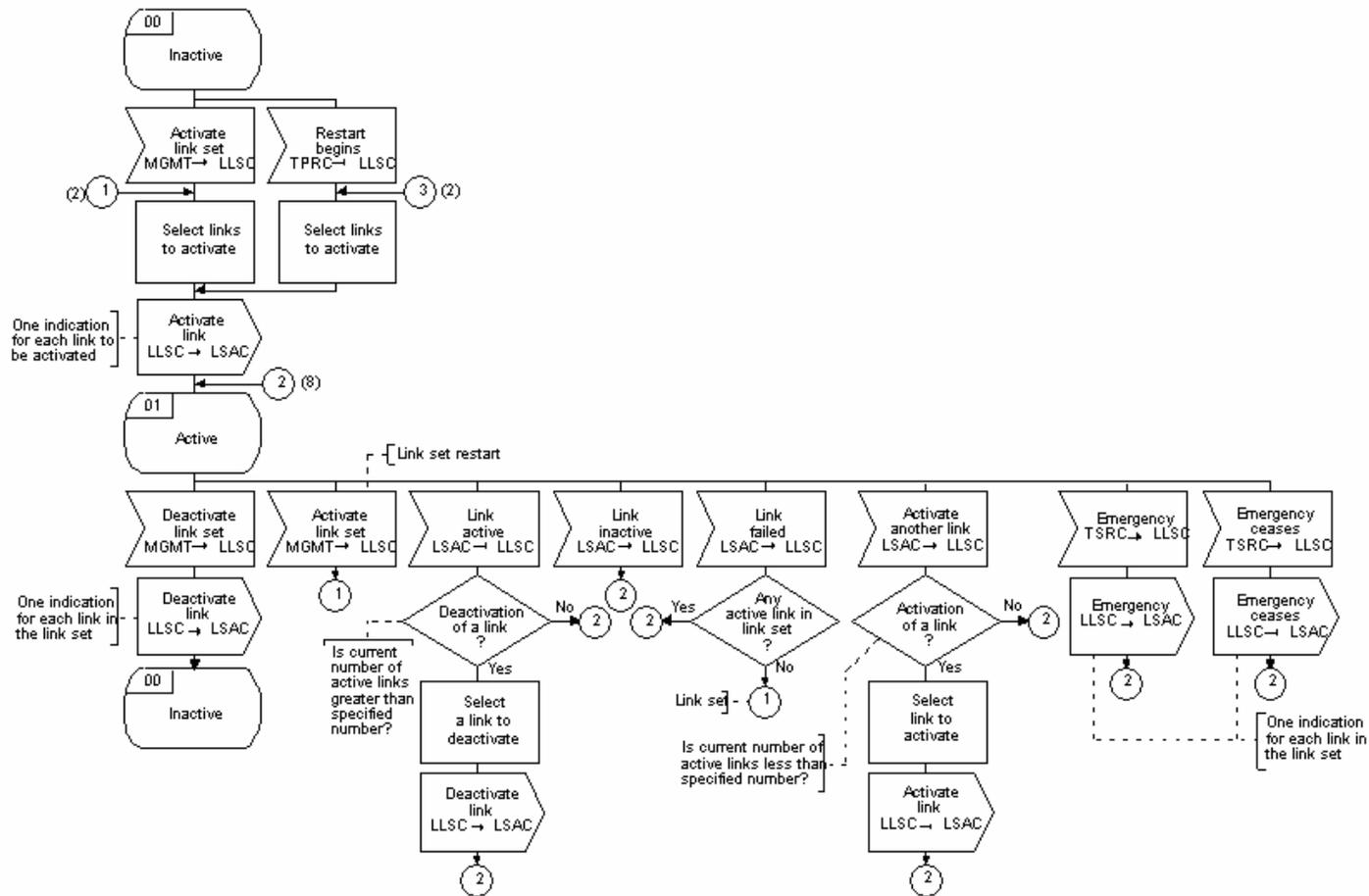


Figure 35/T1.111.4 Signalling Link Management (SLM) - Functional Block Interactions



Note 1: It is assumed that this function has access to information regarding the number and the status of links in a link set.
 Note 2: It should be ensured that signalling link activation and deactivation attempts are not made simultaneously for the same signalling link.

Figure 36/T1.111.4 Signalling Link Management - Link Set Control (LLSC) (Sheet 1 of 2)

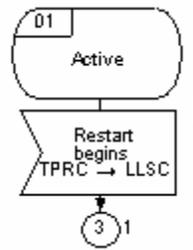


Figure 36/T1.111.4 Signalling Link Management - Link Set Control (LLSC) (Sheet 2 of 2)

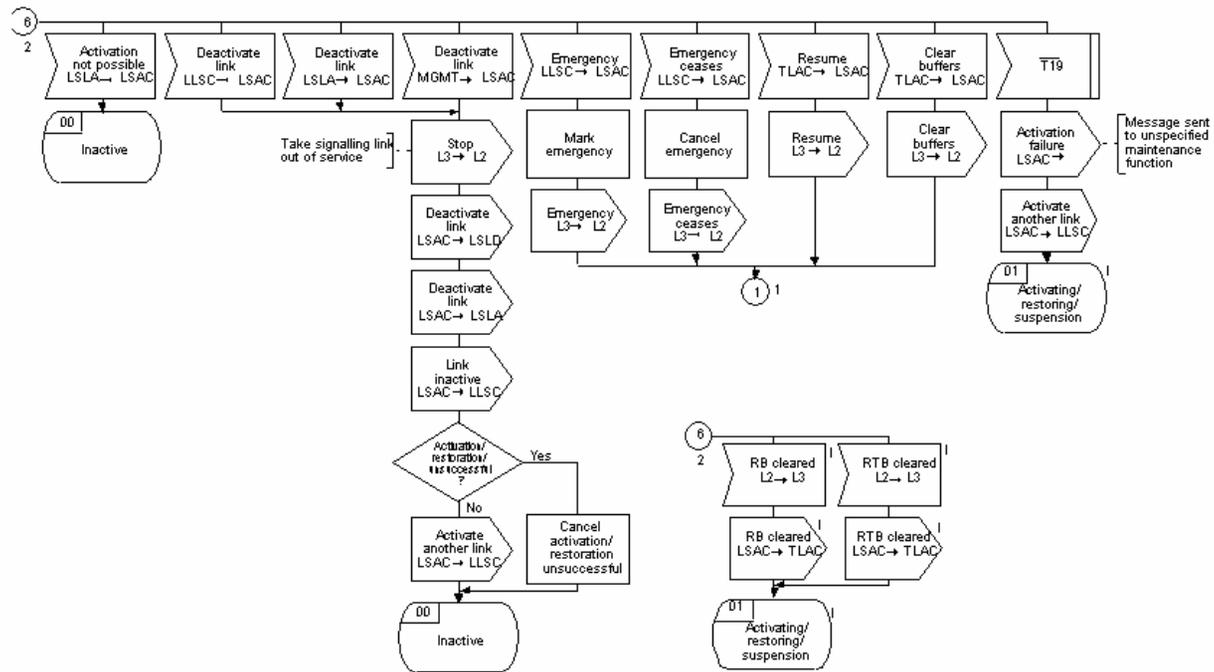


Figure 37/T1.111.4 Signalling Link Management - Signalling Link Activity Control (LSAC) (Sheet 2 of 4)

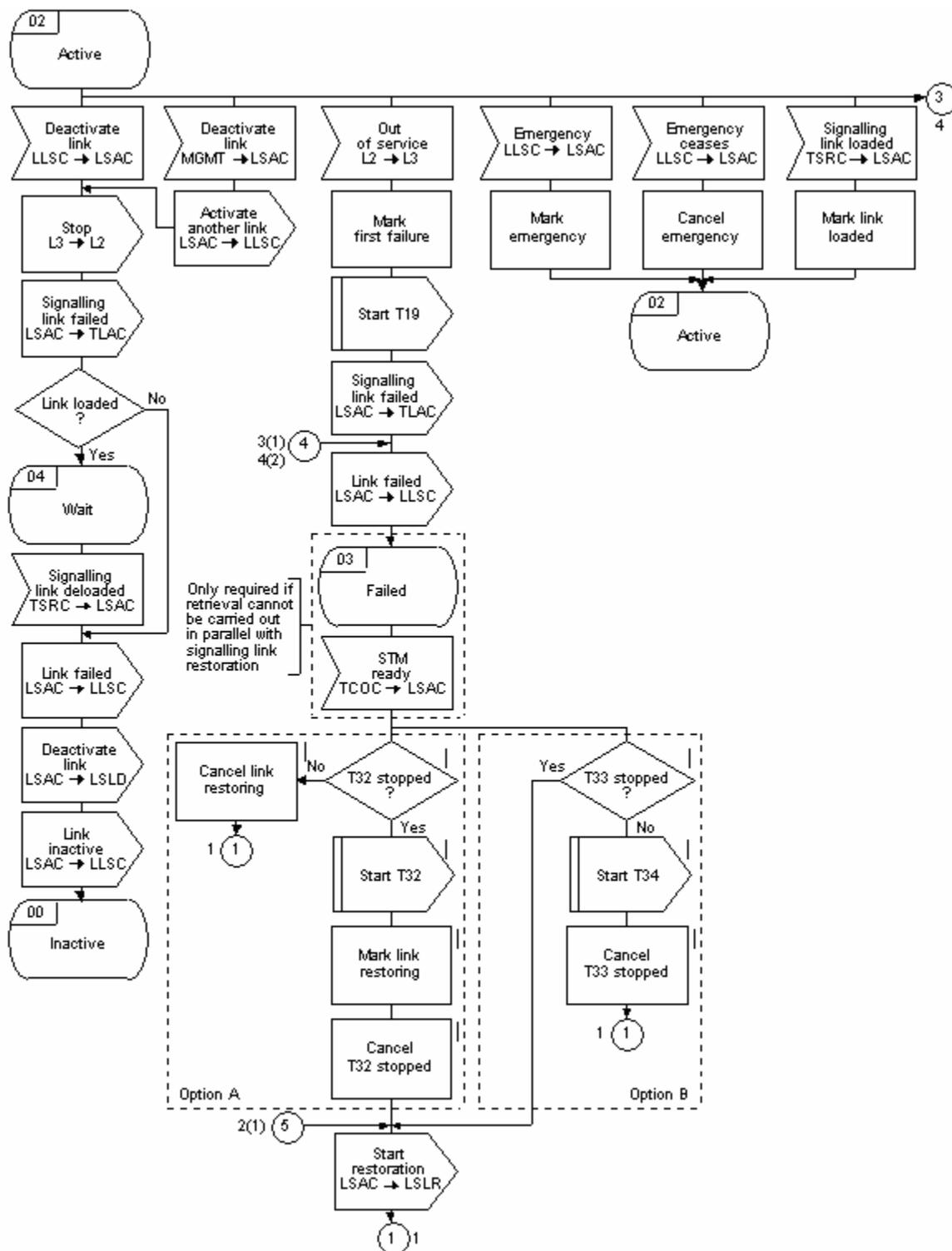


Figure 37/T1.111.4 Signalling Link Management - Signalling Link Activity Control (LSAC) (Sheet 3 of 4)

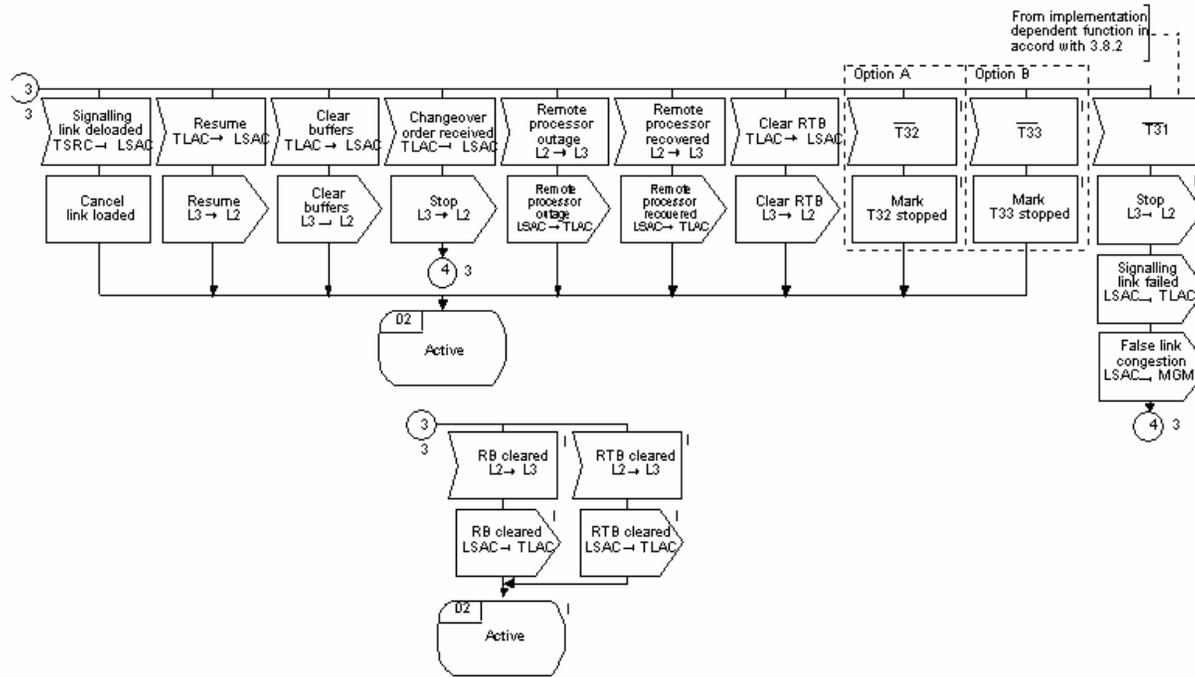


Figure 37/T1.111.4 Signalling Link Management - Signalling Link Activity Control (LSAC) (Sheet 4 of 4)

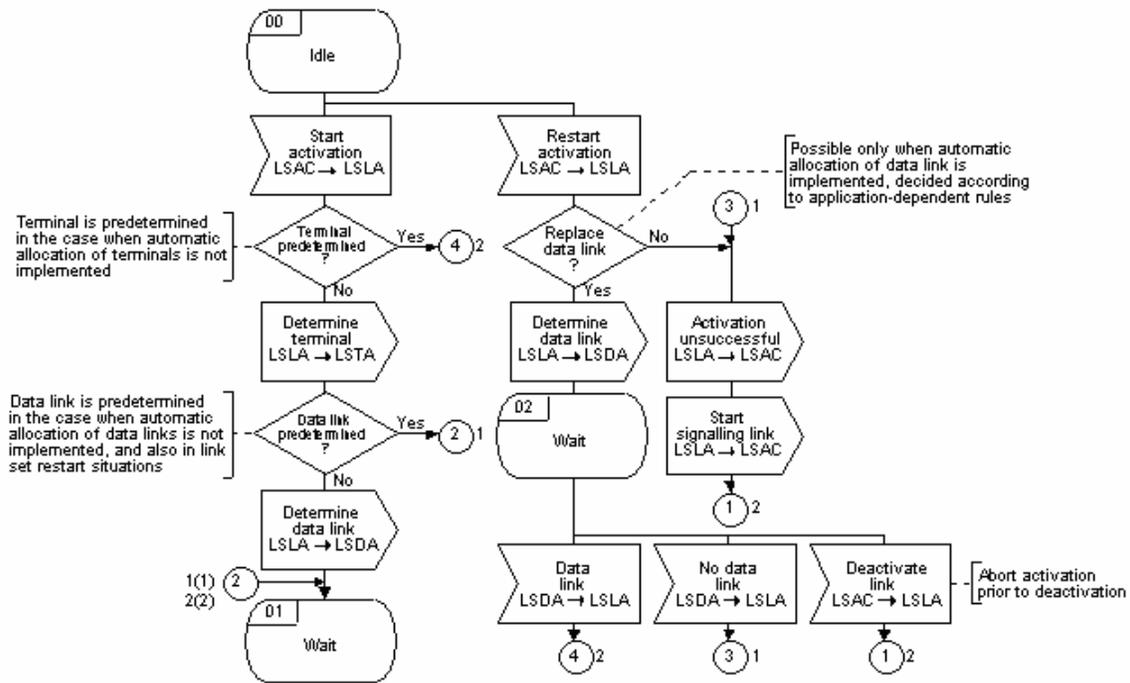


Figure 38/T1.111.4 Signalling Link Management - Signalling Link Activation (LSLA) (Sheet 1 of 2)

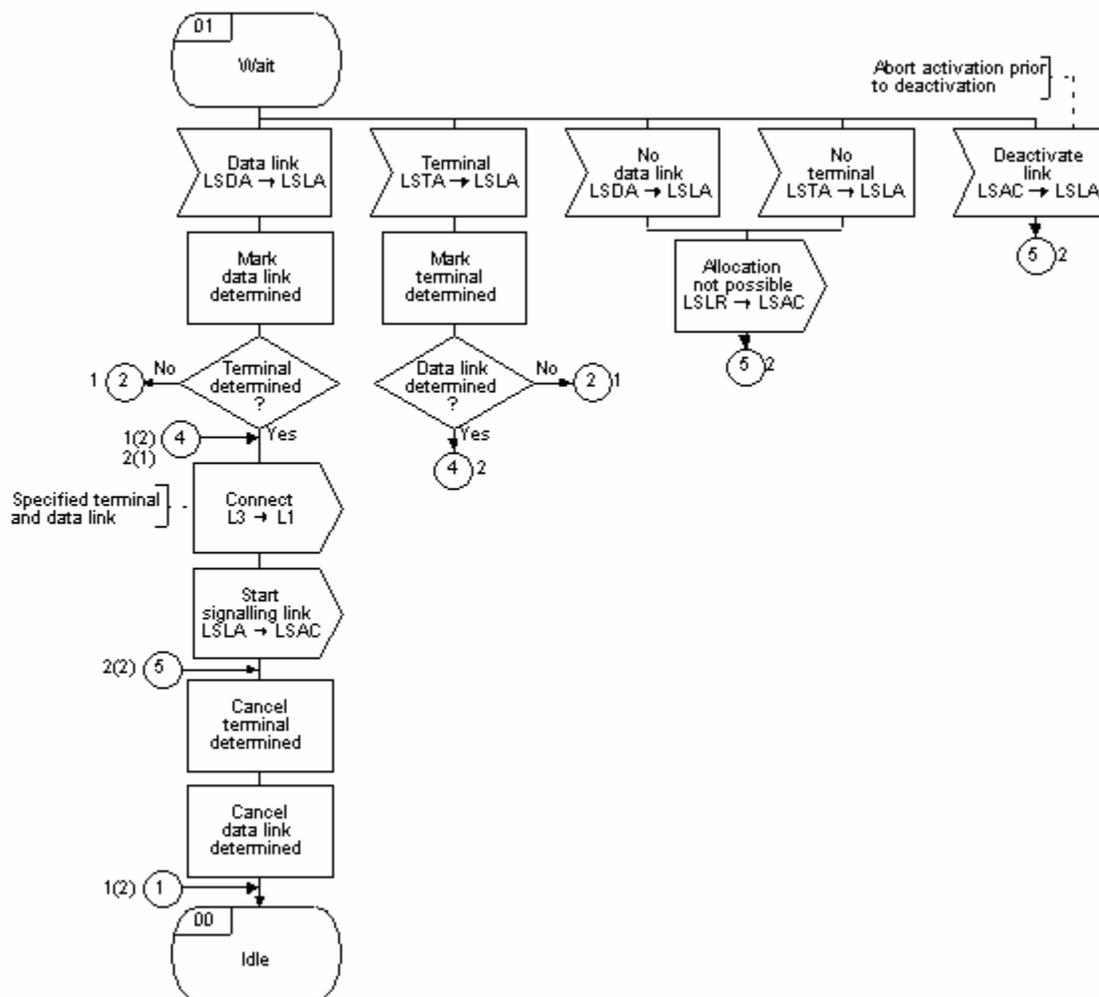


Figure 38/T1.111.4 Signalling Link Management - Signalling Link Activation (LSLA)
(Sheet 2 of 2)

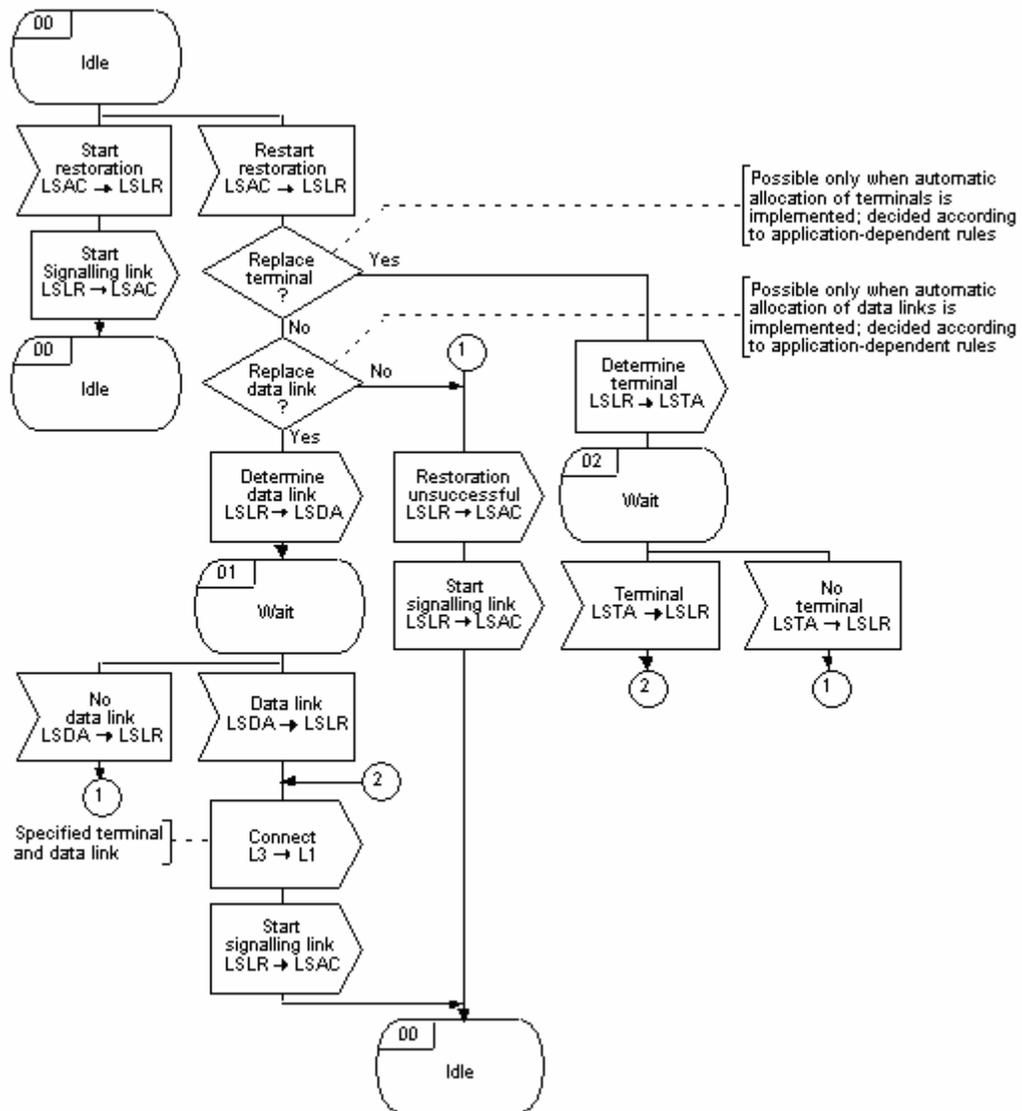


Figure 39/T1.111.4 Signalling Link Management - Signalling Link Restoration (LSLR)

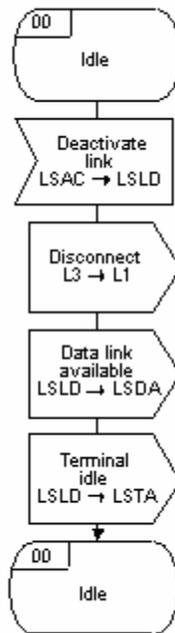


Figure 40/T1.111.4 Signalling Link Management - Signalling Link Deactivation (LSD)

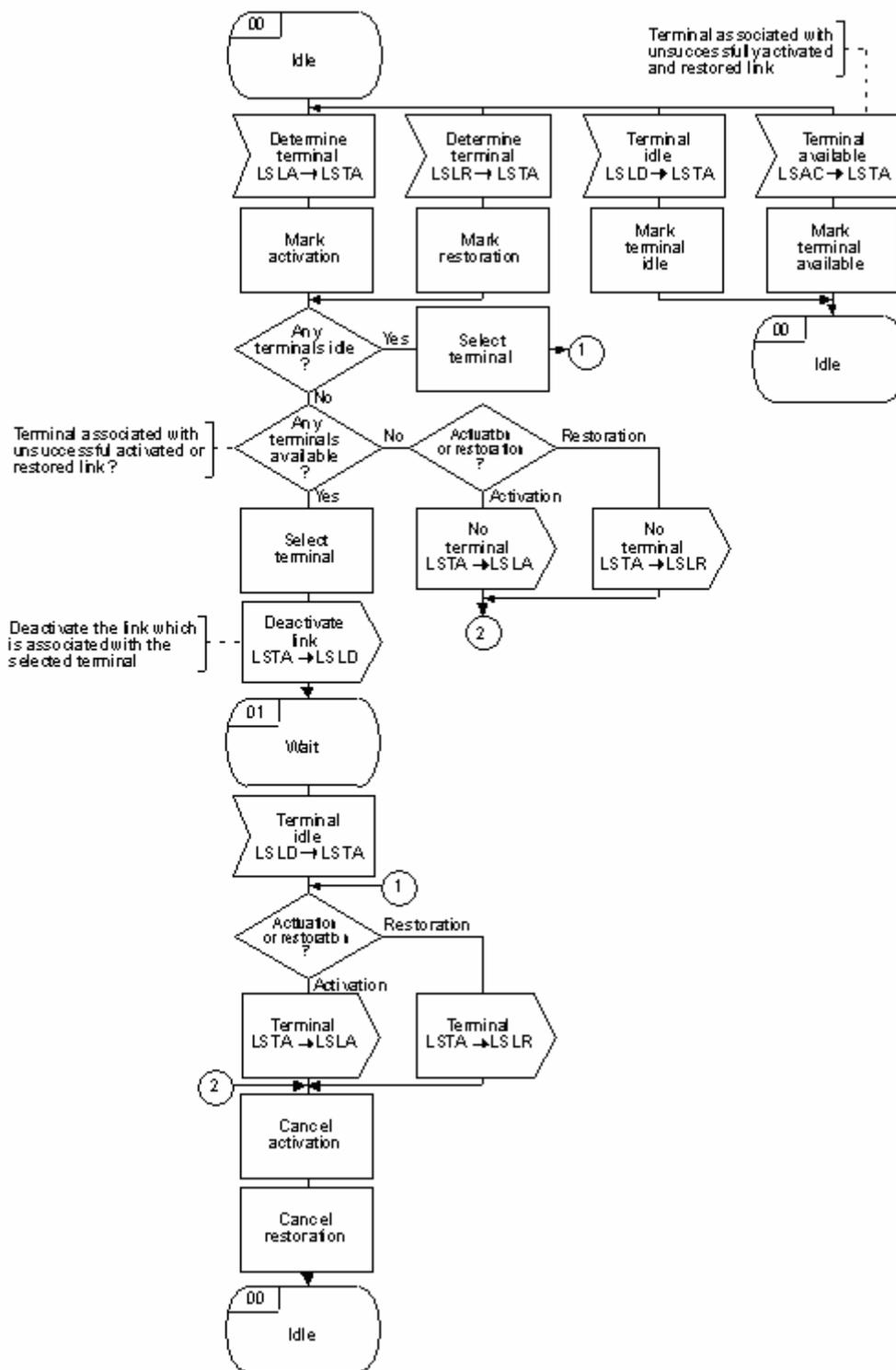


Figure 41/T1.111.4 Signalling Link Management - Signalling Terminal Allocation (LSTA)

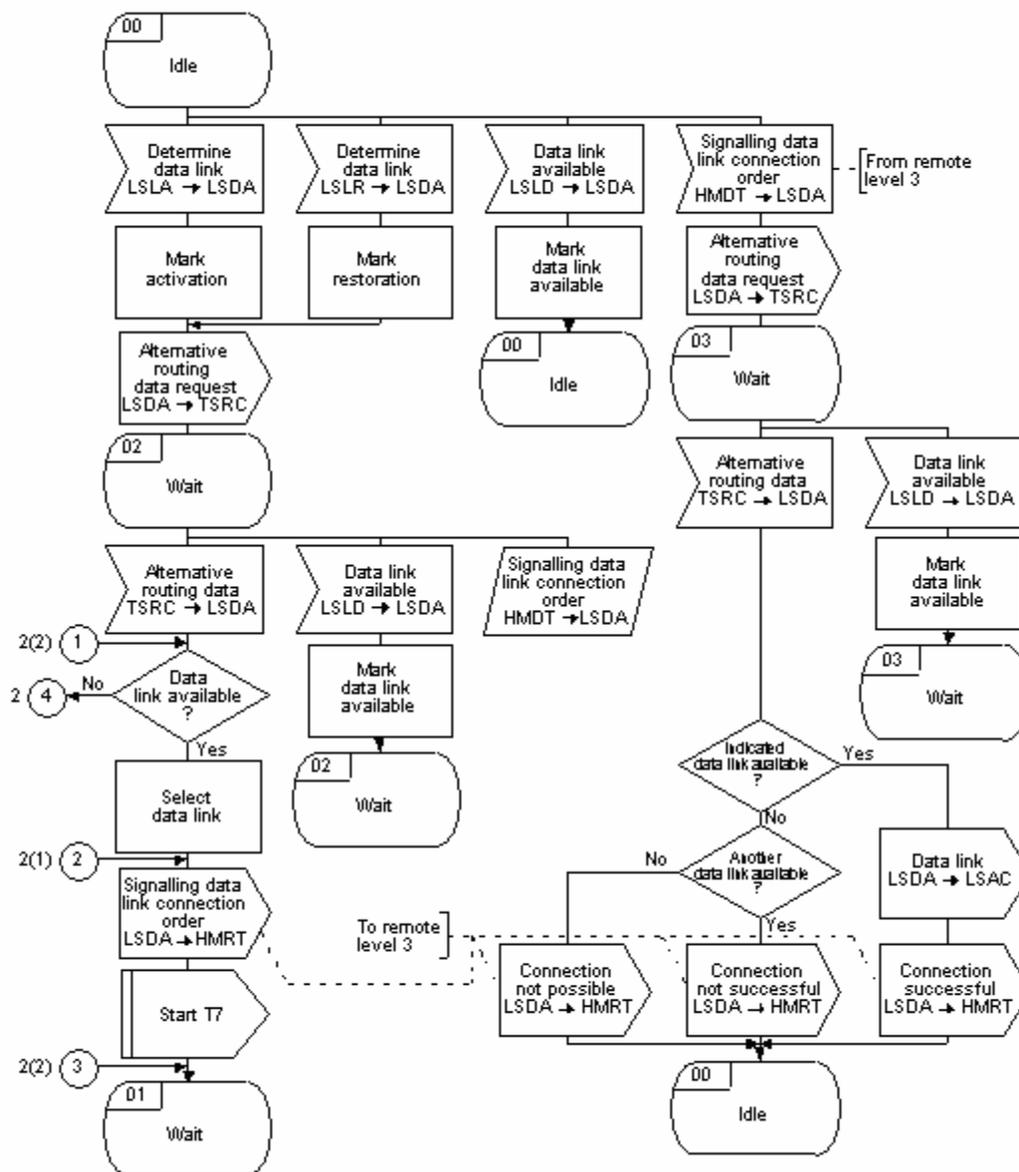


Figure 42/T1.111.4 Signalling Link Management - Signalling Data Link Allocation (LSDA) (Sheet 1 of 2)

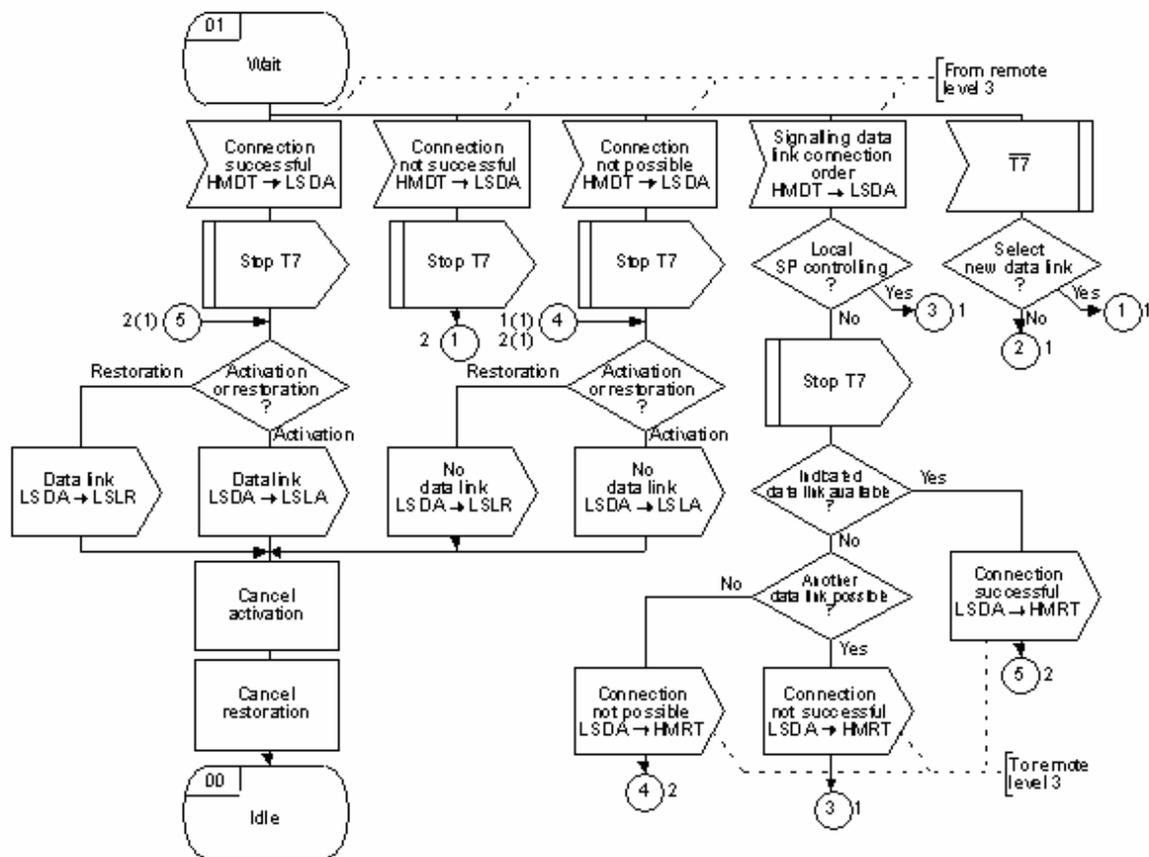
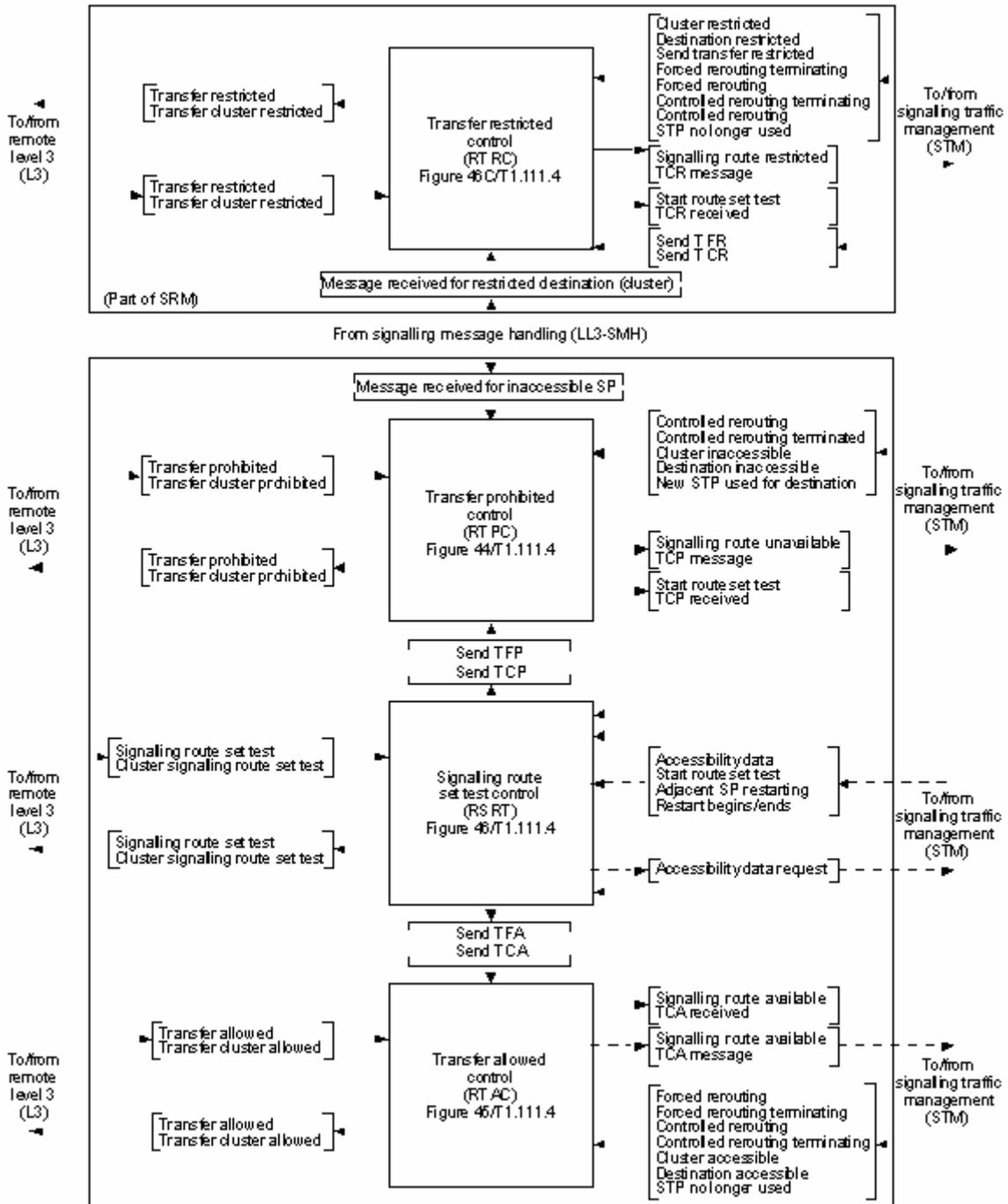


Figure 42/T1.111.4 Signalling Link Management - Signalling Data Link Allocation (LSDA) (Sheet 2 of 2)



Note - Abbreviated message names have been used in this diagram (i.e., origin - destination codes are omitted).

Figure 43/T1.111.4 - Signalling Route Management (SRM); Functional Block Interactions (Sheet 1 of 2)

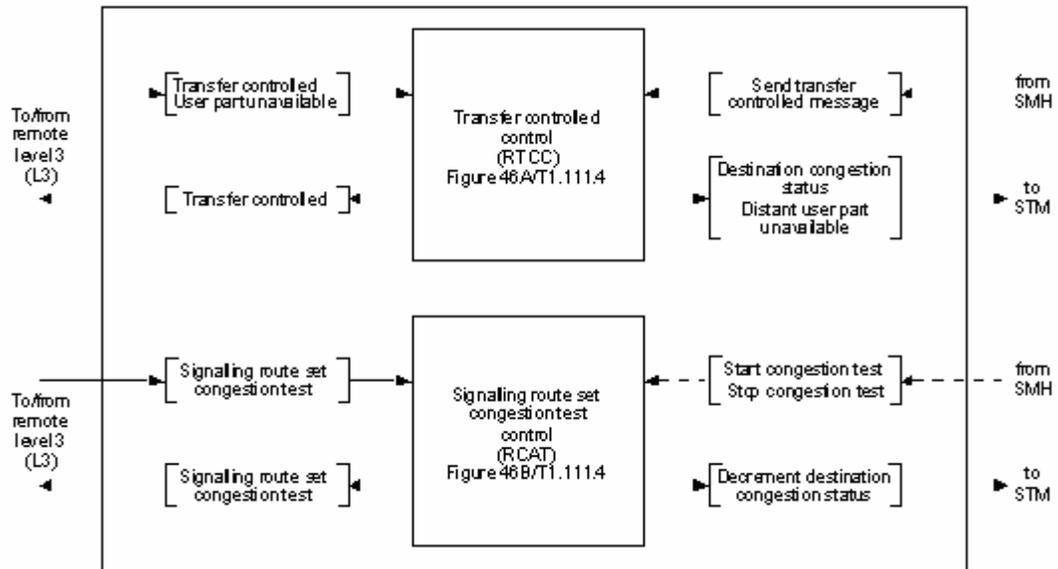


Figure 43/T1.111.4 - Signalling Route Management (SRM); Functional Block Interactions (Sheet 2 of 2)

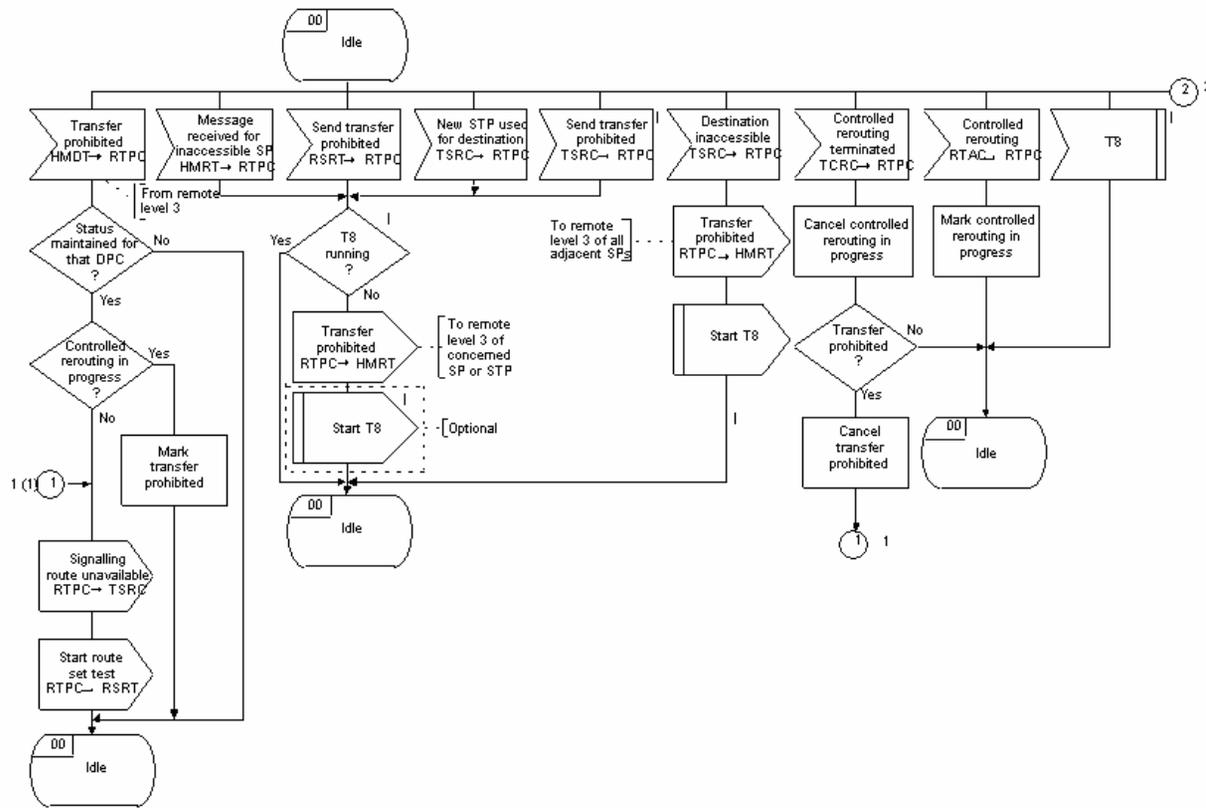


Figure 44/T1.111.4 - Signalling Route Management; transfer Prohibited Control (RTPC) (Sheet 1 of 2)

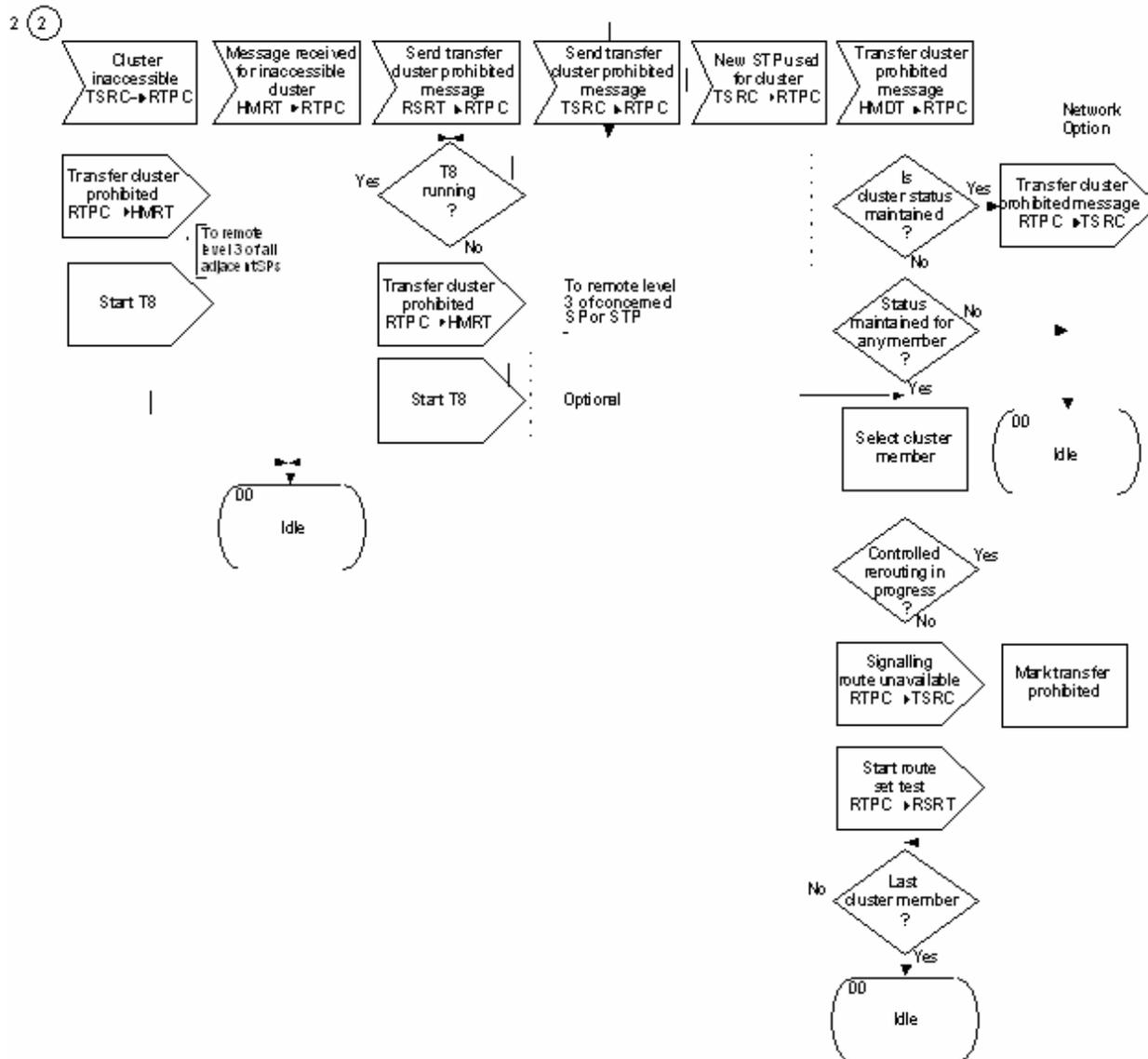


Figure 44/T1.111.4 - Signalling Route Management; Transfer Prohibited Control (RTPC) (Sheet 2 of 2)

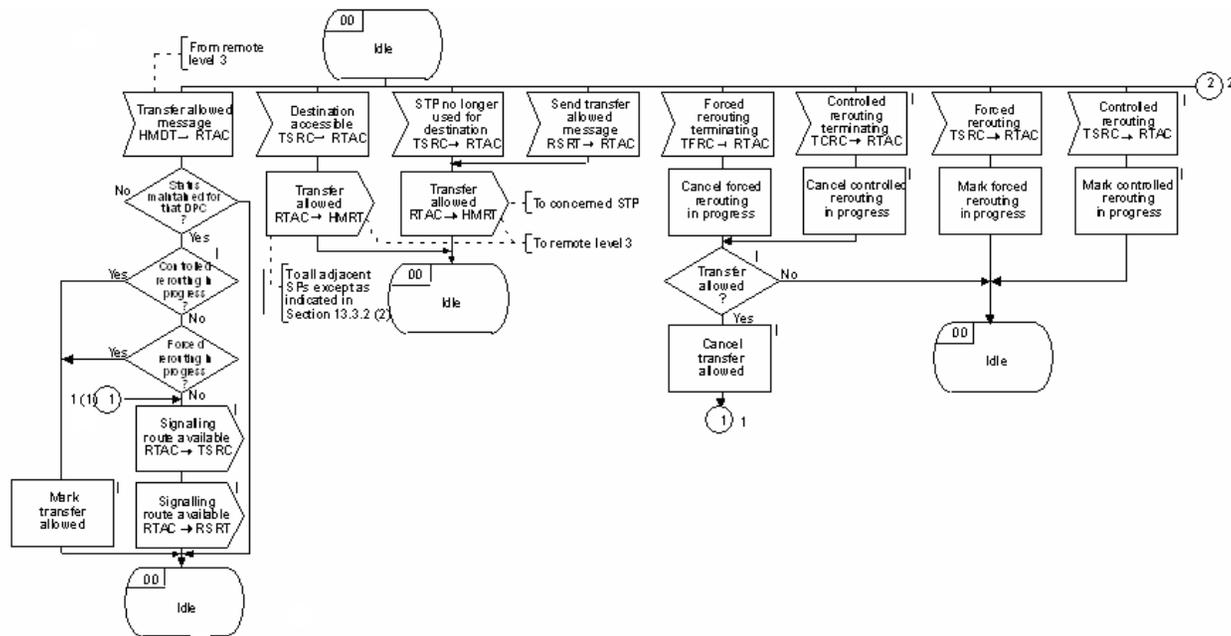


Figure 45/T1.111.4 - Signalling Route Management; Transfer Allowed Control (RTPC)
(Sheet 1 of 2)

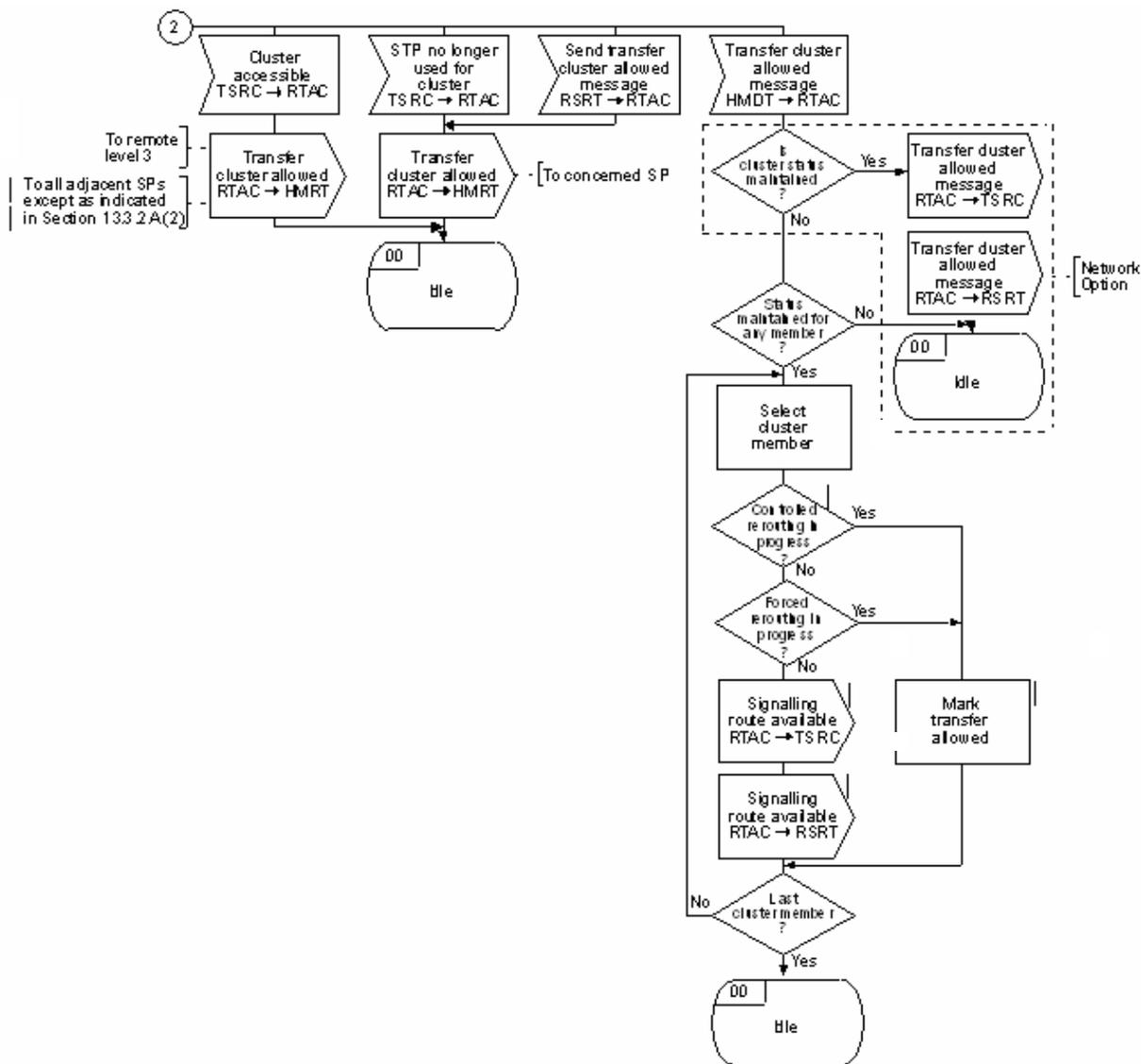


Figure 45/T1.111.4 - Signalling Route Management; Transfer Allowed Control (RTPC) (Sheet 2 of 2)

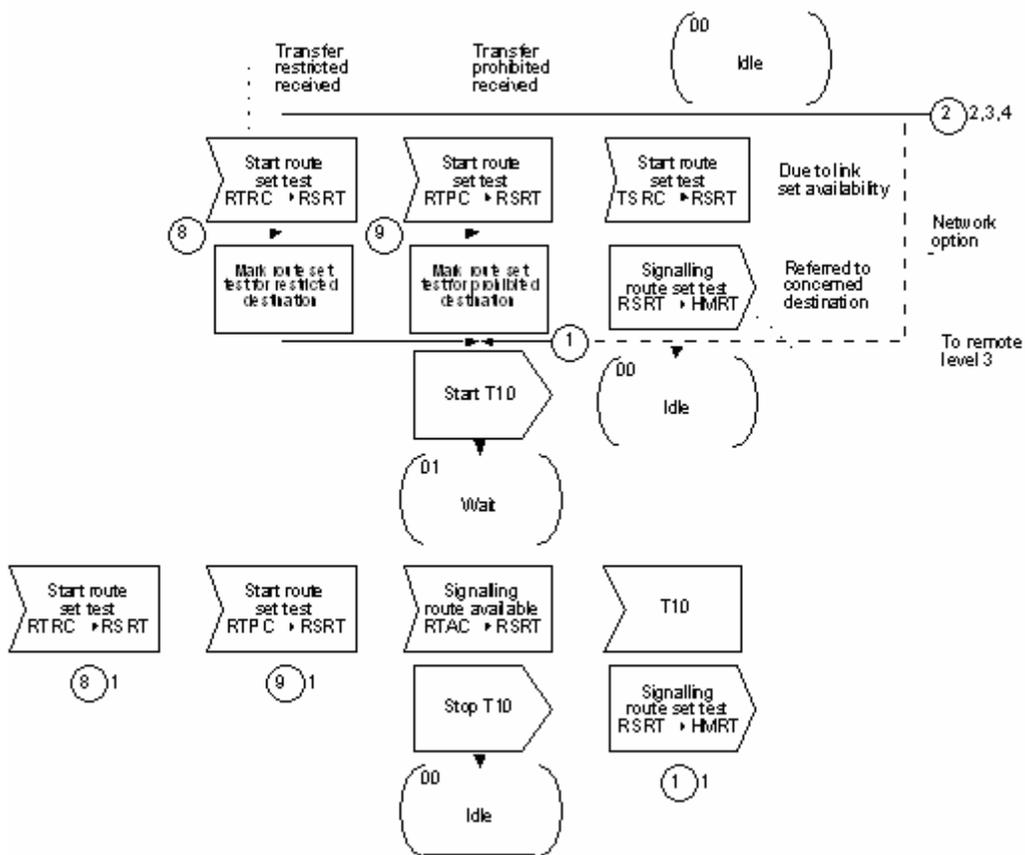


Figure 46/T1.111.4 - Signalling Route Management; Signalling Route Test Control (RSRT) (Sheet 1 of 5)

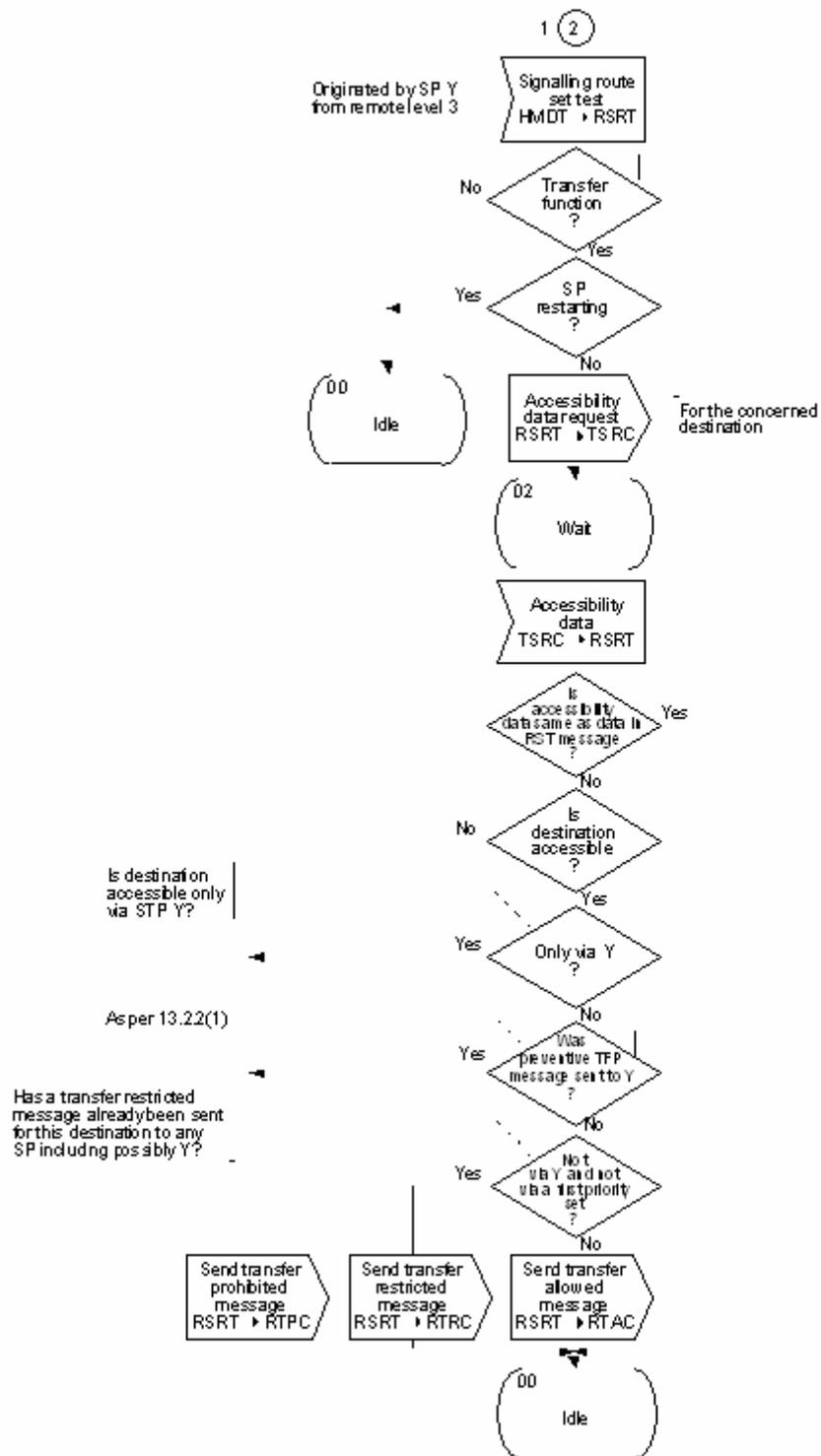


Figure 46/T1.111.4 - Signalling Route Management; Signalling Route Test Control (RSRT) (Sheet 2 of 5)

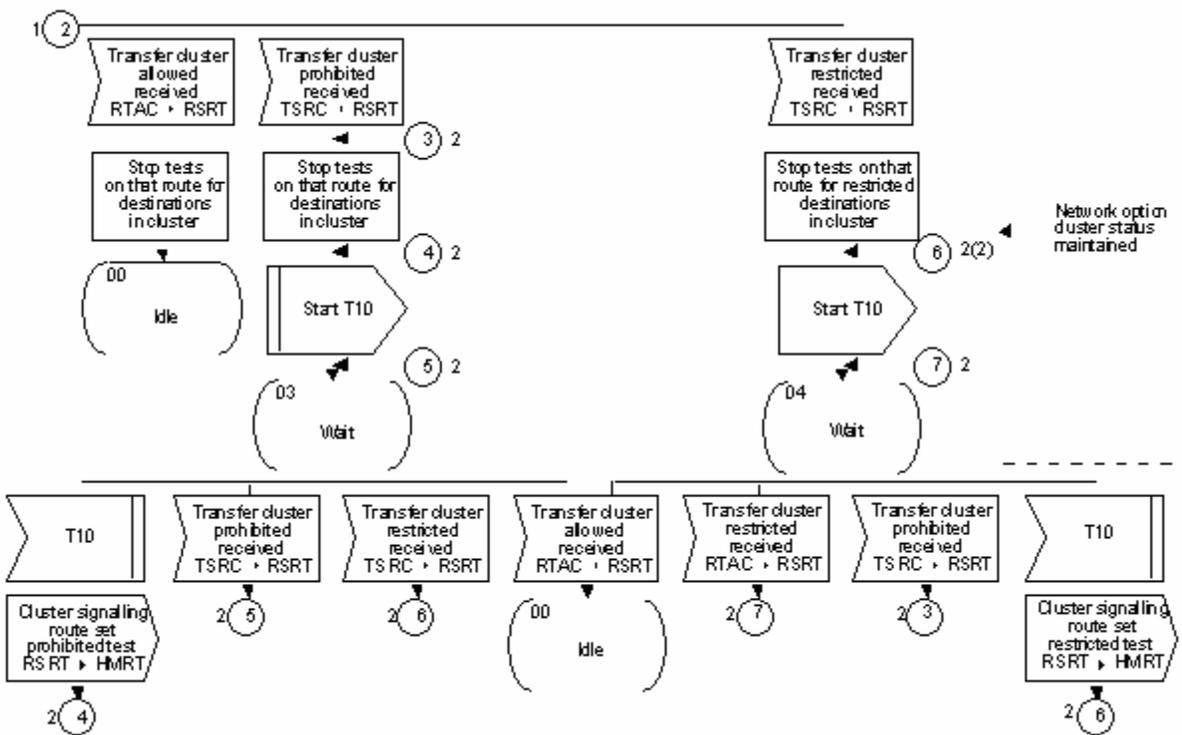


Figure 46/T1.111.4 - Signalling Route Management; Signalling Route Test Control (RSRT) (Sheet 3 of 5)

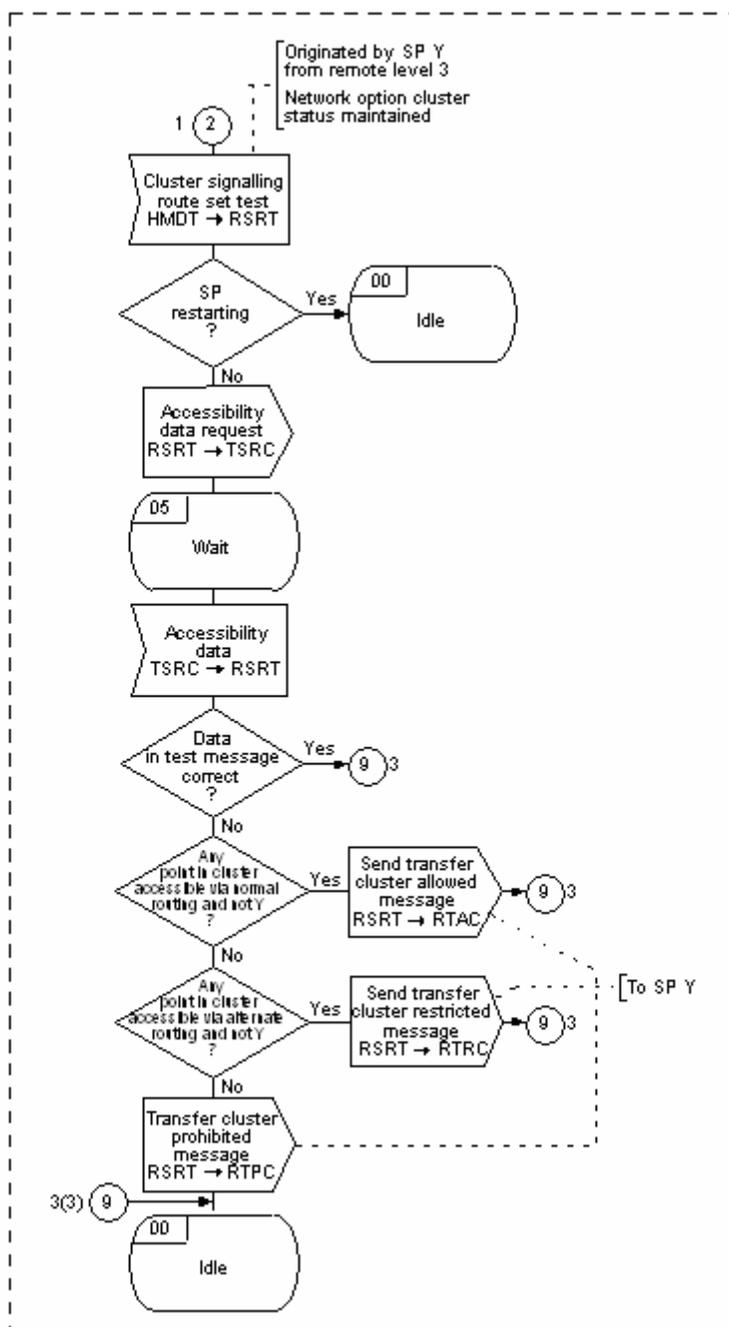


Figure 46/T1.111.4 - Signalling Route Management; Signalling Route Test Control (RSRT) (Sheet 4 of 5)

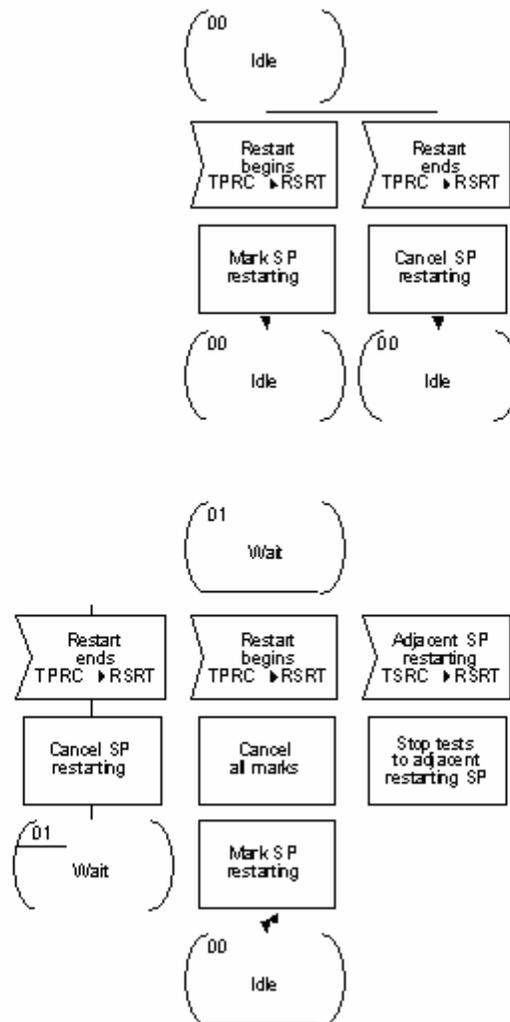


Figure 46/T1.111.4 - Signalling Route Management; Signalling Route Test Control (RSRT)
(Sheet 5 of 5)

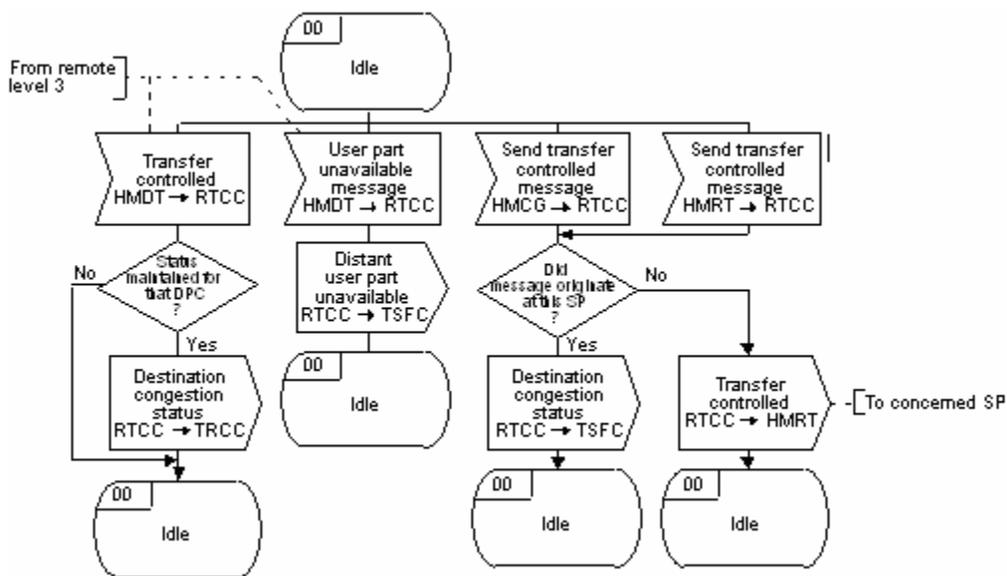


Figure 46A/T1.111.4 - Signalling Route Management; transfer Controlled Control (RTCC)

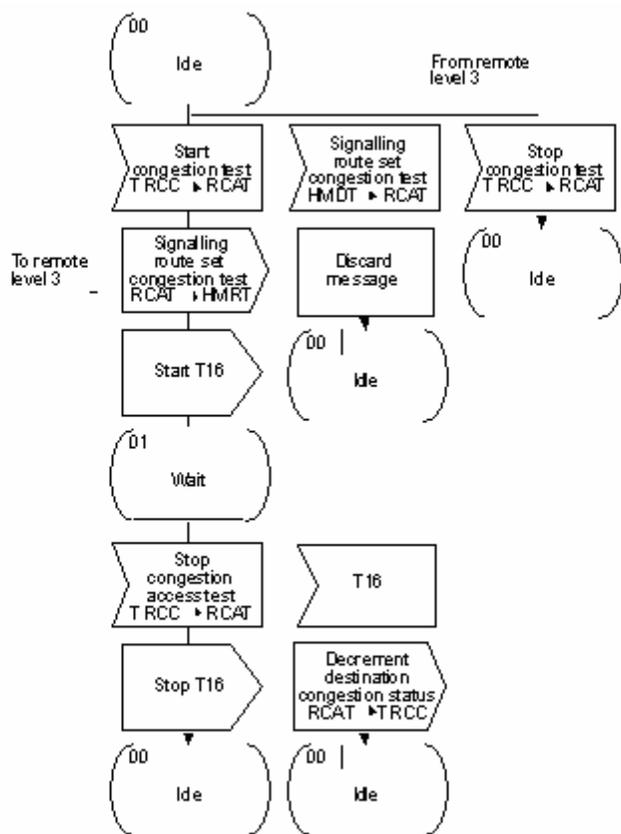


Figure 46B/T1.111.4 - Signalling Route Management; Signalling Route Set Congestion Test Control (RCAT)

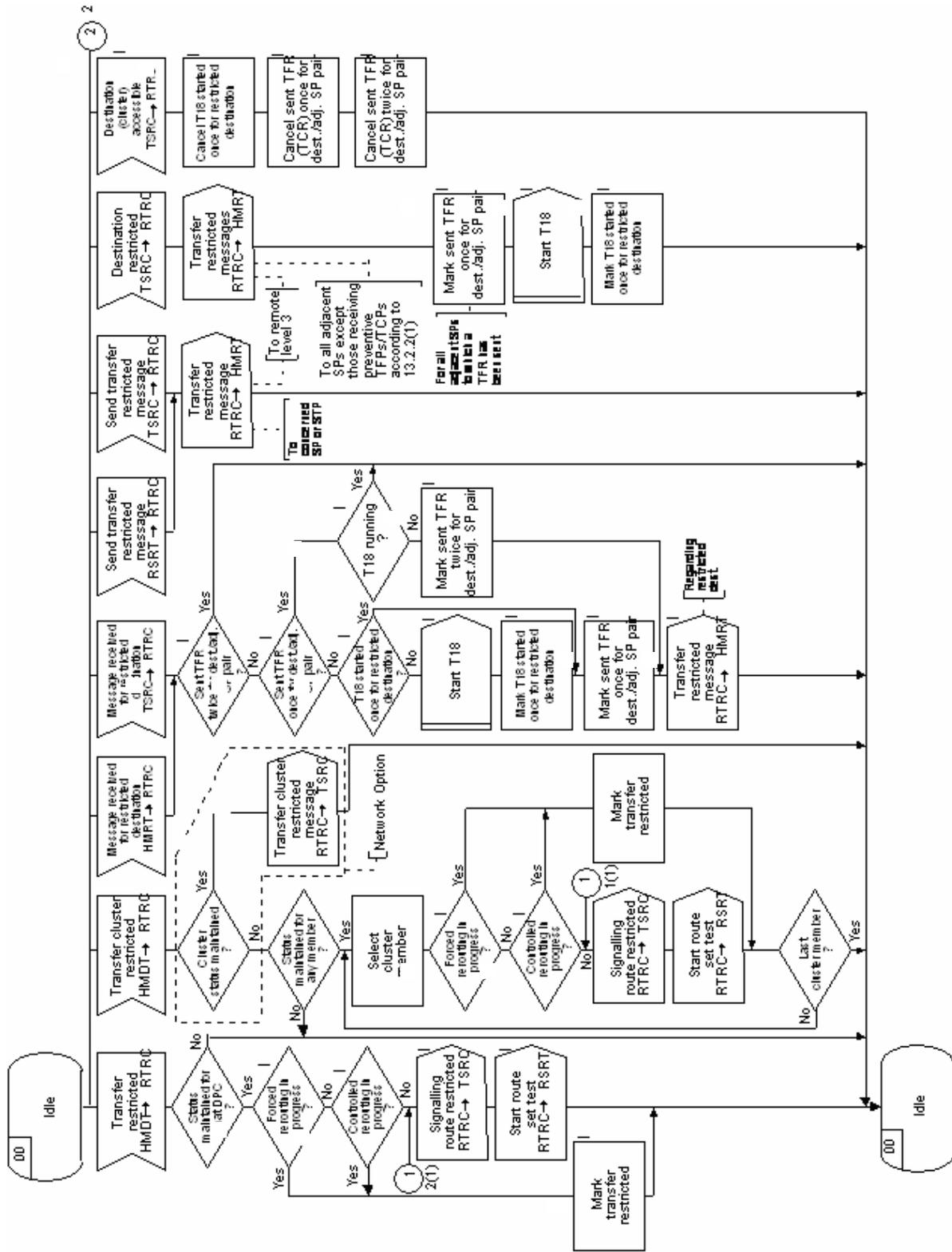


Figure 46C/T1.111.4 - Signalling Route Management; Transfer Restricted Control (RTRC) (Sheet 1 of 2)

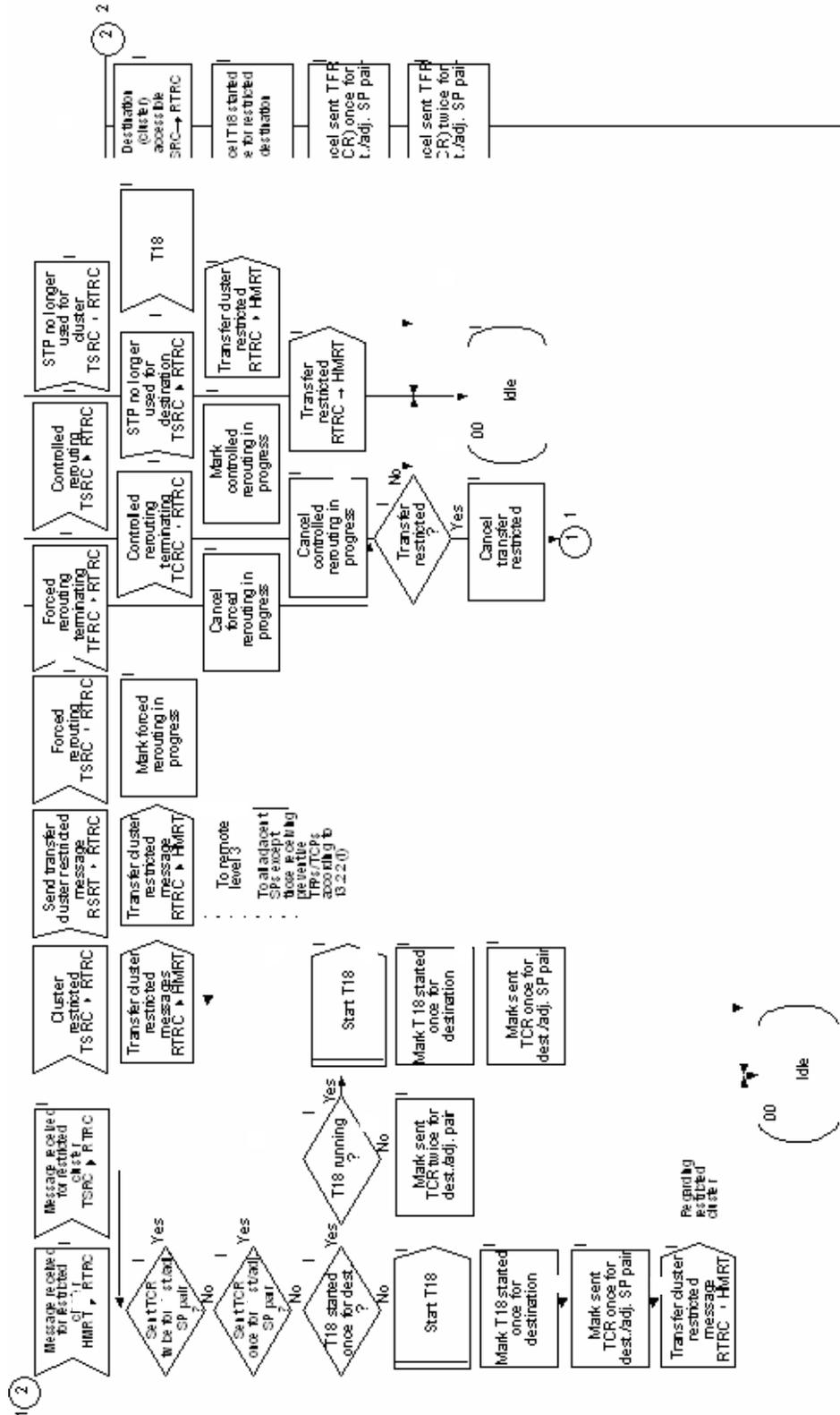


Figure 46C/T1.111.4 - Signalling Route Management; Transfer Restricted Control (RTRC) (Sheet 2 of 2)

Annex A
(Informative)

A SUMMARY OF MODIFICATIONS TO MTP LEVEL 3 FOR USE OF THE SERVICES OFFERED BY SSCF AT NNI (SAAL LINKS)

This Annex summarizes the modifications to procedures which perform the functions of the Message Transfer Part Level 3 in an environment in which signalling links offer the layer service defined in T1.645 [8] (SSCF at NNI) rather than the layer service defined in T1.111.3 (MTP Level 2). Links offering the services of SSCF at NNI will be referred to as "SAAL links."

The differences between the layer service offered by SSCF at NNI and that offered by MTP Level 2, and the resultant impact on MTP Level 3 are summarized as follows:

1. The maximum size service data unit (SDU) supported by SSCF at NNI is 4096 octets, whereas the maximum size SIF supported by MTP Level 2 is 272 octets. In principle, signalling links that provide the services of SSCF at NNI and signalling links offering the services of MTP Level 2 could be connected to the same signalling point. Network design or administrative means beyond the scope of this standard shall prevent the routing of messages that are too long (as defined in T1.111.3) to links offering the services of MTP Level 2. Any additional specifications for the interworking between signalling links that provide the services of SSCF at NNI and signalling links offering the services of MTP Level 2 are beyond the scope of this standard.
2. The relationship between the order in which octets are passed across the service boundary of SSCF at NNI and the actual transmission order of the bits in those octets is not the same as for octets passed across the service boundary of MTP Level 2. The coding conventions for messages generated by MTP Level 3 that are passed to SSCF at NNI are provided in Section 14 of T1.111.4.
3. The sequence numbers used in the retrieval service offered by SSCF at NNI are 24 bits, not 7 bits as in the retrieval service offered by MTP Level 2. This requires that changeover messages used by MTP Level 3 for SAAL links carry 24 bit sequence numbers. The format of changeover messages for SAAL links is provided in Section 15.4 of T1.111.4.
4. If a processor outage condition exists when proving is completed before entering the "In-Service" state, MTP Level 2 remains in the "Aligned/Not Ready" state. Under the same circumstances, SSCF at NNI transitions to the "Out of Service" state. This has no impact on procedures currently defined in T1.111.4. In addition, a processor condition while a SAAL link is in the "In-Service" state causes the link to fail. Therefore, the time-controlled changeover procedure is not applicable for a processor outage condition (i.e., the normal changeover procedure is executed).
5. Procedures for automatic allocation of signalling data links or signalling terminals by MTP Level 3 for links offering the service of SSCF at NNI are left for further study.

Annex B
(Normative)

B SERVICE INDICATOR EXTENSION

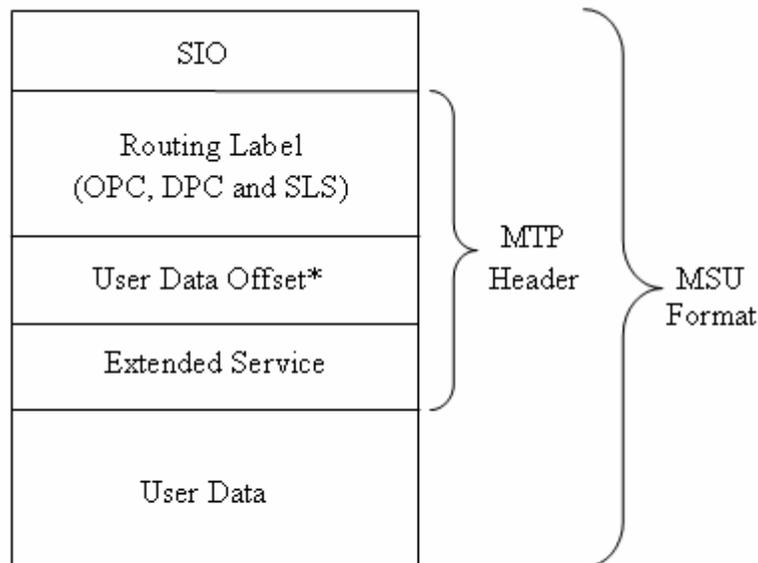
B.1 Introduction

A Service Indicator extension mechanism has been defined to allow new SS7 applications using the MTP to be deployed.

This mechanism is backwards (and forwards) compatible, and does not require changes to STPs in the SS7 network.

B.2 Outline of Extension Mechanism

Messages for applications using this mechanism have the general structure shown below, including the fields marked with the symbol *:



* Present only when SI = 1111(15)

Figure B.1/T1.111.4 - General MSU Format at MTP level 3

The User Data offset and Extended Service Indicator fields are placed after the routing label (see Figure B-1/T1.111.4), this change of the MSU format is transparent to intermediate STPs³⁸.

In signalling end points, only the MTP distribution function and small parts of MTP management (signalling traffic flow control) have to be modified.

B.3 Backward Compatibility Considerations

The MTP payload size is (minimally) reduced for new user parts, this does not cause a problem for existing user parts and thus creates no compatibility problems. New user parts should be made aware of this reduced size at the time of their specification.

The MTP network management procedure user part unavailability (within signalling traffic flow control (TSFC)) broadcast of STATUS indications in signalling end points involving the new user parts has to be extended.

If an MSU assigned to a "new" user part is sent to a node not supporting it, that node's MTP might also not yet support the new message/UPU format. In this case it replies with an old format UPU message identifying user "1111" as unavailable. In the node receiving the UPU, no information would be available as to which of the new user parts was "unequipped". As, however, no new user part at all is available at the "old" node, informing all new user parts of this unavailability cannot cause harm. New user parts can be designed to ignore any "unequipped" STATUS for destinations with which no signalling relation exists.

New nodes would have to support the two possible formats of UPU message, the old and the new one (see Figure B-3/T1.111.4), and choose among them according to which type of user part is concerned.

Thus, backward compatibility with nodes not providing the new user parts is guaranteed.

B.4 Details of New MSU Format and Forward Compatibility Considerations

The User Data offset field is a mechanism to support forward compatibility, and is included in the MTP header when the SI field is "1111". This provides a facility for future format extensions such as a further SI extension, an SLS extension, or even an extension of the point codes.

³⁸ Only if such STPs were to screen MSUs on an SI basis - a possible but non-standard feature - and wanted to screen for specific new SI values would a modification of the screening process be necessary. For routing purposes alone, however, no modification is required.

| 8 | 7 | 6 | 5 | 4 | 3 | 2 | 1 | Bit | Octet |
|-----------------------------------|---|---|---|---------------------------------------|---|---|---|-----|-------|
| MSB Sub-Service Field LSB | | | | MSB Service Indicator LSB | | | | | 1 |
| | | | | 1 | 1 | 1 | 1 | | |
| MSB DPC LSB | | | | | | | | | 2 |
| | | | | | | | | | 3 |
| | | | | | | | | | 4 |
| MSB OPC LSB | | | | | | | | | 5 |
| | | | | | | | | | 6 |
| | | | | | | | | | 7 |
| MSB SLS LSB | | | | | | | | | 8 |
| MSB User Data Offset LSB | | | | | | | | | 9 |
| 0 | 0 | 0 | 0 | 0 | 0 | 1 | 0 | | |
| MSB SI Extension LSB | | | | MSB Service Indicator Tail LSB | | | | | 10 |
| Extended Service Indicator | | | | | | | | | |
| User Data | | | | | | | | | 11 |
| User Data | | | | | | | | | ... |
| User Data | | | | | | | | | n |

Figure B.2/T1.111.4 - Detailed MSU Format for Extension of Service Indicator

If the SI is coded '1111' then the "routing label" is extended by 2 octets. Octet 9 is currently coded "00000010" and contains the offset (from octet 9) of the actual user data, allowing a backward compatible extension of the routing label in the future.

The Extended Service Indicator is contained in octet 10 and consists of the SI Tail and the SI Extension. If the SI Extension is coded '0000' then the SI Tail contains an (old) 4 bit SI value. This allows the new MSU format to be used for current user parts. If the SI Extension is not coded '0000' then the Extended SI (XSI) represents a "new" user part. The XSI can, therefore, be

regarded as a single field identifying a user part, whether new or old. Thus, there is room for 240 new user parts.

MTP implementations supporting the new format must at least accept – and distribute correctly – the new MSU format (with the SI Extension containing ‘0000’) for MSUs addressed to old user parts, including MTP management. While currently only MSUs for "new" user parts will use the new format, in the future if other "extensions" should be defined, the new format will also be used for existing user parts, including MTP management and testing.

B.5 UPU Format and for Extended User Part Identities

| 8 | 7 | 6 | 5 | 4 | 3 | 2 | 1 | Bit | Octet |
|---------------------------------------|---|---|----------------------------------|-----------|---|---|---|-----|-------|
| MSB Sub-Service Field LSB | | | MSB Service Indicator LSB | | | | | | 1 |
| MSB DPC LSB | | | | | | | | 2 | |
| | | | | | | | | 3 | |
| | | | | | | | | 4 | |
| MSB OPC LSB | | | | | | | | 5 | |
| | | | | | | | | 6 | |
| | | | | | | | | 7 | |
| MSB SLS LSB | | | | | | | | 8 | |
| H1 | | | | H0 | | | | 9 | |
| Destination | | | | | | | | 10 | |
| | | | | | | | | 11 | |
| | | | | | | | | 12 | |
| MSB Unavailability Cause LSB | | | MSB User Part ID LSB | | | | | | 13 |
| | | | 1 1 1 1 | | | | | | |
| MSB User Part ID Extension LSB | | | MSB User Part ID Tail LSB | | | | | | 14 |
| Extended User Part ID | | | | | | | | | |

Figure B.3/T1.111.4 - Format of User Part Unavailable Message for Extended User Part ID

Chapter T1.111.5
Signalling Network Structure

EDITORIAL NOTE – In this Chapter, all page numbers are in the format T1.111.5-#.

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Signalling System Number 7 (SS7) – Signalling Network Structure

1 SCOPE, PURPOSE, & APPLICATION¹

This Chapter describes aspects that 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). The United States national networks are described in clause 7. Clause 6A describes the interconnection of networks.

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 that 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 described in clause 7, as other networks are either a subset of the mesh network or are structured using this network or its subsets as components.

This chapter may contain requirements that reference other American National Standards. If so, when the American National Standards reference in the requirements are superseded by revisions approved by the American National Standards Institute, Inc., the revisions shall apply.

¹ A "|" indicates a change from T1.111-2001.

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 that provide for message error control (detection and subsequent correction). In addition, provision for maintaining the correct message sequence is provided [see Chapter T1.111.3 or T1.637-1999 (R2005)].

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 if it is also an originating or destination point (see Chapter T1.111.4, clause. 2.4).

A signalling point that transfers messages from one signalling link to another at level 3 serves as a Signalling Transfer Point (STP). The STP function may be combined with some other (e.g., switching) function.

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 1/T1.111.5. 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.

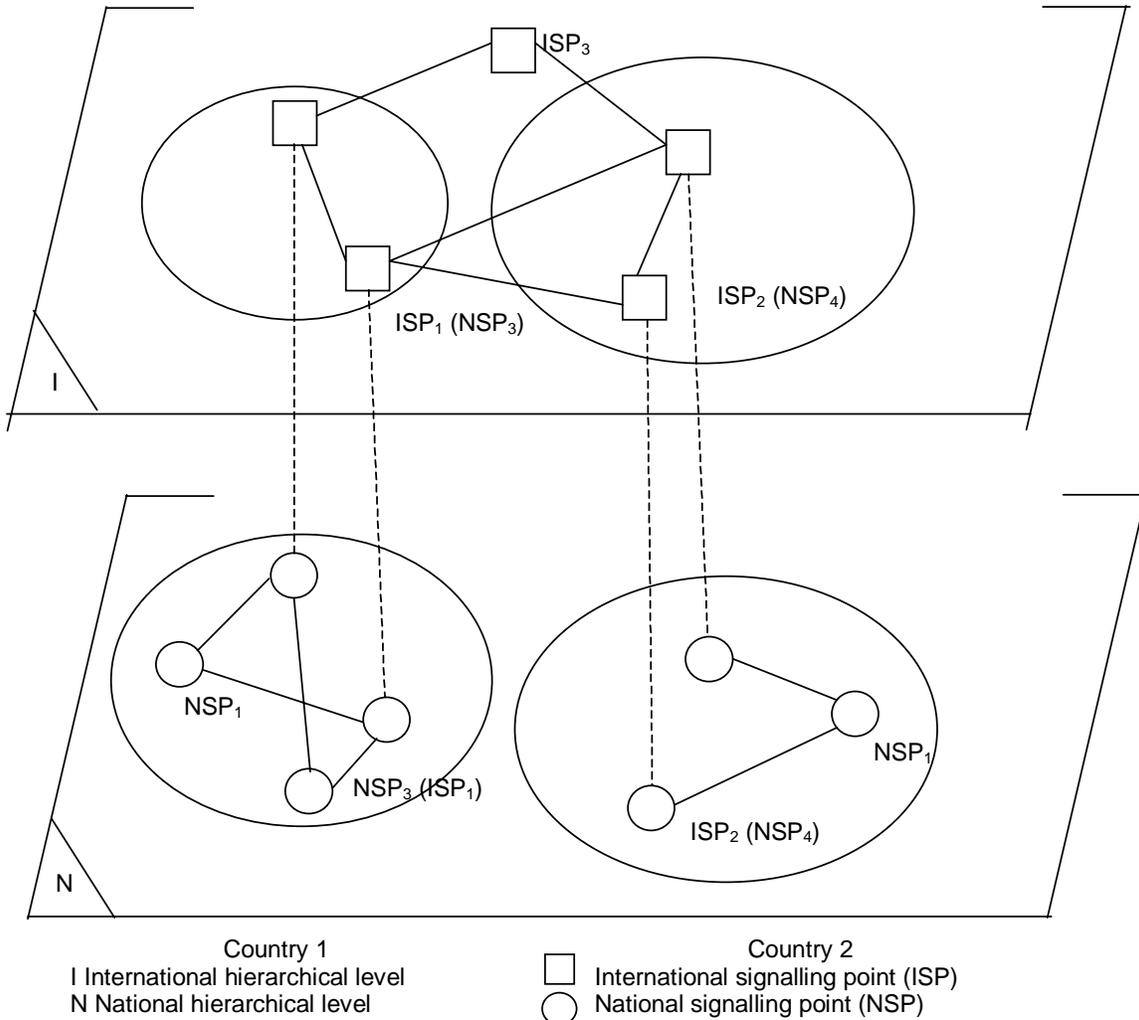


Figure 1/T1.111.5 International and National Signalling Networks

A Signalling Point (SP) including a Signalling Transfer Point (STP), may be assigned to one of three categories:

1. National signalling point (Signaling 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 plan² of signalling points;
2. 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.
3. 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

² A physical node can have multiple point codes where each point code represents a virtual signalling point.

is identified by a specific signalling point code (OPC or DPC) in each of the signalling networks.

If a discrimination between international and national signalling point codes is necessary at a signalling point, the national indicator is used (see Chapter T1.111.4, Clause 14.2.2).

4 CONSIDERATIONS COMMON TO BOTH INTERNATIONAL & 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 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 structure 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:

1. Total traffic load;
2. Availability of the links;
3. Required availability of the path between the two signalling points concerned; and
4. Bit rate of the signalling links.

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 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 T1.111.6.

4.5 Satellite Working

Due to the considerable increase in overall signalling delay, the use of satellites in Signalling System No. 7 connections requires consideration and further study is required.

In international operation, when the network served by the signalling network is routed on terrestrial circuits, only in exceptional circumstances should a satellite circuit be employed for the supporting signalling connection.

5 INTERNATIONAL SIGNALLING NETWORK

(Not applicable).

6 SIGNALLING NETWORK FOR CROSS-BORDER TRAFFIC

(To be specified).

6A SIGNALLING NETWORK FOR INTER-NETWORK TRAFFIC

6A.1 General

For inter-network traffic between signalling points, the need for special capabilities and configurations is likely. Screening and measurement capabilities for a network boundary are network specific. (See also clause 8.)

6A.2 Integrated Numbering of National Signalling Networks

Gateway signalling points are assigned signalling point codes by the network providers providing the gateways. The signalling point codes assigned to the gateways are contained in the signalling point code domain assigned to the network provider.

6A.3 Interworking of National Signalling Networks

At the inter-network signalling network interface, capabilities to provide security are network specific. (See also clause 5.5 of T1.111.6.)

6A.4 Inter-Network Signalling Network Structure

The United States network structures provide access to each other via link sets with diverse facilities between CCS networks. Where mated STPs are interconnected, the configuration should be as shown in Figure 3/T1.111.5. Signalling end points may also be directly interconnected to other signalling end points or to STPs.

The above interconnection scenarios are shown in Figures 2/T1.111.5 and 3/T1.111.5.

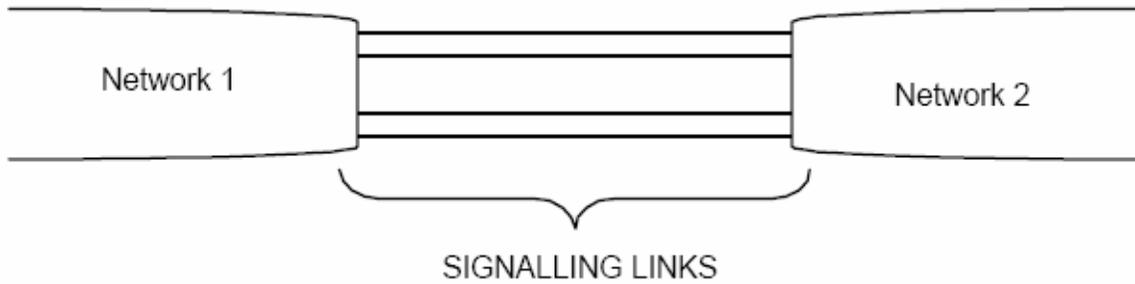


Figure 2/T1.111.5 Inter-network Interconnection of Network 1 and Network 2

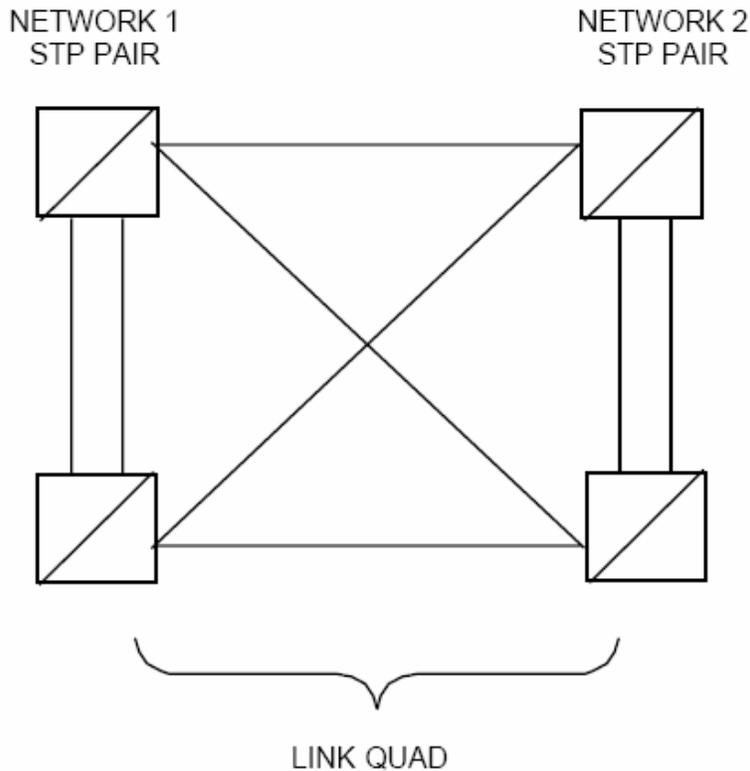


Figure 3/T1.111.5 STP Pair from Network 1 Interconnecting with an STP Pair from Network 2

6A.5 Routing in the Absence of Failures

All United States networks use the SLS field for load sharing. To ensure a balanced mix of SLS codes, the method of SLS rotation is used.³ The SLS field is eight-bits. SLS rotation is described in clause 7.

6A.6 Routing under Failure

If a signalling link in the United States inter-network structure fails, its traffic will be rerouted to one or more signalling links within the same combined link set using the standard changeover procedure described in clause 5 of Chapter T1.111.4. The traffic from the failed links is load shared over the working links in the combined link set.

When a United States inter-network signalling link recovers from a failure, its traffic will be changed back using the changeback procedure. The changeback procedure is described in clause 6 of Chapter T1.111.4.

7 NATIONAL SIGNALLING NETWORKS

7.1 General

This clause describes the basic network structure used in common channel signalling networks. This structure is the framework upon which United States CCS networks should be based.

The network structure is built from the basic mesh network shown in Figure 4/T1.111.5. Signalling Transfer Points (STPs) are joined together with signalling links, called C-links, to form mated STP pairs. These STP pairs are connected to other STP pairs with a signalling link quad structure designed to provide high reliability. Each signalling link quad is composed of four link sets between the STP pairs. Several of these STP pairs are joined together in the network to form the "backbone" STP network.

³ Other methods of load sharing are for further study.

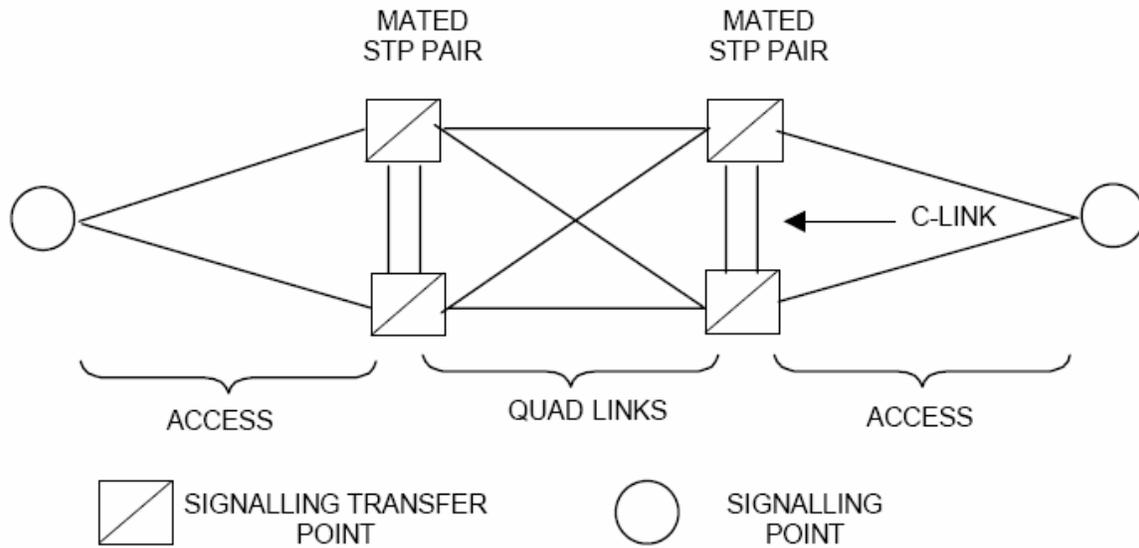


Figure 4/T1.111.5 Mesh Structure

Signalling points, not serving as STPs, use pairs (layers) of Access links, called A-links, to access an STP pair. A-links will always be installed in pairs from signalling points, with one link to each mate STP. A combined node with STP and some other (e.g., switching) functionality does not need pairs of A-links to access an STP pair, see Figure 4A/T1.111.5.

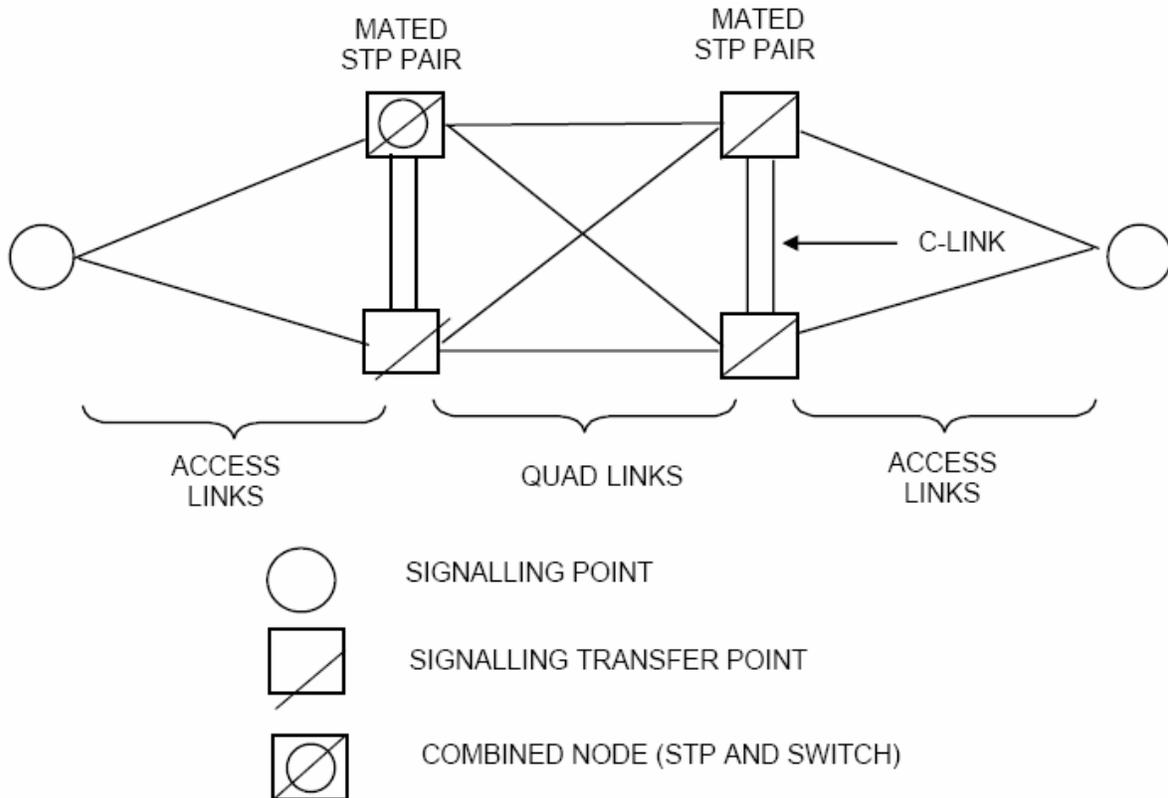


Figure 4A/T1.111.5 Mesh Structure and Node with Combined Function

7.2 Network Structure

7.2.1 One Level Hierarchy

Figure 4/T1.111.5 can also be used to illustrate a one level STP hierarchy. A signalling network can consist of a single STP pair or multiple STP pairs. Each STP pair and the signalling points accessing that STP pair can be viewed as a sub-network. Such a mated STP pair is designated as a Primary STP pair.

All Primary STP pairs in a single signalling network will be fully interconnected via signalling link quads with all other Primary STP pairs in that signalling network. These links are called B-links. Interconnection of signalling networks is discussed in clause 6A. The number of Primary STP pairs will depend on STP capacity sub-network, network and inter-network traffic levels, and individual company policies.

7.2.2 Two Level Hierarchy

A two level STP hierarchy is an extension (or growth) of the one level hierarchy. Some networks, typically those with high levels of sub-network traffic volume, may have another level of STP pairs, designated as the Secondary STP pairs (Figure 5/T1.111.5). As with Primary STP pairs, Secondary STPs always occur in mated pairs and interconnect with other STP pairs via link quads.

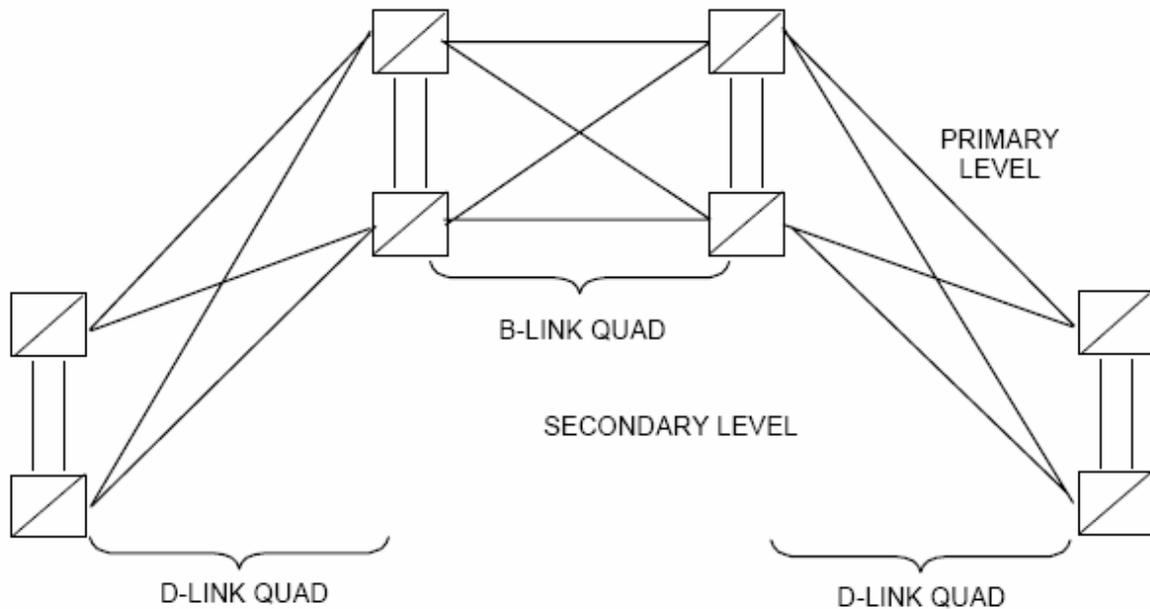


Figure 5/T1.111.5 Two Level STP Hierarchy

Secondary STP pairs are always homed to specific Primary STP pairs. There may be more than one Secondary STP pair connected to any particular Primary STP pair. The connection is made via signalling link quads called D-link quads.

Within a sub-network, Secondary STP pairs may be connected to each other via B-link quads. If no connection exists, signalling between Secondary STP pairs is routed through the Primary STP pair.

Connections between STP pairs in one network and STP pairs in another network are designated as D-links.

7.2.3 Clustering

Procedures in T1.111.4 and the network address structure are designed to support clustering of network signalling points. A signalling point is any addressable node in the signalling network. A cluster of signalling points is defined as a group of signalling points that directly home on a mated pair of STPs and that are addressable as a group. The address plan allows the cluster address to refer to the cluster as a whole for network management.⁴ In addition, each STP is a single node cluster by itself so that it is uniquely addressable by the information in the Network

⁴ An alias point code may be assigned to an STP pair only to access the SCCP Global title translation function. The alias point code is not necessarily a cluster address.

Cluster field (i.e., no other signalling points in that network share the same cluster code with that STP).

One level and two level clustering (addressing) can be supported by the network address. Two level clustering (addressing) requires the Network Cluster field to be sub-divided and sub-clusters to be defined.

All signalling networks, at a minimum, support one level of addressing. The use of two level clustering (addressing) should be a network option. Those STPs that support one or two level clustering (addressing) should be capable of communicating to signalling point and networks that support the other method of clustering (addressing).

Two level clustering (addressing) requires the definition of large and small clusters. Cluster boundaries are defined around Primary and Secondary STP groupings. A small cluster is defined as a set of signalling points that directly home on an STP pair. This is the same as the definition used in one level clustering (addressing) for a cluster. Multiple small clusters can be defined to be homed on a single STP pair. The large cluster is composed of a set of small clusters that directly home on the Primary STP pair and/or home on its associated Secondary STP pairs (i.e., a large cluster is a group of small clusters).

7.2.4 Signalling Point Access

Signalling points in the network are normally connected to their home STP pair via Access link (A-link) pairs (See Figure 6/T1.111.5). These A-links must be provided on diverse route to each STP in the mated pair. The signalling point may be a switching office, a database, or any other signalling node (except an STP). A combined node with STP and some other (e.g., switching) functionality need not require pairs of A-links to access the home STP pair as long as it is functioning as one of the STPs in the home STP pair.

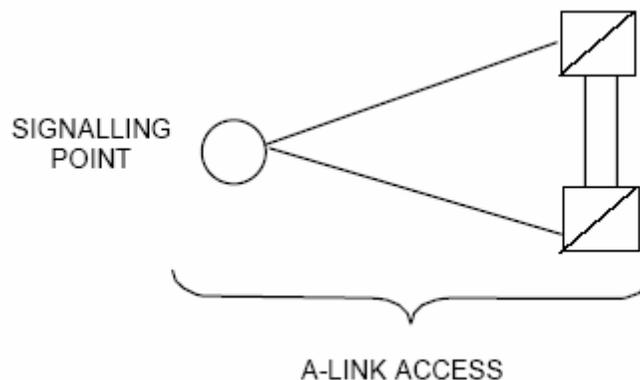


Figure 6/T1.111.5 A-Link Access

In addition to A-link access to a SP's home STP pair, a SP may have a pair of link sets to any other STP pair in the signalling network. These extended access links are called E-links and must also be provided on diverse routes to both STPs in the target STP pair (See Figure

7/T1.111.5). These links may be used by network planners to alleviate traffic load in regional STPs.

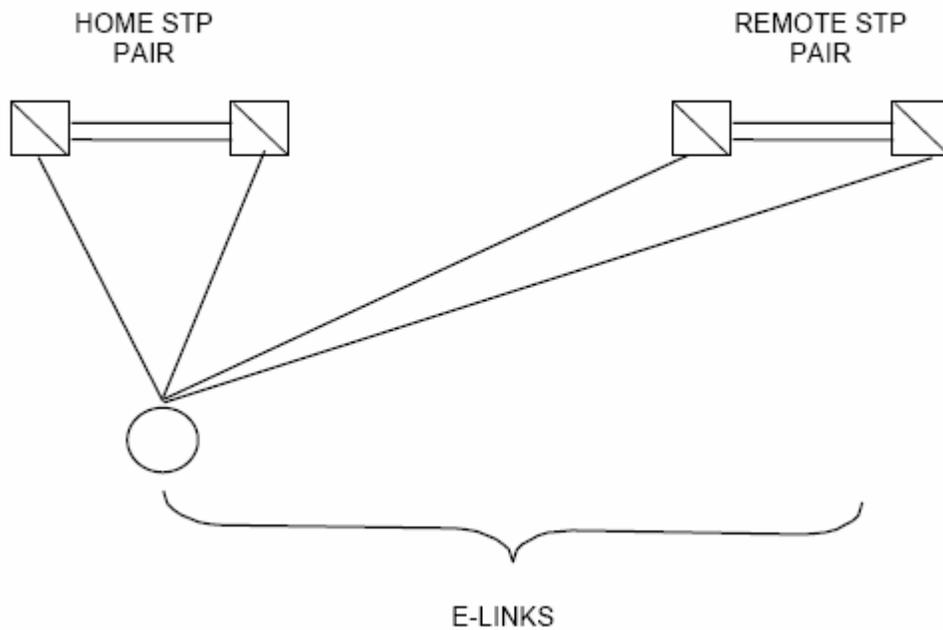


Figure 7/T1.111.5 E - Link Access

Signalling points may also communicate with each other directly from point to point. Such signalling is called associated signalling and uses F-links (See Figure 8/T1.111.5).

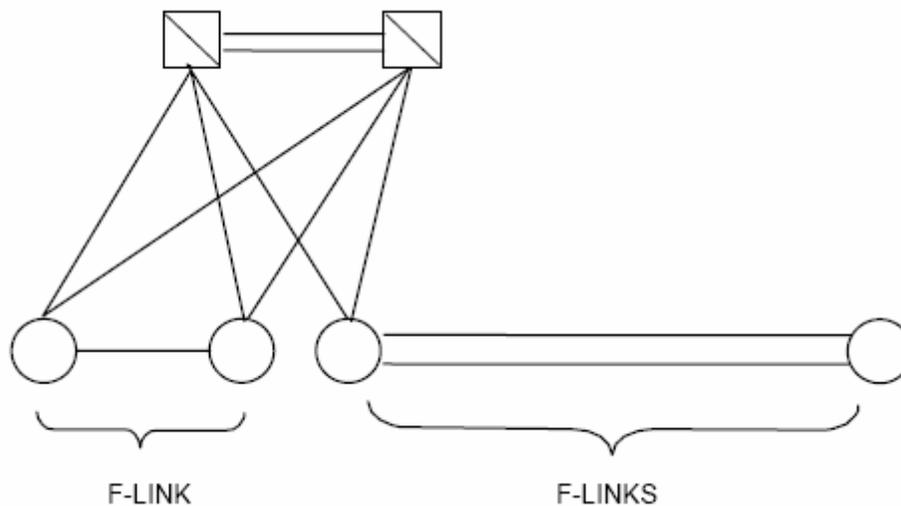


Figure 8/T1.111.5 - F-Link Access

Associated signalling using F-links may be used between any two signalling points within or outside of the STP homing groups (clusters). Provision for alternate routing of F-link traffic into would be allowed.

7.3 Routing

7.3.1 Routing in the Absence of Failures

7.3.1.1 Load Sharing

Load sharing of messages between routes (links) is done using an eight-bit SLS code⁵ as described in clause 2.2.4 of T1.111.4. The eight-bit SLS code load sharing methodology described in this clause was designed to be backward compatible with the five-bit SLS code load sharing methodology, so that both may co-exist in the same network if needed. During an interim period with both five and eight-bit when the majority of the traffic uses an eight-bit code. The use of an eight-bit SLS code is preferred over a five-bit SLS code because of its ability to provide a more even distribution of traffic. A five-bit SLS code methodology is identical to the eight-bit SLS code methodology described in this clause except that it would use only the five least significant bits; the three most significant bits are marked as spare and are assumed to be zero.

In this aspect of routing, the traffic load is distributed evenly over the links of a link set or combined link set (whichever is applicable). All signalling points load share among those link sets at the same priority level that move the traffic in the direction of the message's destination. Many load sharing methodologies use a technique called bit rotation, illustrated in Figure

⁵ The five-bit load sharing methodology is the same as that used for an eight-bit SLS code, except the three most significant bits are not used and are assumed to be equal to zero.

9/T1.111.5. Normally all bits are rotated, but to provide backward compatibility with a five-bit SLS code scheme, only the five least significant bits are rotated.

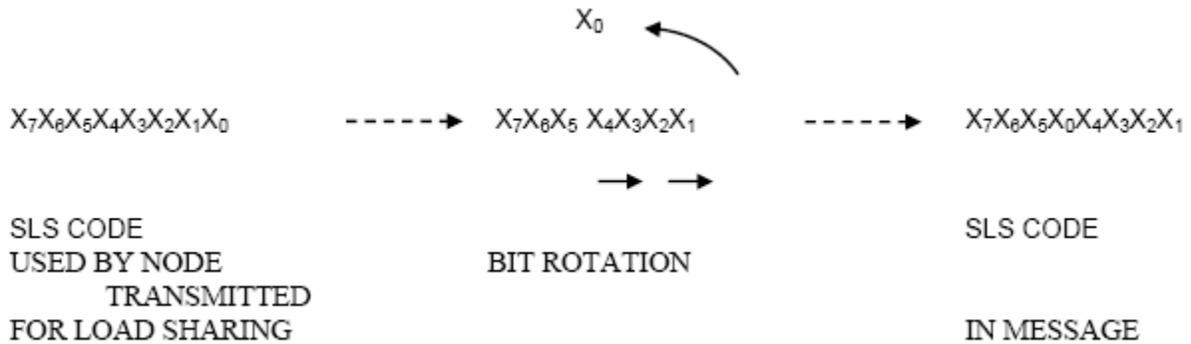


Figure 9/T1.111.5 Bit Rotation

In Figure 9/T1.111.5 an X_1 represents a bit (0 or 1) of the SLS code. Prior to transmission, the five least significant bits of the SLS code are rotated -- i.e., shifting only the five least significant bits one position to the right and placing the previous first bit into the fifth bit position. In a five-bit SLS scheme, the three most significant bits are assumed to be zero (i.e., $X_5 = X_6 = X_7 = 0$). To achieve backward compatibility, the three most significant bits X_5 , X_6 , and X_7 are not included in the rotation.

Rotation is done prior to transmission on all link sets except C-links. Bit rotation is necessary for all load sharing methodologies that use the least significant bit for selecting a link set from combined link set. Bit rotation is used so that information to load share at any subsequent signalling point is independent of the information used at the previous signalling point.

An example of load sharing methodology is called modified SLS rotation. This methodology uses bit rotation since it uses the least significant bit for link set selection. This methodology also specifies that when a link set selection is not necessary, the least significant bit is included in the link selection. This feature of the methodology allows access link sets (e.g., A links and E links) to contain 16 links. All other sets are limited to 8 links.

Figures 10/T1.111.5 and 11/T1.111.5 illustrate the use of this methodology in load sharing over a combined link set consisting of two link sets. Figures 12/T1.111.5 and 13/T1.111.5 illustrate the use of this methodology in load sharing over a single link set. In these figures, an X represents a uniform distribution of 0's and 1's in all cases, an X_0 represent a uniform distribution of 0's and 1's when the SLS is generated from a signalling point that supports an eight-bit SLS code (otherwise it is assumed to be 0), and a Y represents a uniform distribution of 0's and 1's only in the case where the signalling point itself is generating the SLS codes for the messages. When combined link sets are used, the fifth least significant bit (i.e., Y in Figure 10/T1.111.5) of the SLS code in messages received from other signalling points generally does not have an equal

distribution of 0 and 1 values because this bit of the SLS code was used at the previous signalling point to select the link set into the current signalling point.⁶

When load sharing over a combined link set of more than one link set, the least significant bit is used to choose a link set.⁷ The remaining seven most significant bits (four bits for a five-bit SLS code) are used to choose a link from the chosen link set. A signalling end-point should use all remaining bits to choose a link from a link set. An intermediate signalling point should use only six of the remaining seven bits for choosing a link from a link set (three bits five-bit SLS code). The selection of the link set and the link is illustrated in Figure 10/T1.111.5.

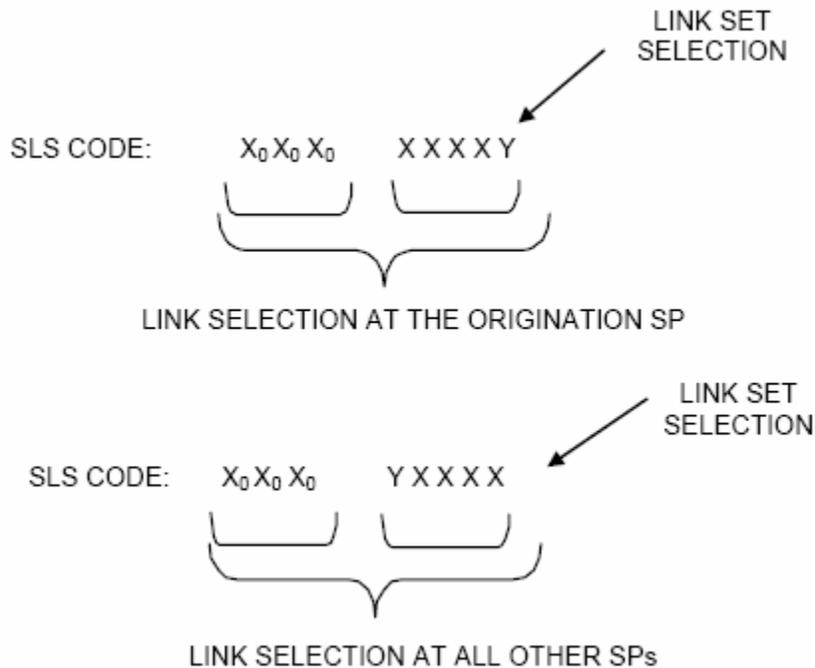


Figure 10/T1.111.5 Load Sharing Over a Combined Link Set (non-failure condition)

Figure 11/T1.111.5 illustrates the link set selection on a model of a combined link set of more than one link set. The figure shows that when the least significant bit is a 0, the upper link set is selected. When the least significant bit is a 1, the lower link set is selected. The SLS codes that appear in the messages on the links are the codes that were formed after the sending node has performed the bit rotation.

⁶ Methods used by network operators to administer the network such that the fifth least significant bit of the SLS field in received messages has an equal distribution of 0's and 1's are useful only in special cases and only when all traffic incoming from other networks.

⁷ This is only true when all links in the combined link set are carrying traffic. If one or more links have failed, the least significant bit is no longer used for link set selection. Instead, the 128 codes made up of the three most significant and the four least significant bits of the SLS code are distributed across the non-failed links such that all links have the same number of codes assigned or differ from each other by no more than one code assignment (see clause 7.3.2.1).

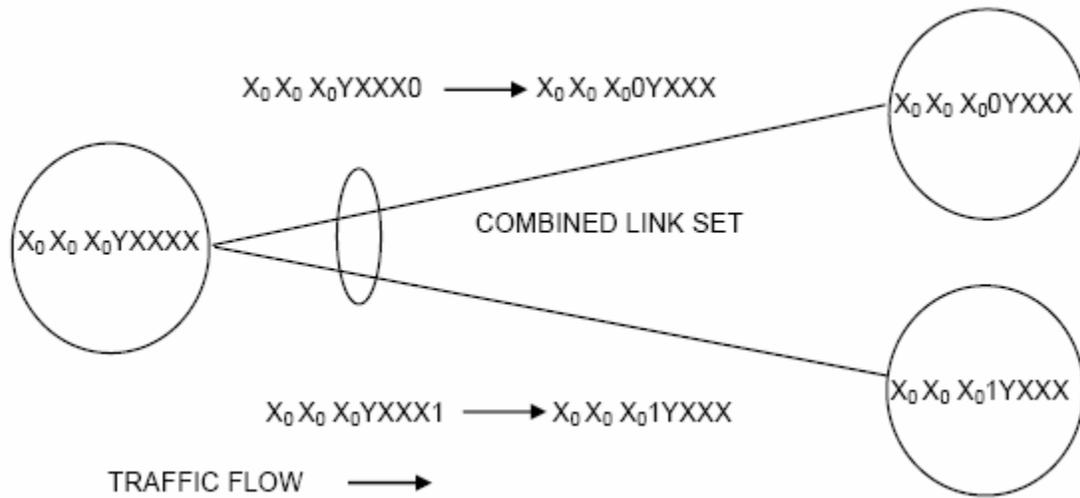


Figure 11/T1/111.5 Combined Link Set Model - Load Sharing

When load sharing over a single link set, the three most significant bits concatenated with the four least significant bits are used to choose the link from the single link set. A signalling endpoint should use all eight-bits since the fifth least significant bit will always be a uniform distribution of 0's and 1's. The selection of a link from a single link set is illustrated in Figure 12/T1.111.5. Figure 13/T1.111.5 illustrates the link selection on a model of a single link set.

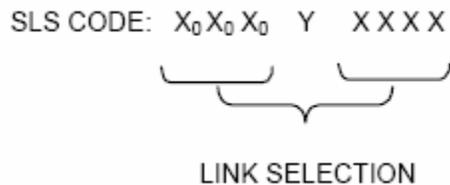


Figure 12/T1.111.5 - Load Sharing Over a Single Link Set

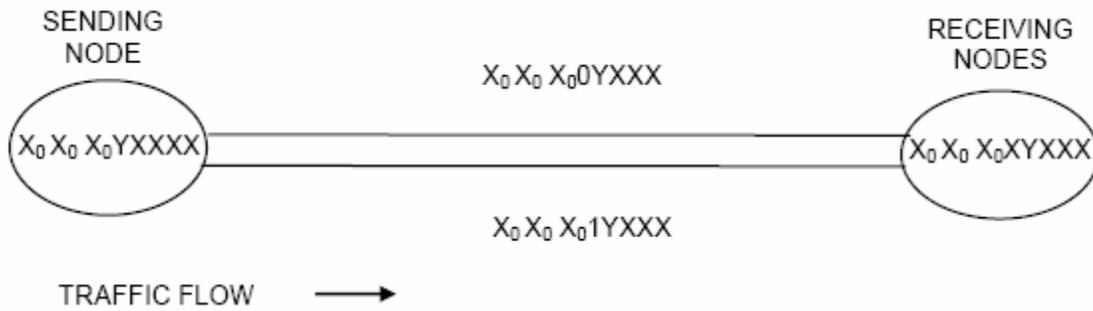


Figure 13/T1.111.5 - Single Link Set Model - Load Sharing

Figure 14/T1.111.5 illustrates an example of an end-to-end connection between two signalling points. For simplicity, all link sets contain a single link and only messages from signalling point A to signalling point F are illustrated. The figure shows the SLS codes that the signalling points use for load sharing and the SLS codes that are transmitted in the messages on the links (i.e., bit rotation is performed by the sending node).

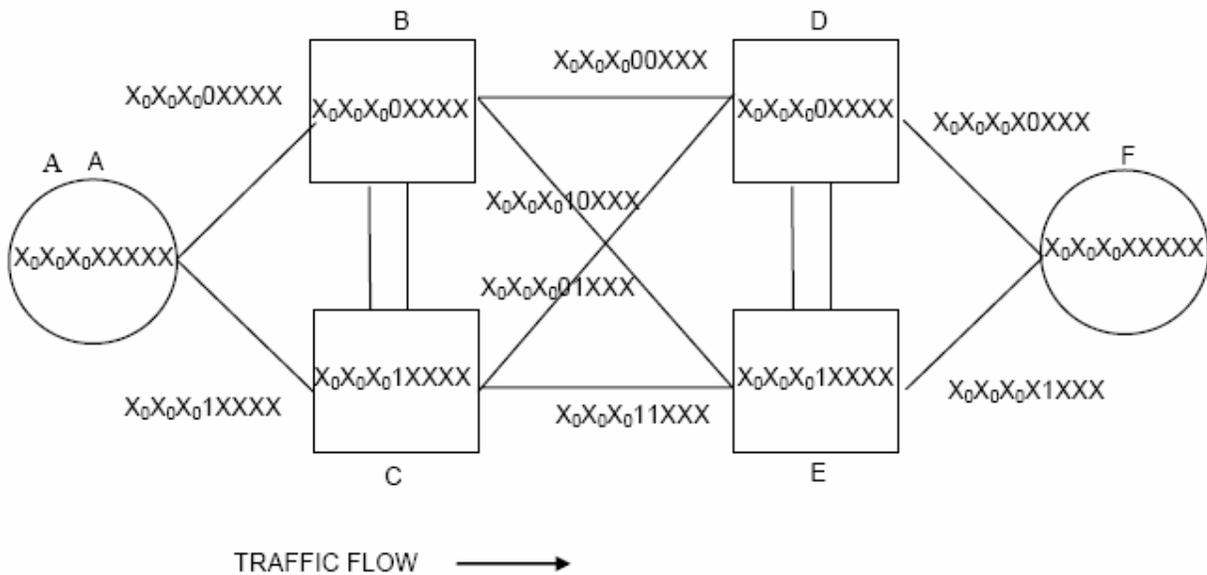


Figure 14/T1.111.5 End-to-End Load Sharing Example

In the example illustrated in Figure 14/T1.111.5, SP A is sending messages to SP F. For these messages, SP A load shares the messages over the combined link set to STPs B and C. If the least significant bit of the SLS code in the message is a 0, then SP A chooses the link set to STP B (i.e., SLS type $X_0X_0X_0XXXX0$, where $X = 0$ or 1). Similarly, SP A chooses the link set to STP C on SLS type $X_0X_0X_0XXXX1$. Prior to transmission, bit rotation is performed on the SLS code.

STPs B and C use the same load sharing procedure to send the messages to STPs D and E. STP B chooses the link set to STP D on SLS type $X_0X_0X_00XXX0$. The link set to STP E from STP B is chosen on SLS type $X_0X_0X_00XXX1$. Similarly, STP C chooses the link set to STP D on SLS type $X_0X_0X_01XXX0$ and the link set to STP E on SLS type $X_0X_0X_01XXX1$.

Having the link sets to STP D chosen on SLS type $X_0X_0X_0YXXX0$ ensures that STP D will have a uniform distribution of the four least significant bits in addition to the three most significant bits (i.e., $X_0X_0X_00XXXX$) for load sharing (i.e., receiving SLS types $X_0X_0X_000XXX$ from STP B and $X_0X_0X_001XXX$ from STP C to form

SLS type $X_0X_0X_00XXXX$). This is also the case for STP E (i.e., receiving SLS types $X_0X_0X_010XXX$ and $X_0X_0X_011XXX$ to form SLS type $X_0X_0X_01XXXX$). This method ensures that each subsequent signalling point will have at least, a uniform distribution of the three most significant bits (if the SLS code was generated by a signalling point that supports an eight-bit SLS code) and the four least significant bits of the SLS code available for load sharing.

Both STPs D and E have a single link set to reach SP F. Since link set selection is not needed, STPs D and E will use the three most significant bits concatenated with the four least significant bits to choose a link from the link set.

This load sharing methodology is sufficient to handle any number of STPs in the signalling route.

7.3.1.2 Normal Routing

Offices may use F-links, E-links, or A-links to route traffic to a destination point. The preferred route shall always be the most direct one. Therefore, if an SP has F-links to a destination, the F-link link-set shall be the preferred route. If F-links do not exist and the SP has E-links to the destination STP, then the E-links shall be the preferred route. If E and F-links do not exist, A-links shall be used. Alternatives under failure are discussed in the next clause.

STPs may use B-link quads, D-link quads, E-links or A-links to route traffic to a destination point. If A-links exist to a specific destination, they shall be the preferred route. If A-links do not exist, any E-links to the destination shall be the preferred route. If the message must be routed to another STP, the "homing" STP pair of the destination is preferred, followed by the Primary STP pair of the destination followed by the Primary STP pair of the originating point.

7.3.2 Routing under Failure Conditions

7.3.2.1 Alternative Routing of Traffic From Failed Links

This clause considers the alternate routing of traffic when links fail, but the corresponding link sets have not failed. Link set failures are discussed in the next clause.

When a link fails, the load it was carrying that was being routed over a combined link set is load shared over all remaining links in the combined link set. This is done by reassigning the SLS codes that were previously assigned to the failed link to the remaining links in the combined link set. The load the failed link was carrying that was being routed only on the

corresponding link set is load shared over the remaining links in that link set. When the concatenated SLS codes⁸ associated with the failed link are reassigned within the (combined) link set, the reassignment should be performed so that the total number of codes associated with each available link differs by no more than one code. During an interim period when not all signalling points are supporting the eight-bit SLS code, the intermediate signalling points (e.g., signal transfer points (STPs)) must also assure that the concatenated SLS code values 0 through 15 associated with the available links differ by no more than one SLS code.

The following example illustrates the redistribution of SLS codes at an intermediate signalling point during the interim period when both five-bit and eight-bit SLS codes are present. The example is for a combined link set with three links per link set. The codes shown in the figures are the concatenated SLS code values with the fifth least significant bit removed. table 1/T1.111.5 illustrates the non- failure case.

Table 1/T1.111.5 Concatenated SLS Code Assignment (Non-Failure Case)

| Link Set/Link | Concatenated SLS Code Assignment | | | | | |
|---------------|----------------------------------|----|----|-----|-----|-----|
| 1/1 | 0 | 6 | 12 | ... | 120 | 126 |
| 2/1 | 1 | 7 | 13 | ... | 121 | 127 |
| 1/2 | 2 | 8 | 14 | ... | 122 | |
| 2/2 | 3 | 9 | 15 | ... | 123 | |
| 1/3 | 4 | 10 | 16 | ... | 124 | |
| 2/3 | 5 | 11 | 17 | ... | 125 | |

Table 2/T1.111.5 illustrates the reassignment of the concatenated SLS codes when link 2 in link set I fails. Note that the concatenated SLS code values less than 16 (shown in **bold** typeface) are distributed so that only the first (1/1) has one more code than the other available links (concatenated SLS code values 0, 6, 12, and 14). The remaining concatenated SLS codes, greater than 15 (the concatenated values), are distributed so that the total number of codes associated with any available links differs by no more than one code.

Table 2/T1.111.5 Concatenated SLS Code Assignment (Failure Case)

| Link Set/Link | Concatenated SLS Code Assignment | | | | | | | | | | | |
|---------------|----------------------------------|-----------|-----------|-----|-----|-----|----------|-----------|----|----|-----|-----|
| 1/1 | 0 | 6 | 12 | ... | 120 | 126 | | 14 | | 50 | 80 | 110 |
| 2/1 | 1 | 7 | 13 | ... | 121 | 127 | | | 26 | 56 | 86 | 116 |
| 1/2 | - | - | - | ... | - | - | - | - | - | - | - | - |
| 2/2 | 3 | 9 | 15 | ... | 123 | | | 20 | 32 | 62 | 92 | |
| 1/3 | 4 | 10 | 16 | ... | 124 | | 2 | | 38 | 68 | 98 | 122 |
| 2/3 | 5 | 11 | 17 | ... | 125 | | 8 | | 44 | 74 | 104 | |

⁸ Full eight-bit/five-bit SLS codes for signalling end points.

7.3.2.2 Alternate Routing of Traffic From Failed Link Sets

In order to handle failure conditions that may develop, each signalling point has alternative routing information that specifies alternate link set(s) to be used when the normal link set becomes unavailable (see T1.111.4, clause 4.2).

Table 3/T1.111.5 gives, as an example, a list of alternative link sets for all normal links at signalling point A and at Signalling Transfer Point B for the network model illustrated in Figure 15/T1.111.5. In the basic mesh network, all link sets except those between Signalling Transfer Points of the same pair are normal links that carry signalling traffic in the absence of failures. Alternate link sets may be assigned a priority based upon the order of their use during failure conditions. When the STP is a signalling message source sending messages to its mate STP, the C-links are the normal links for this traffic. A priority 1 alternate is first choice (i.e., a normal link set), followed by a priority 2 alternate (e.g., link sets between Signalling Transfer Points of the same pair) that is used only when there are no priority 1 link sets available.

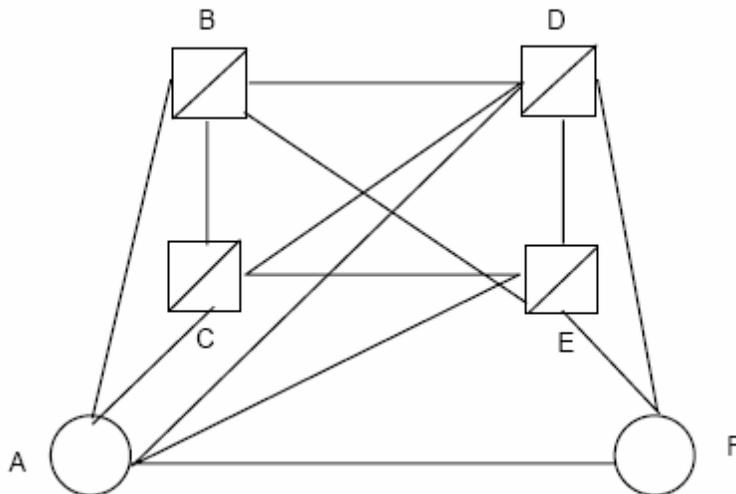


Figure 15/T1.111.5 Model to Illustrate Alternate Link Sets

Table 3/T1.111.5 Alternate Link Sets

| AT SIGNALING POINT | NORMAL LINK SET | ALTERNATIVE LINK SET | PRIORITY ^{a)} LEVEL |
|--------------------|------------------|----------------------|------------------------------|
| A | AF ^{b)} | AD | 2 |
| | | AE | 2 |
| | AC | AB | 1 |
| | AB | AC | 1 |
| | AE ^{b)} | AD | 1 |
| | AD | AE | 1 |
| B | BD | BE | 1 |
| | | BC | 2 |
| | BE | BD | 1 |
| | | BC | 2 |
| | BA | BC | 2 |
| | BC | NONE | - |

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.
2. Additional alternate routing for F-links and E-links is possible but is not necessary to meet performance requirements and is therefore not included here.

Subclauses 7.3.2.2.1 to 7.3.2.2.5 present some typical examples of the consequences of faults in signalling links and signalling points on the routing of signalling traffic. For simplicity, link sets are assumed to consist of only one link.

7.3.2.2.1 Non-Backbone Link Set Failure Examples

Example 1: Failure of a link set between two signalling points (Figure 16/T1.111.5).

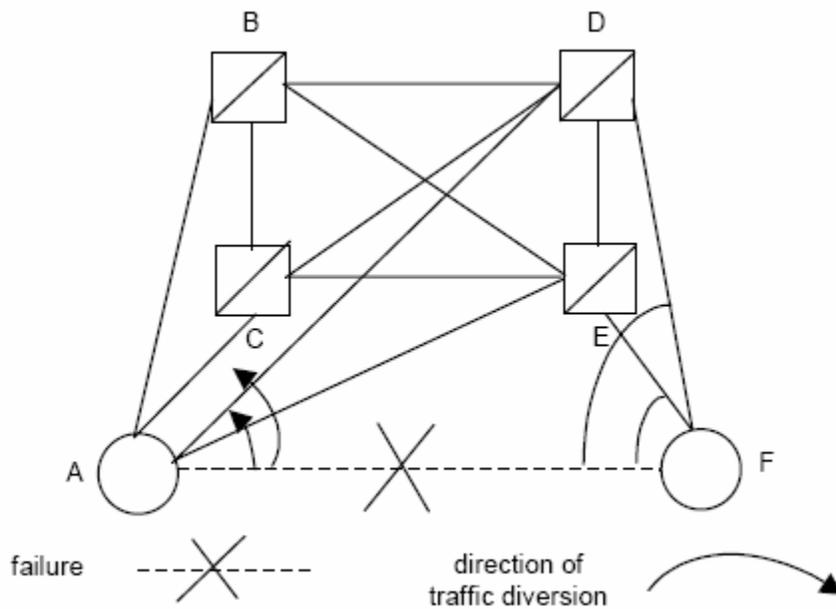


Figure 16/T1.111.5 Failure of Link Set AF (F-Link)

As indicated in table 3/T1.111.5, signalling point A diverts traffic from the failed link set AF (F-link) to the alternate link sets AD and AE (load sharing). [Note that the use of link sets AB and AC at priority 3 is not required based on performance requirements, but may be specified as a network option.] This provides a back up route for F-link traffic through the backbone STP network. Similarly, SP F diverts traffic from link set AF to link sets FE and FD.

Example 2: Failure of E-link between a signalling point and an STP pair (Figure17/T1.111.5)

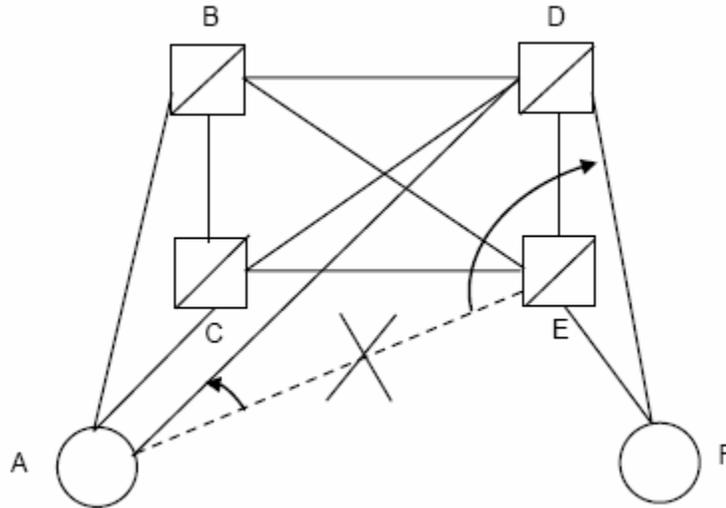


Figure 17/T1.111.5 Failure of Link Set AE

On the failure of link set AE (E-link), SP A diverts traffic to the other priority 1 link set AD. STP E diverts traffic to the link set ED (C-link).

Example 3: Failure of both E-links between a signalling point and an STP pair (Figure 18/T1.111.5).

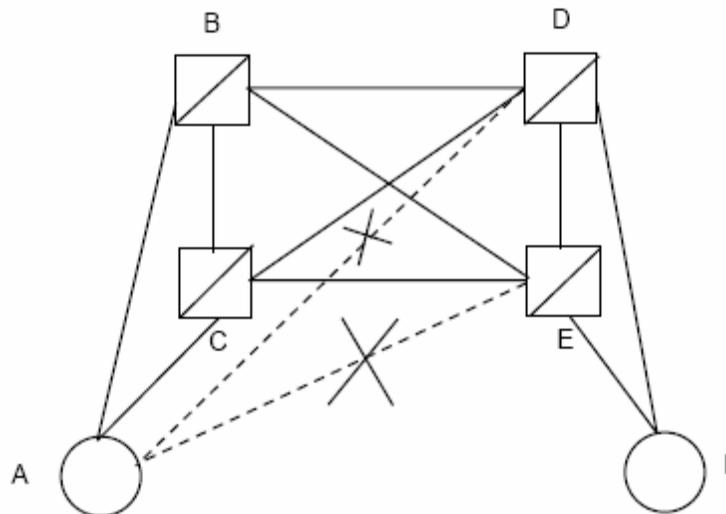


Figure 18/T1.111.5 Failure of E-Links AE and AD

If both link sets (E-links) from SP A to STP pair D/E fail, traffic is blocked from originating point A to those destinations that home on STP pair D/E. Similarly, traffic is blocked from STP pair D/E to signalling point A. No other alternate routes are needed as system availability requirements are met without them. As a network option, link sets AB and AC could be specified as alternate routes with priority 2.

Example 4: Failure of an A-link between an SP and an STP pair (Figure 19/T1.111.5)

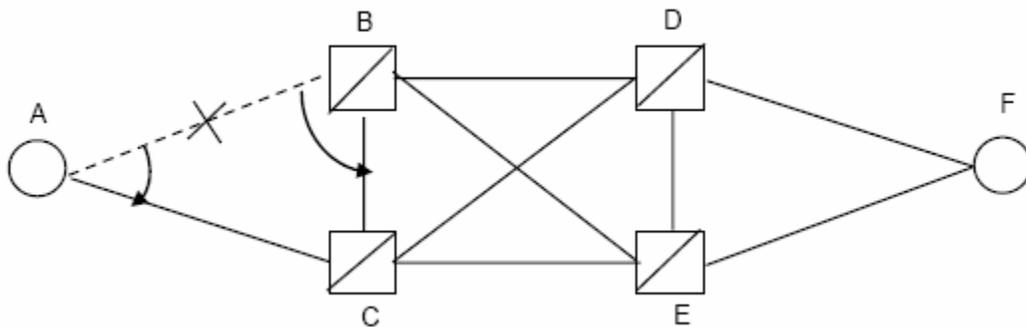


Figure 19/T1.111.5 Failure of Link Set AB (A-Link)

SP A diverts traffic from link set AB to link set AC. STP B diverts traffic from link set BA to link set BC. It should be noted that the number of STPs traversed by signalling messages from SP F to SP A, which pass through STP B, is increased by one and becomes three in this case.

The principle to minimize the number of intermediate STPs is applied in this case at STP B to get around the failure. In fact, the procedures defined in T1.111.4 assume that traffic is diverted at a signalling point only in the case of a link set being unavailable on the route outgoing from that signalling point. Should the failure exist for greater than T11⁹, an indication is sent from STP B to STPs D and E to divert traffic on link sets DB and EB destined to SP A to link sets DC and EC, respectively.

⁹ See T1.111.4-2001 for the value of timer.

Example 5: Failure of both A-links between an SP and a STP pair (Figure 20/T1.111.5)

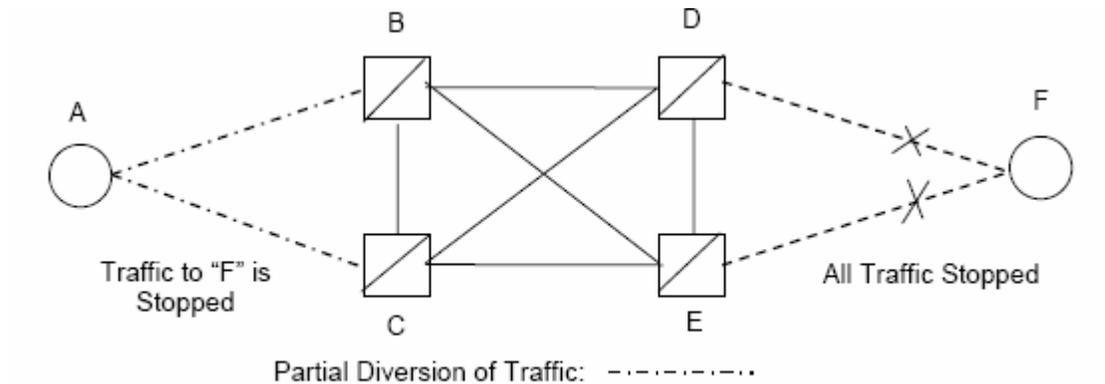


Figure 20/T1.111.5 Failure of Link Sets DF and EF

This example is very similar to Example 3 above. SP F is inaccessible by any other SP of the network. Therefore, SP F stops all outgoing signalling traffic, while SP A (and any other SP) stops its traffic destined to SP F.

7.3.2.2 Backbone Link Set Failure Examples

Example 1: Failure of an inter-Signalling Transfer Point link set (Figure 21/T1.111.5)

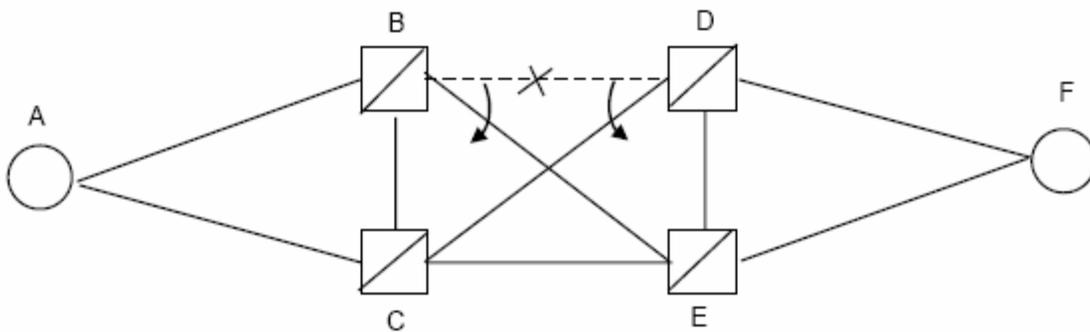


Figure 21/T1.111.5 Failure of Link Set BD

As indicated in table 1/T1.111.5, STP B diverts traffic from link set BD to link set BE. Similarly, STP D diverts traffic from link set DB to link set DC.

Example 2: Failure of C-links between an STP pair (Figure 22/T1.111.5)

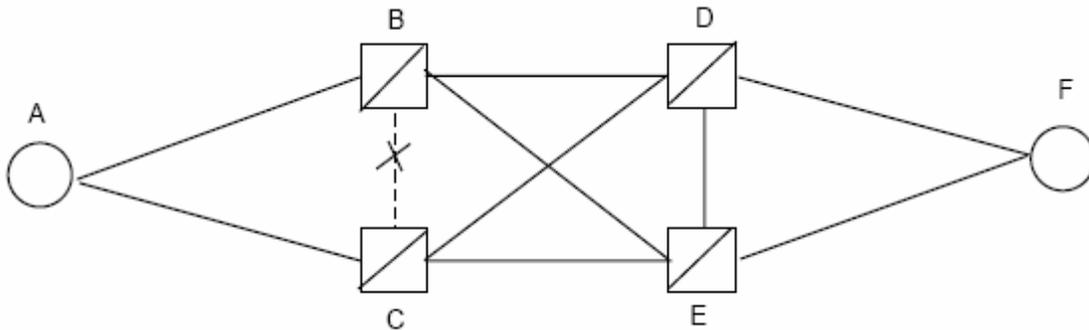


Figure 22/T1.111.5 Failure of Link Set BC (C-Links)

No routing change is required as a result of this kind of failure. Only STPs B and C take note that the link set BC has become unavailable.

7.3.2.2.3 Multiple Link Set Failure Examples

Since there are many cases in which more than one link set becomes unavailable, only some typical cases are given as examples.

Example 1: Failure of an A-link and C-link link set (Figure 23/T1.111.5)

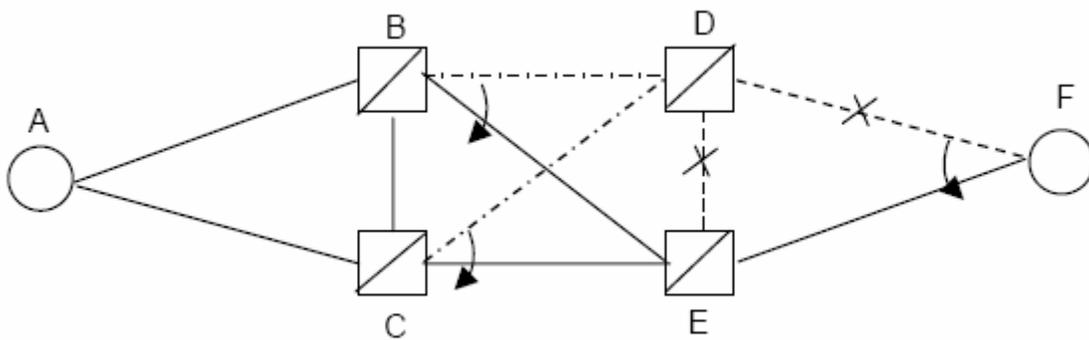


Figure 23/T1.111.5 Failure of Link Sets DE and DF

STP B diverts traffic destined to SP F from link set BD to link set BE, because destination F is inaccessible via STP D. It should be noted that not all traffic is diverted from link set BD to link set BE. Only the traffic destined to SP F is diverted from link set BD to link set BE. Similarly,

STP C diverts traffic destined to SP F from link set CD to link set CE. SP F diverts all the traffic formerly carried by link FD to link FE in the same way as the single link set failure in Example 4, clause 7.3.2.2.1.

Example 2: Failure of two inter-Signalling Transfer Point link sets (Figure 24/T1.111.5).

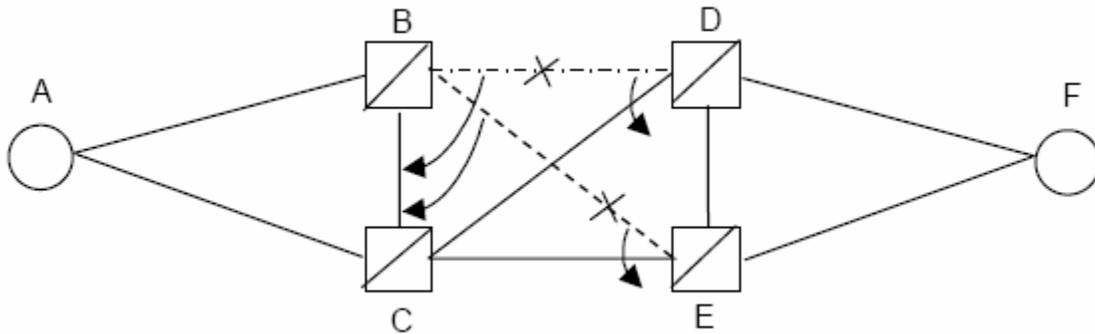


Figure 24/T1.111.5 Failure of Link Sets BD and BE

STP B diverts traffic formerly carried by link set DB to link set BC. This is because alternate link set BE, priority 1 is also unavailable. The same applies for the traffic formerly carried by link set BE. STPs D and E divert traffic formerly carried by link sets DB and EB to link sets DC and EC, respectively.

Should the failures exist for greater than timer T11¹⁰ an indication is sent from STP B to SP A to divert traffic destined to SP F from link set AB to link set AC.

¹⁰ See Chapter T1.111.4.

Example 3: Failure of an A-link link set and an inter-STP link set (Figure 25/T1.111.5).

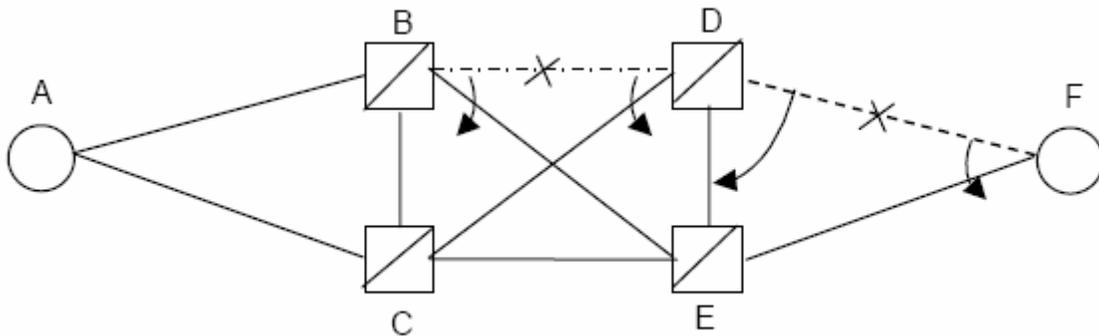


Figure 25/T1.111.5 Failure of Link Sets DF and DB

This example is a combination of Examples 4 and I in clauses 7.3.2.2.1 and 7.3.2.2.2, respectively. STP D diverts traffic formerly carried by link set DF to link set DE. Similarly, SP F diverts traffic from link set FE. Also, STP D diverts traffic formerly carried by link set DB to link set DC (this traffic is generated by all SPs connected to STP D). In the same way, STP B diverts traffic carried by link set BD to link set BE.

It should be noted that, in this case, only the portion of traffic sent by STP C to SP F via STP D transverses three STPs (C, D, and E), while all other portions continue to transverse two. Should the failure of link set DF exist longer than T11⁹ an indication is sent from STP D to STP C to divert traffic destined for SP F from link set CD to link set CE.

7.3.2.2.4 Single Signalling Point Failure Examples

Example 1: Failure of an STP (Figure 26/T1.111.5).

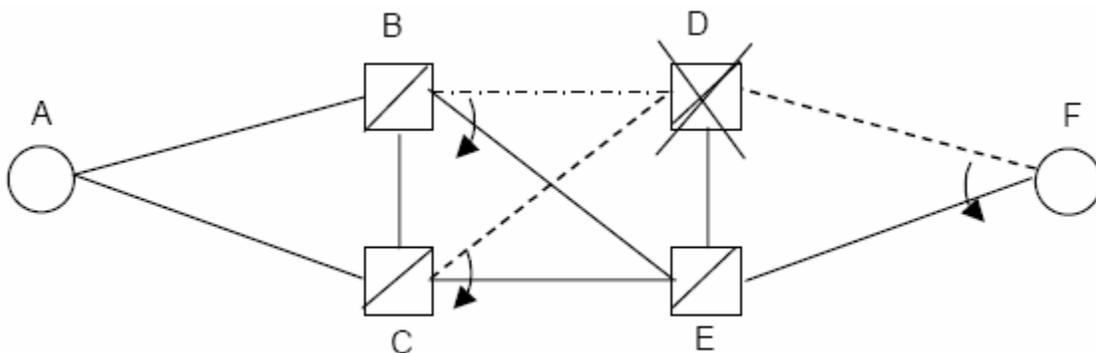


Figure 26/T1.111.5 Failure of STP D

STP B diverts all the traffic formerly carried by link set BD to link set BE. Similarly, STP C diverts all traffic carried by link set CD to link set CE. SP F diverts all traffic carried by link FD to link set FE. It should be noted that all SPs homed on STP pair D/E, of which SP F is one, must divert traffic from STP D to STP E.

Attention is drawn to the difference from Example 1 in clause 7.3.2.2.3 where only a portion of the traffic previously carried by links sets BD and CD was diverted.

Example 2: Failure of a signalling point (Figure 27/T1.111.5)

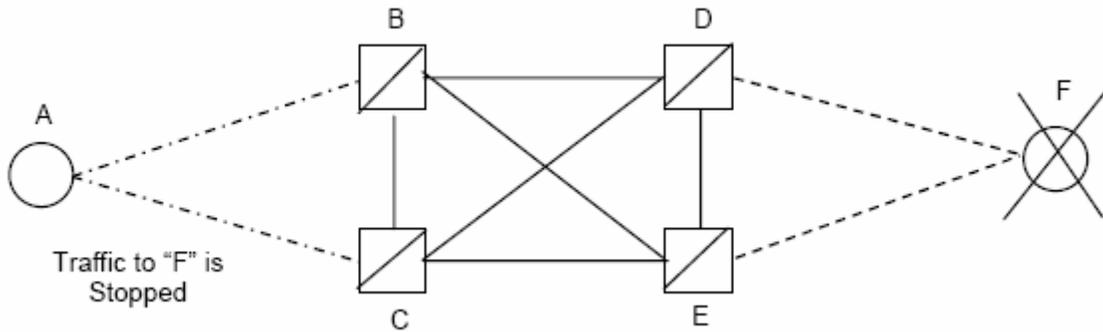


Figure 27/T1.111.5 Failure of Signalling Point F

In this case, SPA stops all the traffic destined for SP F formerly carried by link sets AB and AC.

7.3.2.2.5 Multiple Signalling Transfer Point Failure Examples

Two cases of two Signalling Transfer Points failing together are presented in the following examples.

Example 1: Failure of two non-mate STPs (Figure 28/T1.111.5).

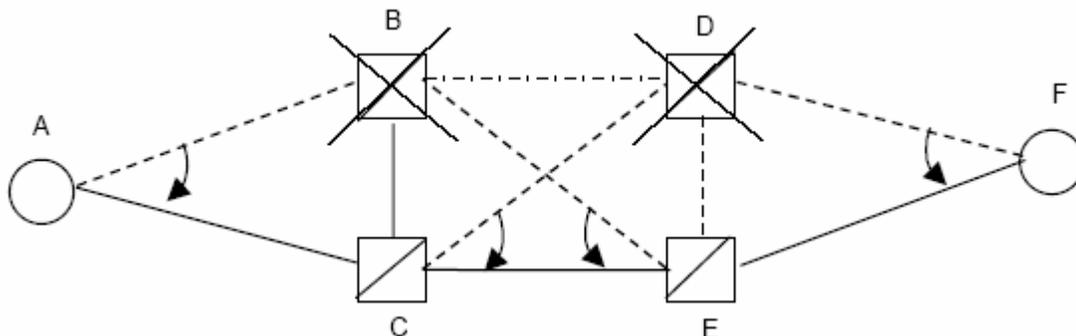


Figure 28/T1.111.5 Failure of Signalling Transfer Points B and D

As a result of the failure of STP B, SP A diverts traffic formerly carried by link set AB to link set AC, while STP E diverts traffic formerly carried by link set EB to link set EC. Similarly, as a result of the failure of STP D, SP F diverts traffic formerly carried by link set FD to link set FE, while STP C diverts traffic formerly carried by link set CD to link set CE.

It should be noted that, in this example, all the traffic between SPs home on STP pairs B/C and D/E is concentrated on only one inter-Signalling Transfer Point link set (failure of a Signalling Transfer Point is equivalent to a simultaneous failure of all the signalling link sets connected to it). Under normal engineered load, link set CE will congest in this case and notification of this may be sent to the SPs homing on the STP pairs B/C and D/E.

Example 2: Failure of a mated pair of Signalling Transfer Points (Figure 29/T1.111.5).

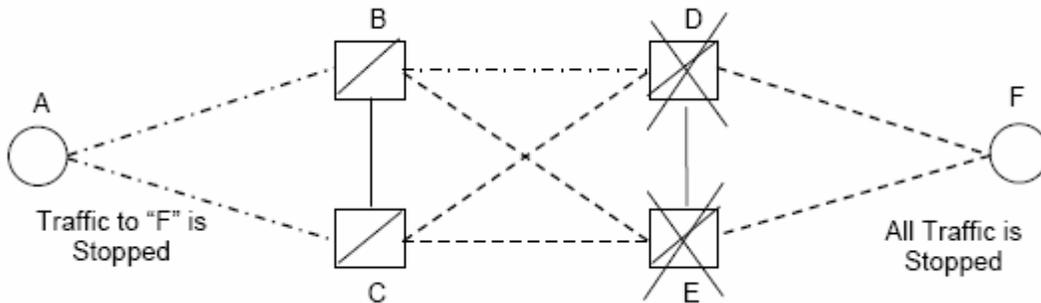


Figure 29/T1.111.5 Failure of Signalling Transfer Points B and D

This example is equivalent to Example 5 in clause 7.3.2.2.1 as far as the inaccessibility of SP F is concerned, but in this case, all SPs homed on the STP pair D/E (e.g., SP F) are inaccessible. SP A and STP pair B/C stop all signalling traffic destined to SPs homed on the failed STP pair D/E (e.g., SP F). SPs home on the failed STP pair D/E stop all outgoing signalling traffic.

7.4 Address Structure

The signalling point code structure is the same as described in clause 2.2.3A of T1.111.4 and is illustrated below in Figure 30/T1.111.5.

| Network Identification | Network Cluster | Network Cluster Member |
|------------------------|-----------------|------------------------|
| 8 bits | 8 bits | 8 bits |

Figure 30/T1.111.5 Signalling Point Code Structure

The Network Identification field identifies United States signalling networks. A few (see T1.111.8) of the Network Identification field codes have been reserved as an escape mechanism so that the Network Cluster field can also be used to identify smaller signalling networks.

The Network Cluster field identified groups of signalling points and individual STPs of a signalling network. This field could also be subdivided to support two levels of addressing and clustering, but this is left as a network option.

The Network Cluster Member field identifies individual signalling points within a cluster. clause 2.2.3D of T1.111.4 provides additional information regarding the encoding of member code zero in the Network Cluster Member field.

Table 4/T1.111.5 gives, as an example, the signalling point code assignments for the signalling points in the network model illustrated in Figure 31/T1.111.5. An arbitrary network identification code assignment of 00011010 was chosen for the network in this example.

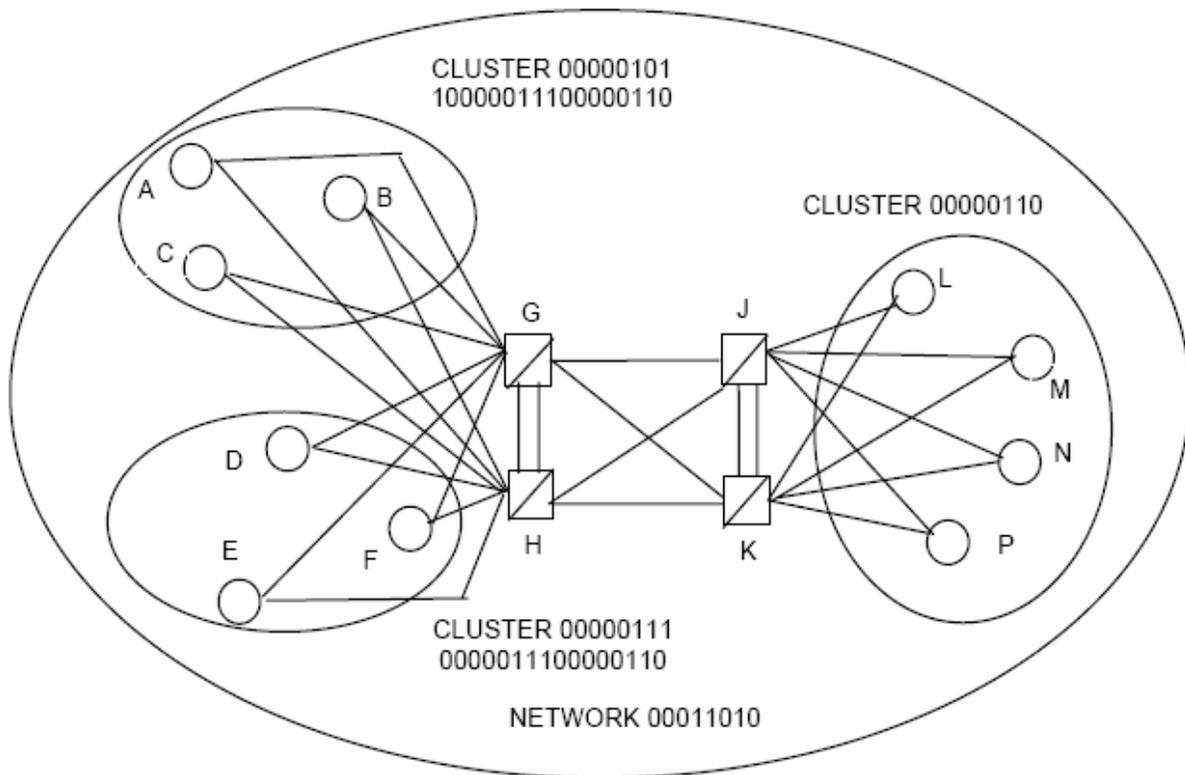


Figure 31/T1.111.5 Model to Illustrate Addressing of Signalling Points

Table 4/T1.111.5 Addressing of Signalling Points for the Model in Figure 31/T1.111.5

| Signalling Point | Signalling Point Code | | |
|------------------|-----------------------|----------|----------|
| | Network | Cluster | Member |
| G | 00011010 | 00000001 | 00000000 |
| H | 00011010 | 00000010 | 00000000 |
| J | 00011010 | 00000011 | 00000000 |
| K | 00011010 | 00000100 | 00000000 |
| A | 00011010 | 00000101 | 00000001 |
| B | 00011010 | 00000101 | 00000010 |
| C | 00011010 | 00000101 | 00000011 |
| L | 00011010 | 00000110 | 00000001 |
| M | 00011010 | 00000110 | 00000010 |
| N | 00011010 | 00000110 | 00000011 |
| P | 00011010 | 00000110 | 00000100 |
| D | 00011010 | 00000111 | 00000001 |
| E | 00011010 | 00000111 | 00000010 |
| F | 00011010 | 00000111 | 00000011 |

8 PROCEDURES TO PREVENT UNAUTHORIZED USE OF AN STP

8.1 General

Administrations may make bilateral agreements to operate SS7 between their networks. These agreements may place restrictions on SS7 messages authorized for one administration to send to the other. Restrictions could be made, for example, in the interest of network security or as a result of service restrictions. Unauthorized signalling traffic may be, for example, STP traffic for calls set up via networks other than that containing the STP, which has not been agreed bilaterally.

An Administration making an agreement with restrictions may wish to identify and provide special treatment to unauthorized SS7 messages.

The measurements in table 6/T1.111.5 (see T1.111.5 Signalling System Number 7 (SS7) - Monitoring and Measurements) provide some capability to identify unauthorized SS7 messages. The procedures in this clause for identifying and responding to unauthorized traffic are additional options for use at an STP with signalling links to other networks.

8.2 Identifying Unauthorized SS7 Messages

In addition to the normal signalling message handling, procedures specified in T1.111.4, it shall be possible to inhibit/allow messages destined for another signalling point (SP) based on any one or combination of the following options to:

1. inhibit/allow STP access by a combination of designated incoming link sets to designated DPCS, this combination of DPC/incoming link set shall effectively operate in the form of a single matrix. This matrix shall consist of a maximum of 128 DPCs and a maximum of 64 incoming link sets. (These values are for guidance and may be adjusted to satisfy the requirements of the concerned Operator/ Administration.)
2. inhibit/allow STP access by a combination of designated outgoing link sets to designed DPCS, this combination of DPC/outgoing link set shall effectively operate in the form of a single matrix. This matrix shall consist of a maximum of 128 DPCs and a maximum of 64 outgoing link sets. (These values are for guidance and may be adjusted to satisfy the requirements of the concerned Operator/ administration.)
3. inhibit/allow STP access by examination of OPC and DPC combination in the incoming message. This combination of DPC/OPC shall effectively operate in the form of a single matrix. This matrix shall consist of a maximum of 128 DPCs and a maximum 128 OPCS. (These values are for guidance and may be adjusted to satisfy the requirements of the concerned Operator/ Administration.)

8.3 Treatment of Unauthorized SS7 Messages

An STP identifying unauthorized SS7 messages should be able, on a link set or per signalling point code basis, to:

1. provide all unauthorized SS7 messages with the same handling as authorized traffic, or
2. discard all unauthorized SS7 messages.

In addition, an STP should be able to:

1. allow all STP messages outside the designated ranges as given in 8.2,
2. bar (discard) all STP messages outside the designated ranges as given in 8.2.

8.4 Measurements

An STP identifying unauthorized SS7 messages incoming from another network should be able to count and record details of the unauthorized messages on a per link set and/or signalling point code basis.

8.5 Notification to Unauthorized User

An STP identifying unauthorized SS7 messages from another network may wish to notify the Administration originating the unauthorized message(s).

This notification should be undertaken by administrative means and not involve any mechanism in Signalling System No. 7.

In addition, a violation fault report shall be issued giving the unauthorized message content. It shall be possible to selectively restrict the number of violation reports on a link set and/or signalling point code basis.

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It shall also be possible to inhibit the violation reporting mechanism on a point code/link set basis, nodally, or on a message direction basis (i.e., if an inhibited message is destined for a network then it shall be possible to suppress the violation reports while allowing violation reports on inhibited messages from that network).

Annex A¹¹
(normative)

A SS7 NETWORK SIGNALLING MESSAGE PRIORITIES

A.1 Scope, Purpose and Application

T1.111.4 requires the assignment of each SS7 message to one of four congestion priorities (0 through 3, with 3 being the highest) and provides procedures that limit offered loads to the current capacity of each signalling route by selectively controlling messages according to the priority of each. This Annex contains the requirements for the assignment of these signalling message priorities and gives specific priority assignments for messages to be transferred between U.S. SS7 networks. These priority assignments are also suitable for use within such networks and it is strongly suggested that network providers give consideration to adhering to the message priorities assigned below within their own networks.

A.2 Administration of Signalling Message Priorities

As new messages and their associated priorities are incorporated into these SS7 Standards, and as experience with SS7 networks leads to modification of these initial allocations of message priorities, this Annex will be reissued to reflect the latest ANSI supported agreements.

New services based on the SS7 protocol shall specify their message priority needs in the appropriate service descriptions.

A.3 Message Priority Assignment

The message priority for ISUP, SCCP, OMAP, and MTP messages, by message type, given in tables A1/T1.111.5 to A4/T1.111.5, respectively, shall be used across network boundaries. If bilateral agreements are negotiated to change these priorities, the involved administrations are strongly urged to inform the developer of this standard of such changes.

¹¹ This Annex and the following annexes are not present in ITU-T Rec. Q.705. For reasons of formatting redundancy, the entire Annex will not be marked with "*" to indicate differences.

Table A.1/T1.111.5 - Annex A - Priority Assignments For ISUP Messages

| Message Type | | Priority |
|--------------|--|-------------------|
| ACM | Address Complete | 1 |
| ANM | Answer | 2 |
| APM | Application Transport | 0-1 ¹² |
| BLA | Blocking Acknowledgement | 0 |
| BLO | Blocking | 0 |
| CCR | Continuity Check Request | 1 |
| CFN | Confusion | 0 |
| CGB | Circuit Group Blocking | 0 |
| CGBA | Circuit Group Blocking Acknowledgement | 0 |
| CGU | Circuit Group Unblocking | 0 |
| CGUA | Circuit Group Unblocking Acknowledgement | 0 |
| COT | Continuity | 1 |
| CPG | Call Progress | 1 |
| CQM | Circuit Query | 0 |
| CQR | Circuit Query Response | 0 |
| CRA | Circuit Reservation Acknowledgement | 0 |
| CRM | Circuit Reservation | 0 |
| CVR | Circuit Validation Response | 0 |
| CVT | Circuit Validation Test | 0 |
| EXM | Exit (Intra Network Applications Only) | - |
| FAC | Facility | 1-2 ¹³ |
| FOT | Forward Transfer | 1 |
| GRA | Circuit Group Reset Acknowledgement | 0 |
| GRS | Circuit Group Reset | 0 |
| IAM | Initial Address | 0* |
| INF | Information | 1 |
| INR | Information Request | 1 |
| LPA | Loop Back Acknowledgement | 1 |
| PAM | Pass Along | 0-2 ¹⁴ |
| PRI | Pre-Release Information | 0 |
| REL | Release | 1 |
| RES | Resume | 1 |
| RLC | Release Complete | 2 |
| RSC | Reset Circuit | 0 |
| SGM | Segmentation | 0 ¹⁵ |
| SUS | Suspend | 1 |
| UBA | Unblocking Acknowledgement | 0 |
| UBL | Unblocking | 0 |
| UCIC | Unequipped Circuit Identification Code | 1 |

¹² The default value is "0". Criteria for assigning a value other than "0" is for further study.

¹³ Further study is needed on the exact assignment of a priority to the facility message. An assignment of 0 or 1 is given for guidance until complete service and network capability uses and needs of the facility message are determined.

¹⁴ Assigned the priority of the message it contains.

¹⁵ The default value is "0". Criteria for assigning a value other than "0" is for further study.

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NOTE - Message priority level 1 shall be limited to those network services or capabilities that have been approved in ANSI TI standards to have an IAM message priority of 1 (e.g., High Probability of Completion, Multi-level Precedence and Preemption, Emergency Calling Service).

Table A.2/T1.111.5 - Annex A -Priority Assignments For SCCP Messages

| Message Type | | Priority |
|--------------|----------------------------------|-------------------|
| AK | Acknowledgement | 0-1 ¹⁶ |
| CC | Connection Confirm | 1 |
| CR | Connection Request | 0-1 ¹⁶ |
| CREF | Connection Refused | 1 |
| DTI | Data Form I | 0-1 ¹⁶ |
| DT2 | Data Form 2 | 0-1 ¹⁶ |
| EA | Expedited Data Acknowledgement | 1 |
| ED | Expedited Data | 1 |
| ERR | Error | 1 |
| IT | Inactivity Test | 1 |
| LUDT | Long Unit Data | 0-2 ¹⁷ |
| LUDTS | Long Unit Data Service | 0-2 ¹⁷ |
| RLC | Release Complete | 2 |
| RLSD | Released | 2 |
| RSC | Reset Confirmation | 1 |
| RSR | Reset Request | 1 |
| SBR | Subsystem-Backup-Routing | 0 |
| SNR | Subsystem-Normal-Routing | 0 |
| SOG | Subsystem-Out-Of-Service-Grant | 1 |
| SOR | Subsystem-Out-Of-Service-Request | 1 |
| SRT | Subsystem-Routing-Status-Test | 0 |
| SSA | Subsystem-Allowed | 3 |
| SSP | Subsystem-Prohibited | 3 |
| SST | Subsystem-Status-Test | 2 |
| UDT | Unit Data | 0-2 ¹⁷ |
| UDTS | Unit Data Service | 0-2 ¹⁷ |
| XUDT | Extended Unit Data | 0-2 ¹⁷ |
| XUDTS | Extended Unit Data Service | 0-2 ¹⁷ |

¹⁶ The priority of corresponding messages should match that of the connection request. Selection of priorities within the given range is application dependent.

¹⁷ Priority 2 is reserved for OMAP use. Selection of priorities 0 and 1 is application dependent. Priority 2 is also reserved for application use in support of calls limited to those network services or capabilities that have been approved in ANSI TI standards to have an IAM message priority of 1 (e.g., High Probability of Completion, Multi-level Precedence and Preemption).

Table A.3/T1.111.5 - Annex A - Priority Assignments For OMAP Messages

| Message Type | | Priority |
|--------------|---|-----------------|
| BULK | OMAP Bulk Data Transfer (for further study) | 0 |
| FTA | Facility Test Acknowledgement | 2 |
| FIFL | Facility Test Loopback | 2 |
| FTR | Facility Test Results | 2 |
| FTU | Facility Test Underway | 2 |
| LEA | Link Equipment Available | 2 |
| LEU | Link Equipment Unavailable | 2 |
| MRVA | MTP Routing Verification Acknowledgement | 2 ¹⁸ |
| MRVR | MTP Routing Verification Result | 2 ¹⁴ |
| MRVT | MTP Routing Verification Test | 2 ¹⁴ |
| SRVA | SCCP Routing Verification Acknowledgement | 2 ¹⁴ |
| SRVR | SCCP Routing Verification Result | 2 ¹⁴ |
| SRVT | SCCP Routing Verification Test | 2 ¹⁴ |

¹⁸ Priority level 3 may be used optionally for intranetwork MRV and SRV messages when severe network conditions, such as congestion due to a routing problem, do not allow the test to run at priority 2.

Table A.4/T1.111.5 - Annex A - Priority Assignments For MTP Messages

| Message Type | | Priority |
|--------------|---|-------------------|
| CBA | Changeback-Acknowledgement Signal | 3 |
| CBD | Changeback-Declaration Signal | 3 |
| CNP | Connection-Not-Possible Signal | 3 |
| CNS | Connection-Not-Successful Signal | 3 |
| COA | Changeover-Acknowledgement Signal | 3 |
| COO | Changeover-Order Signal | 3 |
| CSS | Connection-Successful Signal | 3 |
| DLC | Data-Link-Connection-Order Signal | 3 |
| ECA | Emergency-Changeover-Acknowledgement Signal | 3 |
| ECO | Emergency-Changeover-Order Signal | 3 |
| LFU | Link Force Uninhibit Message | 3 |
| LIA | Link Inhibit Acknowledgement Message | 3 |
| LID | Link Inhibit Denied Message | 3 |
| LIN | Link Inhibit Message | 3 |
| LLI | Link Local Inhibit Signal | 3 |
| LRI | Link Remote Inhibit Test Signal | 3 |
| LUA | Link Uninhibit Acknowledgement | 3 |
| LUN | Link Uninhibit Message | 3 |
| RCP | Route-Set-Test Cluster Prohibited Signal | 3 |
| RCR | Route-Set-Test Cluster Restricted Signal | 3 |
| RCT | Route-Set-Congestion-Test Signal | 0-2 ¹⁹ |
| RSP | Route-Set-Test Prohibited Signal | 3 |
| RSR | Route-Set-Test Restricted Signal | 3 |
| SLT | Signalling-Link Test Message | 3 |
| SLA | Signalling-Link Test Acknowledgement | 3 |
| TCA | Transfer-Cluster-Allowed Signal | 3 |
| TCP | Transfer-Cluster-Prohibited Signal | 3 |
| TCR | Transfer-Cluster-Restricted Signal | 3 |
| TFA | Transfer-Allowed Signal | 3 |
| T'FC | Transfer-Controlled Signal | 3 |
| T'FP | Transfer-Prohibited Signal | 3 |
| T'FR | Transfer-Restricted Signal | 3 |
| T'RA | Traffic-Restart-Allowed Signal | 3 |
| TRW | Traffic-Restart-Waiting Signal | 3 |
| UPU | User Part Unavailable Signal | 3 |

¹⁹ Priority assignment is always one less than current congestion level.

Annex B

(informative)

B RATIONALE FOR SELECTED MESSAGE PRIORITIES

B.1 Principles of Priority Assignment

In order to maintain long-term consistency in supporting congestion control strategies in SS7 networks, the following principles should be used to direct the future assignment of signalling message priorities. Generally;

1. The priority of messages that would result in a future demand on or allocation of resources in the signalling network should be less than or equal to the priority of messages that provide for the confirmation, completion, or release of resources previously allocated.
2. Service initiating messages should be restricted to priority level 0.
3. Larger messages should be given lower priority.
4. A message generated as a direct result of a received message should have the same or higher priority as the received message, except when explicitly stated otherwise in the standards, e.g., MTP Route Set Congestion Test Signals.

B.2 Additional Guidelines

The integrity of the SS7 network should be the primary consideration when assigning signalling message priorities. The following guidelines are given for consideration when preparing service descriptions and the inclusion of new message types in the various protocols:

1. The assignment of message priorities should support a rapid and graceful recovery from a congestion condition in the signalling network.
2. Message priorities should be assigned so as to maximize signalling network throughput during a congestion condition.
3. The message priority assignment structure should not increase the possibility of signalling network congestion.

B.3 MTP Messages

MTP messages, with a one exception, shall all be assigned priority level 3. This is directly supported by the existing standards. The exception is Signalling-Route-Set-Congestion-Test Signal.

As provided for in the standards, the Route Set Congestion Test Signal messages can have a priority of 0, 1, or 2. When generated, these messages are to be sent out with a priority of one less than the current congestion level.

B.4 *SCCP Messages*

Four major classes of SCCP messages are:

- ◆ Subsystem Prohibited, Allowed, and Status Test Messages.
- ◆ Subsystem Out-Of-Service Request and Grant Messages.
- ◆ Subsystem Normal Routing, Backup Routing, and Routing Status Test Messages.
- ◆ SCCP Connection Oriented and Connectionless Service Messages.

For the first class, if congestion in the signalling network resulted from the failure of a large subsystem, traffic to other subsystems can be directly impacted. Therefore, in these situations, the SCCP Subsystem Prohibited (SSP) message may provide significant traffic reduction benefits. This, in turn, may restore normal levels of service to those other subsystems. In the ANSI standards, an SSP message is broadcast once to the appropriate SCCP peers. Assigning SSP messages to priority level 3 should not generate enough traffic to degrade MTP management of the signalling network while providing traffic reduction benefits.

Subsystem Allowed (SSA) messages are the vehicle to restore normal signalling operation to a subsystem. This recovery process should have the same priority as the SSP process in order to prevent over control and restore service in an expeditious manner. Since the ANSI standards provide for the broadcast of a single SSA to the appropriate SCCP peers, assigning SSA messages to priority level 3 should not generate enough traffic to degrade MTP management of the signalling network.

In response to a received SSP, Subsystem Status Test (SST) messages are generated. These SST messages are sent out repetitively until a test result of allowed is received. Since this is a "fail safe" procedure and could increase the signalling network load, the priority of SST messages should be set at level 2.

The second class of messages (Subsystem Out-Of-Service Request and Subsystem Out-Of-Service Grant) are viewed as being initiated by manual procedures as part of subsystem administration. Assigning a low priority may require a limited number of procedure restarts but this should not seriously impact this manual procedure. Therefore, these two messages are assigned priority level 1.

The third class of messages (Subsystem Backup Routing, Subsystem Normal Routing, and Subsystem Routing Status Test) are seen as "information" messages that can be delayed or be reinitiated without adverse operational impact. These messages are all assigned a priority level of 0.

The last class of Connection Oriented and Connectionless SCCP service messages are considered as priority level wise, a near equivalent to the ISDN-UP establishment of a circuit call. As such, the principles and considerations in this Annex fully apply. In particular, the initiation of service, with the associated allocation of resources in the signalling network, should be restricted to levels 0 and 1. Priority level 2 may be used for applications in support of calls limited to those network services or capabilities that have been approved in ANSI TI standards to have an IAM message priority level of 1 (e.g., High Probability of Completion, Multi-level Precedence and Preemption). Service confirmation, completion, and release messages are assigned to priority levels of an equal or higher value. Since Released and Release Complete

were both seen as directly freeing signalling network resources, they were considered important enough to both be assigned to priority level 2. SCCP messages should receive the same priority level as the corresponding OMAP messages they are carrying.

B.5 ISUP Messages

Trunk maintenance messages should not be given a priority higher than 0. Consider the flow of traffic between two networks that conforms to the recommended message distribution. If the interconnecting signalling network were in a congestion state of one, then most of the Initial Address Messages (IAMS) between the networks would be blocked. It is therefore counterproductive to have trunk maintenance messages at priority one since this may prolong the duration of or increase the level of congestion and further degrade the through put of IAMS and also effect calls already in progress. Simply put, in the face of signalling network congestion, providing a perfectly managed trunk network does not make sense.

All circuit maintenance messages should be given the lowest priority on the belief that they could all be temporarily deferred during a congestion situation.

Requests for initiating service -- i.e., IAMs -- with the anticipated future demand on resources in the signalling network, should be restricted to level 0. However, message priority level 1 for IAMs shall be limited to those network services or capabilities that have been approved in ANSI T1 standards to have an IAM message priority of 1 (e.g., High Probability of Completion, Multi-level Precedence and Preemption, Emergency Calling Service). Messages that are associated with the continuation of calls for which the IAM has already been sent were then assigned to priority levels of an equal or higher value.

Circuit Reservation Messages (CRMS) are triggered when a multifrequency call is interworked to the ISDN-UP. The received information is insufficient to determine what priority the Information Digits (or other received information) might convey for the call. Therefore, lacking this added information, there is no choice but to assign the CRM to priority level 0.

Pass Along Messages (PAMS) are the only way to communicate information or requests end-to-end in the SS7 network when there is no call reference. Since the PAM functions as an "envelope" for other SS7 messages, the PAM should be given the priority of the message it contains.

For unstable calls -- i.e., calls for which no Address Complete Message (ACM) [or Answer Message if no ACM] has been received -- the receipt of an Unequipped Circuit Identification Code (UCIC) message triggers the switch to release the identified circuit. Since the receiving switch does not expect a subsequent Release message for that circuit, the two messages are functionally the same. Therefore, the UCIC message should have the same priority as the Release message, namely, priority level 1.

The standards require the periodic resending of Release messages if a Release Complete message is not received. Since Release messages can be long while Release Complete messages are short, it is important that the extra signalling load of multiple Release messages be avoided as much as possible. Therefore, the Release Complete message type is assigned to priority level 2.

To achieve the distribution of messages included in the "Principles of Priority Assignment," either the Answer or Release message types should be assigned to priority level 2. Since Answer messages are central to call connection and charging and the procedures associated with timing out awaiting answer would generate additional signalling load, Answer messages are assigned to priority level 2.

The Circuit Group Reset and Circuit Group Reset Acknowledgement messages are assigned level 0 since the former is specified to be repeated automatically every 4 to 15 seconds if lost and may, in some cases, result in the generation of numerous Blocking or Circuit Group Blocking messages from the exchange that sends the Circuit Group Reset Acknowledgement message.

B.6 OMAP Messages

Normal screening at the network gateway Signal Transfer Points would not allow MTP Routing Verification Test (MRVT) messages to have a level 3 assignment. If the congestion was a result of a routing problem, the MRVT messages should have a high enough priority to have a reasonable chance at getting through and having the test results returned. Therefore the MTP Routing Verification Test, MTP Routing Verification Result, and MTP Routing Verification Acknowledgement message types are all assigned priority level 2.¹⁴ A similar argument results in a similar assignment for those messages associated with the SCCP Routing Verification Test procedure.

Link Equipment Failure and Link Fault Sectionalization messages are used to isolate and sectionalize terminal equipment failures in the signalling network as the first step in restoring normal operation as quickly as possible. Since such failures may cause congestion in other parts of the network, the messages that support rapid sectionalization must be able to route through the network in spite of congestion. Facility Test Underway, Facility Test Loopback, Facility Test Acknowledgement, and Facility Test Results messages are assigned priority level 2.

B.7 Distribution of Message Priorities

The goal of having various MTP messages priorities is to achieve the distribution as shown below in Table B.1/T1.111.5.

Table B.1/T1.111.5 - Annex B Network Signalling Message Distribution

| Priority | Percent of Total Messages |
|-----------------|----------------------------------|
| 3 | 0 - 5 |
| 2 | 0 - 20 |
| 1 | 30 - 45 |
| 0 | 30 -45 |

Annex C

(informative)

C ROUTING METHODS

C.1 Introduction

There are two basic methods for routing messages based on the Destination Point Code (DPC) in the MTP routing label. The first method examines the entire DPC to determine how the message is to be routed. This requires the node to know the DPC and maintain its routing status. The second method only examines part of the DPC to determine how the message is to be routed. This method only requires the node to know enough of the DPC (e.g., the network node) to be able to determine the route the message is taken. The rest of the DPC's address is unknown to the node and hence routing status would not be maintained for these addresses.

The remainder of this Annex discusses the second routing method that bases its routing on only parts of the DPC. The signalling point codes used in the examples are symbolic and were derived from the CCS network model illustrated in Figure 31/T1.111.5 and table 4/T1.111.5.

C.2 Routing Method Description

The routing method discussed in this Annex provides the ability to route signalling messages on part

of the Destination Point Code (DPC) instead of using the entire point code in all cases. This routing method is very similar to the method used by Switching Offices for call setup. For example, in call setup, the trunk groups towards a destination are selected based on part of the called address (i.e., the dialed digits). Initially, some Switching Offices may examine only the NPA (i.e., area code), others may examine only the NXX (i.e., central office code), and the terminating Switching Office may only need to examine the XXXX (i.e., station number).

For CCS network nodes, they only need to examine parts of the "address" (i.e., DPC) until there is sufficient information to route the message in the direction of its final destination. Examining the whole address is not needed in the majority of cases.

This routing method also has the ability that it can allow some signalling points to substantially reduce their routing database (and status database). Since the method only requires the examination of part of the DPC for routing, nodes may not necessarily need to maintain routing status information for entire point codes. If a node does not maintain the complete status for an entire point code, then that point code is "unknown" to the node (hence, the creation of the term: the "unknown" point node). But signalling message may still be routed to an unknown point code from a node if the node has a default route associated with either the unknown point code's network or cluster.

C.3 Routing Model

The following is a brief model of the routing method described above. The model assumes that if a Global Title Translation was needed, then it was performed first.

- ◆ Step 1: The Network code of the DPC is examined.
 - If a route does not exist for the Network code then proceed to the next step. Otherwise, the message is routed based on the Network code's route (i.e., a default route for all nodes of a network).
- ◆ Step 2: The Cluster code of the DPC is examined.
 - If a route does not exist for the Cluster code then proceed to the next step. Otherwise, the message is routed based on the Cluster code's route (i.e., a default route for all nodes of a cluster). At this point some cluster status information may be known.
- ◆ Step 3: The Member code of the DPC is examined.

At this point, some Member codes (of a network cluster) may have some routing status information and a route associated with them. The rest of the Member codes may either:

 - have a default route associated with them (node does not maintain any routing status information for these specific members of this network cluster or
 - be invited (node does maintain routing status information for the members of this network cluster), in which case, the current routing error procedures are initiated.

In Step 1, it may be required of the STPs to verify that the network code is an "assigned" or authorized network code. If the network is not an assigned or authorized code and the message is being routing at the MTP level, the message should be discarded. The verification of the network codes can be optional at Signalling End Points.

An example of Step I at a Signalling End Point (SEP) could be for all network codes to have a default route except for the SEP's own network code. In this case, more of the DPC needs to be examined (i.e., the cluster code) to determine if the message is destined for one of the SEP's home STPs.

The Signalling Connection Control Part (SCCP) also performs a pre-routing function and this routing method can also be used by the SCCP. If at the SCCP level it is determined that a message cannot be routed (passed to the MTP for routing), then the routing failure procedures should be initiated.

The routing model is further illustrated in Figures B1/T1.111.5 and B2/T1.111.5. These figures also illustrate the "minimal routing status information" needed by signalling nodes. This topic is discussed in the next clause. Figures B1/T1.111.5 and B2/T1.111.5 use the network model illustrated in Figure 31/T1.111.5. Figure B1/T1.111.5 illustrates an example of a routing database at an SEP. Figure B2/T1.111.5 illustrates an example of a routing database at an STP. These figures are only examples and they do not represent all of the possible cases.

C.4 Minimal Routing Status Information for Signalling Points

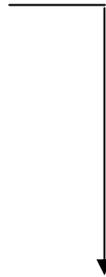
In the clauses above, it was mentioned that by using this routing method, signalling points may be able to maintain a smaller routing database. This clause proposes a minimal set of network, cluster, and signalling point routing status information needed by every signalling point. This minimal set of routing status information differs for each type of a signalling point in the network. The "rule-of-thumb" used is that a minimal set of routing status information must contain at least all of the signalling points that are connected to a node.

The following is a list of the different signalling point types and their minimal set of routing status information.

1. Signalling End Points (SEPS) - Switching Offices:
 - a. The Switching Office's home STP pair.
 - b. All STPs (including their alias point code) that directly provide Global Title Translation services for the node. If the home STP pair provides all of the nodes direct Global Title Translation needs, then only the status of the STP pair's alias point code is needed.
 - c. Desirable but optional - All other Switching Offices that have a direct signalling relation with the node. For example, the other Switching Offices that have trunks directly connecting to the node.
 - d. Optional - Other members of the node's cluster.
 - e. Optional - Other clusters of the node's network.
 - f. Optional - Other networks.
2. Signalling End Points (SEPS) - Network Databases:
 - a. The Network Database's backup (if applicable).
 - b. The Network Database's home STP pair.
 - c. All STPs (including their alias point code) that directly provide Global Title Translation services for the node. If the home STP pair provides all of the nodes direct Global Title Translation needs, then only the status of the STP pair's alias point code is needed.
 - d. Optional - Other members of the node's cluster.
 - e. Optional - Other clusters of the node's network.
 - f. Optional - Other networks.
3. Signalling Transfer Points (STPs):
 - a. All signalling points (Switching Offices, Network Databases, and other STPs) that directly connect to the STP via signalling links.
 - b. All "assigned" networks that the STP's network is authorized to have signalling communication with.
 - c. All other STPs (including their alias point code) that may provide some additional Global Title Translation services for the STP (e.g., Global Title traffic bound for other networks).
 - d. Optional - Other clusters of the STP's network.

Network Table

| Network Code | Route/ More Info Needed |
|--------------------|-------------------------------|
| node A's network | more info needed |
| all other networks | default |



Node A's Network - Cluster Table

| Network Cluster Code | Cluster Status | Route/ More Info Needed |
|---------------------------|-------------------|-------------------------------|
| 0000 000 I (STP G) | allowe d | route 1 |
| 0000 0010 (STP H) | allowe d | route 2 |
| ? (STPs G & H's alias) | allowe d | route 3 |
| all other clusters | N/A | default |

Figure C.1/T1.111.5 Routing Database Example for Node A

Network Table

| Network Code | Route/ More Info Needed |
|--------------------|----------------------------|
| STP J's network | more info needed |
| all other networks | default |

STP J's Network - Cluster Table

| Network Cluster Code | Cluster Status | Route/ More Info Needed |
|----------------------|----------------|----------------------------|
| 0000 0 1 00 (STP K) | allowed | route 10 |
| 0000 000 I (STP G) | allowed | route 11 |
| 0000 0010 (STP H) | allowed | route 12 |
| 0000 0110 | allowed | more info needed |
| All other clusters | N/A | default |

Cluster 0000 0110 - Member Table

| Member Code | Status | Route |
|-------------------|------------|----------|
| 0000 0001 (L) | allowed | route 20 |
| 0000 0010 (M) | prohibited | route 21 |
| 0000 0011 (N) | congested | route 22 |
| 0000 0100 (P) | allowed | route 23 |
| All other members | N/A | no route |

Figure C.2/T1.111.5 Routing Database Example for STP J

Chapter T1.111.6

Message Transfer Part Signalling Performance

EDITORIAL NOTE – In this Chapter, all page numbers are in the format **T1.111.6-#**.

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Signalling System Number 7 (SS7) – Message Transfer Part Signalling Performance

1 SCOPE, PURPOSE, & APPLICATION¹

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 service 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 that 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:

1. 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.
2. The second group covers the features of the signalling traffic, such as the loading potential and the structure of the signalling traffic.
3. The third group covers the given environmental influences, such as the characteristics (e.g., error rate and proneness to burst) 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.

This chapter may contain requirements that reference other American National Standards. If so, when the American National Standards referenced in the requirements are superseded by revisions approved by the American National Standards Institute, Inc. the revisions shall apply.

¹ A "|" indicates a change from T1.111-2001. In actuality, there are no changes from that document, other than this footnote and the header change to reflect 2005 instead of 2001.

2 BASIC PARAMETERS RELATED TO MESSAGE TRANSFER PART

Signalling performance is defined by a great number of different parameters. In order to ensure a proper signalling performance for all users to be served by the common Message Transfer Part, the following design objectives are established for the Message Transfer Part.

2.1 *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 availability of a signalling route set within a signalling network may be improved by replication of signalling links, signalling paths, and signalling routes.

2.2 *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, mis-sequencing and loss of messages in the Message Transfer Part cannot be excluded in extreme cases.

For all users, the following conditions are guaranteed by the Message Transfer Part:

1. *Undetected Errors.* On a signalling link employing a signalling data link, which has the error rate characteristic as described in Chapter T1.111.2-2001, not more than one in 10^9 of all signal unit errors will be undetected by the Message Transfer Part.
2. *Loss of Messages.* Not more than one in 10^7 messages will be lost due to failure in the Message Transfer Part.
3. *Messages Out-of-Sequence.* Not more than one in 10^{10} messages will be delivered out-of-sequence to the users due to failure in the Message Transfer Part. This value also includes duplication of messages.

2.3 *Message Transfer Times*

This parameter includes:

1. Handling times at the signalling points (see Implementors' Guide for ITU-T Rec. Q.706)
2. Queueing delays including retransmission delays (see Implementors' Guide for ITU-T Rec. Q.706)
3. Signalling data link propagation times

2.4 *Signalling Traffic Throughput Capability*

Needs further study (see 3.2).

3 SIGNALLING TRAFFIC CHARACTERISTICS

3.1 *Labeling Potential*

The design of Signalling System No. 7 provides the potential for labels to identify 16,777,216 signalling points (24 bits). For each of the upper layer entities identified by the 4 bit service indicator or other means for distribution a number of user transactions may be identified -- e.g., in the case of the ISDN capability up to 16,384 speech circuits.

3.2 *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 that is acceptable from different points of view.

When determining the normal load of the signalling channel, the need to ensure a sufficient margin for peak traffic loads shall be taken into account.

The loading of signalling channel is restricted by several factors, which are itemized below.

3.2.1 **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 Implementors' Guide for ITU-T Rec. Q.706).

3.2.2 **Security Requirements**

The most important security arrangement is redundancy in conjunction with changeover. As load sharing may be 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 predetermined link but also in the case of load distribution to the remaining links.

3.2.3 **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 for MTP level 2. For SAAL links, the use of 24 bits for sequence numbering limits the number of Sequenced Data PDUs sent but not yet acknowledged to the value of 16,777,215.

In practice this will not impose a limitation on the loading potential.

3.2.4 Signalling Channels Using Lower Bit Rates

A loading value for a signalling channel using bit rates of less than 56/64 kbit/s will result in greater queueing delays than the same loading value for a 56/64/ kbit/s signalling channel.²

3.3 Structure of Signalling Traffic

The Message Transfer Part of Signalling System No. 7 serves different users as a joint transport system for messages. As a result, the structure of the signalling traffic largely depends on the types of users served. It can be assumed that at least in the near future the telephone service will represent the main part of the signalling traffic in integrated networks.

It cannot be foreseen yet how the signalling traffic will be influenced by the integration of existing and future services. The traffic models given in 5.2.4 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.

4 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 ITU Study Groups - and their consequences on the specifications of the Signalling System No. 7 Message Transfer Part.

4.1 Application of Signalling System No. 7 to 56/64 kbit/s and 1.536 Mbit/s Links

The Message Transfer Part is designed to operate satisfactorily with the following transmission characteristics:

1. A long-term bit error rate of the signalling data link of less than 10^{-6} (see Reference [1]).
2. A medium-term bit error rate of less than 10^{-4} .
3. Random errors and error bursts including long bursts that 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 10.2 of Chapter T1.111.3) and the errored interval monitor for 1.536 Mbit/s links (see 10.2A of Chapter T1.111.3).

4.2 Application of Signalling System No. 7 to Links Using Lower Bit Rates

(Needs further study.)

² The performance requirements of this document assume the use of 56/64 kbit/s signalling links. Use of lower bit rate links is not preferred.

5 PARAMETERS OF INFLUENCE ON SIGNALLING PERFORMANCE

5.1 *Signalling Network*

Signalling System No. 7 is designed for both associated and nonassociated 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 2.1 has to be observed irrespective of the number of signalling links in tandem of which it is composed.

5.1.1 International Signalling Network

(Needs further study.)

5.1.2 National Signalling Network

The national signalling network can be partitioned into three types of segments (refer to Figure 1/T1.111.6): the backbone network segment, the network access segment, and the user interface segment. With this partitioning, the downtimes per year of each segment can be added to approximate signalling network downtime per year. Nominal requirements for each of these network segments have been assigned as follows.

1. The unavailability of each User Interface Segment should not exceed 3 minutes per year.
2. The unavailability of each Network Access Segment should not exceed 2 minutes per year.
3. The unavailability of each Backbone Network Segment should be a negligible amount of time.

5.2 *Queueing Delays*^{3,4}

See the Implementors' Guide to ITU-T Rec. Q.706 (12/99) for the updated text and figures for this section and the remainder of T1.111.6-2001. The Implementors' Guide has updated ITU-T Rec. Q.706 to include the following:

- ◆ Corrected the formulas for the queueing delays using the signal unit error rate, not the MSU rate;
- ◆ Corrected the typographical errors in the Preventive Cyclic Retransmission (PCR) formulas;
- ◆ Updated tables 6 and 7 and figures 8, 13, 15, and 16;
- ◆ Align ITU-T Rec. Q.706 with ITU-T Rec. E.733;

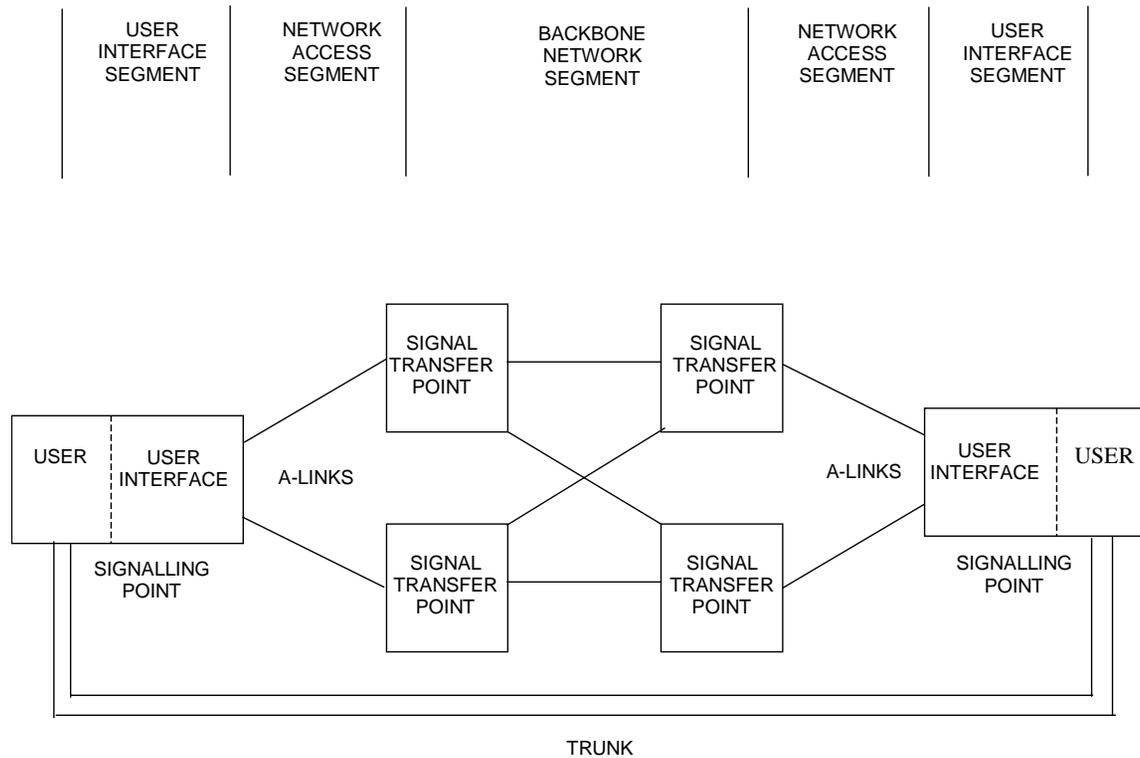
³ The analysis provided in Section 5.2 does not apply to SAAL links.

⁴ Section 5.2 corresponds to Section 4.2 in Q.706.

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Chapter T1.111.6

- ◆ Expansion of Annex B to include a brief derivation of the Basic Error Correction (BEC) queueing delay in the absence of disturbance;
- ◆ Provided separate subsections for BEC and PCR; and
- ◆ Accounted for long messages and high link loadings.



NOTE - The backbone network segment may consist of a number of networks in tandem to provide a signalling path.

Figure 1/T1.111.6 National Signalling Network

Chapter T1.111.7
Testing and Maintenance

EDITORIAL NOTE – In this Chapter, all page numbers are in the format T1.111.7-#.

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Signalling System Number 7 (SS7) – Testing and Maintenance

1 SCOPE, PURPOSE, & APPLICATION¹

In order to realize the performance requirements described in Chapter T1.111.6, means and procedures for signalling network testing and maintenance are required, in addition to the means defined in Chapters T1.111.3 and T1.111.4.

This chapter may contain requirements that reference other American National Standards. If so, when the American National Standards referenced in the requirements are superseded by revisions approved by the American National Standards Institute, Inc., the revisions shall apply.

2 TESTING

2.1 *Signalling Data Link Test*²

As defined in clause 1 of Chapter T1.111.2, 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 its constituent parts are described in clause 1 of Chapter T1.111.2.

The signalling data link and its parts shall be tested before being put into service to ensure that they meet the requirements of clause 3 of Chapter T1.111.2.

Since interruptions of the signalling data link will affect many transactions, they shall be treated with the utmost care. Appropriate special measures should be taken to prevent unauthorized maintenance access that 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. The signal unit error rate monitor and the alignment error rate monitor, described in clause 10 of Chapter T1.111.3 also provide means for detecting deterioration of a signalling data link (for further study).

2.1.1 Data Link Testing Overview

With signalling data link tests, faulty link components can be easily identified from an operations and maintenance center without the dispatch of maintenance personnel. Also,

¹ A "|" indicates a change from T1.111 - 2001. In actuality, there are no changes to that document other than this footnote and the header change to reflect 2005 instead of 2001.

² The testing procedures specified in clause 2.1 do not apply to SAAL links.

marginally performing links can be tested and changed link components can be verified. Data link tests are carried out by management functions that test each link component. Level 1 tests a single link component in response to a command from management functions. The next clauses describe the Level 1 interface with management and the actions Level 1 takes to execute data link tests.

2.1.2 Management Interface

Data link testing functions are carried out in response to a management request. Only deactivated links are tested. The results of data link tests are returned to the initiating management function when the test is concluded. The test results are also returned anytime there is a management request for the current test status.

2.1.2.1 Test Initiation Request

Data link tests are initiated by management functions. Data link tests are initiated on any deactivated link. One link component is tested at a time. The following parameters are given when a link test is initiated:

1. the component to be looped back;
 - a. DS-0 dataport (line side)
 - b. DS-0 dataport (drop side)
 - c. Latching Office Channel Unit (OCU)
 - d. Latching channel
 - e. Non-latching OCU
 - f. Non-latching channel
 - g. Non-latching DSU
 - h. Network Element Interface
 - i. Remote link interface
 - j. Local link interface (optional)
 - k. Local V.35 DSU (optional)
 - l. Remote V.35 (optional)

See figures 1-3/T1.111.7 for examples of the above loopbacks.

2. If latching loopback, the Loopback Select Code (LSC) and the number of components with the same LSC (N);
3. Test message or pattern to be sent - these messages and patterns are described in the following clauses;
4. Amount of time the test should run (could be until management termination); and
5. Error threshold allowed before testing is terminated.

2.1.2.2 Test Results

The results of a data link test are returned to management for the following reasons:

1. Management requested the test results during a data link test;
2. The amount of time specified to run the test in the initial message elapsed;
3. The error threshold was exceeded; or
4. Management terminated the test

The following test results are returned to management:

1. Number of bit errors recorded,
2. Number of errored seconds,
3. Indication of failure or success of the test, and
4. Elapsed time of the test.

2.1.2.3 Test Messages and Patterns

One of the parameters specified by management when tests are initiated is the type of test message or pattern to be sent during the test. The following clauses outline the messages and patterns.

2.1.2.3.1 Pseudorandom Test Data Bytes

The test initiation command may request either a 511 bit or 2047 bit pattern. The 511 bit pattern is generated in a nine-stage shift register whose fifth and ninth stage outputs are exclusive OR'ed, and the result is fed back to the input of the first stage. The 2047 bit pattern is generated in an eleven-stage shift register whose ninth and eleventh stage outputs are exclusive OR'ed, and the result is fed back to the input of the first stage. The resulting series of test patterns contain the majority of eight-bit sequences likely to be met in transmission of actual data. The pseudorandom test data byte may be sent during latching and non-latching loopback.

2.1.2.3.2 Pattern Sensitive Messages

One of the following four repetitive patterns may be specified in the test message parameter from management:

1. A repeated pattern consisting of 100 octets of 11111111 followed by 100 octets of 00000000,
2. A repeated pattern consisting of 100 octets of 01111110 followed by 100 octets of 00000000,
3. A continuous series of octets of 00110010, or
4. A continuous series of octets of 01000000.

The Pattern Sensitive Messages may only be sent for latching loopback.

2.1.2.3.3 Management Specified Data Byte

The test initiation request may specify a data byte to be sent. If so, the data byte is sent continuously until the test ends. The management specified data byte may only be sent for latching loopback.

2.1.3 Level 1 Actions to Perform Data Link Tests

Level 1 has the following functions for carrying out data link tests:

1. Test initiation,
2. Test operation,
3. Request for test results, and
4. Test termination.

This clause describes the actions needed for each function.

2.1.3.1 Data Link Testing Initiation

Data link tests are initiated by management request on deactivated links. A new data link test initiation request is not honored until the current test terminates. The loopback procedure varies according to the component to be tested. The following clauses describe the Level 1 actions to operate a loopback.

2.1.3.1.1 Operation of Latching Loopbacks

Latching loopbacks are initiated by a specific sequence of DS-0 control codes. The loopback remains in effect until the loopback is removed with another sequence of DS-0 control codes. The following sequence is transmitted toward the link component to be tested to operate the loopback:

1. A minimum of 40 Transition in Progress (TIP) bytes.
2. 40 Loopback Select Code (LSC) data bytes (see Table 1/T1.111.7 for the LSC bytes).
3. 120 Loopback Enable (LBE) bytes.
4. 40 all-ones data bytes plus 120 LBE bytes for N iterations, where N is the number of loopbacks of the same type, not including the target device, that is the same LSC, that lie between the SP and the link component to be tested. N is specified in the command.
5. A minimum of 40 Far End Voice (FEV) bytes.
 - a. The Far End Voice (FEV) code is then sent from, and returned to the sending SP as an acknowledgment that the loopback has been operated. An operated and latched loopback will be indicated when the FEV code is returned to the sending SP. If the expected byte structure is not received in two seconds a time out should occur and the test should be terminated.

2.1.3.1.2 Non-Latching OCU Loopbacks

The following sequence is sent toward the Office Channel Unit (OCU) to be looped back:

1. Approximately one second of OCU Loopback codes. A multiple of 20 must be sent.
2. Alternating pattern of OCU Loopback codes and pseudorandom test data bytes.
 - a. The alternating pattern consists of one OCU Loopback code followed by one byte of test data. Refer to Table 2/T1.111.7 for the exact encoding of the OCU Loopback code. See clause 2.1.2.3.1 for an explanation of pseudorandom test data generation.

The SP attempts to frame on the returning test data pattern to determine the expected value of the arriving pseudorandom test data bits. Returning test data bytes are interleaved with a constant data byte introduced by the OCU in place of the loopback code. The constant data byte introduced by the OCU in place of the loopback code contains data in bits 2 through 7. The eighth bit, the control bit is set to 1. It is possible that the returned test data may slip across the boundary provided by the 8 kHz clock. The test data might slip exactly eight bits so the slip is not distinguishable. Bit 8 of the constant data byte must be aligned with the 8 kHz clock. Refer to Table 2/T1.111.7 for the confirmation bytes.

The SP receives an alternating stream of pseudorandom test data and constant data bytes. First, the SP must align the bit stream with the 8 kHz clock to determine the beginning and end of a byte. Then the SP attempts to frame on the returning test data bytes in order to determine the expected value of arriving bits. This is illustrated in figure 4/T1.111.7 *Possible Received Data Stream at SP Before Framing*. If the SP cannot frame on the returning test data pattern within five to ten seconds, loopback initiation failed.

2.1.3.1.3 Non-Latching Channel Loopback

The following sequence is transmitted:

1. Approximately one second of Channel Loopback codes in multiples of 20 must be sent.
2. Alternating pattern of Channel Loopback codes and pseudorandom test data bytes.
3. The alternating pattern consists of one Channel Loopback code followed by one byte of test data. Refer to Table 2/T1.111.7 for the exact encoding of the Channel Loopback code. See clause 2.1.2.3.1 for an explanation of pseudorandom test data generation.
4. The SP attempts to frame on the returning test data pattern to determine the expected value of the arriving pseudorandom test data bits. Returning test data bytes are interleaved with a constant data byte introduced by the Channel loopback in place of the loopback code. The constant data byte introduced by the Channel loopback in place of the loopback code contains data in bits 2 through 7. The eighth bit, the control bit is set to 1. It is possible that the returned test data may slip across the boundary provided by the 8 kHz clock. The test data might slip exactly eight bits so the slip is not distinguishable. Bit 8 of the constant data byte must be aligned with the 8 kHz clock. Refer to Table 2/T1.111.7 for the confirmation bytes.
5. The SP receives an alternating stream of pseudorandom test data and constant data bytes. First, the SP must align the bit stream with the 8 kHz clock to determine the

beginning and end of a byte. Then the SP attempts to frame on the returning test data bytes in order to determine the expected value of arriving bits. This is illustrated in figure 4/T1.111.7: Possible Received Data Stream at SP. If the SP cannot frame on the returning test data pattern within five to ten seconds, loopback initiation failed.

2.1.3.1.4 Non-Latching DSU Loopbacks

A Data Service Unit (DSU) provides a standard V.35 interface to link equipment. The following sequence of control codes are sent to initiate the loopback:

1. Approximately one second of DSU Loopback codes in multiples of 20 must be sent.
2. Alternating pattern of DSU Loopback codes and pseudorandom test data bytes.

The alternating pattern consists of one DSU Loopback code followed by one byte of test data. Refer to Table 2/T1.111.7 for the exact encoding of the DSU Loopback code. See clause 2.1.2.3.1 for an explanation of pseudorandom test data generation.

The SP attempts to frame on the returning test data pattern to determine the expected value of the arriving pseudorandom test data bits. Returning test data bytes are interleaved with a constant data byte introduced by the DSU in place of the loopback code. The constant data byte introduced by the DSU in place of the loopback code contains data in bits 2 through 7. The eighth bit, the control bit is set to 1. It is possible that the returned test data may slip across the boundary provided by the 8 kHz clock. The test data might slip exactly eight bits so the slip is not distinguishable. Bit 8 of the constant data byte must be aligned with the 8 kHz clock. Refer to table 2/T1.111.7 for the confirmation bytes.

The SP receives an alternating stream of pseudorandom test data and constant data bytes. First, the SP must align the bit stream with the 8 kHz clock to determine the beginning and end of a byte. Then the SP attempts to frame on the returning test data bytes in order to determine the expected value of arriving bits. This is illustrated in figure 4/T1.111.7: Possible Received Data Stream at SP. If the SP cannot frame on the returning test data pattern within five to ten seconds, loopback initiation failed.

2.1.3.5 Remote Link Interface Loopback

When this optional loopback is operated, all incoming data is echoed back onto the signalling link. This loopback is operated by connecting the receive and transmit lines. No test statistics such as bit errors and errored seconds are collected during this loopback by the remote link interface.

2.1.3.1.6 Local DSU Loopback

This optional loopback is initiated by invoking the non-standard local loopback circuit test on V.35 signalling links. The loopback is successfully operated when the non-standard test mode circuit is activated from the DSU. While the loopback is operated, all data is looped back at the local DSU.

2.1.3.1.7 Remote DSU Loopback

This optional loopback is initiated by invoking the non-standard remote circuit test on V.35 signalling links. The loopback is successfully operated when the non-standard test mode circuit is activated from the local DSU. While the loopback is operated, all data is looped back at the remote DSU.

2.1.3.1.8 Local Link Interface Loopback

This optional loopback is initiated by connecting the output of the link transmitter to the link receiver. The link interface output is blocked during this loopback. With this loopback in effect, all transmitted data is looped back to the link interface receiver.

2.1.3.2 Operation During Data Link Testing

While a data link test is in progress, Level 1 sends the specified test message and verifies that the same message is looped back. The message verification is a bit-by-bit compare of the sent message bytes to the received message bytes. Any bit errors are recorded for later reports to management of test statistics. The number of seconds in which one or more bit errors occurred is also recorded.

Besides sending messages and verifying the returning data, Level 1 checks for test ending conditions. If the elapsed test time exceeds the requested test time, the test is terminated. Also, if any error threshold is specified and the number of bit errors is greater than the threshold, the test is terminated.

2.1.3.2.1 Latching Loopbacks

Once the latching loopback has been operated successfully, any of the defined test patterns may be sent. The only restrictions on the test data that may be sent are as follows: A maximum of 20 consecutive TIP or LBE bytes may be sent, and if transmitted, such a group must be followed by at least 20 non-TIP or 20 non-LBE bytes.

2.1.3.2.2 OCU, DSU and Channel Loopbacks

After the loopback has initiated, Level 1 verifies that the alternating pattern of confirmation bytes and data bytes continues. The data bytes are verified on a bit-by-bit basis and statistics are recorded.

2.1.3.2.3 Local and Remote DSU Loopbacks and Local Link Interface Loopback

After the loopback is operated, any of the defined test patterns may be sent. The returning messages are verified and statistics are recorded.

2.1.3.3 Response to Request for Test Results

While a link is under test, management functions may request the current test results. The number of bit errors, errored seconds and an indication of the failure or success of the test are given in response. The operation of the test is not interrupted by the test results request.

2.1.3.4 Data Link Testing Termination

Data link testing is terminated by Level 1 for two reasons: (1) When the error threshold is exceeded or (2) when the test has run the amount of time specified by the test initiation message. Data link tests also end when Level 1 receives the management test termination request.

When it is time to terminate the data link test, Level 1 halts the transmission of test messages. Next, any actions to remove the loopback are performed (see next clauses for details.) The elapsed time of the test is calculated, this is the amount of time since the loopback was operated. The test results are then returned to management.

The following clause describes the actions to remove loopbacks.

2.1.3.4.1 Latching Loopbacks

To remove the loopback, the SP transmits a group of 40 TIP bytes. It continues to transmit TIP bytes in multiples of 20 until no TIP bytes are returned. If TIP bytes are returned after two seconds from when the first TIP byte was transmitted, the loopback take down failed. Otherwise it is considered successful.

2.1.3.4.2 OCU, DSU and Channel Loopbacks

The SP ends the loopback condition by halting the alternating pattern.

2.1.3.4.3 Remote Link Interface Loopback

The loopback is removed by disconnecting the transmit and receive lines. Management is informed that no test statistics were collected in the test results by the remote link interface during this test.

2.1.3.4.4 Local DSU Loopback

This loopback is canceled by deactivating the non-standard local loopback circuit test.

2.1.3.4.5 Remote DSU Loopback

This loopback is canceled by deactivating the non-standard remote loopback circuit test

2.1.3.4.6 Local Link Interface Loopback

This loopback is removed by disconnecting the output of the link transmitter from the link receiver. Any blocking on the link interface from this test is removed.

2.1.3.5 Response to Reception of Control Codes

Link interfaces that provide the DS-0 interface respond to latching network element interface loopback control codes. When the link interface receives the latching loopback control sequence with the network element interface LSC, it responds to the sequence by sending the appropriate confirmation bytes. The link interface also echoes all incoming bytes until the release sequence is received.

2.2 Signalling Link Test

As defined in clause 1.1 of Chapter T1.111.3, and illustrated in figure 1/T1.111.1, the signalling link is composed of 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 mandatory when a signalling link is activated or restored. The signalling link becomes available only if the test is successful. This procedure, which is intended for use while the signalling link is in service, verifies the physical link assignments and can detect looped links and other irregularities in the operation of the link. In addition, local failure detection procedures should be performed at either end; these are not specified in this Chapter.

In the case the signalling link test (SLT) is applied while the signalling link is in service, the signalling test message is sent at regular intervals T2 (see 5.5). The testing of a signalling link is performed independently from each end whether the link is experiencing transmit or receive congestion or not.

The ability to send a signalling link test acknowledgment shall always be provided at a signalling point, but the provision for periodic 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 that is chosen at the discretion of the end initiating the test and the SLC of the signalling link being tested. After receiving a signalling link test message, a signalling point responds with a signalling link test acknowledgment message on the same signalling link only if the SLC code identifies the physical link on which the signalling link test message is received and the OPC identifies the signalling point at the other end of the link.

Otherwise, the signalling link test message is discarded and signalling link test acknowledgment message is not sent. The test pattern included in the signalling link test acknowledgment message is identical to the test pattern received. In the case that a test pattern in a received signalling link test acknowledgment is the same as that sent in a signalling link test message, no further action is taken.

In the case when:

1. A signalling link test acknowledgment message is not received on the link being tested within, T1 (see 5.5), after the signalling link test message has been sent; or
2. A signalling link test acknowledgment 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 with the same test pattern. In the case when the repeated test also fails, a management system must be informed, and the link is taken out of service.

The formats and codes of signalling link test and signalling link test acknowledgment messages used for signalling link testing are specified in 5.4.

2.3 *Signalling Route Test*

In addition to the procedures specified in clause 13 of Chapter T1.111.4, the need for, and form of, other line procedures are for further study.

2.4 *Circular Route Detection Test³*

MTP messages can be routed endlessly in a circular route if the routing data were provisioned incorrectly or corrupted. This procedure is designed to automatically detect the circular routing problem, prohibit the route, and notify a management system to conduct additional unspecified diagnostic tests and to correct the routing data.

1. One of two events, but not both, must be used to trigger the execution of the circular route test: onset of congestion and rerouting of signalling traffic.
 - a. The congestion trigger is based on a link transmission queue increasing in congestion status. When the first link in a link set becomes congested (i.e., exceeds onset congestion threshold 1), a signalling transfer point continues to monitor only this link in the link set for further increases in congestion status. After the link increases in congestion status, including the initial onset of congestion, the signalling transfer point tabulates the DPCs of a certain number of messages, N (table 4/T1.111.7), being transmitted on the link of concern. The signalling transfer point then sends circular route test messages to signalling points of the M (table 4/T1.111.7) most frequently occurring DPCs. A subsequent test is executed upon the next increase in congestion status after the test messages are transmitted for the previous test. When the congestion status of the concerned link abates to 0 or if the concerned link fails, the signalling transfer point returns to monitoring the entire link set for an increase in congestion status of any link in the link set.

The test messages must be assigned SLS codes such that all STPs that could be used to reach the destination under test could be tested. This may be accomplished, for

³ As a result of the OPC screening procedure in the Message Discrimination and Distribution Functions (see T1.111.4, clause 2.4.1), message discard must be used as a criterion for triggering the detection of circular routes.

example, by assigning a randomized SLS code to each test message or by assigning a single SLS code to all test messages for a given test trigger and changing the SLS code for each triggering of the test.

The test is executed for congestion on any link set, including the C-link set. Alternatively, an option is to not execute the test on the C-link set.

- b. Alternatively, the circular route test can be triggered when a signalling transfer point reroutes traffic to a destination (i.e., upon changeover/changeback, forced/controlled rerouting, or a change in routing data, and not during MTP Restart) to a different priority route. If the signalling transfer point reroutes to a different priority combined link set, the test is executed on both link sets. Test messages are sent to each destination affected by the rerouting. For this triggering method, the test is not executed when rerouting to the C-link set. The SLS codes shall be assigned with a uniform distribution to the test messages for all destinations.

If a signalling transfer point reroutes for a cluster to which it is cluster routing, the signalling transfer point sends one test message to one signalling point code⁴ in the cluster. Subsequent procedures, other than those stated in item 2 below (except for optionally sending transfer-cluster-prohibited messages), are network dependent. This triggering mechanism will detect most but not all MTP circular routes.

The test message is the signalling-route-set-congestion-test message with the priority assigned to 3. When a signalling point receives a circular route test message addressed to itself, it should discard the message.

2. If the signalling transfer point receives a test message originated by itself, it marks the current route(s) and lower priority routes unavailable to the destination and sends transfer-prohibited messages using the response or broadcast method to adjacent signalling points. A management system is notified of the destination that is involved in the circular route. The unavailable state of the route(s) is maintained until operations personnel or a management system corrects the routing problem and resets the unavailable state to available. Higher priority routes may be used if they become available.

Signalling-route-set-test messages are not sent by the signalling transfer point on the routes of concern for the destination involved in the loop.

If the triggering mechanism is not used for the C-link set, the signalling transfer point must also screen for test messages originated by its mate signalling transfer point. Additional procedures for a signalling transfer point upon receiving a test message originated by its mate are network dependent.

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 study. (See clause 6A for additional references.)

⁴ It is not required that this signalling point code be assigned in the network.

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 contained in Chapter T1.116. The requirement for additional messages and procedures is for further study.

5 FORMATS & CODES OF SIGNALLING NETWORK TESTING & 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 clause 2 of Chapter T1.111.3. As indicated in clause 14.2 of Chapter T1.111.4, these messages are distinguished by the configuration 0001 or 0010 of the Service Indicator (SI). The Subservice Field (SSF) of signalling network testing and maintenance messages is used in accordance with clause 14.2 of Chapter T1.111.4.

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 clause 15.2 of Chapter T1.111.4.)

5.3 Heading Code H0

The heading code H0 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 | 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/T1.111.7. The signalling link test messages are made up of the following fields:

1. Label: (56 bits), see 5.2
2. Heading code H0: (4 bits)
3. Heading code H1: (4 bits)
4. Signalling Link Code: (4 bits)
5. Length indicator: (4 bits)
6. Test pattern: ($n \times 58$ bits with $n \leq 15$)

For the signalling link test described in 2.2, the SI configuration = 0010.

The heading code H1 contains signal codes as follows:

| bits | D | C | B | A | |
|------|---|---|---|---|---|
| | 0 | 0 | 0 | 1 | signalling link test message |
| | 0 | 0 | 1 | 0 | signalling link test acknowledgment message |

The requirements for additional H1 codes is for further study.

The signalling link code (SLC) indicates the signalling link to which the test applies.

The length indicator gives the number of octets that the test pattern comprises.

The test pattern is an integral number of octets and is chosen at the discretion of the originating point.

5.5 *Time-out Values and Tolerances*

Refer to table 3/T1.111.7 for time-out values and tolerances.

6 STATE TRANSITION DIAGRAMS

This clause contains the description of the testing and maintenance functions, described in this chapter, in the form of state transition diagrams according to the ITU-T Specification and Description Language (SDL).

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 clauses.

The state transition diagram (figure 6/T1.111.7) is intended to show precisely the behavior 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 diagram is used only to facilitate understanding of the system behavior, and is not intended to specify the functional partitioning to be adopted in a practical implementation of the signalling system.

The state transition diagram (figure 7/T1.111.7) is intended to show the system action for the detection of circular MTP routes.

6A RELATED STANDARDS

The following standards documents are recommended as guides on testing and maintenance:

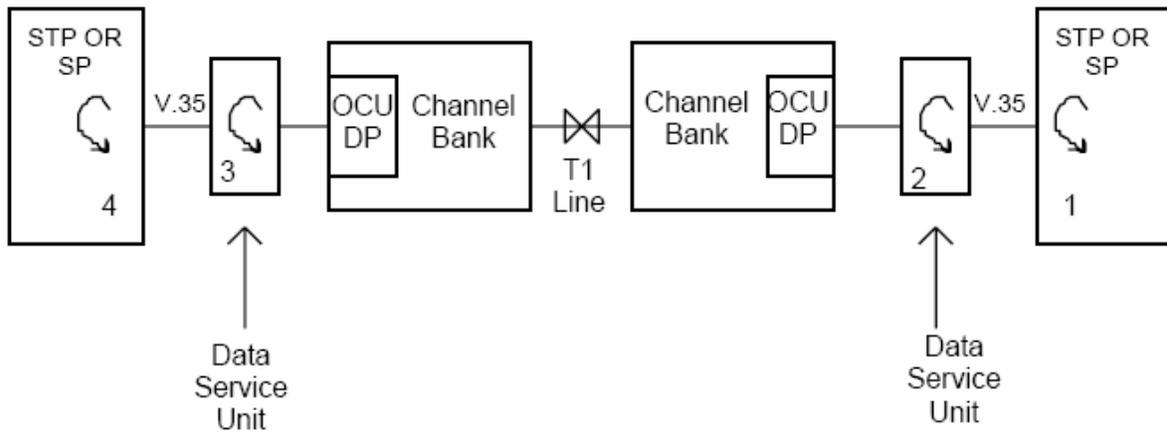
T1.116-2000 (R2005), *Signalling System No. (SS7) - Operations Maintenance and Administration Part (OMAP)*.⁵

ITU-T Rec. M.729, *Organization of the maintenance of international public switched telephone circuits used for data transmission*.⁶

ITU-T Rec. Q.706, *Message transfer part signalling performance*.⁶

⁵ This document is available from The Alliance for Telecommunications Industry Solutions < <http://www.atis.org> >.

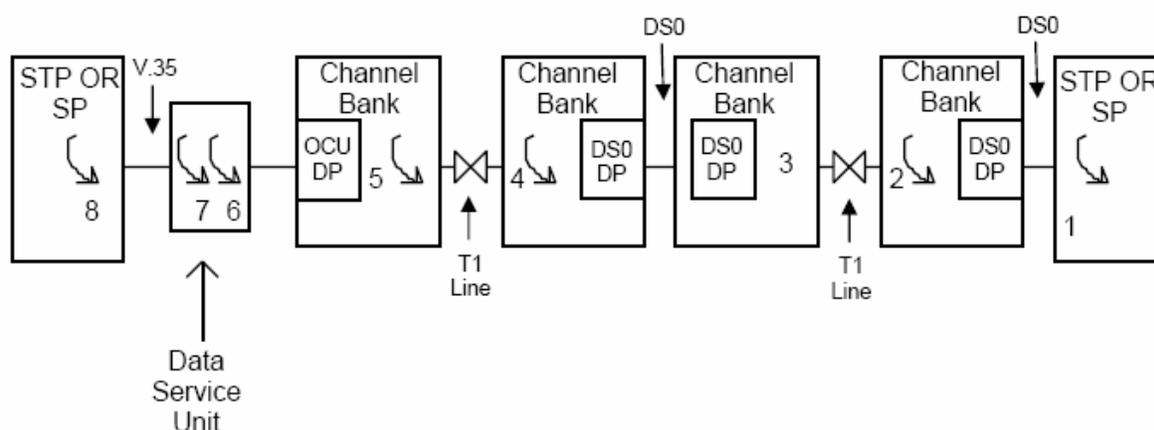
⁶ This document is available from the International Telecommunications Union. < H<http://www.itu.int/ITU-T/H> >.



KEY:

- 1: LOCAL LINK INTERFACE LOOPBACK
- 2: LOCAL DSU LOOPBACK (LL)
- 3: REMOTE DSU LOOPBACK (RT)
- 4: REMOTE LINK INTERFACE LOOPBACK

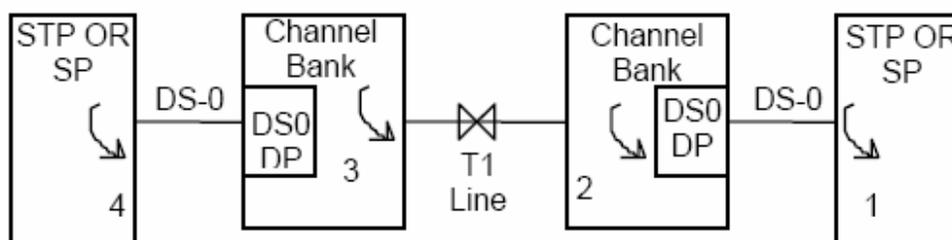
Figure 1/T1.111.7 Optional Loopbacks on V.35 to V.35 Signalling Links



KEY:

- 1: LOCAL LINK INTERFACE LOOPBACK
- 2: DS-0 DATAPORT "LINE" LOOPBACK
- 3: DS-0 DATAPORT "DROP" LOOPBACK
- 4: DS-0 DATAPORT "LINE" LOOPBACK
- 5: OCU LOOPBACK
- 6: CHANNEL LOOPBACK
- 7: DSU LOOPBACK
- 8: REMOTE LINK INTERFACE LOOPBACK

Figure 2/T1.111.7 Loopbacks on V.35 to DS-0 Signalling Links



KEY:

- 1: LOCAL LINK INTERFACE LOOPBACK
- 2: DS-0 DATAPORT "LINE" LOOPBACK
- 3: DS-0 DATAPORT "DROP" LOOPBACK
- 4: REMOTE LINK INTERFACE LOOPBACK OR LATCHING NETWORK ELEMENT INTERFACE LOOPBACK

Figure 3/T1.111.7 Loopbacks on DS-0 to DS-0 Signalling Links

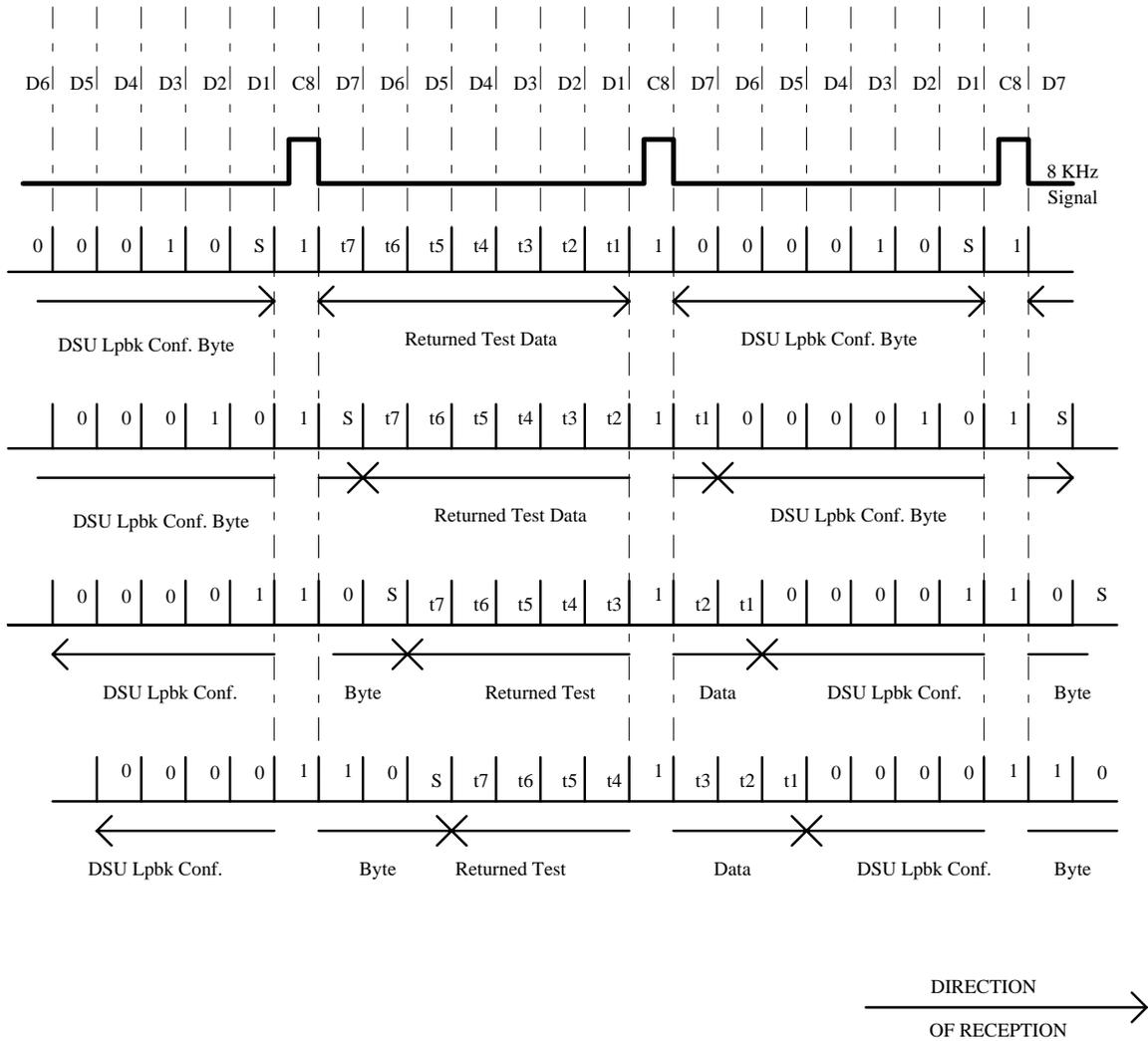


Figure 4/T1.111.7 Possible Received Data Stream at SP Before Framing

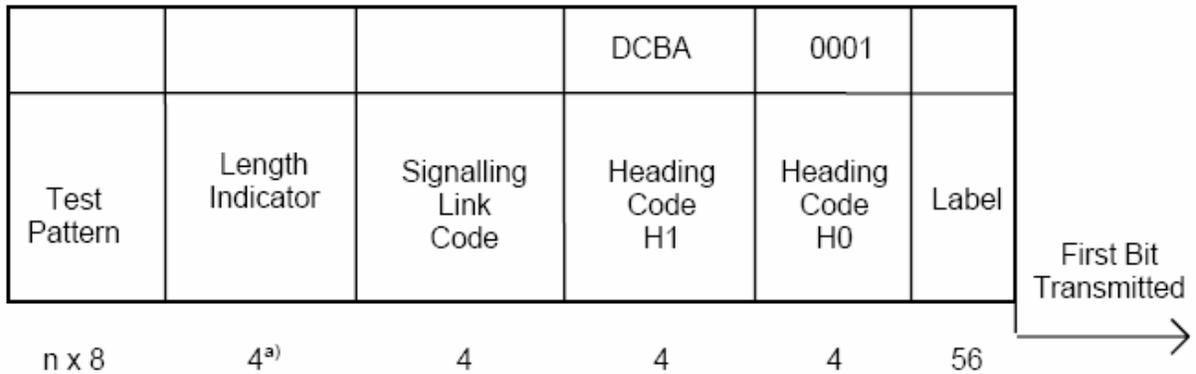


Figure 5/T1.111.7 Signalling Link Test Messages

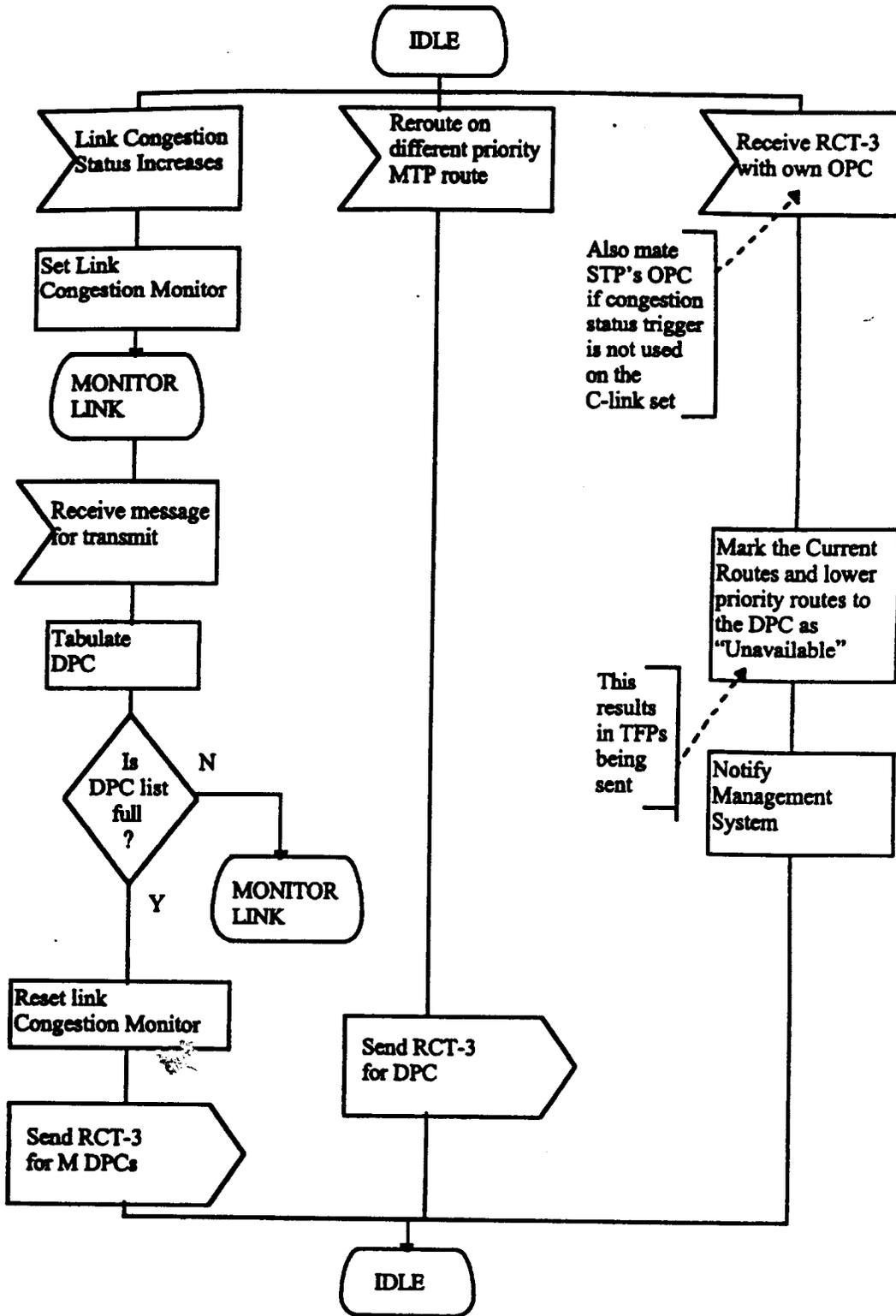


Figure 7/T1.111.7 Circular Route Detection Control

Table 1/T1.111.7 DS-0 Latching Loopback Control Codes for Data Link Testing

| Definition | DS-0 Code |
|------------------------------|-----------|
| DS0 DATAPORT "DROP SIDE" | S0000101 |
| DS0 DATAPORT "LINESIDE" | S0000101 |
| CHANNEL LOOPBACK | S0110001 |
| NETWORK ELEMENT INTERFACE | S1000001 |
| FAR END VOICE (FEV) | S1011010 |
| LOOPBACK ENABLE (LBE) | S1010110 |
| OCU LOOPBACK | S1010101 |
| TRANSITION IN PROGRESS (TIP) | S0111010 |

where: S = 1 when byte is transmitted

S = "don't care" when byte is received

Table 2/T1.111.7 Non-Latching Loopback Codes and Confirmation Bytes

| Loopback Type | DS-0 Code | Confirmation Byte |
|------------------|-----------|-------------------|
| DSU Loopback | S0101100 | S0100001 |
| OCU Loopback | S0101010 | S0100001 |
| Channel Loopback | S0101000 | S0101001 |

where: S = 1 when byte is transmitted

S = "don't care" when byte is received

Table 3/T1.111.7 Time-out Values and Tolerances

| T1.111.7 Timer | Range |
|---|--|
| T1 (see clause 2.2) Supervision timer for signalling link test acknowledgment message | 4 - 12 sec. (equal or greater than T6 of T1.111.3- 2001) |
| T2 (see clause 2.2) Interval timer for sending signalling link test messages | 30 - 90 sec. |

Table 4/T1.111.7 Parameter Ranges for the Circular Route Test

| Definition | Range |
|--|--------|
| N (see clause 2.4) Number of Message to Tabulate DPCs | 50-200 |
| M (see clause 2.4) Number of Destinations to Test Per Execution | 3-10 |

Chapter T1.111.8

Numbering of Signalling Point Codes

EDITORIAL NOTE – In this Chapter, all page numbers are in the format **T1.111.8-#**.

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Signalling System Number 7 (SS7) – Numbering of Signalling Point Codes

1 SCOPE, PURPOSE, & APPLICATION¹

This chapter describes the numbering scheme of signalling point codes for ANSI Common Channel Signalling (CCS) System Number 7 (SS7) networks. The technical aspects of the signalling networks are specified in Chapter T1.111.5.

The network structure described in Chapter T1.111.5 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.

It is also noted that the point code is intended to be processed within the Message Transfer Part (MTP) of each signalling point or signalling transfer point, so that there is no direct relationship to the telephone, data, or ISDN numbering.

1.1 Definitions

The following terms are used in this chapter:

1.1.1 ANSI-41 networks: For the purpose of this document, ANSI-41 networks are mobile networks using TIA/EIA-41 as the Mobile Application Part for intersystem interfaces.

1.1.2 CCS Group: A signalling point or group of signalling points that are not part of a CCS network but are commonly owned or administered is referred to as a CCS Group. A CCS Group is identified as a group of signalling points without any STP (i.e., none of the nodes in the group have STP functionality).

1.1.3 CCS Network: A set of signalling points (including STPs), using out-of-band signalling, that are operated, administered, and maintained by the operator of the network.

1.1.4 Code Administrator: The entity authorized by PTSC and the companies supporting PTSC to administer signalling point code assignments according to the guidelines set forth in this document. The Code Administrator administers the network codes and point code blocks.

1.1.5 Large CCS Network: A large CCS network is a CCS network that provides signalling for more than 75 signalling points (operated, administered, and maintained by the operator of the network) in the first year of operation and at least 150 signalling points (belonging to the

¹ A "|" indicates a change from T1.111-2001.

network) by the end of the first 5 years of operation. Also, it must have at least 6 network elements providing STP functionality in the first year of operation, and at least 12 network elements providing STP functionality by the end of 5 years of operations.

1.1.6 Network Administrator: Administrator of a CCS network or CCS group. The administrator of a CCS network or CCS group, who is directly affiliated with the CCS network or CCS group, serves as the contact between the Code Administrator and the CCS network or CCS group in regards to ANSI signalling point codes. It is the responsibility of the Network Administrator to keep the Code Administrator informed of any information changes regarding information supplied at the time of the code assignment request. The Network Administrator administers the point codes within the network code and point code blocks of its affiliated CCS network or CCS group respectively that have been assigned by the Code Administrator (see A.3.2).

1.1.7 North America: For simplicity of reference in this document, those countries served by the North American Numbering Plan (NANP).

1.1.8 Signaling Point - A node in a signalling network that either originates and receives signalling messages, or transfers signalling messages from one signalling link to another, or both.

1.1.9 Signalling Point Code: A code used to identify a signalling point and processed within the MTP of each signalling point and within users of the MTP.

1.1.10 Small CCS Network: A small CCS network is a CCS network that does not meet the criteria of being a large CCS network.

1.2 Abbreviations & Acronyms

| | |
|------|---|
| ANSI | American National Standards Institute |
| CCS | Common Channel Signalling |
| EIA | Electronic Industries Association |
| ISDN | Integrated Services Digital Network |
| MTP | Message Transfer Part |
| NANP | North American Numbering Plan |
| NID | Network Identification |
| SPC | Signalling Point Code |
| SS7 | Signalling System No. 7 |
| STP | Signalling Transfer Point |
| TIA | Telecommunications Industry Association |

2 FORMAT OF ANSI SIGNALLING POINT CODE

2.1 Binary Code Format

Signalling points are identified by a 24-bit binary code that is called a signalling point code or point code. A point code should be assigned to each signalling point that belongs to an ANSI CCS network or CCS group of signalling points.

2.2 Fields of a Point Code

A point code consists of three fields as indicated in Figure 1/T1.111.8. The most significant field of 8 bits identifies a signalling network. The next field of 8 bits identifies a cluster in a specific network. The least significant field of 8 bits identifies a member (i.e., signalling point) of a specific cluster (see 7.4 of T1.111.5 for information regarding network structure and routing).

NOTE - An extension to this general scheme is used to identify small CCS networks and CCS groups (see 3.3).

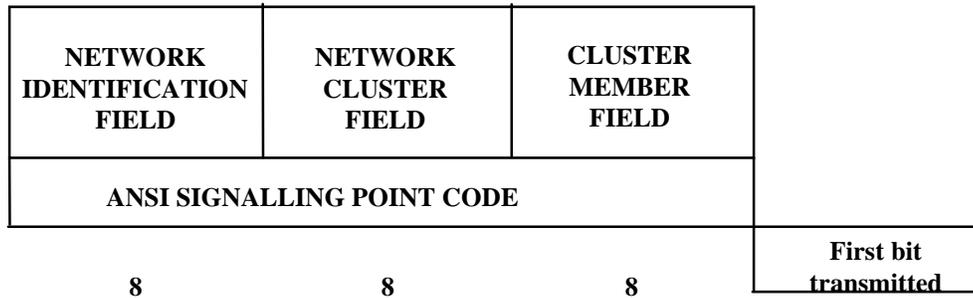


Figure 1/T1.111.8 - Format for ANSI signalling point codes

2.3 Available Number of Point Codes

The system of network codes will provide for $249 + (4 \times 255) = 1269$ network codes. The system of signalling point codes will provide for $(249 \times 256 \times 256) + (5 \times 255 \times 256) = 16,644,864$ signalling point codes.

3 NUMBERING OF SIGNALLING POINTS IN ANSI NETWORKS

3.1 Assignment Categories

United States CCS (SS7) networks and CCS groups, other CCS networks and CCS groups utilizing the NANP and ANSI-41 CCS networks and CCS groups outside of North America may be assigned a network code or point code block and shall follow the guidelines in Annex A.

The Code Administrator shall be responsible for assigning and administering the following categories of codes:

1. *Network codes* from the Network Identification Field (NID) for large networks;
2. *Cluster codes* from NID 1 through 4 for small networks;
3. *Point code blocks* from NID 5 for CCS Groups (blocks of signalling point codes from the cluster member field); and
4. *Cluster codes and point code blocks* from NID 6 for ANSI-41 CCS networks and CCS groups outside of North America; and
5. *cluster codes* for internal CCS network or CCS group use as assigned in clause 6.

Guidelines for the assignment and administration of network codes and signalling point code blocks are provided in Annex A.

3.2 Unused Code

The network code of 0 (0000 0000) shall not be used. When the network cluster field is used to identify small networks, the network cluster code of 0 (0000 0000) shall not be used. When the Cluster Member Field is used to identify a CCS Group, the Cluster Member code of 0 shall not be used.

3.3 Small Network and Group Codes

Five of the network identification field codes, namely 1, 2, 3, 4, and 5 are reserved for assignment to small CCS networks and CCS groups. For network codes 1, 2, 3, and 4, their associated network cluster field codes shall be assigned as network codes for small networks. For network code 5, the network cluster and cluster member fields shall be partitioned into signalling point code blocks that shall be assigned to CCS groups that are not eligible for a network code assignment. For network code 5, a network cluster code is associated with each State, Province, or Territory in the United States and Canada. Similarly, specific network clusters are associated with the Caribbean, Atlantic, and Pacific countries, and territories within North America. Point code blocks from the respective network cluster codes are assigned to CCS groups according to the physical locations of the signalling points in the CCS groups.

3.4 Code for ANSI-41 CCS Networks and Groups Outside North America

Network identification field code 6 is reserved for assignment outside North America to ANSI-41 CCS networks and CCS groups.

3.5 Test Code

The network code of 229 (1110 0101) is assigned by PTSC for testing.

3.6 Reserved Code

The network code of 255 (1111 1111) is reserved for future use.

4 GENERAL PRINCIPLES

4.1 A large CCS network may be assigned a network code based upon the applicant's compliance with the guidelines in normative Annex A. A secondary network code may be assigned to a large CCS network provided that the applicant satisfies the criteria in Annex A

NOTE - A large CCS network is not eligible for more than two network codes.

A small CCS network may be assigned up to four "small" network codes upon request and more than four based on the applicant's compliance with the guidelines in Annex A. A CCS Group will be assigned the exact number of signalling point code blocks (four codes per block) requested based on the applicant's compliance with the guidelines in Annex A (see A.1).

4.2 Lists of network codes and signalling point code blocks are maintained by the Code Administrator. Once a network code or signalling point code block has been assigned to a CCS network or CCS group, respectively, the assignment of point codes to individual signalling points is the responsibility of that network or group. (See Chapter T1.111.5, *Signalling Network Structure*, for information on routing, addressing, and examples of individual point code assignments.)

4.3 In the case where small networks are assigned more than one network code and the NIDs of the network codes have different values, the Network Administrator shall use point codes having the same value in the NIDs to address a mated pair of STPs. This requirement is justification for a small network to request additional cluster codes to satisfy this condition.

5 SHARED CLUSTERS & GROUPS

If through merger, acquisition, divestiture, joint venture, or partnership split, a signalling point(s) or cluster(s) now belongs to a CCS network or CCS group different from the one originally assigned the large network code, small network code, or point code block, the new CCS network or CCS group may retain the point code(s) or cluster(s) temporarily, provided that

the network connections do not change due to the reorganization (e.g., other networks will not need to change their routing). This would allow a network element to retain its original point code and remain in operation when acquired by a different CCS network or CCS group as a result of any of the mentioned events. In this case, the Code Administrator shall be notified and will maintain assignment information for both CCS networks or CCS groups about that specific point code(s). The CCS network or CCS group originally assigned the network code or point code block is still considered to be the assignee of the point codes and has primary responsibility for coordinating the sharing arrangement. This allowance does not affect the method by which the Code Administrator assigns point codes. (Allowing network reconfiguration when network elements retain their original SPCs and move to a different CCS network or CCS group is not addressed.)

When the point codes are no longer used by the acquired CCS network or CCS group in a shared arrangement (i.e., as a result of point code change), the Code Administrator shall be informed and the point codes shall be returned to the full control of and use by the original assignee.

6 POINT CODES FOR INTERNAL CCS/NETWORK/GROUP USE

Some SS7 signaling nodes in a CCS network or group are configured in point-to-point signaling relations (with one or more peer nodes) using F-links internally within the CCS network or group and therefore do not support any internetwork signaling relations. Such nodes only need to be identified uniquely within the CCS network or CCS group. To conserve point codes, network codes 100-0 through 100-10 are assigned for use by any carrier to support internal point-to-point signalling arrangements. Therefore, multiple networks may assign the same values within these clusters. Network codes 100-11 through 100-255 are reserved. Similarly, multiple nodes within one network may be assigned the same value as long as this does not result in routing ambiguities.

| Network Identification | Network Cluster | |
|------------------------|-----------------|--|
| 100 | 0-10 | Internal Network/Group Use. Assigned for use by any carrier for internal network/group point-to-point signaling arrangements. |
| 100 | 11-255 | Reserved |

A network administrator may use the point codes under network codes 100-0 through 100-10 assigned for "Internal Network/Group Use" to support internal point-to-point signaling relations within a CCS network or CCS group. Use of these point codes and individual assignment within a CCS network or CCS group is the responsibility of the individual network administrator. It is recommended that a network administrator only assign one of the point codes assigned for "Internal Network Use," to a CCS node provided that the node meets the following criteria:

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1. All signalling between the node and any and all other nodes is on a point-to-point (i.e., F-link) basis. All MSU's go only between these nodes.
2. No connectivity exists between the node and an STP.
3. The node supports only intra-network signaling relations (i.e., signaling relations within the CCS network or CCS group).

Note that the point codes under network codes 100-0 through 100-10 are assigned for use by all carriers. Due diligence to avoid conflicts is the responsibility of the network administrators.

Annex A
(normative)

A CCS CODE ADMINISTRATION GUIDELINES

A.1 Eligibility for CCS code assignment

A.1.1 A CCS network (defined in 1.1) is a set of signalling points with an STP or STP functionality using out-of-band signalling that are operated, administered, controlled, and maintained by the operator of the network.

A.1.2 Any United States CCS (SS7) network, other CCS networks utilizing the North American Numbering Plan (NANP), or ANSI-41 CCS network outside of North America may be assigned a network code.

A.1.3 A single signalling point or group of signalling points without a STP or STP functionality (referred to as a CCS group) is not considered a network and will not be eligible for a unique network code assignment. These CCS groups will instead be eligible for assignment of a signalling point code block(s).

A.1.4 Any United States CCS group, other CCS group utilizing the North American Numbering Plan, or ANSI-41 CCS group outside of North America is eligible for point code block assignment.

A.1.5 Only CCS networks and CCS groups will be assigned network codes and signalling point code blocks, respectively. Firms or groups of firms that are associated with CCS networks or CCS groups (e.g., own, share, or lease) are not eligible for network code or signalling point code block assignment. The intent is to assign network codes or signalling point code blocks to CCS networks or CCS groups, and not to a firm or group of firms associated with a CCS network or CCS group.

A.1.6 All applicants shall follow the guidelines in this Annex.

A.2 Administration of CCS code assignments

A.2.1 General Administration Principles

A.2.1.1 There shall be no advance reservation process for code assignments. Codes shall be assigned when the indication of building and operating a CCS network or CCS group is given to the Code Administrator.

A.2.1.2 The plan is to assign unique network codes and signalling point codes that shall be used by CCS networks or CCS groups anywhere in the United States, North America, or by ANSI-41 CCS networks outside of North America. Signalling point code blocks assigned to CCS groups shall share a network code and network cluster codes, but the signalling point codes assigned shall be unique. Once a network code or point code block is assigned, the Code Administrator is not responsible for assigning the point codes to SPs or STPs within a network or group.

A.2.1.3 The network code of 0 shall not be used. The network code of 255 is reserved for future use. The network codes 1, 2, 3, and 4 are reserved for small network code assignments using the network cluster field. The network code 5 is reserved for assignment of signalling point code blocks to CCS groups. The network code 6 is reserved for assignment outside of North America to ANSI-41 CCS networks and CCS groups.

A.2.1.4 Large networks shall be assigned network codes starting with 254 and decrementing. Small networks shall be assigned network codes starting with network identification field code 1 and cluster field code 1 (small network code 1-1), and incrementing. When using the network cluster field to assign network codes, the network cluster code of 0 shall not be used.

A.2.1.5 These guidelines authorize the Code Administrator to assign ANSI CCS point codes to ANSI-41 CCS networks and CCS groups that are outside North America. Network identification field code 6 has been reserved for this purpose

A.2.2 Criteria for large network code assignment

A.2.2.1 A CCS network shall be assigned a large network code if all of the following conditions are met:

1. The applicant certifies that its network includes at least 75 signalling that are or will be operational within a year.
2. The applicant certifies that its network includes at least 6 network elements providing STP functionality that are or will be operational within the first year.
3. The applicant certifies that its network includes at least 150 signalling points that are or will be operational by the end of 5 years.

4. The applicant certifies that its network includes at least 12 network elements providing STP functionality that are or will be operational by the end of 5 years.

A.2.2.2 Other CCS networks not satisfying the conditions described above shall be assigned a small network code (see A.2.3). CCS groups are not eligible for a network code assignment and shall be assigned signalling point code blocks (see A.2.4).

A.2.2.3 The first network code assigned shall be called the "primary" code. Additional network codes shall be called "supplemental" codes.

A.2.2.4 A large CCS network has the potential of being assigned only one supplemental code, based on a listing of signalling points identified in the applicant's request for a supplemental code, to accommodate exhaust of the primary code.

A.2.3 Criteria for small network code assignment

A.2.3.1 CCS networks not satisfying all the criteria established for large network codes in A.2.2.1 shall be assigned a small network code.

A.2.3.2 A small CCS network shall have the potential of being assigned up to four small network codes on the initial request, and more than four based on compliance with the requirements described below.

A.2.3.3 A valid small network code request shall include:

- ◆ The number of signalling points;
- ◆ The number of network elements providing STP functionality;
- ◆ The number of cluster codes requested; and
- ◆ Certification that the network will be operational within one year.

More than four small network codes will be assigned providing that the Network Administrator provides the aforementioned items and justifies the need for signaling point(s) in new clusters, instead of the existing cluster. Such needs may include, but are not limited to:

- ◆ Existing cluster(s) must be split because of capacity or survivability constraints including but not necessarily limited to traffic, port translations, or numbering such that the existing STP pair is expected to exhaust within 3 years.

- ◆ A new signalling point is being installed; however, it is expected to be re-homed within 5 years on a STP pair that will have a different network identification cluster code.
- ◆ Network configuration, routing, or screening in the requesting or adjacent networks will be simplified if some signaling points within previously assigned clusters are placed in a new cluster or if a new signalling point is installed in a cluster separate from those previously assigned.
- ◆ Additional codes are needed to satisfy the requirement that a mated STP pair must be assigned point codes from the same NID (see 4.3).

Cluster member code 0 is reserved for addressing STPs; however, a STP is not required to have an address with cluster member code 0.

NOTE - Clause 2.2.3D of T1.111.4 provides information regarding the encoding of member code 0 in the network cluster member field.

A.2.4 Criteria for point code block assignment

A.2.4.1 CCS groups are not eligible for a network code assignment (i.e., no signalling point with transfer functionality) and shall be assigned signalling point code blocks for their use.

A.2.4.2 A CCS group may be assigned any number of signalling point code blocks based on compliance with the requirements described below.

A.2.4.3 A valid signalling point code block request shall justify the need for each supplemental point code block request. A CCS group will be assigned the exact number of signalling point code blocks required based on the number of signalling points being placed into service within one year of the request and the physical location of each signalling point as described below.

A.2.4.4 A signalling point code block contains four contiguous signalling point codes. For network code 5, a network cluster code is associated with each State, Province, or Territory in the United States and Canada. Similarly, specific network cluster are associated with the Caribbean, Atlantic, and Pacific countries, and territories within North America. Point code blocks from the respective network cluster codes are assigned to CCS groups according to the physical locations of the signalling points in the CCS groups. Within each network cluster code associated with a particular State, Province, and Territory, signalling point code blocks shall be assigned starting with the first block of signalling points (signalling point codes 5-X-0 through 5-X-3) and incrementing. Cluster member code zero (0) is reserved for addressing signaling transfer points, therefore those point code values (including signalling point code blocks [Network Identifier 5-X-4 through 5-X-73] beyond cluster 13) shall not be assigned to signalling points without the transfer function.

NOTE - A CCS group by definition does not have a signalling point with the transfer function. Clause 2.2.3D of T1.111.4 provides additional information regarding the encoding of member code 0 in the network cluster member field.

When the last point code block within a network cluster code for a state, province, or territory or North American country using the NANP has been assigned, the Code Administrator shall associate the next unused network cluster code of network code 5 with the state, province, or country using the NANP.

NOTE - A provider that started initially as a CCS group and later decides to introduce a signalling point with STP functionality shall request an network code, large or small (based on the appropriate assignment criteria), in addition to its existing codes. A CCS group point code block shall not be assigned if the group of signaling points has a signalling point with transfer functionality.

A.2.5 Specific and Additional Criteria and Procedures for CCS Networks and CCS Groups Outside of North America Using ANSI-41

A.2.5.1 Applicants shall not apply for nor be assigned large network codes.

A.2.5.2 Applicants will adhere to all conditions, criteria, and procedures as detailed for North American networks in other sections of this document, when applying for a network code or point code block.

A.2.5.3 ANSI-41 CCS networks or CCS groups outside of North America will be assigned small network codes or point code blocks respectively, only from NID 6.

A.2.5.4 Network codes and point code blocks that are assigned under the conditions, criteria, and procedures contained in this Annex are subject to the same reclamation procedures as detailed in this document for North American networks.

A.2.5.5 An ANSI-41 CCS network outside of North America that spans multiple countries (i.e., a multi-national network or group) is treated as a single network. Applicants shall not apply for nor shall the Code Administrator assign network codes on a per country basis.

A.2.5.6 The following additional conditions, criteria, and procedures apply to code applicants operating ANSI-41 CCS networks and CCS groups outside of North America:

- ◆ The applicant network must identify itself to the Code Administrator by certifying that it is an ANSI-41-based CCS network or CCS group outside of North America and by providing its full international address.

- ◆ The applicant network must identify the country(ies) in which it operates and, in the case of multiple countries, which country(ies) the applied for network code(s) or point code block(s) will be utilized.
- ◆ If the criteria for a CCS small network are met, the Code Administrator will make the requested assignment of a small network code from NID 6 starting with cluster 1 in ascending order.
- ◆ If the criteria for a CCS group point code block are met, the Code Administrator will make the requested assignment of a point code block from a cluster in NID 6 that the Code Administrator has reserved, starting from cluster 254 in descending order.

A.3 Procedure for requesting a code assignment

A.3.1 It is required that the Network Administrator of the CCS network or CCS group desiring a network code or point code block assignment, respectively, contact the Code Administrator (see A.6).

A.3.2 The Network Administrator of the CCS network or CCS group must submit a completed application form (Contact Code Administrator for Application Form) to the Code Administrator requesting an assignment. When requesting a network code or signalling point code block assignment, the Network Administrator of the CCS network or CCS group must provide an exact corporate name and address, and list all of the firms associated with the CCS network or CCS group. It must also inform the Code Administrator of any previously assigned network codes or signalling point code blocks. Exact spelling, capitalization, hyphenation, and the like are necessary. In addition, the Network Administrator of a CCS group must also inform the Code Administrator of the state, province, territory, or country where each signalling point is physically located. When requesting an assignment, the Network Administrator of the CCS network or CCS group must give some justification for the assignment (see A.2).

A.3.3 The Network Administrator of the CCS network or CCS group must indicate whether it is an ANSI-41 CCS network or CCS group outside of North America (See A.2.5).

A.3.4 Assignments shall be on a first-come, first-served basis. A CCS network requesting an assignment shall be given the next available network code. A CCS group in North America requesting an assignment shall be given the next available signalling point code block of the network cluster code of network code 5 associated with the State, Province, Territory, or North American country using NANP where each signalling point is physically located. An ANSI-41 network outside North America qualifying as a CCS group and requesting an assignment shall be given the next available signalling point code block of the network cluster code reserved for CCS group assignment within NID = 6. The CCS group Network Administrator shall assign point codes to its signalling points based on the association of the network cluster codes of the assigned signalling point code blocks to the states, provinces, or countries using NANP a where the signalling points are physically located. See Figure A.1 describing the application process.

When a new network code or signalling point code block is assigned, the Code Administrator shall notify PTSC (i.e., the Chair of the Interoperability Subcommittee) and provide a written confirmation to the Network Administrator of the CCS network or CCS group.

A.4 Reclaiming Assigned Codes

A.4.1 Assigned network codes and signalling point code blocks shall remain in effect as long as the CCS network or CCS group is in operation. If a CCS network or CCS group is no longer in operation, the Network Administrator of the CCS network or CCS group agrees to relinquish the codes or signalling point code blocks within 60 days in writing to the Code Administrator. The Code Administrator, upon determining that a network code is no longer in operation, should verify it by attempting to contact the authorized representative for that network and request voluntary return of their code. If no response is received within 60 days or if the entity does not object, the entity is notified that their code is being reclaimed and will become available for reassignment after a 6-month transition period.

A.4.2 Network codes or signalling point code blocks are not transferable from one CCS network or CCS group to another.

A.4.3 If a number of firms merge and a consolidated operation of their CCS networks results, the newly consolidated CCS network may choose which code(s) is to be retained for operation. The Network Administrator shall notify the Code Administrator of such code(s). The code(s) that is not retained shall become available for reassignment after a 6-month transition period. A similar situation involving CCS groups may not require the relinquishing of any assigned signalling point code blocks.

A.4.4 If a number of firms merge and separate network operations are maintained, the Code Administrator shall be notified and the code(s) may be retained by the individual CCS networks. The Code Administrator shall verify with the merged firms that the separate network operations are to be maintained.

A.4.5 A CCS group that was assigned point code blocks before the assignment guidelines were revised to take into account the physical location of signalling points may voluntarily choose to release its currently used point code blocks for reclamation and be assigned new point code blocks based on the physical location of its signalling points. The point code blocks to be reclaimed must be indicated to the Code Administrator and requests for new point code blocks must be submitted to the Code Administrator according to A.3.

A.5 Conservation of Codes

Initially only one network code shall be assigned to a large CCS network. Up to four small network codes will be assigned to a small network -- potentially more if justified. The number of signalling point code blocks assigned to a CCS group is dependent on the demonstrated need of the CCS group. It is the responsibility of the Code Administrator to continually monitor the assignment of the network codes and signalling point code blocks, and the potential for their exhaust. The Code Administrator is to inform PTSC (i.e., the Chair of the Interoperability Subcommittee) if there is a potential of exhaust and the type of conservation action that has been put into effect.

A.5.1 Conservation of Large Network Codes

If the assignment of codes reaches the 80% level of available large network codes (200 large network codes), then no supplemental codes shall be assigned. If the assignment of codes reaches the 90% level of available large network codes (225 large network codes), then an attempt shall be made to reclaim any supplemental codes assigned. It is expected that the industry would cooperate and voluntarily offer to release minimally used codes. The Code Administrator should negotiate with code assignees to identify such codes for potential release and reassignment.

A.5.2 Conservation of Small Network Codes

If the assignment of codes reaches the 70% level of available small network codes, then the first course of action would be to reserve an additional large network code. If the assignment of large network codes has reached the 80% level, then a large network code shall not be reserved. Instead, the potential of being assigned up to four small network codes at the initial request will be reduced to three. If the assignment of codes reaches the 80% level of available small network codes, then no supplemental codes shall be assigned. If the assignment of codes reaches the 90% level of available small network codes, then an attempt shall be made to reclaim any supplemental code assigned. It is expected that the industry would cooperate and voluntarily offer to release minimally used codes. The Code Administrator should negotiate with code assignees to identify such codes for potential release and reassignment.

A.5.3 Conservation of Signalling Point Code Blocks

If the assignment of signalling point code blocks reaches the 90% level of available signalling point code blocks, then the first course of action would be to reserve an additional large network code. If the assignment of large network codes has reached the 80% level, then a large network code shall not be reserved. Instead an attempt shall be made to reclaim any unused or lightly used blocks assigned. It is expected that the industry would cooperate and voluntarily offer to release minimally used blocks. The Code Administrator should negotiate with code assignees to identify such codes for potential release and reassignment.

A.6 Code Administrator

The Code Administrator is given the full authority by PTSC and the companies supporting PTSC to carry out these guidelines. Contact the PTSC Secretariat² to obtain the name and address of the current Code Administrator.

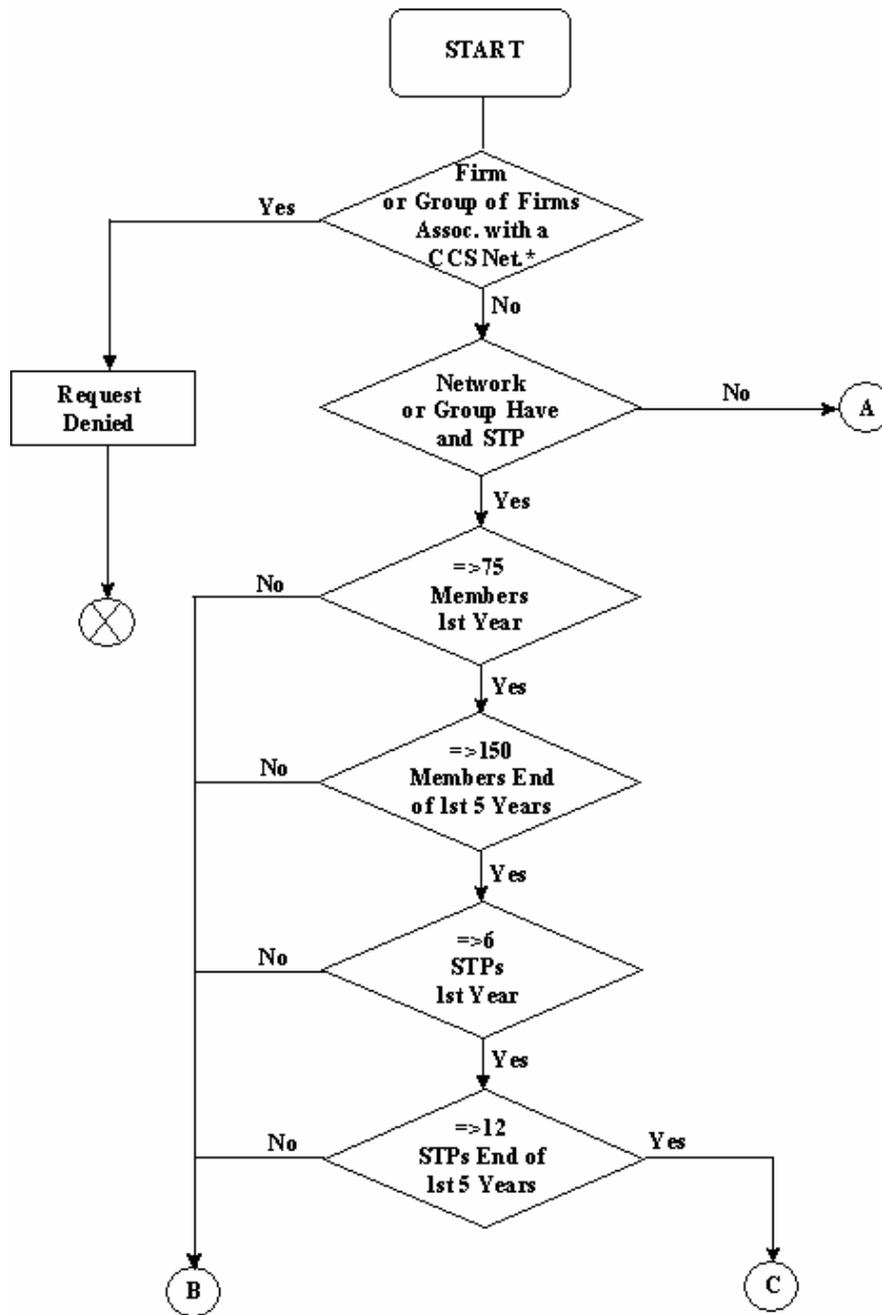
A.7 Interpretation of These Guidelines

In order for signalling communications to occur between SS7 nodes, it is necessary for these nodes to be identified. This is true, regardless of the "nature" of the CCS network (e.g., "public" or "private"). Therefore, no restriction should be made based on the "nature" of the CCS network with respect to its eligibility for an SS7 code assignment.

NOTE - Contact the Code Administrator for an Application Form.

² At the Alliance for Telecommunications Industry Solutions, 1200 G Street NW, Suite 500, Washington, DC 20005.

SIGNALLING POINT CODE ASSIGNMENT RULES



* NOTE - See Annex A, clause A.1

Figure A.1/T1.111.8 - Signalling Point Code Assignment Rules (sheet 1 of 4)

POINT CODE BLOCK

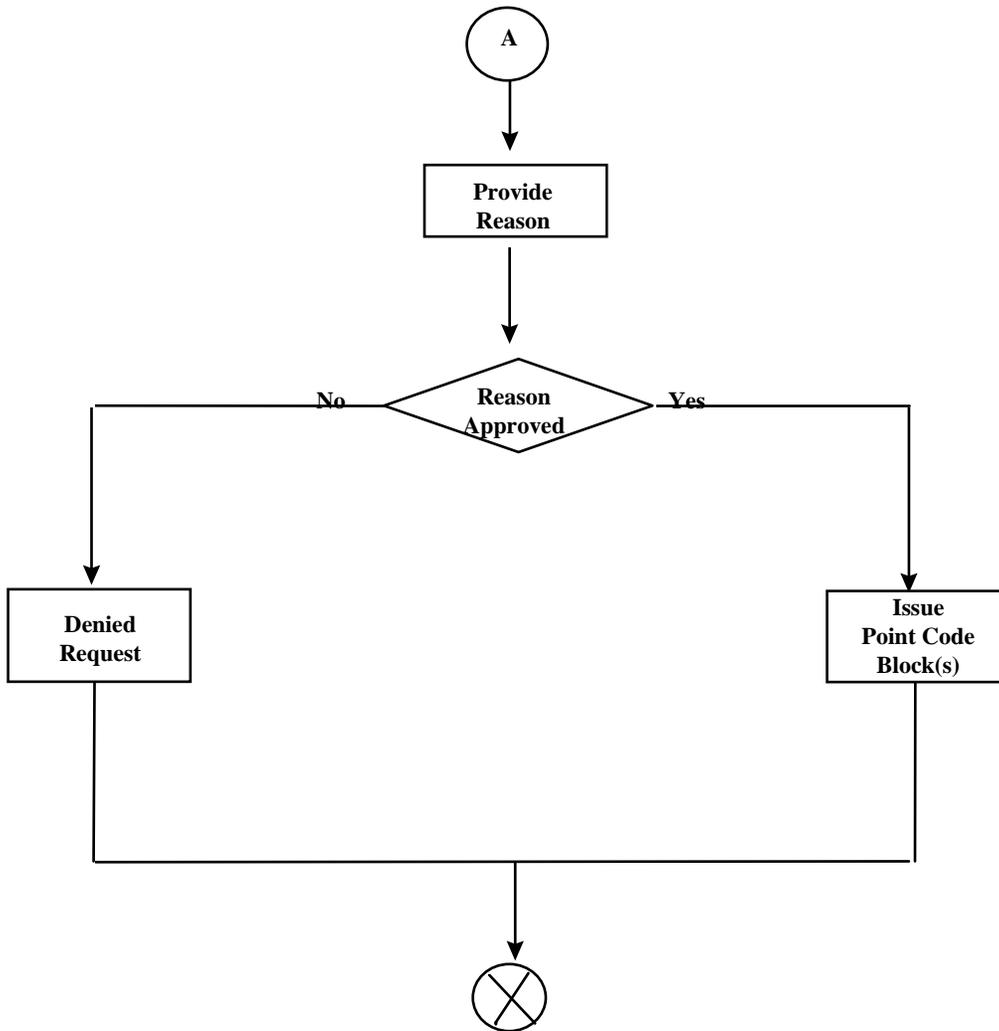


Figure A.1/T1.111.8 - Signalling Point Code Assignment Rules (Sheet 2 of 4)

SMALL NETWORK CODE

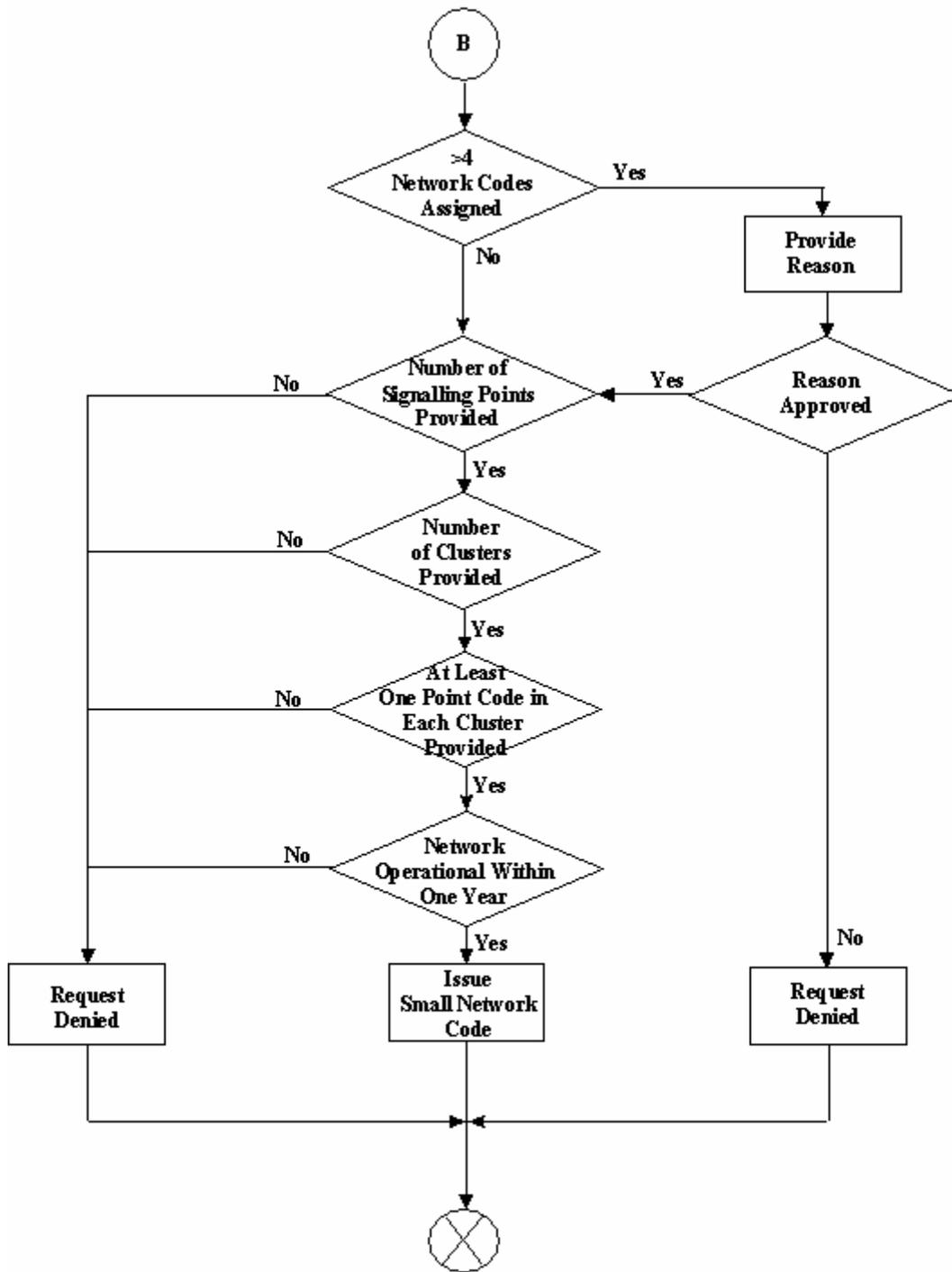


Figure A.1/T1.111.8 - Signalling Point Code Assignment Rules (sheet 3 of 4)

LARGE NETWORK CODE

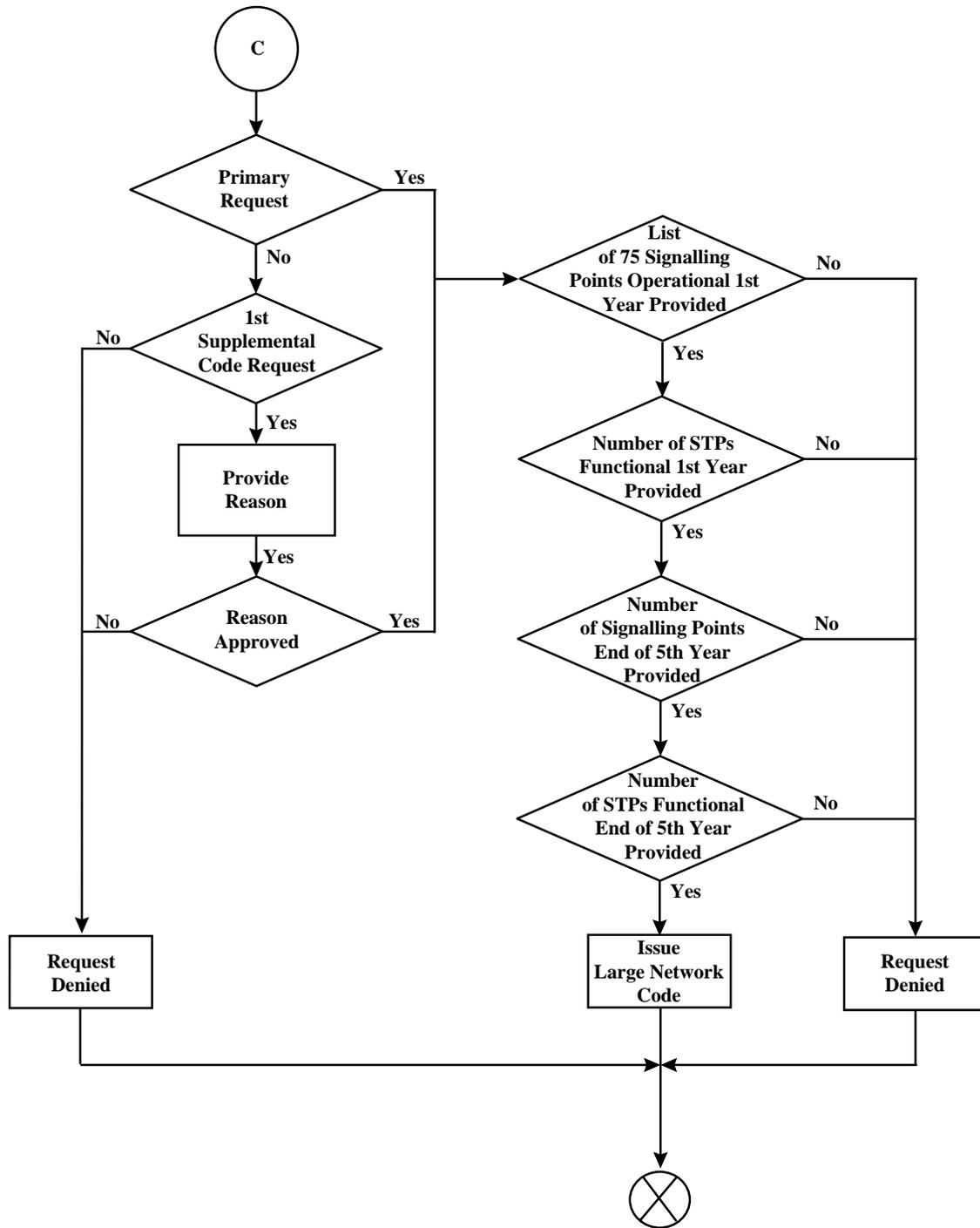


Figure A.1/T1.111.8 - Signalling Point Code Assignment Rules (sheet 4 of 4)