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Recommendation Q.704

SIGNALLING NETWORK FUNCTIONS AND MESSAGES

National option.

1 Introduction

1.1 *General characteristics of the signalling network functions*

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

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

— *signalling message handling* , and

— *signalling network management* .

The signalling message handling functions are briefly summarized in § 1.2, the signalling network management functions in § 1.3. The functional interrelations between these functions are indicated in Figure 1/Q.704.

1.2 *Signalling message handling*

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

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

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

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

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

— the *message routing* | unction , used at each signalling point to determine the outgoing signalling link on which a message has to be sent towards its destination point;

— the *message discrimination* | unction , 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;

— the *message distribution* | unction , 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 § 2.

Figure 1/Q.704, (M), p.

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 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/Q.704, the signalling network management functions are divided into:

— *signalling traffic management* ,

— *signalling link management* , and

— *signalling route management* .

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

1.3.3 §§ 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 § 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 *signalling point restart* . They are specified in §§ 5 to 9 respectively. A signalling link may be made unavailable to User Part generated traffic by means of the management inhibiting procedure described in § 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 § 11.

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

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

1.3.6 The format characteristics, common to all message signal units which are relevant to the Message Transfer Part, level 3, are specified in § 14.

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

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 § 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 messages to be sent, while message distribution is a function concerning the received messages. The functional relations between message routing and distribution appear in Figure 2/Q.704.

Figure 2/Q.704, (M), p.

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 § 15 for the signalling network management messages. The label used for signalling network management messages is also used for testing and maintenance messages (see Recommendation Q.707). 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 Recommendation Q.705.

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 Recommendation Q.705, § 8.

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.

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

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

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

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

2.2.2 The standard routing label has a length of 32 bits and is placed at the beginning of the Signalling Information Field. Its structure appears in Figure 3/Q.704.

Figure 3/Q.704, (M), p.

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

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

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

In the case of circuit related messages of the TUP, the field contains the least significant bits of the circuit identification code (or bearer identification code, in the case of the Data User Part), and these bits are not repeated elsewhere. In the case of all other User Parts, the SLS is an independent field in accordance with the criteria stated in § 2.2.5.

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

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

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

2.3 *Message routing function*

2.3.1 The message routing function is based on information contained in the routing label, namely on the destination point code and on the signalling link selection field; moreover, in some circumstances the service indicator may also need to be used for routing purposes.

Note — A possible case for the use of the service indicator is that which would arise from the use of messages supporting the signalling route management function (i.e. transfer-prohibited, transfer-allowed and signalling-route-set-messages) referring to a destination more restrictive than a single signalling point (e.g., an individual User Part) (see § 13). Some specific routing may be required for the MTP Testing User Part (for further study).

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

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

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

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

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

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 the international network.

In case a), the traffic flow carried by a link set is shared (on the basis of the signalling link selection field) between different signalling links belonging to the link set. An example of such a case is given by a link set directly interconnecting the originating and destination points in the associated mode of operation, such as represented in Figure 4/Q.704.

Figure 4/Q.704, (M), p.

In case b) traffic relating to a given destination is shared (on the basis of the signalling link selection field) between different signalling links not belonging to the same link set, such as represented in Figure 5/Q.704. The load sharing rule used for a particular signalling relation may or may not apply to all the signalling relations which use one of the signalling links involved (in the example, traffic destined to B is shared between signalling links DE and DF with a given signalling link selection field assignment, while that destined to C is sent only on link DF, due to the failure of link EC).

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

Principles relating to the number of load-shared links appear in Recommendation Q.705.

Figure 5/Q.704, (M), p.

2.3.3 The routing information mentioned in § 2.3.1 should be appropriately updated when some event happens in the signalling network, which is relevant to the concerned signalling point (e.g., failure of a signalling link or unavailability of a signalling route). The updating of the routing information is made according to the particular event (see § 3) and to the signalling routing modification rules specified in § 4. If a signalling transfer point receives a message for destination point code which according to the routing information does not exist, the message is discarded and an indication is given to a management system.

2.3.4 *Handling of level 3 messages*

2.3.4.1 Messages not related to a signalling link have the signalling link code 0000 (e.g., transfer prohibited and transfer allowed). They are handled in accordance with the normal routing function, where the signalling link code (SLC) is used in the same way as SLS for load sharing.

2.3.4.2 Messages related to a signalling link should be subdivided into 2 groups:

a) Messages that are to be transmitted over a specific signalling link (e.g., changeback declaration (see § 6) and signalling link test messages (Recommendation Q.707)), where a special routing function must ensure that these messages are transmitted exclusively over a particular signalling link.

b) Messages that must not be transmitted over a specific signalling link (e.g., changeover messages and emergency changeover messages (see § 5)), whose transmission over the signalling link defined by the SLC contained in the label must be avoided.

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).

In national signalling networks, each message may be 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. N + 1 levels of congestion priority (0 N 3) levels are accommodated in the signalling network, with 0 being the lowest and N the highest.

In national signalling networks using more than one congestion priority, the highest priority is assigned to signalling network management messages.

2.3.5.2 *In national signalling networks using multiple congestion priorities*

When a signalling link has been selected for transmitting a message, comparison of the congestion priority of the message is 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:

i) If the congestion priority of the message is greater than or equal to the signalling link discard status, the message is transmitted.

ii) If the congestion priority of the message is less than the signalling link discard status, the message is discarded.

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.

The destination point code field of the received message is examined by the discrimination function in order to determine whether or not it is 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 sections, in order to be sent on the appropriate outgoing link towards the message destination point.

When a signalling transfer point detects that a received message cannot be delivered to its destination point, it sends in response a transfer-prohibited message as specified in § 13.2.

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

Should a User become unavailable (User unavailability is an implementation dependent notion), this is detected by the MTP. Whether the distribution 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 should be returned to the originating end on a response basis. In the originating signalling point, the relevant User Part should be informed via an MTP-STATUS primitive. A mandatory parameter Cause is included in the MTP status indication with two possible values:

— Signalling Network Congestion,

— User Part Unavailability.

The User Part should reduce its traffic in an appropriate manner and take specific actions.

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).

3 Signalling network management

3.1 *General*

3.1.1 The signalling network management functions provide the actions and procedures required to maintain signalling service, and to restore normal signalling conditions in the event of disruption in the signalling network, either in signalling links or at signalling points. The disruption may be in the form of complete loss of a signalling link or a 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 ́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 ‘‘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.

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.

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

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

— changeover (see § 5),

— changeback (see § 6),

— forced rerouting (see § 7),

— controlled rerouting (see § 8),

— signalling point restart (see § 9),

— management inhibiting (see § 10),

— signalling traffic flow control (see § 11).

b) 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 § 12):

— signalling link activation, restoration and deactivation,

— link set activation,

— automatic allocation of signalling terminals and signalling data links.

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

— transfer-controlled procedure (see §§ 13.6, 13.7 and 13.8),

— transfer-prohibited procedure (see § 13.2),

— transfer-allowed procedure (see § 13.3),

— transfer-restricted procedure (see § 13.4),

— signalling-route-set-test procedure (see § 13.5),

— 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/Q.704):

— unavailable, failed or inactive,

— unavailable, blocked,

— unavailable (failed or inactive) and blocked,

— unavailable, inhibited,

— unavailable, inhibited and (failed or inactive),

— unavailable, inhibited and blocked,

— unavailable, (failed or inactive), blocked and inhibited.

The concerned link can be used to carry signalling traffic only if it is available except possibly for certain classes of test and management messages. 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 to 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:

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

— intolerably high signal unit error rate (see Recommendation Q.703, § 10);

— excessive length of the realignment period (see Recommendation Q.703, §§ 4.1 and 7);

— excessive delay of acknowledgements (see Recommendation Q.703, §§ 5.3 and 6.3);

— failure of signalling terminal equipment;

— two out of three unreasonable backward sequence numbers or forward indicator bits (see Recommendation Q.703, §§ 5.3 and 6.3);

— reception of consecutive link status signal units indicating out of alignment, out of service, normal or emergency terminal status (see Recommendation Q.703, § 1.7);

— excessive periods of level 2 congestion (see Recommendation Q.703, § 9).

The first two conditions are detected by the *signal unit error rate monitor* (see Recommendation Q.703, § 10).

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

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

3.2.3 *Signalling link restoration*

A signalling link previously failed is restored when both ends of the signalling link have successfully completed an initial alignment procedure (see Recommendation Q.703, § 7).

3.2.4 *Signalling link deactivation*

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

a) a request is obtained from the signalling link management function (see § 12);

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

3.2.5 *Signalling link activation*

A signalling link previously inactive is recognized by level 3 as activated when both ends of the signalling link have successfully completed an initial alignment procedure (see Recommendation Q.703, § 7).

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 Recommendation Q.703, § 8).

Note — A link becomes unavailable when it is failed or deactivated or [(failed or deactivated) and blocked] or inhibited. See Figure 6/Q.704.

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)] or uninhibited. See Figure 6/Q.704.

Figure 6/Q.704 (feuillet 1 sur 4), (MC), p.6

Figure 6/Q.704 (feuillet 2 sur 4), (MC), p.7

Figure 6/Q.704 (feuillet 3 sur 4), (MC), p.8

Figure 6/Q.704 (feuillet 4 sur 4), (MC), p.9

3.2.8 *Signalling link inhibiting*

A signalling link is recognized as inhibited when:

a) an acknowledgement 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;

b) 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:

a) a request is received to uninhibit the link from a remote end or from a local routing function;

b) an acknowledgement 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/Q.704, 7/Q.704 and 8/Q.704. Typical examples of the application of the procedures to the particular network cases appear in Recommendation Q.705.

Figure 7/Q.704, (M), p.

Figure 8/Q.704, (N), p.

3.3.1 *Signalling link failed*

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

3.3.1.2 Signalling link management: the procedures described in § 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 which can no longer route the concerned signalling traffic applies the transfer-prohibited procedures or transfer-restricted procedures described in § 13.

3.3.2 *Signalling link restored*

3.3.2.1 Signalling traffic management: the changeback procedure (see § 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 § 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 is 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 procedures described in § 13.

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 § 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 § 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 management: as specified in § 3.3.1.1.

As a national option, local processor outage may also be applied to the affected signalling link before commencement of the appropriate signalling traffic management option. On completion of that signalling traffic management action, local processor outage is removed from the affected signalling link. No further signalling traffic management will be performed on that affected signalling link until a timer T24 (see § 16.8) has expired or been cancelled, thus allowing time for indications from the remote end to stabilize as it carries out any signalling traffic management of its own.

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 § 13.

3.3.6 *Signalling link unblocked*

3.3.6.1 Signalling traffic management: the actions will be the same as 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 procedures described in § 13.

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 procedures described in § 13.

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 , unavailable (see also Figure 6/Q.704).

3.4.1 *Signalling route unavailability*

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

3.4.3 *Signalling route restricted* |

A signalling route becomes restricted when a transfer-restricted message, indicating that the signalling traffic towards a particular destination is being transferred with some difficulty via the signalling transfer point sending the concerned message is received (see § 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, are listed. See also Figures 6/Q.704 and 8/Q.704. Typical examples of the application of the procedures to particular network cases appear in Recommendation Q.705.

3.5.1 *Signalling route unavailable*

3.5.1.1 Signalling traffic management: the forced rerouting procedure (see § 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 § 13.

3.5.2 *Signalling route available*

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

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 § 13.

3.5.3 *Signalling route restricted* |

3.5.3.1 Signalling traffic management: the controlled rerouting procedure (see § 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 restricted availability of the signalling route, the network routing is, if possible, reconfigured; procedures described in § 13 are used to advise adjacent signalling points.

3.6 *Status of signalling points*

A signalling point can be in two states; available or unavailable (see Figure 6/Q.704). 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:

— all signalling links connected to the adjacent signalling point are unavailable and

— the adjacent signalling 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 signalling link connected to this 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 that signalling point has restarted, or

— the adjacent signalling point becomes accessible on the reception of a transfer allowed message or a transfer restricted message (see § 13.4).

3.7 *Procedure 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 procedure is used to update the status of the recovered 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 signalling point restart procedure (see § 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:

— avoid loss of messages

— limit the level 3 load due to the restart of a signalling point

— 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 signalling point restart procedure attempts to restore the signalling links of the point which becomes available; the signalling link restoration procedure is used (see § 12);

3.7.2.3 Signalling route management: The second step of the signalling point 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 § 13).

3.7.3 Signalling point congested: (implementation-dependent option, 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 MSU 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.

a) 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.

b) In national signalling networks, with multiple congestion thresholds, N (1 N 3) separate thresholds are provided for detecting the onset of congestion. They are called congestion onset thresholds and are numbered 1, . | | , N , respectively. N separate thresholds are provided for monitoring the abatement of congestion. They are called congestion abatement thresholds and are numbered 1, . | | , N , respectively.

3.8.2.2 In national signalling networks with multiple congestion thresholds N 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, . | | , N , respectively.

Congestion discard threshold n (n = 1, . | | , N) is placed higher than congestion onset threshold n in order to minimize message loss under congestion conditions.

Congestion discard threshold n (n = 1, . | | , N — 1) 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.

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.

In national signalling networks with $N > 1$, the congestion abatement threshold n (n = 2, . | | , N) should be placed higher than the 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, . | | , N) 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/Q.704).

Figure 8a/Q.704, (M), p.

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 ($n = 1, . | | , N$) 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/Q.704).

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

Figure 8b/Q.704, (M), p.

When the current buffer occupancy exceeds congestion discard threshold n ($n = 1, . | | , N — 1$), but does not exceed congestion discard threshold $n + 1$, the current signalling link discard status is assigned the value n (see Figure 8c/Q.704).

Figure 8c/Q.704, (M), p.

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

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

3.8.2.3 In national signalling networks using multiple signalling link congestion states without congestion priority, S + 1(1 S 3) levels of signalling link congestion status are accommodated in the signalling network, 0 being the lowest and S the highest.

The signalling link congestion status is determined by a timing mechanism after the buffer occupancy exceeds the congestion onset threshold, or drops below the congestion abatement threshold. 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 exceeds the congestion onset threshold, the first signalling link congestion status is assigned a value s , predetermined in the signalling network.

If the signalling link congestion status is set to s (s = 1, . | | , S — 1) and the buffer occupancy continues to be above the congestion onset threshold during Tx, the signalling link congestion status is updated by the new value s + 1.

If the signalling link congestion status is set to s (s = 1, . | | , S) and the buffer occupancy continues to be below the abatement threshold during Ty, the signalling link congestion status is updated by the new value s — 1.

Otherwise, the current signalling link congestion status is maintained (see Figure 8d/Q.704).

The congestion abatement threshold should be placed lower than the congestion onset threshold.

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: in the case 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.

Figure 8d/Q.704, (M), p.

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.

a) 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 § 13.6. The congestion status is not retained by level 3 at the receiving signalling point.

b) In national signalling networks with multiple congestion levels corresponding to the $N + 1$ levels of signalling link congestion, there are $N + 1$ values of signalling route set congestion status, with 0 being the lowest and N 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 is updated, in accordance with the transfer-controlled procedure 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.

c) In national signalling networks using multiple congestion levels without congestion priority, there are $S + 1$ values of signalling route set congestion states, with 0 being the lowest and S 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 local signalling link in the signalling route set to a given destination becomes congested, the congested status of the signalling route set is assigned the value of the signalling link congestion status, if it is larger 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 is updated in accordance with the transfer-controlled procedure as specified in § 13.8. The congestion status of the route set towards the congested destination is not retained by level 3 at the receiving signalling point.

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 § 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.

4 Signalling traffic management

4.1 *General*

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

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

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

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

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

— signalling route availability: the controlled rerouting procedure (see § 8) is used to divert signalling traffic to the route made available;

— signalling route restricted : the controlled rerouting procedure (see § 8) is used to divert signalling traffic to an alternative route (if any);

— signalling point availability: the signalling point restart procedure (see § 9) is used to divert the signalling 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 sections. Moreover, these procedures include a modification of the signalling routing, which is made in a systematic way, as described in §§ 4.2 to 4.7.

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

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

For each destination which 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, which may carry signalling traffic towards the concerned destination. The possible link set (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 that 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 of an alternative link set (combined link set).

For each signalling link, the remaining signalling links in the link set are alternative links. The signalling links of a link set are arranged in a certain priority order. Under normal conditions the signalling link (or links) having the highest priority is used to carry the signalling traffic.

These signalling links are defined as normal signalling links, and each portion of load shared traffic has its own normal signalling link. Signalling links other than normal may be active signalling links (but not carrying any signalling traffic at the time) or inactive signalling links (see § 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 to which the unavailable link belongs, the signalling traffic is transferred within the link set to:

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

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

4.3.3 In the case when there is no alternative signalling link within the link set to which the unavailable signalling link belongs, the signalling traffic is transferred to one or more alternative link sets (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).

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 link sets (combined link sets) and from one or more signalling links within each link set.

4.5 *Signalling route unavailability*

When a signalling route becomes unavailable (see § 3.4) signalling traffic currently carried by the unavailable route is transferred to an alternative route by means of forced re-routing 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 § 4.3.3).

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 higher priority than the route (link set) currently used for traffic to the concerned destination (see § 4.4.3).

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

4.7 *Signalling route restriction*

When a 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. The alternative route is determined in accordance with alternate routing defined for the concerned destination (see § 4.3.3).

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 signalling point restart procedure (see § 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 § 4. In summary, two alternative situations may arise (either for the whole diverted traffic or for traffic relating to each particular destination):

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

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

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

a) the new signalling link is parallel to the unavailable one (see Figure 9/Q.704);

b) the new signalling link belongs to a signalling route other than that to which the unavailable signalling link belongs, but this signalling route still passes through the signalling point at the far end of the unavailable signalling link (see Figure 10/Q.704);

c) the new signalling link belongs to a signalling route other than that to which the unavailable signalling link belongs, and this signalling route does not pass through the signalling point acting as signalling transfer point, at the far end of the unavailable signalling link (see Figure 11/Q.704).

Figure 9/Q.704, (M), p.

Figure 10/Q.704, (M), p.

Figure 11/Q.704, (M), p.

Only in the case of c) does a possibility of message mis-sequencing exist: therefore its use should take into account the overall service dependability requirements described in Recommendation Q.706.

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.

The following actions are then performed:

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

b) transmission of link status signal units or fill in signal units, as described in Recommendation Q.703, § 5.3, takes place;

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

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

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

In addition, if traffic toward a given destination is diverted to an alternative signalling link terminating in a signalling transfer point not currently used to carry traffic toward that destination, a transfer-prohibited procedure is performed as specified in § 13.2.

5.3.2 In the case when there is no traffic to transfer from the unavailable signalling link action, only item b) 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:

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

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

iii) the transfer-prohibited procedure is performed, as specified in § 13.2;

iv) the appropriate signalling link management procedures are performed, as specified in § 12.

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 § 5.2) a changeover acknowledgement is sent instead.

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

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

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

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

— the changeover-order (or changeover-acknowledgement) signal; and

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

Formats and codes of the changeover order and the changeover acknowledgement appear in § 15.

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

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

5.5 *Retrieval and diversion of traffic*

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

— the routing of the signalling traffic to be diverted is changed;

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

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

5.6 *Emergency changeover procedures*

5.6.1 Due to the failure in a signalling terminal it may be impossible for the corresponding end of the faulty signalling link to determine the forward sequence number of the last message signal unit accepted over the unavailable link. In this case, the concerned end accomplishes, if possible, the buffer updating procedures described in § 5.4 but it makes use of an emergency changeover order or an emergency changeover acknowledgement instead of the corresponding normal message; these emergency messages, the format of which appears in § 15, do not contain the forward sequence number of the last accepted message signal unit. Furthermore, the signalling link is taken out of service, i.e. the concerned end initiates, if possible, the sending of *out-of-service* link status signal units on the unavailable link (see Recommendation Q.703, § 5.3).

When the other end of the unavailable signalling link receives the emergency changeover order or acknowledgement, 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:

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

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

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

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

ii) 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 failure of the link.

iii) A signalling link currently carrying traffic has been marked (locally or remotely) inhibited. In this case, time controlled changeover is used to divert traffic for the inhibited link without causing the link to fail.

When the concerned signalling point decides to initiate changeover in such circumstances, after the expiry of a time T1 (see § 16.8), it starts signalling traffic not yet transmitted on the unavailable signalling link on the alternative link(s); the purpose of withholding traffic for the time T1 (see § 16.8) is to reduce the probability of message mis-sequencing.

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

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

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 section allow the completion of the changeover procedures in abnormal cases other than those described in § 5.6.

5.7.2 If no changeover message in response to a changeover order is received within a timer T2 (see § 16.8), new traffic is started on the alternative signalling link(s).

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

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

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

6 Changeback

6.1 *General*

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

6.1.2 Changeback includes the basic procedures to be used to perform the opposite action to changeover, i.e. to divert traffic from the alternative signalling link(s) to a signalling link which has become available (i.e., it was 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 also § 4).

6.2 *Changeback initiation and actions*

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

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

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

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

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

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

On occurrence of changeback, it may happen that traffic towards a given destination is no longer routed via a given adjacent signalling transfer point, towards which a transfer-prohibited procedure was previously performed on occurrence of changeover (see § 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:

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

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

iii) the transfer-allowed procedure is performed, as specified in § 13.3. However, in national networks, when the recovered link is not on the normal route for that destination, the transfer-restricted procedure may be performed as specified in § 13.5.

6.2.4 In the case that the signalling link made available is used to carry signalling traffic towards a destination which was previously declared restricted, the following actions apply:

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

ii) when the recovered link is on the normal route for that destination, the status of the route is changed to available; otherwise, the status of the route remains unchanged.

6.2.5 If the signalling point at the far end of the link made available currently is inaccessible, from the signalling point initiating changeback (see § 9 on Signalling Point 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 made also when the concerned signalling points are accessible, but there is no signalling route to it using the same outgoing signalling link(s) (or one of the same signalling links) from which traffic will be diverted.

6.3 *Sequence control procedure*

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

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

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

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

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

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

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

— the changeback code.

Formats and codes of the changeback declaration and changeback acknowledgement appear in § 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 acknowledgement by the acknowledging signalling point. This allows discrimination between different changeback declarations and acknowledgements when more than one sequence control procedures are initiated in parallel, as follows.

6.3.5 In the case that a signalling point intends to initiate changeback in parallel from more than one alternative signalling 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 acknowledgement relating to that alternative signalling link is received, traffic being diverted from a given alternative signalling link can be restarted on the signalling link made available, starting with the content of the changeback buffer; discrimination between the different changeback acknowledgements is made by the changeback code configuration, which is the same as that sent in the changeback declaration.

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

6.4 *Time-controlled diversion procedure*

6.4.1 The time-controlled diversion procedure is used at the end of the signalling point restart procedure (see § 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/Q.704.

Figure 12/Q.704, (M), p.

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

6.4.2 When changeback is initiated after the signalling point restart procedure, the adjacent signalling point of the point which is restarting stops traffic to be directed from the alternative signalling link(s) for a time T3, after which it starts traffic on the signalling link(s) 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 acknowledgement is received by a signalling point which has not previously sent a changeback declaration, no action is taken.

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

6.5.3 If no changeback acknowledgement is received in response to a changeback declaration within a time T4 (see § 16.8), the changeback declaration is repeated and a new timer T5 (see § 16.8), is started. If no changeback acknowledgement is received before the expiry of T5, the maintenance functions are alerted and traffic on the link made available is started. The changeback code contained in the changeback acknowledgement message makes it possible to determine, in the case of parallel changebacks from more than one reserve 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 Recommendation Q.706).

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

7.2 *Forced rerouting initiation and actions*

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

The following actions are then performed:

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

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

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

d) if appropriate, a transfer-prohibited procedure is performed (see § 13.2.2).

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

a) 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 outgoing from the concerned signalling point;

b) when a transfer-restricted message is received, after signalling traffic management has decided that alternative routing 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 message, indicating that the signalling route has become available, is received; also when a transfer-restricted message is received.

The following actions are then performed:

a) 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’’; a timer T6 (see § 16.8), is started;

b) if the signalling point serves as a signalling transfer point, a transfer-prohibited procedure is performed for the route made available (or the alternative route in the case of reception of a transfer-restricted message, if the alternative route was not previously used), and a transfer-allowed procedure for the alternative one (or on the restricted route in the case of the reception of a transfer-restricted message) (see §§ 13.2.2 and 13.3.2, respectively);

c) at the expiry of T6, the concerned signalling traffic is restarted on an outgoing link set pertaining to the signalling route made available, or the alternative route in the case of reception of the transfer-restricted message, 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 In the case when there is no signalling traffic to be diverted from the route made available, only action b) applies.

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 Signalling point restart

This procedure uses the Traffic Restart Allowed message (TRA) which contains:

— the label indicating the originating signalling point and adjacent destination signalling point;

— the traffic restart allowed signal.

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

9.1 *Actions in a signalling point (having the transfer function) which restarts*

A signalling point restarts when it becomes available (see § 3.6.2.1). A signalling point which restarts starts a timer T18 and starts activating all its signalling links (see § 12).

When the first signalling link of a signalling link set is available, message traffic terminating at the far end of the linkset is immediately restarted (see also § 9.5).

The restarting signalling point takes into account any transfer prohibited, transfer restricted (see § 13) and traffic restart allowed messages received.

When all signalling links are available T18 is stopped.

When T18 is stopped or expires, the following actions are taken:

— the signalling point starts a timer T19 during which it expects to receive additional transfer prohibited, transfer restricted (see § 13) and traffic restart allowed messages;

— when all traffic restart allowed messages are received T19 is stopped.

When T19 is stopped or expires, the signalling point starts a timer T20 during which:

— it broadcasts eventually transfer prohibited and transfer restricted messages (see § 13), taking into account signalling links which are not available and any transfer prohibited and transfer restricted messages eventually received;

— when all these operations are completed, timer T20 is stopped.

When T20 is stopped or expires, the signalling point broadcasts traffic restart allowed messages to all adjacent signalling points and restarts the remaining traffic.

9.2 *Actions in a restarting signalling point (having no transfer function)*

An SP which restarts starts a timer T21 and starts activating all its signalling links (see § 12).

When the first signalling link of a signalling linkset is available, message traffic terminating at the far end of the linkset is immediately restarted (see also § 9.5).

The restarting signalling point takes into account transfer prohibited and transfer restricted messages (see § 13). If a traffic restart allowed message is received T21 is stopped. When T21 is stopped or expires, the signalling point restarts the remaining traffic.

9.3 *Actions in a signalling point X adjacent to a restarting signalling point Y*

Signalling point X knows that signalling point Y is restarting when signalling point Y becomes accessible (see § 3.6.2.2). There are three cases to consider:

i) Signalling points X and Y have the transfer function

a) When signalling point Y becomes accessible because a direct linkset becomes available, signalling point X takes the following action:

— starts a timer T21

— immediately restarts traffic terminating in signalling point Y (see also § 9.5)

— sends any eventual transfer prohibited and transfer restricted messages to signalling point Y (see § 13)

— sends a traffic restart allowed message to signalling point Y

— takes into account the eventual transfer prohibited and transfer restricted messages received from SP Y (see § 13).

When a traffic restart allowed message is received from signalling point Y, timer T21 is stopped. When T21 is stopped or expires, signalling point X restarts any remaining traffic to Y, and broadcasts transfer allowed messages concerning Y, and all SPs made accessible via Y.

b) When signalling point Y becomes accessible on reception of a transfer allowed or transfer restricted message (see § 13), signalling point X sends to signalling point Y any required transfer prohibited and transfer restricted messages on the available route.

ii) Signalling point X has a transfer function and signalling point Y has not

a) When signalling point Y becomes accessible because a direct signalling linkset becomes available, signalling point X takes the following actions:

— immediately restarts traffic terminating in signalling point Y (see also § 9.5)

— eventually sends to signalling point Y any transfer prohibited and transfer restricted messages (see § 13)

— broadcasts transfer allowed messages concerning signalling point Y and sends a traffic restart allowed message to it.

b) When signalling point Y becomes accessible on reception of a transfer allowed or transfer restricted message, signalling point X sends to signalling point Y any required transfer prohibited and transfer restricted messages on the available route.

iii) Signalling point X does not have the transfer function and signalling point Y does or does not have the transfer function.

Signalling point X takes the following action:

— immediately restarts traffic terminating at signalling point Y (see also § 9.5)

— starts a timer T21

— takes into account any eventual transfer prohibited and transfer restricted message received.

On the receipt of a traffic restart allowed message, timer T21 is stopped. When T21 is stopped or expires, signalling point X restarts any remaining traffic.

9.4 *Actions in signalling point X on receipt of unexpected TRA message*

If X has no STP function, no further action is taken.

If X has the STP function, then X sends to the adjacent point Y, from which the TRA message was received, the appropriate TFP and TFR messages. X then operates normally.

9.5 *General rules*

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

Signalling route set test messages received in a signalling point adjacent to a restarting signalling point (before T21 expires) are handled, but the replies consider that all signalling routes using the restarting point are prohibited. When T21 is stopped or expires these signalling routes are allowed unless a transfer prohibited or transfer restricted message has been received from the restarting signalling point during T21.

The procedure includes the general rule that late events [e.g., restoration of a link after T18 expires, transfer prohibited or transfer restricted messages received after T19 expires, etc.] are treated outside the restart procedure.

All messages concerning another destination received in a restarting signalling point are treated normally during the point restart procedure. All messages concerning a local MTP user received in a restarting signalling point (Service Indicator != 0000) are treated normally. All messages received with Service Indicator = 0000 in a restarting signalling point, for the signalling point itself, are treated as described in the signalling point restart procedure; those messages not described elsewhere in the procedure are discarded and no action is taken (message groups CHM, ECM, FCM, RSM, MIM and DLM).

10 Management inhibiting

10.1 *General*

Signalling link management inhibiting is requested by management when it becomes necessary e.g., for maintenance or testing purposes (for example, if the link experiences too many changeovers and changebacks in a short time, or there is a significant link error rate), to make or keep a signalling link unavailable to User Part-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 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.

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 unavailable for other reasons, uninhibiting causes the signalling link to enter the available state and changeback to be initiated.

Periodic tests are made on the inhibit status of inhibited links. Such periodic tests should not add significantly to the traffic load on the signalling network, and remove the need for a signalling point to perform inhibit tests at signalling point restart.

If a test on the inhibit status of a link reveals discrepancies between the signalling points at each end of the link, the link is either uninhibited or force uninhibited as appropriate, to align the inhibit status at each end of the link.

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:

a) 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.

b) 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.

c) 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.

d) If the signalling point ‘‘Y’’ finds that inhibiting of the concerned link is permissible, it sends an inhibit acknowledgement to signalling point ‘‘X’’ and marks the link remotely inhibited.

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. ‘‘Y’’ then starts inhibit test timer T23.

e) On receiving an inhibit acknowledgement message, signalling point ‘‘X’’ marks the link locally inhibited and informs management that the link is inhibited.

If the link concerned is currently carrying traffic, signalling point ‘‘X’’ diverts subsequent traffic for that link, using the time-controlled changeover procedure. ‘‘X’’ then starts inhibit test timer T22.

f) When changeover has been completed, the link while inhibited, will be unavailable for the transfer of user-generated traffic but still permits the exchange of test messages.

g) If, for any reason, the inhibit acknowledgement message is not received, a timer T14 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 signalling link.

A signalling point may not transmit an inhibit message for a particular signalling link if it has already transmitted an uninhibit message for that link, and neither an acknowledgement for that uninhibit message has been received nor has the uninhibit procedure finally timed out.

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 uninhibit request may be initiated for a remotely inhibited link by the signalling routing control function only.

Signalling routing control will initiate signalling link uninhibit 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 were unsuccessful because of a failed or blocked inhibited link, and if that link later recovers or becomes unblocked with the destination still unavailable, uninhibiting is re-attempted.

A signalling point may not transmit an uninhibit message for a particular signalling link if it has already transmitted an inhibit message for that link, and neither an acknowledgement for that inhibit message has been received nor has the inhibit procedure finally timed out.

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:

a) 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.

b) 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.

c) Upon receipt of the uninhibit link message, signalling point ‘‘Y’’ returns an uninhibit acknowledgement message to signalling point ‘‘X’’ and cancels the remote inhibit indication. If no local inhibited, failed or blocked condition exists on the link, it is put in the available state and changeback is initiated.

d) On receipt of the uninhibit acknowledgement message, signalling point ‘‘X’’ cancels the local inhibit indication and informs management that the link has been uninhibited. If no remote inhibited, failed or blocked condition exists on the link, it is put in the available state and changeback is initiated.

e) If, for any reason, the uninhibit acknowledgement message is not received, a timer T12 expires. If this is the first expiry of T12 for this uninhibition attempt on this link, the procedure is restarted including inspection of the status of the destination of the unhibit 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:

a) A check is performed at signalling point ‘‘X’’ to determine whether the concerned inhibited link is marked failed or blocked. If it is, then signalling point ‘‘X’’ is unable to transmit an uninhibit message to signalling point ‘‘Y’’, uninhibiting is therefore not possible, and the uninhibiting attempt is abandoned.

b) 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.

c) If local inhibiting is in effect, then the actions described in §§ 10.3.1 b), c), d) and e) take place. If uninhibition is abandoned, step f) below is taken.

d) If remote inhibiting is in effect, then 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 b), c), d) and e).

The force uninhibit signalling link message is transmitted down the link to be uninhibited.

e) If, for any reason, an uninhibit signalling link message is not received in response to the force uninhibit message, a timer T13 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.

f) 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 a) 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.

10.4 *Receipt of unexpected management inhibition messages*

a) An inhibit signalling link message concerning an inhibited signalling link is answered with an inhibit acknowledgement message without taking any further action.

b) An uninhibit signalling link message concerning an uninhibited signalling link is answered with an uninhibit acknowledgement message without taking any further action.

c) A force uninhibit signalling link message concerning an uninhibited link is answered with an uninhibit signalling link message without taking any further action.

d) If an inhibit acknowledgement message is received and no inhibit signalling link message is outstanding for the concerned link, no action is taken.

e) If an uninhibit acknowledgement message is received and no uninhibit signalling link message is outstanding for the concerned link, no action is taken.

10.5 *Management inhibited link status and processor recovery*

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

b) If messages for Level 4 are received on an inhibited signalling link, the messages will be discriminated and distributed.

10.6 *Inhibit test procedure*

When a signalling link becomes management inhibited, periodic tests are started to guard the inhibition status at each end of the link.

10.6.1 A local inhibit test is performed when timer T22 expires at signalling point X and the concerned link is marked locally inhibited. In this case a local inhibit test message is sent to the signalling point Y at the other end of the link, and timer T22 is restarted.

Reception of a local inhibit test message causes:

i) no action, if the concerned link is marked remotely inhibited at the receiving signalling point Y or:

ii) the force uninhibit procedure to be invoked at the receiving signalling point Y, if the concerned link is not marked remotely inhibited at Y. This procedure causes the locally inhibited status of the link at X to be cancelled.

If a timer T22 expires and the concerned link is not locally inhibited, no further action is taken.

10.6.2 A remote inhibit test is performed when timer T23 expires at signalling point Y and the concerned link is marked remotely inhibited. In this case a remote inhibit test message is sent to signalling point X at the other end of the link, and timer T23 is restarted.

Reception of a remote inhibit test message causes:

i) no action, if the concerned link is marked locally inhibited at the receiving signalling point X or:

ii) the uninhibit procedure to be invoked at the receiving signalling point X, if the concerned link is not marked locally inhibited at X. This procedure causes the remotely inhibited status of the link at Y to be cancelled.

If a timer T23 expires and the concerned link is not remotely inhibited, no further action is taken.

11 Signalling traffic flow control

11.1 *General*

The purpose of the signalling traffic flow control function 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 because of network failures or congestion situations.

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

— Failure in the signalling network (signalling links or signalling points) has resulted in routeset unavailability. In this situation, flow control may provide a short term remedy until more appropriate actions can be taken.

— Congestion of a signalling link or signalling point has resulted in a situation where reconfiguration is not appropriate.

— Failure of a part has made it impossible for the user to handle 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 the local user parts informing them that signalling messages destined to the particular signalling point cannot be transferred via the signalling network. Each user 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 unavailable destination (see §§ 6.2.3 and 8.2.3), an indication is given from the Message Transfer Part to the local user parts informing them that signalling messages destined to the particular signalling point can be transferred via the signalling network. Each user 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:

i) When a message signal unit from a local User Part is received for a congested route set the following actions are performed:

a) The MSU 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 at least every n messages ($n = 8$) received for the congested destination. The congestion indication primitive contains as a parameter the DPC of the affected destination.

ii) When a message signal unit is received at an STP for a congested route set, the following actions take place:

a) The MSU 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) received from any originating point for the congested route set or for every link of the congested route set or for every linkset of the congested route set.

11.2.3.2 After 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 i).

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)*

In the case 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 it 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 the 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 options without congestion priorities)*

For national signalling networks using multiple signalling link congestion states without congestion priority, S + 1(1 S 3) levels of route set congestion status are provided.

The procedure is the same as that specified in § 11.2.3, except that the congestion indication primitive contains the congestion status as a parameter in addition to the DPC of the affected destination.

11.2.6 *Signalling point/signalling transfer point congestion*

The detection of congestion onset and abatement in a signalling point or signalling transfer point should, if required, be implementation dependent. Any resulting action taken, and messages and primitives sent, should align with those procedures, messages and primitives specified for signalling route set congestion.

11.2.7 *MTP user flow control*

If the Message Transfer Part is unable to distribute a received message to a local User Part because that User Part is unavailable, (User Part unavailability is an implementation dependent notion), the Message Transfer Part sends a User Part Unavailable (UPU) message to the Message Transfer Part at the originating signalling point.

When the originating signalling point’s Message Transfer Part receives a User Part Unavailable message, it:

a) informs the management process,

b) sends an indication (MTP-STATUS with the appropriate parameters) to the affected local User Part informing it that that User Part at the particular remote signalling point is unavailable.

The user should then take appropriate action in order to stop generation of signalling information for the unavailable User Part.

The User Part Unavailable message contains:

— the label, indicating the destination and originating points;

— the user part unavailable signal;

— the identity of the unavailable user part.

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

When the Message Transfer Part is again able to distribute received messages to a previously unavailable local User Part, that Message Transfer Part delivers the received messages to that User Part.

11.2.8 *User part congestion*

User part congestion procedures in the MTP are for further study.

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 sections. Each set corresponds to a certain level of automation as regards allocation and reconfiguration of signalling equipment. The basic set of signalling link management procedures (see § 12.2) provides no automatic means for allocation and reconfiguration of signalling equipment. The basic set includes the minimum number of functions which must be provided for international application of the signalling system.

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 § 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 constituent signalling data link and signalling terminals. Thus, the identity referred to by the Signalling Link Code (SLC) included in the label of messages originated at Message Transfer Part level 3 is the signalling link identity and not the signalling data link identity or the signalling terminal identity.

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

In the first case, applicable for the basic signalling link management procedures, a signalling link includes predetermined signalling terminals and a predetermined signalling data link. To replace a signalling terminal or signalling data link, a manual intervention is required. The signalling data link to be included in a particular signalling link is determined by bilateral agreement (see also Recommendation Q.702).

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 done by connecting signalling terminals to signalling data links and for each signalling link performing an initial alignment procedure (see Recommendation Q.703, § 7.3). 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 single signalling link is taken out of service by means of a procedure defined as *signalling link deactivation* .

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

a) no automatic functions are provided for allocation of signalling terminals and signalling data links (see § 12.2).

b) an automatic function is provided for allocation of signalling terminals (see § 12.3).

c) 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, i.e. signalling links which have not been put into operation. Predetermined signalling terminals and a signalling data link are associated with each inactive signalling link.

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

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

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 a signalling link test is started. If the signalling link test is successful the link becomes ready to convey signalling traffic. In the case when initial alignment is not possible, as determined at Message Transfer Part level 2 (see Recommendation Q.703, § 7), new initial alignment procedures are started on the same signalling link after a time T17 (delay to avoid the oscillation of initial alignment failure and link restart. The value of T17 should be greater than the loop delay and less than timer T2, see Recommendation Q.703, § 7.3). If the signalling link test fails, link restoration starts until the signalling link is activated or a manual intervention is made.

12.2.2 *Signalling link restoration*

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

If initial alignment is not possible, as determined at Message Transfer Part level 2 (see Recommendation Q.703, § 7), 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 the signalling link test fails, the restoration procedure is repeated until the link is restored or a manual intervention made.

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.

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:

— link set normal activation,

— 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:

— all signalling links in a link set are faulty,

— a processor restart in a signalling point makes it necessary to re-establish a link set,

— a signalling point recognizes other irregularities concerning the interworking between the two signalling points,

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

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

The signalling link activation procedures are performed on each signalling link in parallel as specified in § 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 is applicable 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. Possible situations for emergency restart are, for example:

— when signalling traffic that may be conveyed over the link set to be restarted is blocked,

— when it is not possible to communicate with the signalling point at the remote end of the link set.

When link set emergency restart is initiated, signalling link activation starts on as many signalling links as possible, in accordance with the principles specified for normal link set activation. In this case, the signalling terminals will have emergency status (see Recommendation Q.703, § 7) resulting in the sending of status indications of type ‘‘E’’ when applicable. Furthermore, the signalling terminals employ the emergency proving procedure and short time-out values in order to accelerate the procedure.

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

12.2.4.3 *Time-out values*

The initial alignment procedure (specified in Recommendation Q.703, § 7.3) 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 terminals*

12.3.1 *Signalling link activation*

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 the 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 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 attemps 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. In the case when an activation attempt performed on the last signalling link in the link set is unsuccessful, the ‘‘next’’ signalling link is the first inactive signalling link in the link set (i.e. there is a cyclic assignment).

Activation of a signalling link may also be initiated manually.

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

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 must 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 initial alignment starts (see Recommendation Q.703, § 7).

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 initial alignment is not possible, as determined at Message Transfer Part level 2 (see Recommendation Q.703, § 7), the activation is unsuccessful and activation of the next inactive signalling link (if any) after a time T17 is initiated. 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 (see § 12.5).

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 Recommendation Q.703, § 7). 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 test fails, 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 a time T17 until a manual intervention is made or the signalling terminal is disconnected (see § 12.5).

Note — In the case when a signalling terminal cannot be replaced, activation of the next signalling link is only initiated if the link set includes an alternative link group having access to signalling terminals other than the one used by 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:

— link set normal activation,

— 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:

— all signalling links in a link set are faulty;

— a processor restart in a signalling point makes it necessary to re-establish a link set;

— a signalling point recognizes other irregularities concerning the interworking between the two signalling points, 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 link 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. (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). 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 the link set normal restart procedure is not fast enough. Emergency restart is performed in the same way as link set normal activation except that, in the case of emergency restart, the emergency proving procedure and the short emergency time-out values (see Recommendation Q.703, § 7) are employed in order to accelerate the procedure (see further § 12.2.4.2).

12.3.4.3 *Time-out values*

The values of the initial alignment time-out T2 (see Recommendation Q.703, § 7) 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 terminals*

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 further § 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 Recommendation Q.703, § 7). 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 initial alignment is not possible, as determined at Message Transfer Part level 2 (see Recommendation Q.703, § 7), alternative signalling data links are automatically connected to the signalling terminal, until an initial alignment procedure is successfully completed. In the case when the function for automatic allocation of signalling data links cannot provide an alternative signalling data link, the activation is regarded as unsuccessful and activation of the next inactive signalling link (if any) is initiated (see, however, the Note to § 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 Recommendation Q.703, § 7). 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 if the 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 after a time T17 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 predetermined list assigning a signalling data link to some or all of the signalling links in the link set. This is done 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:

a) an idle signalling terminal (i.e. a signalling terminal not connected to a signalling data link) is chosen if possible;

b) if no idle signalling terminal is available, a signalling terminal is chosen which is connected to an unsuccessfully restored or activated signalling link.

Note — Activation and restoration is regarded as unsuccessful when it is not possible to complete the initial alignment procedure successfully (see §§ 12.3 and 12.4).

Measures should be employed to ensure that signalling terminal to be allocated to signalling links are able to function correctly (see Recommendation Q.707).

A link set may by 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 set [in accordance with b) above] only when the remaining number of signalling terminals in the link set is not below the specified value.

Note — From a link set with a minimum number of signalling terminals, only one signalling terminal and signalling data link may be removed at a time (e.g. for testing, see Recommendation Q.707).

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 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 message contains:

— the label, indicating the destination and originating signalling points and the identity of the signalling link to activate or restore;

— the signalling-data-link-connection-order;

— the identity of the signalling data link.

Formats and codes for the signalling-data-link-connection-order message appear in § 15.

12.6.3 Upon reception of the signalling-data-link-connection-order, the following applies:

a) In the case when the signalling link to which a received signalling-data-link-connection-order 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 acknowledgement is sent to the remote signalling point.

If it is not possible to connect the appointed signalling data link to a signalling terminal (e.g. because there is no working signalling terminal available), the acknowledgement contains an indication informing the remote signalling point whether or not an alternative signalling data link should be allocated to the concerned signalling link.

b) If the signalling point receives a signalling-data-link-connection-order when waiting for an acknowledgement, the order is disregarded in the case when the signalling point code of the receiving signalling point is higher than the signalling point code of the remote signalling point. If the remote signalling point has the higher signalling point code, the message is acknowledged and the signalling data link referred to in the received message is connected.

c) If a signalling-data-link-connection-order is received in other situations (e.g. in the case of an error in procedure), no actions are taken.

The signalling-data-link-connection-acknowledgement contains the label, indicating the destination and originating signalling points and the identity of the signalling link to activate or restore, and one of the following signals:

— connection-successful signal, indicating that the signalling data link has been connected to a signalling terminal;

— connection-not-successful signal, indicating that it was not possible to connect the signalling data link to a signalling terminal, and that an alternative signalling data link should be allocated;

— connection-not-possible signal, indicating that it was not possible to connect the signalling data link to a signalling terminal, and that no alternative signalling data link should be allocated.

The formats and codes for the signalling data link connection acknowledgement message appear in § 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).

If the acknowledgement indicates that it was not possible to connect the signalling data link to a signalling terminal at the remote end, an alternative signalling data link is allocated and a new signalling-data-link-connection-order is sent (as specified above). However, if the acknowledgement indicates that no alternative signalling data link should be allocated, the activation or restoration procedure is terminated for the concerned signalling link.

If no signalling-data-link-connection-acknowledgement or order is received from the remote signalling point within a time T7 (see § 16), the signalling-data-link-connection-order is repeated.

12.6.5 When a signalling data link is disconnected in conjunction with signalling link restoration or deactivation, the signalling data link is made idle (and available, e.g. as a speech circuit).

12.7 *Different signalling link management procedures at the two ends of a link set*

Normally both ends of a link set will 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.

If 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 the initial alignment time-out T2 do not have to be different at the two ends of the link set.

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