All drawings appearing in this Fascicle have been done in Autocad.

Recommendation Q.704

xe ""§SIGNALLING NETWORK FUNCTIONS AND MESSAGES

1 Introduction

1.1 *General characteristics of the signalling network functions*

1.1.1 This Recommendation describes the functions and procedures for and relating to the transfer of messages between the signalling points, which are the nodes of the signalling network. Such functions and procedures are performed by the Message Transfer Part at level 3, and therefore they assume that the signalling points are connected by signalling links, incorporating the functions described in Recommendations Q.702 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 *xe ""§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:

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

– thexe ""§ message discrimination function, used at a signalling point to determine whether or not a received message is destined to the point itself. When the signalling point has the transfer capability and a message is not destined to it, that message has to be transferred to the message routing function;

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

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

Figure 1/Q.704 - CCITT 35730

1.3 *xe ""§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*[1]), *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 xe ""§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 - CCITT 35740

1) National option.

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 *xe ""§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* and 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 - CCITT 35750

2.2.3 The xe ""§destination point code (DPC) indicates the destination point of the message. The xe ""§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 xe ""§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 xe ""§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 - CCITT 35760

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 - CCITT 35770

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 ($0 \quad N \quad 3$) 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 xe ""§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[2])" or "inhibited", and it becomes once again available if it is recognized as "restored", "activated", "unblocked" or "uninhibited" respectively. A signalling route may be considered by level 3 as "available", "restricted" or "unavailable" too. A signalling point may be "available" or "unavailable". A signalling route set may be "congested" or "uncongested". The detailed criteria for the determination of the changes in the status of signalling links, routes and points are described in §§ 3.2, 3.4 and 3.6 respectively.

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

3.1.3 Whenever a change in the status of a signalling link, 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:
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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):
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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:
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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 *xe ""§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:

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and 7);

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6.3);

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bits (see Recommendation Q.703, §§ 5.3 and 6.3);

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of service, normal or emergency terminal status (see Recommendation Q.703, § 1.7);

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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 *xe ""§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 *xe ""§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 *xe ""§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 *xe ""§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 *xe ""§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) - CCITT 60720

Figure 6/Q.704 (feuillet 2 sur 4) - No number

Figure 6/Q.704 (feuillet 3 sur 4) - CCITT 60721

Figure 6/Q.704 (feuillet 4 sur 4) - CCITT 60731

3.2.8 *xe ""§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 *xe ""§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 withxe ""§ 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 - CCITT 35811

Figure 8/Q.704 - T1121640-88

3.3.1 *Signalling link failed*

3.3.1.1 ignalling 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 ignalling 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 ignalling route management: in the case when the failure of a signalling link causes a signalling route set to become unavailable or restricted[3]), 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 ignalling 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 ignalling 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.

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3) National option.

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[4]), 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, restricted4), unavailable (see also Figure 6/Q.704).

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4) National option.

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* [5])

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 withxe ""§ 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* 5)

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.

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5) National option.

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[6]) 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).

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6) National option.

3.7.3 Signalling point congested: (implementation–dependent option, see § 11.2.6).

3.8 *xe ""§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 $n(n = 1, \ldots, N)$ is placed higher than congestion onset threshold n in order to minimize message loss under congestion conditions.

Congestion discard threshold $n(n = 1, \ldots, N - 1)$ 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 $n(n = 2, \ldots, N)$ 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 - CCITT 73510

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 - CCITT 73520

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 - CCITT 73530

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, $S + 1 (1 \leq S \leq 3)$ 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 $s (s = 1, \ldots, S - 1)$ 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 $s (s = 1, \ldots, S)$ 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 - CCITT 73540

3.8.4 *xe ""§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[7]) 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.

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7)

National option.

c) In national signalling networks using multiple congestion levels[8]) 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 xe ""§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

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8) National option.

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 restricted8): 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 *xe ""§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*[9])

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

9) National option.

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).