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Recommendation Q.705

SIGNALLING NETWORK STRUCTURE

1 Introduction

This Recommendation describes aspects which are pertinent to and should be considered in the design of international signalling networks. Some or all of these aspects may also be relevant to the design of national networks. Some aspects are dealt with for both international and national networks (e.g. availability), others are discussed in the context of the international network only (e.g. number of *signalling transfer points* in a signalling relation). A number of aspects require further study for national networks. This Recommendation also gives in Annex A examples of how the

signalling network procedures may be applied to the mesh network representation.

The national and international networks are considered to be structurally independent and, although a particular *signalling point* may belong to both networks, signalling points are allocated *signalling point codes* according to the rules of each network.

The signalling network procedures are provided in order to effectively operate a signalling network having different degrees of complexity. They provide for reliable message transfer across the network and for reconfiguration of the network in the case of failures.

The most elementary signalling network consists of *originating and destination signalling points* connected by a single *signalling link* . To meet availability requirements this may be supplemented by additional links in parallel which may share the signalling load between them. If, for all signalling relations, the originating and destination signalling points are directly connected in this way in a network then the network operates in the *associated mode* .

For technical or economic reasons a simple associated network may not be suitable and a *quasi-associated network* may be implemented in which the information between originating and destination signalling points may be transferred via a number of signalling transfer points. Such a network may be represented by a *mesh network* such as that given in Annex A, as other networks are either a subset of the mesh network or are structured using this network or its subsets as components.

2 Network components

2.1 *Signalling links*

Signalling links are basic components in a signalling network connecting together signalling points. The signalling links encompass the *level 2* functions which provide for message error control (detection and subsequent correction). In addition, provision for maintaining the correct message sequence is provided (see Recommendation Q.703).

2.2 *Signalling points*

Signalling links connect signalling points at which signalling network functions such as message routing are provided at *level 3* and at which the user functions may be provided at *level 4* if it is also an originating or destination point (see Recommendation Q.704, § 2.4).

A signalling point that only transfers messages from one signalling link to another at level 3 serves as a signalling transfer point (STP).

The signalling links, signalling transfer points, and signalling (originating or destination) points may be combined in many different ways to form a *signalling network* .

3 Structural independence of international and national signalling networks

The worldwide signalling network is structured into two functionally independent levels, namely the international and national levels, as illustrated in Figure 1/Q.705. This structure makes possible a clear division of responsibility for signalling network management and allows numbering plans of signalling points of the international network and the different national networks to be independent of one another.

Figure 1/Q.705. p.

A signalling point (SP), including a signalling transfer point (STP), may be assigned to one of three categories:

— national signalling point (NSP) (signalling transfer point) which belongs to the national signalling network only (e.g. NSP_1) and is identified by a signalling point code (OPC or DPC) according to the national numbering plan of signalling points;

— international signalling point (ISP) (signalling transfer point) which belongs to the international signalling network only (e.g. ISP_3) and is identified by a signalling point code (OPC or DPC) according to the international numbering plan of signalling points;

— a node that functions both as an international signalling point (signalling transfer point) and a national signalling point (signalling transfer point) and therefore belongs to both the international signalling network and a national signalling network and accordingly is identified by a specific signalling point code (OPC or DPC) in each of the signalling networks.

If a discrimination between international and national signalling point codes is necessary at a signalling point, the network indicator is used (see Recommendation Q.704, § 14.2).

4 Considerations common to both international and national signalling networks

4.1 *Availability of the network*

The signalling network structure must be selected to meet the most stringent availability requirements of any User Part served by a specific network. The availability of the individual components of the network signalling links, (signalling points, and signalling transfer points) must be considered in determining the network structure (see Recommendation Q.709).

4.2 *Message transfer delay*

In order to take account of signalling message delay considerations, regard should be given, in the structuring of a particular signalling network, to the overall number of signalling links (where there are a number of signalling relations in tandem) related to a particular user transaction (e.g., to a specific call in the telephone application) (see Recommendation Q.709).

4.3 *Message sequence control*

For all messages for the same transaction (e.g. a telephone call) the Message Transfer Part will maintain the same routing provided that the same *signalling link selection* code is used in the absence of failure. However, a transaction does not necessarily have to use the same signalling route for both forward and backward messages.

4.4 *Number of signalling links used in load sharing*

The number of signalling links used to share the load of a given flow of signalling traffic typically depends on:

- the total traffic load,
- the availability of the links,
- the required availability of the path between the two signalling points concerned, and
- the bit rate of the signalling links.

Load sharing requires at least two signalling links for all bit rates, but more may be needed at lower bit rates.

When two links are used, each of them should be able to carry the total signalling traffic in case of failure of the other link. When more than

two links are used, sufficient reserve link capacity should exist to satisfy the availability requirements specified in Recommendation Q.706.

4.5 *Satellite working*

Due to the considerable increase in overall signalling delay, the use of satellites in Signalling System No. 7 connections requires consideration, and further study is required.

In international operation, when the network served by the signalling network is routed on terrestrial circuits, only in exceptional circumstances should a satellite circuit be employed for the supporting signalling connection.

5 International signalling network

5.1 *General*

The international signalling network will use the procedures to be defined in the Signalling System No. 7 Recommendations. The international network structure to be defined can also serve as a model for the structure of national networks.

5.2 *Number of signalling transfer points in signalling relations*

In the international signalling network the number of signalling transfer points between an originating and a destination signalling point should not exceed two in a normal situation. In failure situations, this number may become three or even four for a short period of time. This constraint is intended to limit the complexity of the administration of the international signalling network.

5.3 *Numbering of signalling points*

A 14-bit code is used for the identification of signalling points. The allocation scheme of international signalling point codes is defined in Recommendation Q.708.

5.4 *Routing rules*

5.4.1 In order to ensure full flexibility for the routing of signalling in the System No. 7 international signalling network it appears desirable that at least one signalling point in each country should provide means for the international STP function. Such an approach should ease the use of Signalling System No. 7 on small traffic routes.

5.4.2 *Other routing rules*

(For further study.)

5.5 *Structures*

(Requires further study.)

5.6 *Procedures*

(Requires further study.)

6 **Signalling network for cross-border traffic**

6.1 *General*

For cross-border traffic between signalling points, the need for a special signalling network configuration is identified, because their common interests are such as to generate a considerable volume of traffic between them.

Two alternative arrangements of the signalling network for cross-border traffic are provided so that Administrations may adopt either alternative upon a bilateral agreement.

6.2 *Use of international hierarchical level*

6.2.1 This arrangement could be applied in the case that there are only a relatively small number of signalling points in a country which serve for cross-border traffic.

6.2.2 The signalling points and the signalling transfer points which are involved in a signalling of cross-border traffic should belong to the international hierarchical level described in § 3. When those signalling points or signalling transfer points are also involved in signalling of national traffic, they should belong to their national hierarchical level as well. Therefore the double numbering of signalling point codes based on both the international and national numbering schemes should be required.

6.2.3 A discrimination between international and national point codes is made by the network indicator in the service information octet (see Recommendation Q.704, § 14.2).

6.2.4 Signalling network management procedures in this network arrangement require further study.

6.3 *Integrated numbering of national signalling networks*

6.3.1 By this arrangement the signalling points, which serve cross-border traffic, should be identified by common national signalling point codes.

6.3.2 Common block of national signalling point codes is provided by bilateral agreement (further study is required).

6.4 *Interworking of national signalling networks*

At the cross-border signalling network interface, the international specification of Signalling System No. 7 should be preferred without exclusion of bilateral agreements.

7 National signalling network

Any specific structures for national signalling networks are not required to be included in the Recommendation, however, Administrations should cater for requirements imposed on a national network for the protection of international services in terms of network related user requirements such as availability and performance of the network perceived by users, (see Recommendation Q.709).

8 Procedures to prevent unauthorized use of an STP (Optional)

8.1 *General*

Administrations may make bilateral agreements to operate SS7 between their networks. These agreements may place restrictions on the SS7 messages authorized for one administration to send to the other. Restrictions could be made, for example, in the interest of network security or as a result of service restrictions. Unauthorized signalling traffic may be, for example, STP traffic for calls set up via networks other than that containing the STP, which has not been agreed bilaterally.

An Administration making an agreement with restrictions may wish to identify and provide special treatment to unauthorized SS7 messages.

The measurements in Table 6/Q.791 provide some capability to identify unauthorized SS7 messages. The procedures in this section for identifying and responding to unauthorized traffic are additional options for use at an STP with signalling links to other networks.

8.2 *Identifying unauthorized SS7 messages*

In addition to the normal signalling message handling, procedures specified in Recommendation Q.704, it shall be possible to inhibit/allow

messages destined for another signalling point (SP) based on any one or combination of the following options:

i) to inhibit/allow STP access by a combination of designated incoming link sets to designated DPCs;

This combination of DPC/incoming link set shall effectively operate in the form of a single matrix. This matrix shall consist of a maximum of 128 DPCs and a maximum of 64 incoming link sets. (These values are for guidance and may be adjusted to satisfy the requirements of the concerned Operator/Administration.)

ii) To inhibit/allow STP access by a combination of designated outgoing link sets to designated DPCs.

This combination of DPC/outgoing link set shall effectively operate in the form of a single matrix. This matrix shall consist of a maximum of 128 DPCs and a maximum of 64 outgoing link sets. (These values are for guidance and may be adjusted to satisfy the requirements of the concerned Operator/Administration.)

iii) to inhibit/allow STP access by examination of OPC and DPC combination in the incoming STP message.

This combination of DPC/OPC shall effectively operate in the form of a single matrix. This matrix shall consist of a maximum of 128 DPCs and a maximum of 128 OPCs. (These values are for guidance and may be adjusted to satisfy the requirements of the concerned Operator/Administration.)

8.3 *Treatment of unauthorized SS7 messages*

An STP identifying unauthorized SS7 messages should be able, on a per link set or per signalling point code basis, to:

i) provide all unauthorized SS7 messages with the same handling as authorized traffic, or

ii) discard all unauthorized SS7 messages.

In addition, an STP should be able to:

i) allow all STP messages outside the designated ranges as given in § 8.2,

ii) bar (discard) all STP messages outside the designated ranges as given in § 8.2.

8.4 *Measurements*

An STP identifying unauthorized SS7 messages incoming from another network should be able to count and record details of the unauthorized messages on a per link set and/or signalling point code basis.

8.5 *Notification to unauthorized user*

An STP identifying unauthorized SS7 messages from another network may wish to notify the Administration orginating the unauthorized message(s).

This notification should be undertaken by administrative means and not involve any mechanism in Signalling System No. 7.

In addition, a violation fault report shall be issued giving the unauthorized message content. It shall be possible to selectively restrict the number of violation reports on a per link set and/or signalling point code basis.

It shall also be possible to inhibit the violation reporting mechanism on a point code/link set basis, nodally, or on a message direction, i.e. if an inhibited message is destined for an RPOA then it shall be possible to suppress the violation reports whilst allowing violation reports on inhibited messages from the RPOA.

ANNEX A
(to Recommendation Q.705)

Mesh signalling network examples

A.1 *General*

This Annex is provided to demonstrate the procedures defined in Recommendation Q.704. While the example uses a specific *mesh* network to demonstrate the procedures, it is not the intent of this annex to recommend either implicitly or explicitly the network described.

The *mesh* network is used to demonstrate the Message Transfer Part level 3 procedures because it is thought to be a possible international network implementation as shown on it, or subsets of it, may be used to construct other network structures.

A.2 *Basic network structures (example)*

Figure A-1/Q.705 shows the basic mesh network structure, while three simplified versions derived from this basic network structure are shown in Figure A-2/Q.705. More complex signalling networks can be built, using these as building components.

In the following, the basic mesh network Figure A-1/Q.705 is taken as an example to explain the procedures defined in Recommendation Q.704.

In this network, each signalling point with level 4 functions is connected by two link sets to two signalling transfer points. Each pair of signalling transfer points is connected to each other pair by four link sets. Moreover, there is a link set between the two signalling transfer points of each pair.

The simplified versions a), b) and c) of the basic signalling network are obtained by deleting respectively:

a) two out of four intersignalling transfer point link sets;

b) link sets between signalling transfer points of the same pair; and

c) a) and b) together.

It should be noted that for a given signalling link availability, the more signalling link sets removed from the basic signalling network [e.g. in going from Figure A-1/Q.705 to Figure A-2c)/Q.705], the lower the avail ability of the signalling network. However, an increase in the availability of the simplified signalling networks may be attained by adding one or more parallel signalling links to each of the remaining signalling link sets.

Figure A-1/Q.705, p.

Figure A-1/Q.705, p.

A.3 *Routing*

A.3.1 *General*

This section gives some routing examples in the basic mesh network in Figure A-1/Q.705. Routing actions required to change message routes under failure conditions are described in § A.4. The following routing principles are assumed for the examples in § A.3:

— Message routes should pass through a minimum number of intermediate signalling transfer points.

— Routing at each signalling point will not be affected by message routes used up to the concerned signalling transfer points.

— When more than one message route is available, signalling traffic should be load-shared by such message routes.

— Messages relating to a given user transaction and sent in a given direction will be routed over the same message route to ensure correct message sequence.

A.3.2 *Routing in the absence of failures*

Figure A-3/Q.705 illustrates an example of routing in the absence of failures for messages from signalling point A to signalling point F.

Figure A-3/Q705, p.

The following points are worthy of note:

a) In distributing traffic for load-sharing at the originating signalling point and intermediate signalling transfer points, care should be taken in the use of signalling link selection

(SLS) codes so that traffic will be distributed over four available routes evenly. In the example, originating signalling point A uses the second least significant bit of the signalling link selection code, and signalling transfer points B and C the least significant bit.

b) Other than that described above, the choice of a particular link for a given signalling link selection code can be made at each signalling point independently. As a result, message routes for a given user transaction (e.g. SLS = 0010) in two directions may take different paths (e.g. A C D F and F E B A).

c) Links BC and DE are not used in the absence of failures. They will be used in certain failure situations described in § A.4.

d) When the number of links in a link set is not a power of 2 (i.e. 1, 2, 4, 8), SLS load sharing does not achieve even distribution of traffic across the individual links.

A.3.3 *Routing under failure conditions*

A.3.3.1 *Alternative routing information*

In order to cope with failure conditions that may arise, each signalling point has alternative routing information which specifies, for each normal link set, alternative link set(s) to be used when the former become(s) unavailable (see Recommendation Q.704, § 4.2).

Table A-1/Q.705 gives, as an example, a list of alternative link sets for all normal link sets at signalling point A and at signalling transfer point B. In the basic mesh network, all link sets except those between signalling transfer points of the same pair are normal links which carry signalling traffic in the absence of failures. In case a normal link set becomes unavailable, signalling traffic formerly carried by that link set should be diverted to the alternative link set with priority 1. Alternative

link sets with priority 2 (i.e. link sets between signalling transfer points of the same pair) will be used only when both the normal link set and alternative link set(s) with priority 1 become unavailable.

Paragraphs A.3.3.2 to A.3.3.5 present some typical examples of the consequences of faults in signalling links and signalling points on the routing of signalling traffic. For the sake of simplicity, link sets are supposed to consist of only one link each.

H.T. [T1.705]
TABLE A-1/Q.705
List of alternative link sets at signalling points A and B

	Normal link set	Alternative link set	Priority | ua)
Signalling point A	AB AC	AC AB	1 1
Signalling transfer point B	BA BC BE BD	BC None BD BC BE BC	2 1 2 1
2			

a) *Priority 1* — used with normal link set on load-sharing basis in the absence of failures.

Priority 2 — used only when all the link sets with priority 1 become unavailable.

Table [T1.705], p.

A.3.3.2 *Single link failure examples*

Example 1: Failure of a link between a signalling point and a signalling transfer point (e.g. link AB) (see Figure A-4/Q.705).

Figure A-4/Q.705, p.

As indicated in Table A-1/Q.705, A diverts traffic formerly carried by link AB to link AC, while B diverts such traffic to link BC. It should be noted that the number of signalling transfer points traversed by signalling messages from F to A which passes through B is increased by one and becomes three in this case.

The principle to minimize the number of intermediate signalling transfer points in § A.3.1 is applied in this case at signalling transfer point B to get around the failure. In fact, the procedures defined in Recommendation Q.704 assume that traffic is diverted at a signalling point only in the case of a signalling link being unavailable on the route outgoing from that signalling point. Therefore, the procedures do not provide for sending an indication that traffic routed via signalling transfer point B will traverse a further signalling transfer point.

Example 2: Failure of an intersignalling transfer points link (e.g. link BD) (see Figure A-5/Q.705).

As indicated in Table A-1/Q.705, B diverts traffic carried by link BD to link BE. In the same sense, D diverts traffic carried by link DB to link DC.

Figure A-5/Q.705, p.

Example 3: Failure of a link between signalling transfer points of the same pair (e.g. link BC) (see Figure A-6/Q.705).

No routing change is required as a result of this kind of failure. Only B and C take note that the link BC has become unavailable.

Figure A-6/Q.705, p.7

A.3.3.3 *Multiple link failure examples*

As there are a variety of cases in which more than one link set becomes unavailable, only some typical cases are given as examples in the following.

Example 1: Failure of a link between a signalling point and a signalling transfer point, and of the link between that signalling transfer point and that of the same pair (e.g. links DF, DE) (see Figure A-7/Q.705).

B diverts traffic destined to F from link BD to link BE, because destination F becomes inaccessible via D. It should be noted that only the traffic destined to F is diverted from link BD to link BE, and not all the traffic on link BD. The same applies to C, which diverts traffic destined to F from link CD to link CE. F diverts all the traffic formerly carried by link FD to link FE in the same way as the single link failure example in § A.3.3.2.

Figure A-7/Q.705, p.8

Example 2: Failure of two intersignalling transfer point links (e.g. links BD, BE) (see Figure A-8/Q.705).

B diverts traffic formerly carried by link BD to link BC, because its alternative link set with priority 1, i.e. link BE, is also unavailable. The same applies to traffic formerly carried by link BE, and B diverts it to link BC. D and E divert traffic formerly carried by links DB and EB respectively to links DC and EC in the same way as the single link failure example in § A.3.3.2.

Figure A-8/Q.705, p.9

Example 3: Failure of a link between a signalling point and a signalling transfer point, and of an intersignalling transfer point link (e.g. links DF and BD) (see Figure A-9/Q.705).

This example is a combination of Examples 1 and 2 in § A.3.3.2. D diverts traffic formerly carried by link DF to link DE, while F diverts it to link FE. Moreover D diverts traffic formerly carried by link DB to link DC (this traffic will be that generated by signalling points other than F connected to D). In the same sense, B diverts traffic carried by link BD to link BE.

It should be noted that in this case only the portion of traffic sent by C to F via D traverses three signalling transfer points (C, D and E), while all the other portions continue to traverse two.

Figure A-9/Q.705, p.10

Example 4: Failure of the two links between a signalling point and its signalling transfer points (e.g. DF and EF) (see Figure A-10/Q.705).

In this case the signalling relations between F and any other signalling point of the network are blocked. Therefore F stops all outgoing signalling traffic, while A stops only traffic destined to F.

Figure A-10/Q.705, p.

A.3.3.4 *Single signalling point failure examples*

Example 1: Failure of a signalling transfer point (e.g. D) (see Figure A-11/Q.705).

B diverts all the traffic formerly carried by link BD to link BE. The same applies to C which diverts all the traffic carried by link CD to link CE. Originating point F diverts all the traffic carried by link FD to link FE as in the case of the link FD failure (see Example 1 in § A.3.3.2).

Figure A-11/Q.705, p.

Attention is drawn to the difference to Example 1 in § A.3.3.3 where only a part of the traffic previously carried by links BD and CD was diverted.

Example 2: Failure of a destination point (e.g. F) (see Figure A-12/Q.705).

In this case A stops all the traffic to F formerly carried on links AB and AC.

Figure A-12/Q.705, p.

A.3.3.5 *Multiple signalling transfer point failure examples*

Two typical cases of two signalling transfer points failing together are presented in the following examples.

Example 1: Failure of two signalling transfer points not pertaining to the same pair (e.g. B and D) (see Figure A-13/Q.705).

As a result of the failure of B, A diverts traffic formerly carried by link AB to link AC, while E diverts traffic formerly carried by link EB to link EC. Similarly as a result of the failure of D, F diverts traffic formerly carried by link FD to link FE, while C diverts traffic formerly carried by link CD to link CE.

It should be noted that, in this example, all the traffic between A and F is concentrated on only one intersignalling transfer point link, since failure of a signalling transfer point has an effect similar to a simultaneous failure of all the signalling links connected to it.

Figure A-13/Q.705, p.

Example 2: Failure of two signalling transfer points pertaining to the same pairs (e.g. D and E) (see Figure A-14/Q.705).

This example is equivalent to Example 4 in § A.3.3.3 as far as the inaccessibility of F is concerned, but in this case any other signalling point connected by its links to D and E also becomes inaccessible. In this case A stops signalling traffic destined to F, while F stops all outgoing signalling traffic.

Figure A-14/Q.705, p.

A.4 *Actions relating to failure conditions*

In the following, four typical examples of the application of signalling network management procedures to the failure cases illustrated in § A.3.3 are shown. In the case of multiple failures, an arbitrary failure (and restoration) sequence is assumed for illustrative purpose.

A.4.1 *Example 1: Failure of a link between a signalling point and a signalling transfer point (e.g. link AB)* (see Figure A-15/Q.705)

(Same as § A.3.3.2, Example 1.)

Figure A-15/Q.705, p.

A.4.1.1 *Failure of link AB*

a) When the failure of link AB is detected in A and in B, they initiate the changeover procedure, by exchanging changeover messages via C. Once buffer updating is completed, A restarts the traffic originally carried by the failed link on link AC; similarly, B restarts traffic destined to A on link BC.

b) In addition, B sends a transfer-prohibited message to C referred to destination A (according to the criterion indicated in Recommendation Q.704, § 13.2.2).

c) On the reception of the transfer-prohibited message, C starts the periodic sending of signalling-route-set-test messages, referred to A, to B (see Recommendation Q.704, § 13.5.2).

A.4.1.2 *Restoration of link AB*

When the restoration of link AB is completed, the following applies:

a) B initiates the changeback procedure, by sending a changeback declaration to A via C. Once it has received the changeback acknowledgement, it restarts traffic on the restored link. Moreover, it sends to C a transfer-allowed message, referred to destination A (see Recommendation Q.704, § 13.3.2). When C receives the transfer-allowed message, it stops sending signalling-route-set-test messages to B.

b) A initiates the changeback procedure, by sending a changeback declaration to B via C; once it has received the changeback acknowledgement, it restarts traffic on the normal link. The only traffic to be diverted is that for which link AB is the normal link set according to the load sharing rule (see § A.3.3.1). It must be pointed out, however, that if there is load sharing on parallel links between B and C, there is the possibility of missequencing. Concerning b), for example, the changeback declaration sent from A to B via C might overrun messages still buffered at signalling point C (due to e.g. retransmissions on the parallel link CB).

A.4.2 *Example 2: Failure of signalling transfer point D* | (see Figure A-16/Q.705)

(Same as § A.3.3.4, Example 1.)

Figure A-16/Q.705, p.

A.4.2.1 *Failure of signalling transfer point D*

a) Changeover is initiated at signalling points B, C and F from blocked links BD, CD and FD to the first priority alternative links BE, CE and FE respectively. Due to the failure of D, the concerned signalling points will receive no changeover acknowledgement message in response, and therefore they will restart traffic on alternative links at the expiry of the time T2 (see Recommendation Q.704, § 5.7.2). In addition E will send to B, C and F transfer-prohibited messages referred to destination D. These signalling points (B, C and F) will thus start periodic sending to E of signalling-route-set-test messages referred to D.

b) When B receives a transfer-prohibited message from E referred to D, it updates its routing information so that traffic to D will be diverted to C, thus sending a transfer-prohibited message to C referred to D. The same applies to C, and C sends a transfer-prohibited message to B.

c) So, when B receives a transfer-prohibited message from C, it finds that destination D has become inaccessible and sends a transfer-prohibited message to A. The same applies to C and thus C also sends a transfer-prohibited message to A. Having received transfer-prohibited messages from both B and C, A recognizes that D has become inaccessible and stops traffic to D.

d) In the same manner, i.e. link-by-link transmission of transfer-prohibited messages referred to D, other signalling points B, C, E and F will finally recognize that destination D has become inaccessible. Each signalling point will, therefore, start periodic sending of signalling-route-set-test messages referred to D to their respective adjacent signalling points.

A.4.2.2 *Recovery of signalling transfer point D*

a) Signalling points B, C, E send traffic restart allowed messages to signalling point D, as soon as signalling point D becomes accessible.

b) Signalling transfer point D broadcasts traffic restart allowed messages, after T20 (see Recommendation Q.704, § 16.8) has stopped or expired, to all adjacent SPs.

c) Changeback at signalling points B, C and F from the alternative to their normal links is performed. In all the three cases changeback includes the time-controlled diversion procedure (see Recommendation Q.704, § 6.4), since D is still inaccessible via E at B, C and F (as a result of previous reception of transfer-prohibited message from E).

d) E sends to B, C and F transfer-allowed messages referred to destination D. These signalling points will thus send transfer allowed messages to their respective adjacent signalling points. Thus, the link-by-link transmission of transfer-allowed messages will declare to all signalling points that destination D has become accessible.

e) On reception of a transfer-allowed message, each signalling point stops periodic sending of signalling-route-set-test messages to their respective adjacent signalling points.

f) On recovery of the previously unavailable links BD, CD and FD, signalling points B, C and F will restart all the traffic normally routed via signalling transfer point D after T21 (see Recommendation Q.704, § 16.8) has stopped or expired. (They would restart any traffic terminating at D, if D had an endpoint function as well as being an STP, immediately D becomes accessible, that is after successful signalling link tests to D.)

A.4.3 *Example 3: Failure of link between a signalling point and a signalling transfer point, and of the link between that signalling transfer point and that of the same pair (e.g. links DF, DE)* (see Figure A-17/Q.705)

(Same as § A.3.3.3, Example 1.)

Figure A-17/Q.705, p.

A.4.3.1 *Failure of link DE*

On failure of link DE, this link is marked unavailable at both signalling transfer points D and E. Since in the absence of failures, link DE does not carry signalling traffic, no change in message routing takes place at this time.

However, D and E send to signalling points B, C and F transfer-prohibited messages referred to destination E or D respectively. These signalling points will thus start periodic sending of signalling-route-set-test messages, referred to D or E, to E and D respectively.

A.4.3.2 *Failure of link DF in the presence of failure of link DE*

a) On failure of link DF the following actions occur:

i) Signalling point D which no longer has access to signalling point F indicates this condition to signalling transfer points B and C by sending transfer-prohibited messages. B and C will thus start the periodic sending of signalling-route-set-test messages referred to F, to D.

ii) Emergency changeover from link FD to link FE is initiated at signalling point F, since D becomes inaccessible to F due also to the previous failure.

b) On receiving the transfer-prohibited messages forced rerouting is initiated at points B and C. This causes traffic destined to F to be diverted from links terminating on D to links terminating on E. Forced rerouting thus permits recovery from a failure condition caused by a fault in a remote part of the network.

A.4.3.3 *Restoration of link FD in the presence of failure of link DE*

a) On recovery of link FD the following actions occur:

i) Signalling point D sends a transfer-allowed message to B and C to indicate that D once again has access to F. B and C will thus stop the sending of signalling-route-set-test messages referred to F to D.

ii) F initiates changeback with time controlled diversion from link FE to link FD. This procedure permits changeback to be executed at one end of a link, when it is impossible to notify the other end of the link (in this example, because

link DE is unavailable). Traffic in this case is not diverted from the alternative link until a time interval has elapsed, in order to minimize the danger of mis-sequencing of messages (see Recommendation Q.704, § 6.4).

b) On receiving the transfer-allowed message, controlled rerouting of traffic from the alternative routes (BEF, CEF) to the normal routes (BDF, CDF) is initiated at points B and C. Controlled rerouting involves diversion of traffic to a route which has become available after a time interval (see Recommendation Q.704, § 8.2.1), provisionally set at one second to minimize the danger of mis-sequencing messages.

A.4.3.4 *Restoration of link DE*

On recovery of link DE it is marked available at signalling transfer points D and E. Signalling points D and E send to B, C and F transfer-allowed messages referred to destination E or D respectively. These signalling transfer points will thus stop sending of signalling-route-set-test messages.

A.4.4 *Example 4: Failure of links DF and EF* | (see Figure A-18/Q.705)

Figure A-18/Q.705, p.

A.4.4.1 *Failure of link DF*

When the failure of link DF is detected, D and F perform the changeover procedure; D diverts traffic, destined to F, to link DE, while F concentrates all the outgoing traffic on link FE.

In addition, D sends to E a transfer-prohibited message, referred to destination F; E will thus start sending of signalling-route-set-test messages, referred to F, towards D (see also § A.4.1.1).

A.4.4.2 *Failure of link EF in the presence of failure of link DF*

a) When the failure of link EF is detected, the following applies:

i) Since all destinations become inaccessible F stops sending all signalling traffic.

ii) E sends to B, C and D a transfer-prohibited message, referred to destination F. B, C and D start periodic sending of signalling-route-set-test messages referred to F to E.

b) When D receives the transfer-prohibited message, it sends to B and C a transfer-prohibited message, referred to destination F (see Recommendation Q.704, § 13.2.2 | i)). B and C start periodic sending of test messages referred to F to D.

c) When B receives the transfer-prohibited messages from D and E, it sends a transfer-prohibited message to C; the same applies for C (it sends the message to B). As soon as B and C have received the transfer-prohibited messages from all the three possible routes (BD, BE and BC, or CD, CE and CB respectively), they send a transfer-prohibited message to A.

Note — Depending on the sequence of reception of transfer-prohibited messages at B or C, they may start a forced rerouting procedure on a route not yet declared to be unavailable; such procedure is then aborted as soon as a transfer-prohibited message is received also from that route.

d) As soon as A receives the transfer-prohibited messages from B and C, it declares destination F inaccessible and stops sending traffic towards it. Moreover, it starts the periodic sending of signalling-route-set-test messages, referred to F, to B and C.

A.4.4.3 *Restoration of link EF in the presence of failure on link DF*

a) When restoration of link EF is completed, the following applies:

i) Signalling point F restarts traffic on link EF.

ii) E sends a transfer-allowed message, referred to destination F, to B, C and D; moreover it restarts traffic on the restored link.

b) When B and C receive the transfer-allowed message, they send a transfer-allowed message to A and C or A and B, respectively and they stop sending signalling-route-set-test messages to E; moreover, they restart the concerned traffic on link BE or CE respectively.

c) When D receives the transfer-allowed message from E, it sends transfer-allowed messages to B and C and stops sending signalling-route-set-test messages to E; moreover, it starts the concerned traffic on link DE. On receipt of the transfer-allowed message, B and C will divert to links BD and CD, by means of a controlled rerouting procedure, traffic carried by links BE and CE for which they are the normal links (see § A.3.3). Moreover, they will stop sending signalling-route-set-test messages to D.

Note — According to the rules stated in Recommendation Q.704, § 13.3.2, on receipt of transfer-allowed messages from E [phase b) above], B and C should send transfer-allowed messages also to D and E. However, this is not appropriate in the network configurations such as the one here considered, taking into account that:

— there is no route, for example, from D (or E) to F via B (or C) and therefore the transfer-allowed messages would be ignored by D and E;

— on restarting traffic to F on links BD, BE, CD and CE it would anyway be necessary that B and C send transfer-prohibited messages to D and E, which would contradict the previous transfer-allowed messages.

d) As soon as A receives a transfer-allowed message from B or C, it restarts signalling traffic to B and C. If traffic has already been restarted on one link when the transfer-allowed message is received on the other link, a changeback procedure is performed to establish the normal routing situation on both links (i.e. to divert part of the traffic on the latter link).

A.4.4.4 *Restoration of link DF*

When the restoration of link DF is completed, the following applies:

a) D initiates the changeback procedure to link DF; moreover, it sends to E a transfer-allowed message, referred to destination F,

b) F sends signalling-route-set-test message to D referred to the destination points it normally accesses via D. It initiates the changeback procedure to link DF; this procedure refers only to the traffic for which link DF is the normal one, according to the routing rules.

A.5 *Explanatory note from the implementors forum for clarification of load sharing*

A.5.1 In general, to improve the distribution of traffic, load sharing at a particular signalling point (amongst link sets to a given destination) will be on the basis of a part of the signalling link selection field which is different than that part used for load sharing amongst signalling links within a selected link set. In the example represented in Figure 5/Q.704, if link set DF contains more than one signalling link, then the least significant bit of the signalling link selection field is not used in sharing traffic within link set DF amongst the signalling links. Similar considerations can apply to link set DE.

A.5.2 At an originating signalling point it is assumed that for a given signalling relation, signalling link selection field values are evenly distributed and traffic is shared over the appropriate link sets and signalling links within each link set on this basis. In general, to achieve this a different oad sharing rule is needed for each number of link sets, and each number of signalling links within a link set, over which traffic is to be shared. The intention is to attain, for a given signalling relation, as een as possible a traffic balance over the link sets and the signalling links within each link set, based on the signalling link selection field and the numbers of link sets and signalling links within each ink set; such an even traffic balance may result if the fixed part of the signalling link selection field is not excluded from consideration by the load sharing rules.

A.5.3 At a signalling transfer point, for a given signalling relation, signalling link selection field values may not be evenly distributed (see Figure 5/Q.704, signalling transfer point E). A different set of load sharing rules to those for originating signalling points may be provided to deal with this possibility. These are again based on the signalling link selection field and the numbers of link sets and signalling links within each link set, but assume that a particular part of the signalling link selection field is fixed. The fixed part of the signalling link selection field may be different at different signalling transfer points. Where signalling messages for different signalling relations arriving at a particular signalling transfer point do not have the same part of the signalling link selection field fixed, an uneven sharing of traffic for a particular signalling relation amongst the relevant link sets and signalling links within each link set may result.

Recommendation Q.706

MESSAGE TRANSFER PART SIGNALLING PERFORMANCE

The message transfer part of Signalling System No. 7 is designed as a joint transport system for the messages of different users. The requirements of the different users have to be met by the Message Transfer Part. These requirements are not necessarily the same and may differ in importance and stringency.

In order to satisfy the individual requirements of each user the Message Transfer Part of Signalling System No. 7 is designed in such a way that it meets the most stringent User Part requirements envisaged at the time of specification. To this end, the requirements of the telephone service, the data transmission service and the signalling network management, in particular, were investigated. It is assumed that a signalling performance which satisfies the requirements mentioned above will also meet those of future users.

In the light of the above, signalling system performance is understood to be the capability of the Message Transfer Part to transfer messages of variable length for different users in a defined manner. In order to achieve a proper signalling performance, three groups of parameters have to be taken into account:

— The first group covers the objectives derived from the requirements of the different users. The aims are limitation of message delay, protection against all kinds of failures and guarantee of availability.

— The second group covers the features of the signalling traffic, such as the loading potential and the structure of the signalling traffic.

— The third group covers the given environmental influences, such as the characteristics (e.g. error rate and proneness to burst) of the transmission media.

The three groups of parameters are considered in the specification of the procedures to enable the Message Transfer Part to transfer the messages in such a way that the signalling requirements of all users are met and that a uniform and satisfactory overall signalling system performance is achieved.

1 Basic parameters related to Message Transfer Part signalling performance

Signalling performance is defined by a great number of different parameters. In order to ensure a proper signalling performance for all users to be served by the common Message Transfer Part, the following design objectives are established for the Message Transfer Part.

1.1 *Unavailability of a signalling route set*

The unavailability of a signalling route set is determined by the unavailability of the individual components of the signalling network (signalling links and the signalling points) and by the structure of a signalling network.

The unavailability of a signalling route set should not exceed a total of 10 minutes per year.

The unavailability of a signalling route set within a signalling network may be improved by replication of signalling links, signalling paths and signalling routes.

1.2 *Unavoidable message transfer part malfunction*

The Message Transfer Part of Signalling System No. 7 is designed to transport messages in a correct sequence. In addition, the messages are protected against transmission errors. However, a protection against transmission errors cannot be absolute. Furthermore, mis-sequencing and loss of messages in the Message Transfer Part cannot be excluded in extreme cases.

For all User Parts, the following conditions are guaranteed by the Message Transfer Part:

a) *Undetected errors*

On a signalling link employing a signalling data link which has the error rate characteristic as described in Recommendation Q.702 not more than one in 10^{10} of all signal unit errors will be undetected by the message Transfer Part.

b) *Loss of messages*

Not more than one in 10^7 messages will be lost due to failure in the message transfer part.

c) *Messages out-of-sequence*

Not more than one in 10^{10} messages will be delivered out-of-sequence to the User Parts due to failure in the message transfer part. This value also includes duplication of messages.

1.3 *Message transfer times*

This parameter includes:

— handling times at the signalling points (see § 4.3);

— queueing delays including retransmission delays (see § 4.2);

— signalling data link propagation times.

1.4 *Signalling traffic throughput capability*

Needs further study (see § 2.2).

2 Signalling traffic characteristics

2.1 *Labelling potential*

The design of Signalling System No. 7 provides the potential for labels to identify 16 | 84 signalling points. For each of the 16 different User Parts a number of user transactions may be identified, e.g. in the case of the telephone service up to 4096 speech circuits.

2.2 *Loading potential*

Considering that the load per signalling channel will vary according to the traffic characteristics of the service, to the user transactions served and to the number of signals in use, it is not practicable to specify a general maximum limit of user transactions that a signalling

channel can handle. The maximum number of user transactions to be served must be determined for each situation, taking into account the traffic characteristics applied so that the total signalling load is held to a level which is acceptable from different points of view.

When determining the normal load of the signalling channel, account must be taken of the need to ensure a sufficient margin for peak traffic loads.

The loading of a signalling channel is restricted by several factors which are itemized below.

2.2.1 *Queueing delay*

The queueing delay in absence of disturbances is considerably influenced by the distribution of the message length and the signalling traffic load (see § 4.2).

2.2.2 *Security requirements*

The most important security arrangement is redundancy in conjunction with changeover. As load sharing is applied in normal operation, the load on the individual signalling channels has to be restricted so that, in the case of changeover, the queueing delays do not exceed a reasonable limit. This requirement has to be met not only in the case of changeover to one predetermined link but also in the case of load distribution to the remaining links.

2.2.3 *Capacity of sequence numbering*

The use of 7 bits for sequence numbering finally limits the number of signal units sent but not yet acknowledged to the value of 127.

In practice this will not impose a limitation on the loading potential.

2.2.4 *Signalling channels using lower bit rates*

A loading value for a signalling channel using bit rates of less than 64 kbit/s will result in greater queueing delays than the same loading value for a 64-kbit/s signalling channel.

2.3 *Structure of signalling traffic*

The Message Transfer Part of Signalling System No. 7 serves different User Parts as a joint transport system for messages. As a result, the structure of the signalling traffic largely depends on the types of User Parts served. It can be assumed that at least in the near future the telephone service will represent the main part of the signalling traffic also in integrated networks.

It cannot be foreseen yet how the signalling traffic is influenced by the integration of existing and future services. The traffic models given in § 4.2.4 have been introduced in order to consider as far as possible the characteristics and features of different services within an integrated network. If new or more stringent requirements are imposed on signalling (e.g. shorter delays) as a consequence of future services, they should be met by appropriate dimensioning of the load or by improving the structure of the signalling network.

3 Parameters related to transmission characteristics

No special transmission requirements are envisaged for the signalling links of Signalling System No. 7. Therefore, System No. 7 provides appropriate means in order to cope with the given transmission characteristics of ordinary links. The following items indicate the actual characteristics to be expected — as determined by the responsible Study Groups — and their consequences on the specifications of the Signalling System No. 7 Message Transfer Part.

3.1 *Application of Signalling System No. 7 to 64-kbit/s links*

The Message Transfer Part is designed to operate satisfactorily with the following transmission charac teristics:

a) a long-term bit error rate of the signalling data link of less than 10$^{\text{D}}$lF261^{6} [1];

b) a medium-term bit error rate of less than 10$^{\text{D}}$lF261^{4};

c) random errors and error bursts including long bursts which might occur in the digital link due to, for instance, loss of frame alignment or octet slips in the digital link. The maximum tolerable interruption period is specified for the signal unit error rate monitor (see Recommendation Q.703, § 10.2).

3.2 *Application of Signalling System No. 7 to links using lower bit rates*

(Needs further study.)

4 Parameters of influence on signalling performance

4.1 *Signalling network*

Signalling System No. 7 is designed for both associated and nonassociated applications. The reference section in such applications is the signalling route set, irrespective of whether it is served in the associated or quasi-associated mode of operation.

For every signalling route set in a signalling network, the unavailability limit indicated in § 1.1 has to be observed irrespective of the number of signalling links in tandem of which it is composed.

4.1.1 *International signalling network*

(Needs further study.)

4.1.2 *National signalling network*

(Needs further study.)

4.2 *Queueing delays*

The Message Transfer Part handles messages from different User Parts on a time-shared basis. With time-sharing, signalling delay occurs when it is necessary to process more than one message in a given interval of time. When this occurs, a queue is built up from which messages are transmitted in order of their times of arrival.

There are two different types of queueing delays: queueing delay in the absence of disturbances and total queueing delay.

4.2.1 *Assumptions for derivation of the formulas*

The queueing delay formulas are basically derived from the $M/G/1$ queue with priority assignment. The assumptions for the derivation of the formulas in the absence of disturbances are as follows:

a) the interarrival time distribution is exponential (M);

b) the service time distribution is general (G);

c) the number of server is one (1);

d) the service priority refers to the transmission priority within level 2 (see Recommendation Q.703, § 11.2); however, the link status signal unit and the independent flag are not considered;

e) the signalling link loop propagation time is constant including the process time in signalling terminals; and

f) the forced retransmission case of the preventive cyclic retransmission method is not considered.

In addition, for the formulas in the presence of disturbances, the assumptions are as follows:

g) the transmission error of the message signal unit is random;

h) the errors are statistically independent of each other;

i) the additional delay caused by the retransmission of the erroneous signal unit is considered as a part of the waiting time of the concerned signal unit; and

j) in case of the preventive cyclic retransmission method, after the error occurs, the retransmitted signal units of second priority are accepted at the receiving end until the sequence number of the last sent new signal unit is caught up by that of the last retransmitted signal unit.

Furthermore, the formula of the proportion of messages delayed more than a given time is derived from the assumption that the probability density function of the queueing delay distribution may be exponentially decreasing where the delay time is relatively large.

4.2.2 *Factors and parameters*

a) The notations and factors required for calculation of the queueing delays are as follows:

Q_a mean queueing delay in the absence of disturbances

σ_a^2 variance of queueing delay in the absence of disturbances

Q_t mean total queueing delay

σ^2_t .PS 10 variance of total queueing delay

$P(T)$ proportion of messages delayed more than T

a traffic loading by message signal units (MSU) (excluding retransmission)

T_m mean emission time of message signal units

T_f emission time of fill-in signal units

T_L signalling loop propagation time including processing time in signalling terminal

P_u error probability of message signal units

$$k_1 = \frac{2\ nd\ moment\ of\ message\ signal\ units\ emission\ time}{fIT_m fR^2}$$

$$k_2 = \frac{3\ rd\ moment\ of\ message\ signal\ units\ emission\ time}{fIT_m fR^3}$$

$$k_3 = \frac{4\ th\ moment\ of\ message\ signal\ units\ emission\ time}{fIT_m fR^4}$$

Note — As a consequence of zero insertion at level 2 (see Recommendation Q.703, § 3.2), the length of the emitted signal unit will be increased by approximately 1.6 percent on average. However, this increase has negligible effect on the calculation.

b) The parameters used in the formulas are as follows:

$$t_f = T_f/T_m$$

$$t_L = T_L/T_m$$

for the basic method,

$$E_1 = 1 + P_u t_L$$

$$E_2 = k_1 + P_u t_L (t_L + 2)$$

$$E_3 = k_2 + P_u t_L (t_L^2 + 3t_L + 3k_1)$$

for the preventive cyclic retransmission (PCR) method,

$a_3 = \exp(-at_L)$: traffic loading caused by fill-in signal units.

$a_z = 1 - a - a_3$

$H_1 = at_L$

$H_2 = at_L(k_1 + at_L)$

$H_3 = at_L(k_2 + 3at_Lk_1 + a^2t_L^2)$

$F_1 = at_L/2$

$F_2 = at_L(k_1/2 + at_L/3)$

$F_3 = at_L(k_2/2 + at_Lk_1 + a^2t_L^2/4)$

$$q_a = \frac{k_1(a + a_z) + a_3 t_f}{(1 - a)}$$

$$s_a = \frac{ak_1}{1 - a}\, q_a + \frac{k_2(a + a_z) + a_3 t_f^2}{(1 - a)}$$

$$t_a = \frac{ak_1 s_a + 2ak_2 q_a}{(1 - a)} + \frac{(a + a_z)k_3 + a_3 t_f^3}{(1 - a)}$$

$Z_1 = 2 + P_u(1 + H_1)$

$Z_2 = 4K_1 + P_u(5k_1 + 3H_1 + H_2)$

$Z_3 = 8k_2 + P_u(19k_2 + 27k_1H_1 + 9H_2 + H_3)$

$Y_2 = s_a + 4k_1 + F_2 + \{q_a(2 + F_1) + 2F_1\}$

$Y_3 = t_a + 8k_2 + F_3 + \{s_a(2 + F_1) + q_a(4k_1 + F_2) + 2F_2 + 4k_1F_1\} + 12q_aF_1$

$$\alpha = \frac{-a^2 + P_u(1 + at_L)}{+q_a + at_L/2}$$

$$q_d = \frac{Z_2 + \alpha Y_2}{2(1 - aZ_1)}$$

$$s_d = \frac{Z_2}{1 - aZ_1}\, q_d + \frac{Z_3 + \alpha Y_3}{3(1 - aZ_1)}$$

$$q_b = \frac{q_a + 1 + F_1}{1 - a}$$

$$s_b = \frac{s_a + k_1 + F_2}{(1 - a)} + \frac{2\{q_a(1 + F_1) + F_1\}}{(1 - a)}$$

$$q_c = \frac{q_d + 1 + P_u(1 + H_1)}{1 - a}$$

$$s_c = \frac{s_d + k_1 + P_u(3k_1 + H_2)}{(1 - a)} + 2\,\frac{q_d + P_u\{q_d(1 + H_1) + 2H_1\}}{(1 - a)}$$

$$P_V = P_u a\, \frac{q_a + 2 + at_L/2}{1 - 2a} \left(1 + P_u \frac{a + a^2 t_L}{1 - 2a}\right)$$

4.2.3 *Formulas*

The formulas of the mean and the variance of the queueing delays are described in Table 1/Q.706. The proportion of messages delayed more than a given time T_x is:

$$P(T_x) = \exp\left[-\frac{T_x(R) - Q_x(R) + \sigma_x(R)}{\sigma_x(R)}\right]$$

where Q_x | and σ_x | denote the mean and the standard deviation of queueing delay, respectively. This approximation is better suited in absence of disturbances. In the presence of disturbances the actual distribution may be deviated further. Relation between $P(T_x)$ and T_x is shown in Figure 1/Q.706.

4.2.4 *Examples*

Assuming the traffic models given in Table 2/Q.706, examples of queueing delays are calculated as listed in Table 3/Q.706.

Note — The values in the table were determined based on TUP messages. With the increase of the effective message length, using ISUP and TC, these values may be expected to be increased during the course of further study.

Figure 1/Q.706, p.21

H.T. [T1.706]

TABLE 1/Q.706

Queueing delay formula

Error correction method	Disturbance	Mean Q	Variance σ^2
	Absence	{	
	{		
	Presence	{	
Basic	{		
	Absence	{	
	{		
	Presence	{	

	{		
{			

Tableau 1/Q.706 [T1.706], p.22

H.T. [T2.706]

TABLE 2/Q.706

Traffic model

Model	A	B	
Message length (bits)	120	104	304
Percent	100	92	8
Mean message length (bits)	120	120	
k 1	1.0	1.2	
k 2	1.0	1.9	
k 3	1.0	3.8	

Tableau 2/Q.706 [T2.706], p.23

H.T. [T3.706]

TABLE 3/Q.706

List of examples

Figure	Error control	Queueing delay	Disturbance	Model
2/Q.706	Basic/PCR	Mean	Absence	A and B
3/Q.706	Basic/PCR	Standard deviation	Absence	A and B
4/Q.706	Basic	Mean	Presence	A
5/Q.706	Basic	Standard deviation	Presence	A
6/Q.706	PCR	Mean	Presence	A
7/Q.706	PCR	Standard deviation	Presence	A

Tableau 3/Q.706 [T3.706], p.24

Figure 2/Q.706, p.25

Figure 3/Q.706, p.26

Figure 4/Q.706, p.27

Figure 5/Q.706, p.28

Figure 6/Q.706, p.29

Figure 7/Q.706, p.30

4.3 *Message transfer times*

Within a signalling relation, the Message Transfer Part transports messages from the originating User Part to the User Part of destination, using several signalling paths. The overall message transfer time needed depends on the message transfer time components (a) to (e) involved in each signalling path.

4.3.1 *Message transfer time components and functional reference points*

A signalling path may include the following functional signalling network components and transfer time components.

a) Message Transfer Part sending function at the point of origin (see Figure 8/Q.706).

b) Signalling transfer point function (see Figure 9/Q.706).

c) Message Transfer Part receiving function at the point of destination (see Figure 10/Q.706).

d) Signalling data link propagation time (see Figure 11/Q.706).

e) Queueing delay.

An additional increase of the overall message transfer times is caused by the queueing delays. These are described in § 4.2.

Figure 8/Q.706, p.31

Figure 9/Q.706, p.32

Figure 10/Q.706, p.33

Figure 11/Q.706, p.34

4.3.2 *Definitions*

4.3.2.1 **message transfer part sending time T↓m↓s**

F: temps d'´emission du Sous-syst`eme Transport de Messages $T_{m\backslash ds}$

S: tiempo de emisi´on de la parte de transferencia de mensajes $T_{m\backslash ds}$

$T_{m\backslash ds}$ | is the period which starts when the last bit of the message has left the User Part and ends when the last bit of the signal unit enters the signalling data link for the first time. It includes the queueing delay in the absence of disturbances, the transfer time from level 4 to level 3, the handling time at level 3, the transfer time from level 3 to level 2, and the handling time in level 2.

4.3.2.2 **message transfer time at signalling transfer points T↓c↓s**

F: temps de transfert des messages aux points de transfert s´emaphore $T_{c\backslash ds}$

S: tiempo de transferencia de mensajes en los puntos de transferencia de la señalizaci´on $T_{c\backslash ds}$

$T_{c\backslash ds}$ | is the period, which starts when the last bit of the signal unit leaves the incoming signalling data link and ends when the last bit of the signal unit enters the outgoing signalling data link for the first time. It also includes the queueing delay in the absence of disturbances but not the additional queueing delay caused by retransmission.

4.3.2.3 **message transfer part receiving time T_{mr}**

F: temps de réception du Sous-système Transport de Messages T_{mr}

S: tiempo de recepción de la parte de transferencia de mensajes T_{mr}

T_{mr} | is the period which starts when the last bit of the signal unit leaves the signalling data link and ends when the last bit of the message has entered the User Part. It includes the handling time in level 2, the transfer time from level 2 to level 3, the handling time in level 3 and the transfer time from level 3 to level 4.

4.3.2.4 **data channel propagation time T_p**

F: temps de propagation sur la voie de données T_p

S: tiempo de propagación del canal de datos T_p

T_p is the period which starts when the last bit of the signal unit has entered the data channel at the sending side and ends when the last bit of the signal unit leaves the data channel at the receiving end irrespective of whether the signal unit is disturbed or not.

4.3.3 *Overall message transfer times*

The overall message transfer time T_o is referred to the signalling relation. T_o starts when the message has left the user part (level 4) at the point of origin and ends when the message has entered the user part (level 4) at the point of destination.

The definition of the overall message transfer time and the definitions of the individual message transfer time components give rise to the following relationships:

a) In the absence of disturbances

$$T_{oa} = T_{ms} + \sum_{i=1}^{n+1} T_{pi} + \sum_{i=1}^{n} T_{csi} + T_{mr}$$

b) In the presence of disturbances

$$T_o = T_{oa} + \sum (Q_t - Q_a)$$

Here

$T_{o\backslash da}$ overall message transfer time in the absence of disturbances

$T_{m\backslash ds}$ Message Transfer Part sending time

$T_{m\backslash dr}$ Message Transfer Part receiving time

$T_{c\backslash ds}$ Message transfer time at signalling transfer points

n number of STPs involved

T_p data channel propagation time

T_o overall message transfer time in the presence of disturbances

Q_t total queueing delay (see § 4.2)

Q_a queueing delay in the absence of disturbances (see § 4.2)

Note — For σ"(Q_t — Q_a), all signalling points in the signalling relation must be taken into account.

4.3.4 *Estimates for message transfer times*

(Needs further study.)

The estimates must take account of:

— the length of the signal unit,

— the signalling traffic load,

— the signalling bit rate.

The estimates for $T_{m\dr}$, $T_{m\ds}$ | and $T_{c\ds}$ | will be presented in the form of:

— mean values,

— 95% level values.

The estimates for $T_{c\ds}$ | for a signalling transfer point are given in Table 4/Q.706.

TABLE [T4.706], p.

Note — the values in the table were determined based on TUP messages. With the increase of the effective message length, using ISUP and TC, these values may be expected to be increased during the course of further study.

These figures are related to 64-kbit/s signalling bit rate. The normal signalling traffic load is that load for which the signalling transfer point is engineered. A mean value of 0.2 Erlang per signalling link is assumed. The message length distribution is as given in Table 2/Q.706.

4.4 *Error control*

During transmission, the signal units are subject to disturbances which lead to a falsification of the signalling information. The error control reduces the effects of these disturbances to an acceptable value.

Error control is based on error detection by redundant coding and on error correction by retransmission. Redundant coding is performed by generation of 16 check bits per signal unit based on the polynomial described in Recommendation Q.703, § 4.2. Moreover, the error control does not introduce loss, duplication or mis-sequencing of messages on an individual signalling link.

However, abnormal situations may occur in a signalling relation, which are caused by failures, so that the error control for the signalling link involved cannot ensure the correct message sequence.

4.5 *Security arrangements*

The security arrangements have an essential influence on the observance of the availability requirements listed in § 1.1 for a signalling relation.

In the case of Signalling System No. 7, the security arrangements are mainly formed by redundancy in conjunction with changeover.

4.5.1 *Types of security arrangements*

In general, a distinction has to be made between security arrangements for the individual components of the signalling network and security arrangements for the signalling relation. Within a signalling network, any security arrangement may be used, but it must be ensured that the availability requirements are met.

4.5.1.1 *Security arrangements for the components of the signalling network*

Network components, which form a signalling path when being interconnected, either have constructional security arrangements which exist from the very beginning (e.g. replication of the controls at the exchanges and signalling transfer points) or can be replicated, if need be (e.g. signalling data links). For security reasons, however, replication of signalling data links is effected only if the replicated links are independent of one another (e.g. multipath routing). In the case of availability calculations for a signalling path set, special care has to be taken that the individual signalling links are independent of one another.

4.5.1.2 *Security arrangements for signalling relations*

In quasi-associated signalling networks where several signalling links in tandem serve one signalling relation, the security arrangements for the network components, as a rule, do not ensure sufficient availability of the signalling relation. Appropriate security arrangements must therefore be made for the signalling relations by the provision of redundant signalling path sets, which have likewise to be independent of one another.

4.5.2 *Security requirements*

In the case of 64-kbit/s signalling links, a signalling network has to be provided with sufficient redundancy so that the quality of the signalling traffic handled is still satisfactory. (Application of the above to signalling links using lower bit rates needs further study.)

4.5.3 *Time to initiate changeover*

If individual signalling data links fail, due to excessive error rates, changeover is initiated by signal unit error monitoring (see Recommendation Q.703, § 8). With signal unit error monitoring, the time between the occurrence of the failure and the initiation of changeover is dependent on the message error rate (a complete interruption will result in an error rate equal to 1).

Changeover leads to substantial additional queueing delays. To keep the latter as short as possible, the signalling traffic affected by an outage is reduced to a minimum by the use of load sharing on all existing signalling links.

4.5.4 *Changeover performance times*

There are two performance times associated with link changeover. Both times are maximum time values (not normal values). They are defined to be the point at which 95% of the events occur within the recommended performance time at a signalling point traffic load that is 30% above normal.

The performance times are measured from outside the signalling point.

4.5.4.1 *Failure response time*

This time describes the time taken by a signalling point to recognize that a changeover is needed for a signalling link. This time begins when the signalling link is unavailable, and ends when the signalling point sends a changeover (or emergency changeover) order to the remote signalling point. A link is unavailable when a signalling unit with status indication out of service (SIOS) or processor outage (SIPO) is sent or received on the link.

Failure response time (maximum permissible): 500 ms.

4.5.4.2 *Answer time to changeover order*

This time describes the time taken by a signalling point to answer a changeover (or emergency changeover) order. This time begins when the signalling point receives a changeover (or emergency changeover) order message, and ends when the signalling point sends a changeover (or emergency changeover) acknowledgement message.

Answer time to changeover order (maximum permissible): 300 ms.

4.6 *Failures*

4.6.1 *Link failures*

During transmission, the messages may be subject to disturbances. A measure of the quality of the signalling data link is its signal unit error rate.

Signal unit error monitoring initiates the changeover at a signal unit error rate of about 4 | (mu | 0^{D}lF261^{3}.

The error rate, which Signalling System No. 7 has to cope with, represents a parameter of decisive influence on its efficiency.

As a result of error correction by retransmission, a high error rate causes frequent retransmission of the message signal units and thus long queueing delays.

4.6.2 *Failures in signalling points*

(Needs further study.)

4.7 *Priorities*

Priorities resulting from the meaning of the individual signals are not envisaged. Basically, the principle ‘‘first-in — first-out’’ applies.

Although the service indicator offers the possibility of determining different priorities on a user basis, such user priorities are not yet foreseen.

Transmission priorities are determined by Message Transfer Part functions. They are solely dependent on the present state of the Message Transfer Part and completely independent of the meaning of the signals (see Recommendation Q.703, § 11).

5 Performance under adverse conditions

5.1 *Adverse conditions*

(Needs further study.)

5.2 *Influence of adverse conditions*

(Needs further study.)

Reference

[1] CCITT Recommendation *Error performance on an international digital connection forming part of an integrated services digital network* , Vol. III, Rec. G.821.

Recommendation Q.707

TESTING AND MAINTENANCE

1 General

In order to realize the performance requirements described in Recommendation Q.706, means and procedures for signalling network testing and maintenance are required in addition to the means defined in Recommendations Q.703 and Q.704.

2 Testing

2.1 *Signalling data link test*

As defined in Recommendation Q.702, § 1, the signalling data link is a bidirectional transmission path for signalling. Testing and maintenance functions can be initiated independently at either end.

The signalling data link and the constituent parts of the digital and analogue versions are described in Recommendation Q.702, § 1.

They must be tested before being put into service to ensure that they meet the requirements of Recommendation Q.702, § 3.

Since interruptions of the signalling data link will affect many transactions, they must be treated with the utmost care. Appropriate special measures should be taken to prevent unauthorized maintenance access which could result in interruptions to service. These special measures may include marking or flagging the equipment and indications on distribution frames or test bays where access is possible (see Recommendation M.1050 [1]).

The signal unit error rate monitor and the alignment error rate monitor described in Recommendation Q.703, § 10, also provide means for detecting deterioration of a signalling data link.

Further studies are required with reference to Recommendation V.51 [2].

2.2 *Signalling link test*

As defined in Recommendation Q.703, § 1.1.1 and illustrated in Figure 1/Q.701, the signalling link comprises a signalling data link with signalling link functions at either end.

In the following, an on-line signalling link test procedure is specified which involves communication between the two ends of the concerned signalling link. This procedure is to be used when a signalling link is activated or restored (see Recommendation Q.704, § 12). The signalling link becomes available only if the test is successful. This procedure is intended for use while the signalling link is in service. In addition, local failure detection procedures should be performed at either end; these are not specified in this Recommendation.

In case the signalling link test (SLT) is applied while the signalling link is in service the signalling link test message is sent at regular intervals T2 (see § 5.5). The testing of a signalling link is performed independently from each end.

The ability to send a signalling test acknowledgement message, defined below, must always be provided at a signalling point.

The signalling point initiating the tests transmits a signalling link test message on the signalling link to be tested. This message includes a test pattern which is chosen at the discretion of the end initiating the test. After receiving a signalling link test message, a signalling point responds with a signalling link test acknowledgement message on the signalling link identified by the SLS contained in the signalling link test message. The test pattern included in the signalling link test acknowledgement message is identical to the test pattern received.

The signalling link test will be considered successful only if the received signalling link test acknowledgement message fulfills the following criteria:

a) the SLC identifies the physical signalling link on which the SLTA was received.

b) the OPC identifies the signalling point at the other end of the link.

c) the test pattern is correct.

In the case when the criteria given above are not met or a signalling link test acknowledgement message is not received on the link being tested within T1 (see § 5.5) after the signalling link test message has been sent, the test is considered to have failed and is repeated once. In the case when also the repeated test fails, the following actions have to be taken:

— SLT applied on activation/restoration, the link is put out of service, restoration is attempted and a management system must be informed.

— SLT applied periodically, for further study.

The formats and codes of signalling link test and signalling link test acknowledgement messages used for signalling link testing are specified in § 5.4.

3 Fault location

Fault location operations, employing particular manual or automatic internal test equipment are left to the discretion of the individual signalling points.

Tests requiring provision of messages are for further study. See [3].

4 Signalling network monitoring

In order to obtain information on the status of the signalling network, monitoring of the signalling activity must be provided (for example measures of the signalling load on the signalling data link). The specification of such means and procedures is contained in Recommendations Q.791 and Q.795.

5 Formats and codes of signalling network testing and maintenance messages

5.1 *General*

The signalling network testing and maintenance messages are carried on the signalling channel in message signal units, the format of which is described in Recommendation Q.703, § 2. As indicated in Recommendation Q.704, § 14.2.1, these messages are distinguished by the configuration 0001 of the service indicator (SI). The Sub Service Field (SSF) of signalling network testing and maintenance messages is used in accordance with Recommendation Q.704, § 14.2.2.

The Signalling Information Field (SIF) consists of an integral number of octets and contains the label, the heading code and one or more signals and indications.

5.2 *Label*

For signalling network testing and maintenance messages, the label has the same structure as the label of signalling network management messages (see Recommendation Q.704, § 15.2).

5.3 *Heading code H0*

The heading code H0 is the 4-bit field following the label and identifies the message group. The different heading codes are allocated as follows:

0000 Spare

0001 Test messages

The remaining codes are spare.

5.4 *Signalling link test messages*

The format of the signalling link test messages is shown in Figure 1/Q.707.

Figure 1/Q.707, p.

The signalling link test messages, are made up of the following fields:

— Label: (32 bits), see § 5.2

— Heading code H0: (4 bits)

— Heading code H1: (4 bits)

— Spare bits: (4 bits)

— Length indicator: (4 bits)

— Test pattern: ($n \times 8$ bits, 1 n 15).

In the label, the signalling link code identifies the signalling link on which the test message is sent.

The heading code H1 contains signal codes as follows:

bits D	C	B	A	
0	0	0	1	signalling link test message (SLTM)
0	0	1	0	signalling link test acknowledgement message (SLTA)

The length indicator gives the number of octets which the test pattern comprises.

The test pattern is an integral number of octets and is chosen at the discretion of the originating point.

5.5 *Time-out values and tolerances*

Table [T1.707], p.

6 State transition diagrams

The state transition diagram is intended to show precisely the behaviour of the signalling system under normal and abnormal conditions as viewed from a remote location. It must be emphasized that the functional partitioning shown in the following diagram is used only to facilitate understanding of the system behaviour and is not intended to specify the functional partitioning to be adopted in a practical implementation of the signalling system.

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Figure 2/Q.707 (feuillet 1 sur 2), p.38

Figure 2/Q.707 (feuillet 2 sur 2), p.39

References

[1] CCITT Recommendation *Lining up an international point-to-point leased circuit* , Vol. IV, Rec. M.1050.

[2] CCITT Recommendation *Organization of the maintenance of international telephone-type circuits used for data transmission* , Vol. VIII, Rec. V.51.

[3] *Ibid.* , § 5.

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