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SPECIFICATIONS OF SIGNALLING SYSTEM No. 7

SIGNALLING SYSTEM No. 7 – MESSAGE TRANSFER PART SIGNALLING PERFORMANCE

ITU-T Recommendation Q.706

(Previously “CCITT Recommendation”)

FOREWORD

The ITU Telecommunication Standardization Sector (ITU-T) is a permanent organ of the International Telecommunication Union. The ITU-T is responsible for studying technical, operating and tariff questions and issuing Recommendations on them with a view to standardizing telecommunications on a worldwide basis.

The World Telecommunication Standardization Conference (WTSC), which meets every four years, established the topics for study by the ITU-T Study Groups which, in their turn, produce Recommendations on these topics.

ITU-T Recommendation Q.706 was revised by the ITU-T Study Group XI (1988-1993) and was approved by the WTSC (Helsinki, March 1-12, 1993).

NOTES

1 As a consequence of a reform process within the International Telecommunication Union (ITU), the CCITT ceased to exist as of 28 February 1993. In its place, the ITU Telecommunication Standardization Sector (ITU-T) was created as of 1 March 1993. Similarly, in this reform process, the CCIR and the IFRB have been replaced by the Radiocommunication Sector.

In order not to delay publication of this Recommendation, no change has been made in the text to references containing the acronyms "CCITT, CCIR or IFRB" or their associated entities such as Plenary Assembly, Secretariat, etc. Future editions of this Recommendation will contain the proper terminology related to the new ITU structure.

2 In this Recommendation, the expression "Administration" is used for conciseness to indicate both a telecommunication administration and a recognized operating agency.

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INTRODUCTION

The Message Transfer Part (MTP) of Signalling System No. 7 (SS 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 (MTP). 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 MTP 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 MTP 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 MTP 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.

Recommendation Q.706**SIGNALLING SYSTEM No. 7 –
MESSAGE TRANSFER PART SIGNALLING PERFORMANCE***(Geneva, 1980; modified at Helsinki, 1993)***1 Basic parameters related to MTP 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 MTP, the following design objectives are established for the MTP.

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 MTP malfunction

The MTP is designed to transport messages in a correct sequence. In addition, the messages are protected against transmission errors. However, a protection against transmission errors cannot be absolute. Furthermore, missequencing and loss of messages in the MTP cannot be excluded in extreme cases.

For all User Parts, the following conditions are guaranteed by the MTP:

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 message signal units will contain an error that is undetected by the MTP.

b) Loss of messages

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

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 MTP. 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 16 384 signalling points. For each of the 16 different User Parts a number of user transactions may be identified, e.g. in the case of the telephone service up to 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.

With regard to signalling route set congestion (see 11.2.3/Q.704), the last method referred to in 11.2.3.1 ii) b), the congested link method of deciding when to send a Transfer Controlled message, has advantages in the case of asymmetrical load distribution within a link set.

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 MTP 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 MTP.

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

The MTP is designed to operate satisfactorily with the following transmission characteristics:

- a long term bit error rate of the signalling data link of less than 10^{-6} [1];
- a medium term bit error rate of less than 10^{-4} ;
- 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 10.2/Q.703).

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

Needs further study.

3.3 Signalling link delays over terrestrial and satellite links

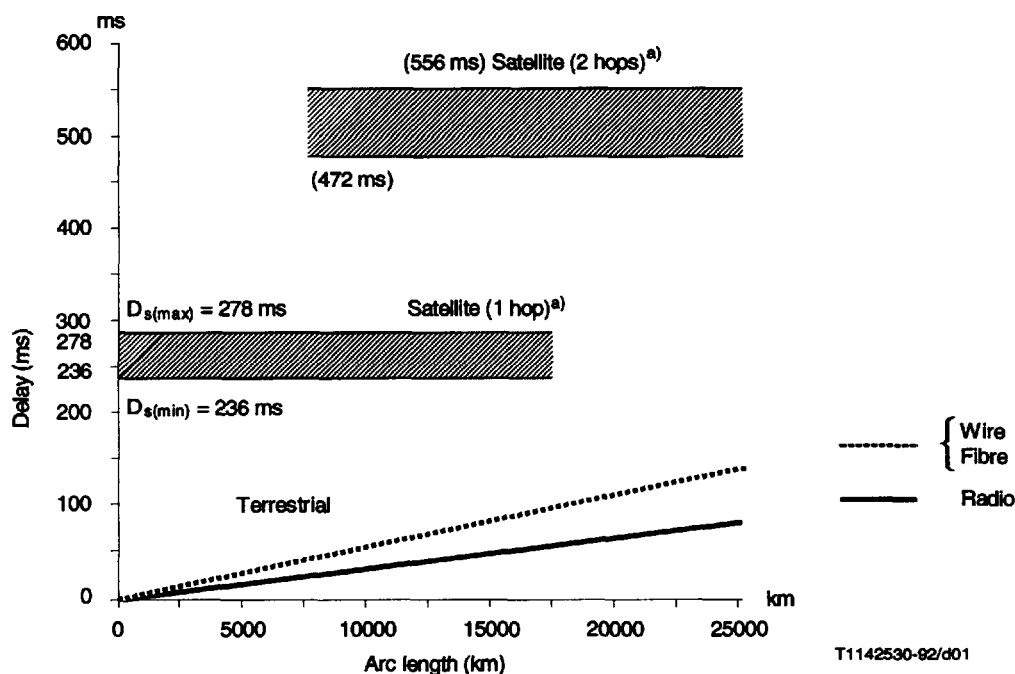
Data Channel Propagation Time (T_p) is defined in 4.3.2.4. It depends on transmission speed, the distance between nodes, repeater spacing and the delays in the repeaters. Transmission speed and repeater delays depend on the type of medium used to transmit the messages. Four types of medium are considered: wire, fibre optic cable, terrestrial radio and satellite systems. (Wire systems comprise standard underground copper cables and undersea cables.)

Table 1 provides representative delay values and Figure 1 shows those results graphically for the various transmission media.

TABLE 1/Q.706

Calculated terrestrial transmission delays for various call distances

Arc length (km)	Delay terrestrial (ms)		
	Wire	Fibre	Radio
500	2.4	2.50	1.7
1 000	4.8	5.0	3.3
2 000	9.6	10.0	16.6
5 000	24.0	25.0	16.5
10 000	48.0	50.0	33.0
15 000	72.0	75.0	49.5
17 737	85.1	88.7	58.5
20 000	96.0	100.0	66.0
25 000	120.0	125.0	82.5



a) Delay varies with distances of each earth station from point on the Earth over which the satellite is located. (See Annex A.)

FIGURE 1/Q.706
Transmission delays using satellite and terrestrial
message handling facilities

The double hop values do not take into consideration any terrestrial extensions and repeaters that may be required.

Formulae for computing the transmission delays are given in Annex A along with the assumptions made.

Due to the longer delay of satellite links and the longer terrestrial links, the message transfer times increase (see clause 5). Therefore care must be taken in the design of signalling networks if they are to meet the overall delay performance criterion (see Recommendation Q.709).

4 Parameters of influence on signalling performance

4.1 Signalling network

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

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

In planning SS No. 7 signalling networks to meet E.721, E.723 and I.352 delay requirements, consideration should be given to

- processing delays in SPs;
- number of SPs;
- number of STPs;

- number of signalling links;
- propagation delays of each signalling link;
- signalling link loading;
- message length mix.

4.1.1 International signalling network

Needs further study.

4.1.2 National signalling network

Needs further study.

4.2 Queueing delays

The MTP 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 11.2/Q.703); 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_t^2 Variance of total queuing 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

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

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

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

NOTE – As a consequence of zero insertion at level 2 (see 3.2/Q.703), 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.

$$a_z = 1 - a - a_3$$

$$H_1 = at_L$$

$$H_2 = at_L(k_1 + at_L)$$

$$H_3 = at_L(k_2 + 3at_L k_1 + a^2 t_L^2)$$

$$F_1 = at_L/2$$

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

$$F_3 = at_L(k_2/2 + at_L k_1 + a^2 t_L^2/4)$$

$$q_a = \frac{k_1(a + a_z) + a_3 t_f}{2(1 - a)}$$

$$s_a = \frac{ak_1}{1 - a} q_a + \frac{k_2(a + a_z) + a_3 t_f^2}{3(1 - a)}$$

$$t_a = \frac{3ak_1 s_a + 2ak_2 q_a}{2(1 - a)} + \frac{(a + a_z)k_3 + a_3 t_f^3}{4(1 - a)}$$

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

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

$$Z_3 = 8k_2 + P_u(19k_2 + 27k_1 H_1 + 9H_2 + H_3)$$

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

$$Y_3 = t_a + 8k_2 + F_3 + 3\{s_a(2 + F_1) + q_a(4k_1 + F_2) + 2F + 2 + 4k_1 F_1\} + 12q_a F_1$$

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

$$q_d = \frac{aZ_2 + \alpha Y_2}{2(1 - aZ_1)}$$

$$s_d = \frac{aZ_3}{1 - aZ_1} q_d + \frac{aZ_3 + \alpha Y_3}{3(1 - aZ_1)}$$

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

$$s_b = \frac{s_a + k_1 + F_2}{(1 - a)^3} + \frac{2\{q_a(1 + F_1) + F_1\}}{(1 - a)^2}$$

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

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

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

4.2.3 Formulas

The formulas of the mean and the variance of the queueing delays are described in Table 2. The proportion of messages delayed more than a given time T_x is:

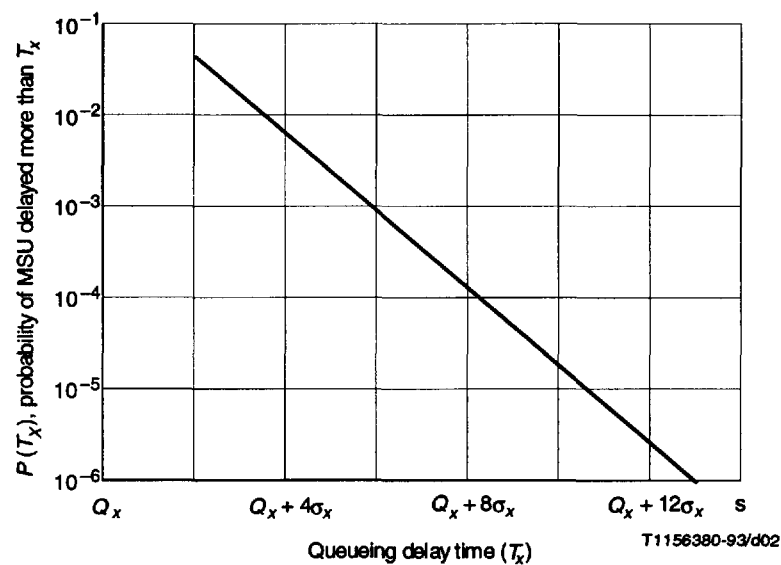
$$P(T_x) \cong \exp \left(- \frac{T_x - Q_x + \sigma_x}{\sigma_x} \right)$$

where Q_x and σ_x denote the mean and the standard deviation of queueing delay, respectively. This approximation is better suited in absence of disturbances. In the presence of disturbances the actual distribution may be deviated further. Relation between $P(T_x)$ and T_x is shown in Figure 2.

TABLE 2/Q.706

Queueing delay formula

Error correction method	Disturbance	Mean Q	Variance σ^2
Basic	Absence	$\frac{Q_a}{T_m} = \frac{t_f}{2} + \frac{ak_1}{2(1-a)}$	$\frac{\sigma_a^2}{T_m^2} = \frac{t_f^2}{12} + \frac{a[4k_2 - (4k_2 - 3k_1^2)a]}{12(1-a)^2}$
	Presence	$\frac{Q_t}{T_m} = \frac{t_f}{2} + \frac{aE_2}{2(1-aE_1)} + E_1 - 1$	$\frac{\sigma_t^2}{T_m^2} = \frac{t_f^2}{12} + \frac{a[4E_3 - (4E_1E_3 - 3E_2^2)a]}{12(1-aE_1)^2} + Pu(1-P_u)t_L^2$
Preventive cyclic retransmission	Absence	$\frac{Q_a}{T_m} = q_a$	$\frac{\sigma_a^2}{T_m^2} = s_a q_a^2$
	Presence	$\frac{Q_t}{T_m} = (1 - P_u - P_v)q_a + P_uq_b + P_vq_c$	$\frac{\sigma_t^2}{T_m^2} = (1 - P_u - P_v)s_a + P_us_b + P_vs_c - \frac{Qs(2,t)}{T_m^2}$



Q_x Mean queueing delay (see Figure 3)
 σ_x Standard deviation (see Figure 4)

FIGURE 2/Q.706
Probability of message signal unit delayed more than T_x