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SERIES Q: SWITCHING AND SIGNALLING

Specifications of Signalling System No. 7 – Message transfer part (MTP)

MESSAGE TRANSFER PART SIGNALLING PERFORMANCE

Reedition of CCITT Recommendation Q.706 published in the Blue Book, Fascicle VI.7 (1988)

NOTES

1 CCITT Recommendation Q.706 was published in Fascicle VI.7 of the *Blue Book*. This file is an extract from the *Blue Book*. While the presentation and layout of the text might be slightly different from the *Blue Book* version, the contents of the file are identical to the *Blue Book* version and copyright conditions remain unchanged (see below).

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

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 16 384 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.

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 characteristics:

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

b) a medium-term bit error rate of less than 10^{-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_t^2	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

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

k_2 = **Error!**

k_3 = **Error!**

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 = **Error!**

s_a = **Error!** q_a + **Error!**

t_a = **Error!** + **Error!**

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

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

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

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

$Y_3 = t_a + 8k_2 + F_3 + 3\{s_a(2 + F_1) + q_a(4k_1 + F_2) + 2F + 2 + 4k_1F_1\} + 12q_aF_1$

α = **Error!**

q_d = **Error!**

s_d = **Error!** q_d + **Error!**

q_b = **Error!**

s_b = **Error!** + **Error!**

q_c = **Error!**

s_c = **Error!** + 2 **Error!**

$P_V = P_ua$ **Error! Error!**

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:

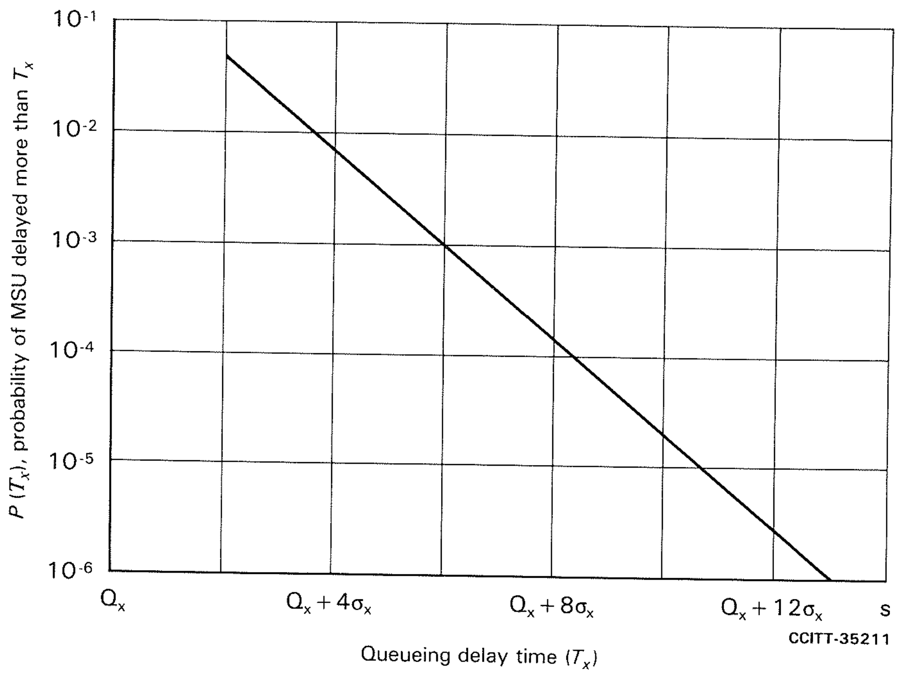
$P\ (T_x) \cong \exp$**Error!**

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.



Q_x Mean queueing delay (see Figure 2/Q.706)
σ_x Standard deviation (see Figure 3/Q.706)

FIGURE 1/Q.706

Probability of message signal unit delayed more than T_x

TABLE 1/Q.706

Queueing delay formula

Error correction method	Disturbance	Mean Q	Variance σ^2
Basic	Absence	**Error!**	**Error!**
	Presence	**Error!**	**Error!** $+ P_u(1 — P_u)t^{2,L}$
Preventive cyclic retrans-mission	Absence	**Error!**	**Error!**
	Presence	**Error!**	**Error!** **Error!**

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	

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

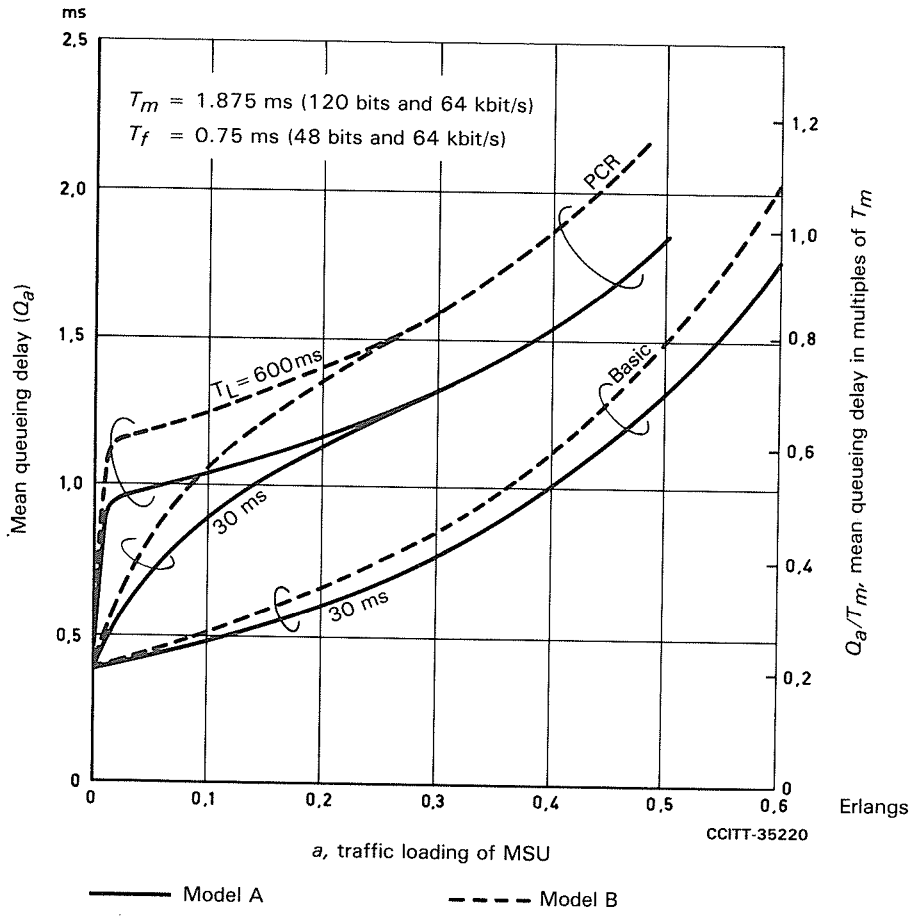


FIGURE 2/Q.706

Mean queueing delay of each channel of traffic in absence of disturbance

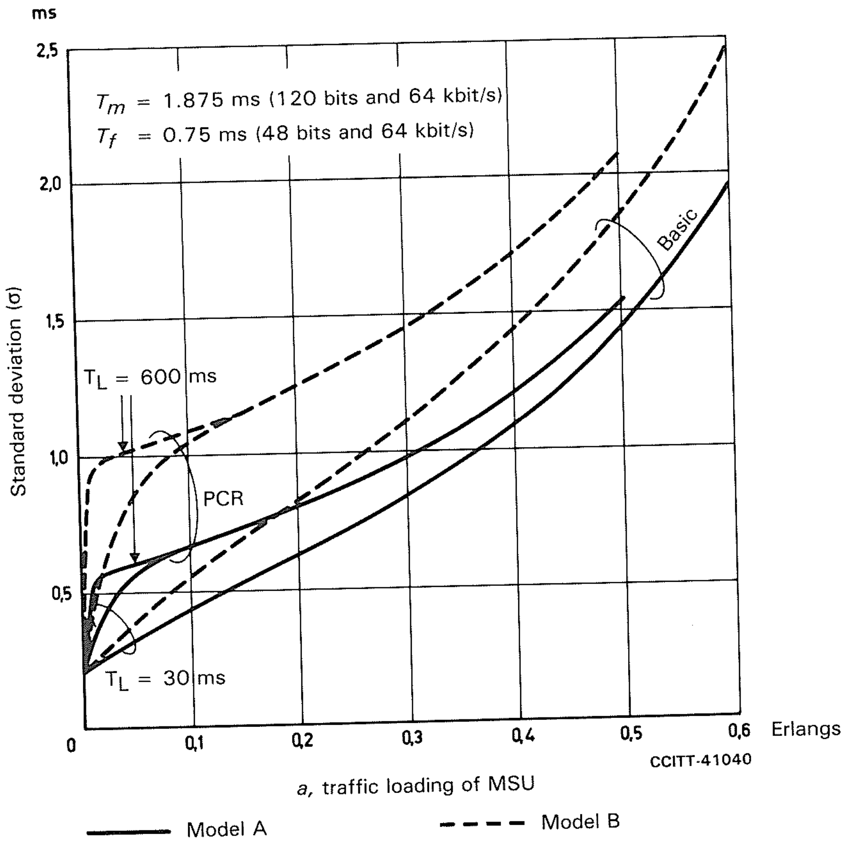


FIGURE 3/Q.706

Standard deviation of queueing delay of each channel of traffic of traffic in absence of disturbance

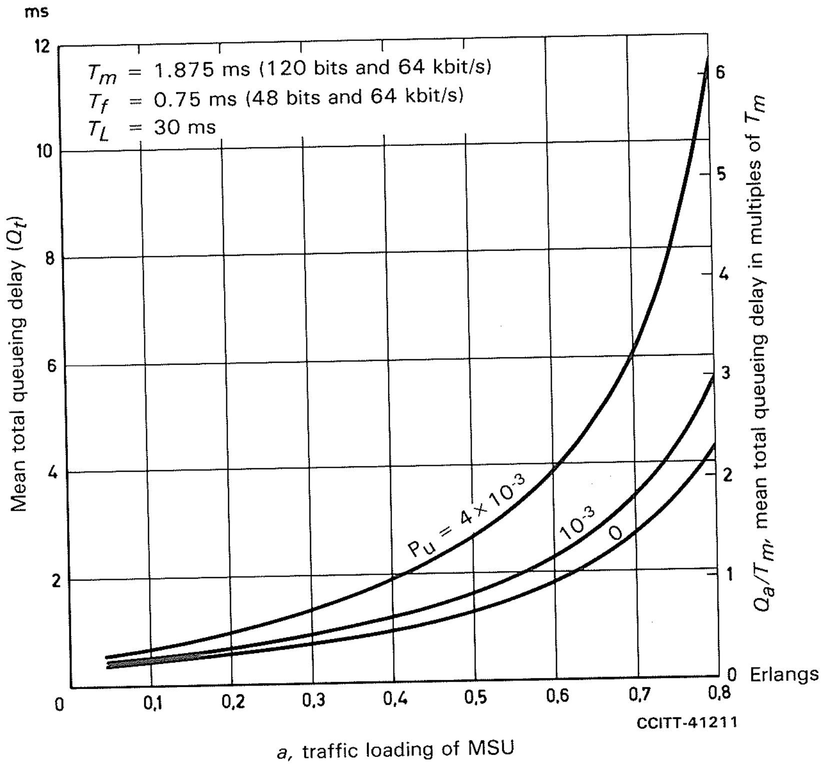


FIGURE 4/Q.706

Mean total queueing delay of each channel of traffic; basic error correction method

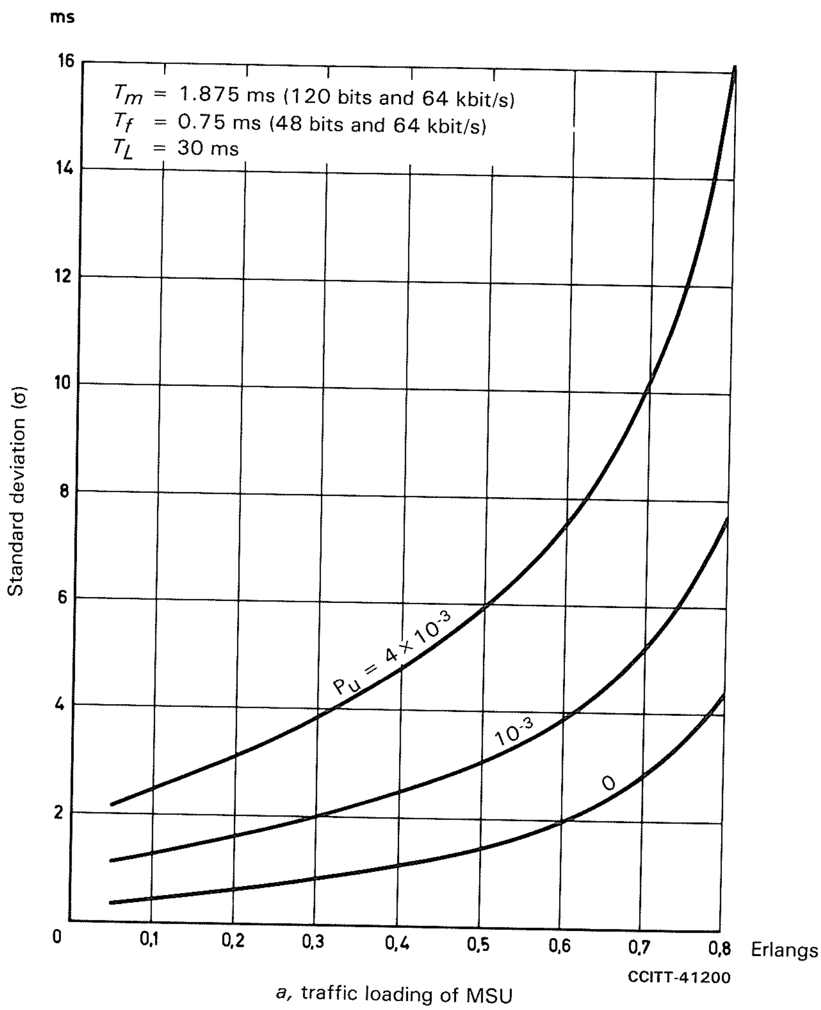


FIGURE 5/Q.706

Standard deviation of queueing delay of each channel of traffic; basic error correction method

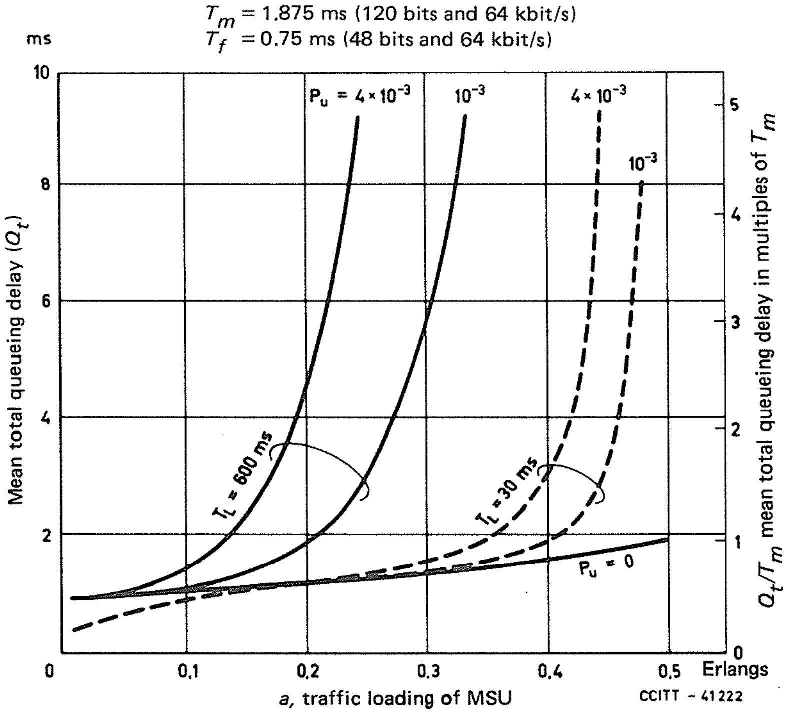


FIGURE 6/Q.706

Mean total queueing delay of each channel of traffic: preventive cyclic retransmission error correction method

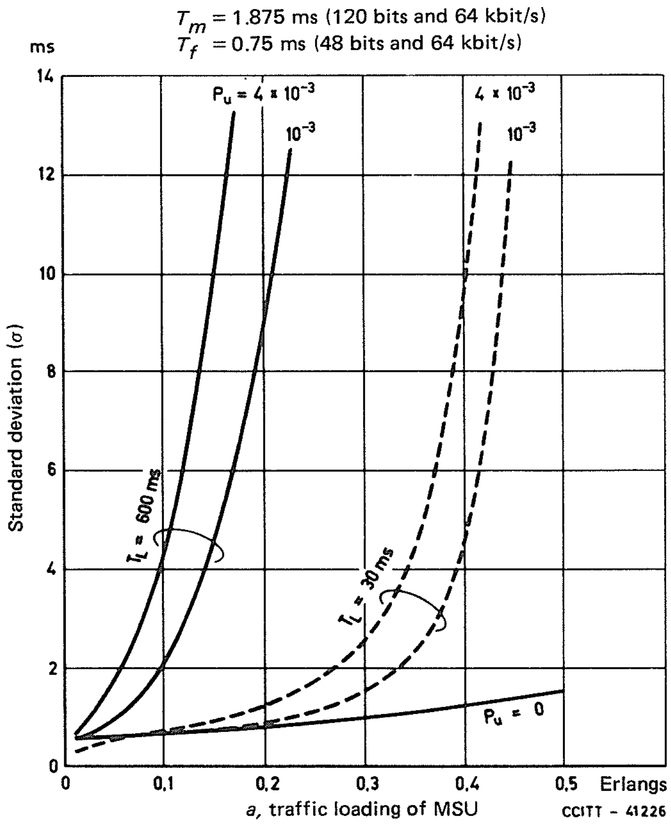


FIGURE 7/Q.706

Standard deviation of queueing delay of each channel of traffic: preventive cyclic retransmission error correction method

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).

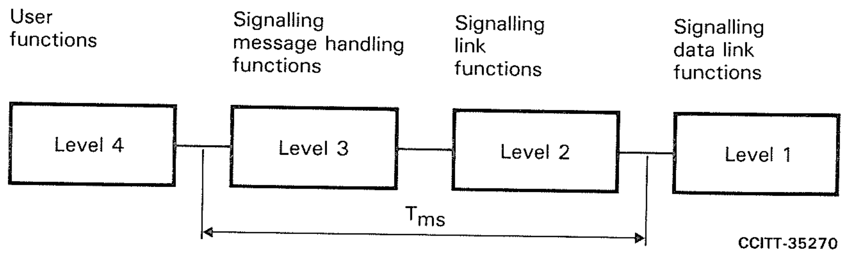
b) Signalling transfer point function (see Figure 9/Q.706).

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.

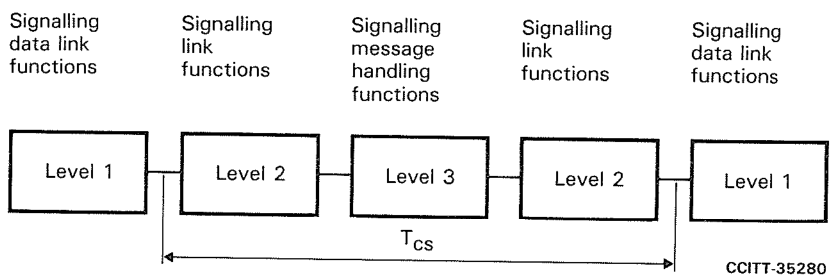
An additional increase of the overall message transfer times is caused by the queueing delays. These are described in § 4.2.



T_{ms} Message Transfer Part sending time

FIGURE 8/Q.706

Functional diagram of the Message Transfer Part sending time



T_{cs} Message transfer time at signalling transfer points

FIGURE 9/Q.706

Functional diagram of the message transfer time at signalling transfer points

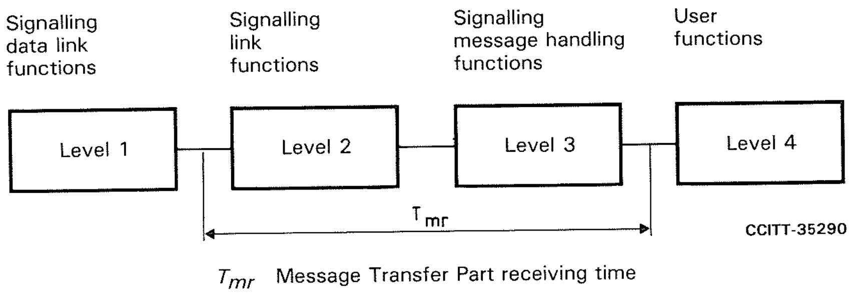


FIGURE 10/Q.706

Functional diagram of the Message Transfer Part receiving time

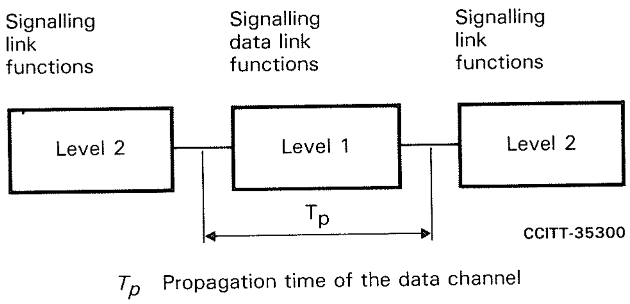


FIGURE 11/Q.706

Functional diagram for the propagation time

4.3.2 *Definitions*

4.3.2.1 **message transfer part sending time T_{ms}**

F: temps d'émission du Sous-système Transport de Messages T_{ms}

S: tiempo de emisión de la parte de transferencia de mensajes T_{ms}

T_{ms} 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_{cs}**

F: temps de transfert des messages aux points de transfert sémaphore T_{cs}

S: tiempo de transferencia de mensajes en los puntos de transferencia de la señalización T_{cs}

T_{cs} 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

Error!

b) In the presence of disturbances

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

Here

T_{oa}	overall message transfer time in the absence of disturbances
T_{ms}	Message Transfer Part sending time
T_{mr}	Message Transfer Part receiving time
T_{cs}	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 $\Sigma(Q_t - Q_a)$, 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_{mr}, T_{ms} and T_{cs} will be presented in the form of:

– mean values,

– 95% level values.

The estimates for T_{cs} for a signalling transfer point are given in Table 4/Q.706.

TABLE 4/Q.706

STP signalling traffic	Message transfer time at an STP (T_{cs}) in ms

load	Mean	95 %
Normal	20	40
+15 %	40	80
+30 %	100	200

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 $4 \cdot 10^{-3}$.

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.

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