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SPECIFICATIONS OF SIGNALLING SYSTEM No. 7

SIGNALLING SYSTEM No. 7 – HYPOTHETICAL SIGNALLING REFERENCE CONNECTION

ITU-T Recommendation Q.709

(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.709 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 Similarly, in this reform process, the CCIR and the IFRB have been replaced by the Radiocommunication Sector.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.

CONTENTS

SIGNALLING SYSTEM No. 7 – HYPOTHETICAL SIGNALLING REFERENCE CONNECTION

(Malaga-Torremolinos, 1984; modified at Helsinki, 1993)

1 Introduction

This Recommendation specifies how the elements of a signalling connection from an originating node to a terminating node are combined to meet the signalling requirements of the networks that it supports. Included are parameters for signalling transfer delay in both national and international networks, and overall signalling delay that such combinations will produce, together with the availability required, to enable the performance of the network served by the signalling network to be maintained.

A probabilistic approach has been taken, i.e. limits are specified for 50% and 95% of connections. These figures will apply to the normal operation of a signalling network. No consideration is given to the "unusually long" signalling paths that are found in some signalling networks. Any unusual routing caused by some network structures and/or reconfigurations due to network failure are considered to be covered in the remaining 5% of connections.

The hypothetical signalling reference connection (HSRC) for international working is specified in this Recommendation by defining the constituent parts of

i) one international section; and

ii) two national sections.

When combing the sections to produce an overall HSRC, it is necessary to consider what impact each of the three component parts have on each other and the full HSRC. This means that certain national or international limits such as the maximum number of signalling transfer points allowed in a signalling relation (see 5.2/Q.705) may require modification and account of this has been taken in this Recommendation.

The effect on the HSRC of larger message sizes (see 7.2) and database queries due to new SS No. 7 applications are also considered (see Annex A).

2 Requirements of networks served by the signalling connection

To meet the requirements of services carried on the network served by the signalling network, the signalling connection performance should be closely aligned with those requirements. Since these services are ultimately to be carried on an ISDN, the HSRC is based upon the hypothetical reference connection developed for ISDN network (see Recommendation G.801). Account must also be taken of the service requirements in Recommendations E.721, E.723 and I.352.

However, for a considerable time the majority of services in the network served by the signalling network will be telephony-based and account must therefore be taken of the reference connection for conventional telephony application (see Recommendation G.101).

3 HSRC components for link-by-link signalling

3.1 General

The components of a HSRC are signalling points and STPs which are connected in series by signalling data links to produce a signalling connection (see Note 1). The number of signalling points and STPs depend on the size and structure of the network. Two limits are prescribed to cover 50% and 95% of cases. Separate cases are allowed for large-size countries and average-size countries (see Note 2). This clause outlines the considerations involved in formulating a HSRC for link-by-link signalling and details the number of HSRC components and the delays they produce.

NOTES

1 The term signalling point is used to designate use of a user function in a signalling point: whether or not STP function is present is irrelevant in this context. The term STP is used to designate use of the STP function in a signalling point: whether or not a user function is present is irrelevant in this context.

2 When the maximum distance between an international switching centre and a subscriber who can be reached from it does not exceed 1000 km or, exceptionally, 1500 km, and when the country has less than $n \times 10^7$ subscribers, the country is considered to be of average-size. A country with a larger distance between an international switching centre and a subscriber, or with more than $n \times 10^7$ subscribers, is considered to be of large-size. (The value of n is for further study.)

3.1.1 Number of signalling points in the HSRC

The number of signalling points in the HSRC has been determined by considering the maximum number of links allowed by the Telephone Routing Plan (see Recommendation E.171). These Recommendations define "last choice" backbone routes and only a small proportion of traffic take these routes. Traffic generated in metropolitan areas, generally the largest source of traffic, usually takes far fewer links to an international switching centre. Even for rural areas a connection to the international switching centre will not generally be required to follow the backbone route.

Limiting the number of signalling points required will reduce the signalling delay, because signalling point delay forms the largest component of signalling delay.

3.1.2 Number of STPs in a HSRC

The number of STPs in a HSRC is a function of the number of signalling points, and the signalling network topology used to connect these signalling points. The number of STPs should be kept to a minimum in order to limit the signalling delay. In some signalling relationship, associated signalling may be used for which no STPs are required. In others, one or more STPs may be used. For international signalling relationship, it is recommended that no more than 2 STPs be used in a signalling relations (see 5.2/Q.705).

3.1.3 Signalling network availability

The availability of a signalling connection is an important network parameter. It is necessary for the availability of the signalling connection to be significantly better than the availability of the component being controlled (e.g. a circuit). The total unavailability figure for any particular signalling route set (see 1.1/Q.706) should not exceed:

– 10 minutes per year.

This corresponds to an availability of 0.99998, which can be achieved by the use of suitable network redundancies.

3.1.4 Signalling message transfer delay

Signalling message transfer delay is another important network parameter. It affects call set up delay and also affects network response time to service requests made during a call. Note that in this Recommendation, the transmission propagation delays are not included (see 7.2).

3.2 International component of HSRC

The international component of the HSRC includes all international signalling points in the connection and the STPs carrying signalling messages between the signalling points. The maximum number of signalling points and STPs allowed are listed in Table 1.

The total unavailability of the overall international component of the signalling network should not exceed the following for both the 50 percent and 95 percent cases:

– 20 minutes per year for large-size country to large-size country;

– 30 minutes per year for large-size country to average-size country; and

– 40 minutes per year for average-size country to average-size country.

The maximum signalling transfer delay under normal conditions for the international component of a connection should not be worse than the values listed in Table 2.

TABLE 1/Q.709

Maximum number of signalling points and STPs in international component

Country size (Note 1)	Percent of connections	Number of STPs	Number of signalling points
Large-size to Large-size	50% 95%	3 4	3
Large-size to Average-size	50% 95%	4 4	4
Average-size to Average-size	50% 95%	5 7	5

NOTES

1 See Note 2 to 3.1.

2 See clause 7.

TABLE 2/Q.709

Maximum signalling delays for international component

Country size	Percent of connections	Delay (ms) (Note 1) Message type	
		Simple (e.g. answer)	Processing intensive (e.g. IAM)
Large-size to Large-size	50% 95%	390 410	600 620
Large-size to Average-size	50% 95%	520 540	800 820
Average-size to Average-size	50% 95%	650 690	1000 1040

NOTES

1 Only the mean delay component from Table 5/Q.706, Table 3/Q.725 and Table 1/Q.766 have been used in calculating the delay. Further study is required, eg. for the mean values as well as the inclusion of overload and/or 95 percentile cases of each component value.

2 See clause 7.

3.3 National components of HSRC

The national components of the HSRC includes all national exchanges in the connection (but does not include the international switching centre in the country) and all STPs carrying signalling messages between the national exchanges and between the highest level national exchange and the international switching centre. The maximum number of signalling points and STPs allowed are listed in Table 3.

TABLE 3/Q.709

Maximum number of signalling points and STPs in national components

Country size (Note 1)	Percent of connections	Number of STPs	Number of signalling points
Large-size	50%	3	3
	95%	4	4
Average-size	50%	2	2
	95%	3	3

NOTES

1 See Note 2 to 3.1.

2 The values in this table are provisional. (A higher number of signalling points and/or STPs might be included in a national network, e.g. in the case that a two-level hierarchical signalling network is adopted. This matter is for further sutdy.)

3 It is for further study how the QOS parameters in Recommendation E.721 can be achieved in networks that use a greater number of STPs.

The unavailability of each of the overall national components of the signalling network should not exceed the following totals per year:

– 20 minutes for the 50% case of average-size countries;

– 30 minutes for the 95% case of average-size countries and the 50% case of large-size countries; and

– 40 minutes for the 95% case of large-size countries.

NOTES

1 Although the signalling component of the international switching centre in the country was not included in Table 3, it is included in the unavailability objectives.

2 The HSRC defines a unique path through the national and international networks, therefore when considering the overall unavailability of each national component, no account is taken of any standby path, if provided, in that national network. The values given are based on those for each component route-set as specified in 1.1/Q.706.

The maximum signalling transfer delay under normal conditions for each of the national components of a connection should not be worse than the values listed in Table 4.

4 Overall signalling delay for link-by-link signalling

From the HSRC and the values of message transfer times given for signalling point and STP, the overall signalling delay due to signalling point, and STP delays can be determined from Tables 2 and 4, for a given load in a given network. Delays for 50% and 95% of connections are given in Table 5 for various combinations of large-size and average-size countries. Average signalling point and STP delays at normal loading are assumed.

These values must be increased by the transmission propagation delays (see Table 1/Q.41).

Annex A considers the impact of database queries on the allowable link-by-link signalling delays.

TABLE 4/Q.709

Maximum signalling delays for each national component

Country size	Percent of connections	Delay (ms) (Notes 1 and 2)	
		Message type	
		Simple (e.g. answer)	Processing intensive (e.g. IAM)
Large-size	50%	390	600
	95%	520	800
Average-size	50%	260	400
	95%	390	600

NOTES

1 See Note to Table 2.

2 The delay does not include any delay for the International Switching Centre in the country, which is included in the international component.

3 See clause 7.

TABLE 5/Q.709

Maximum overall signalling delays

Country size	Percent of connections	Delay (ms) (Note 1)	
		Message type	
		Simple (e.g. answer)	Processing intensive (e.g. IAM)
Large-size to Large-size	50%	1170	1800
	95%	1450	2220
Large-size to Average-size	50%	1170	1800
	95%	1450	2220
Average-size to Average-size	50%	1170	1800
	95%	1470	2240

NOTES

1 See Note to Table 2.

2 See clause 7.

5 HSRC components for end-to-end signalling

5.1 General

The components of a HSRC are signalling end points (SEP), signalling points with SCCP relay function (SPR) and STPs which are connected in series by signalling data links to produce an end-to-end signalling connection (see Note 1). The number of the various signalling nodes depends on the size of the network. Two limits are prescribed to cover 50% and 95% of cases. Separate cases are allowed for large-size countries and average-size countries (see Note 2). This clause outlines the considerations involved in formulating a HSRC and details the number of HSRC components and the delays they produce.

NOTES

1 a) *Signalling End Point* (SEP) – This includes processing in UP/AP (User part/application part), SCCP (Signalling connection control part), MTP (Message transfer part) and also MTP-SCCP-UP/AP;

b) *Signalling Point with SCCP relay function (SPR)* – This includes only processing in MTP-SCCP-MTP;

c) *Signalling Transfer Point* – This includes processing in MTP exclusively.

2 When the maximum distance between an international switching centre and a subscriber who can be reached from it does not exceed 1000 km or, exceptionally, 1500 km, and when the country has less than $n \times 10^7$ subscribers, the country is considered as of average-size. A country with a larger distance between an international switching centre and a subscriber, or with more than $n \times 10^7$ subscribers, is considered as of large-size. (The value of n is for further study.)

5.1.1 Number of signalling nodes in the end-to-end HSRC

The same signalling network is used for end-to-end messages and link-by-link messages. This means that the maximum number of signalling nodes is equal in both cases. The maximum number of signalling nodes from the originating node to the destination node is 18 in 50% of the connections and 23 in 95% of the connections except for average-size to average-size country. In that case the value is 24 (see Table 6 and Table 8).

In general a fast transfer of end-to-end signalling messages is required. For such messages a route with a minimum number of signalling transfer and relay points is highly desirable.

It is desirable to use the message routing of the MTP (STP functions) as far as possible and try in this way to avoid processing in higher layers (SCCP or user functions).

5.1.2 Signalling network availability

The availability of a signalling connection is an important network parameter. It is necessary for the availability to be significantly better than the availability of the component being controlled (e.g. a circuit). A total unavailability figure for any particular signalling route set (1.1/Q.706) should not exceed

– 10 minutes per year.

This corresponds to an availability of 0.99998, which can be achieved by the use of suitable network redundancies.

5.1.3 Signalling message transfer delay

Signalling message transfer delay is another important network parameter. It affects call set up delay and also affects network response time to service requests made during a call.

The use of signalling points with SCCP relay functions (SPR) should be kept to a minimum. In an SPR additional processing is performed which causes an additional delay, for example address translation for CR or UDT message types (processing intensive messages) or a local reference message mapping for CC or DT messages (processing simple message types). The cross-office transit time for SPR is defined in Recommendation Q.716. The cross-office transit time for an SEP is equal to T_{cu} in Recommendation Q.766 or Q.725 and for an STP is equal to T_{cs} in Recommendation Q.706.

5.2 International component of HSRC

The international component of the HSRC includes all international signalling nodes (e.g. SPR and STP) in the connection. The maximum number of SPRs and STPs allowed are listed in Table 6.

TABLE 6/Q.709

Maximum number of SPRs and STPs in international component

Country size	Percent of connections	Number of STPs	Number of SPRs
Large-size to Large-size	50% 95%	4 4	2 3
Large-size to Average-size	50% 95%	6 6	2 3
Average-size to Average-size	50% 95%	8 8	2 4

The unavailability of the overall international component of the signalling network should not exceed the following totals per year for both the 50 percent and 95 percent cases:

- 20 minutes for large-size country to large-size country;
- 30 minutes for large-size country to average-size country; and
- 40 minutes for average-size country to average-size country.

The maximum delay at the signalling nodes under normal conditions for the international component of a connection should not be worse than the values listed in Table 7.

TABLE 7/Q.709

Maximum delay at the signalling nodes for international component

Country size	Percent of connections	Delay (ms)	
		Message type	
		Processing simple	Processing intensive
Large-size to Large-size	50% 95%	300 410	440 620
Large-size to Average-size	50% 95%	340 450	480 660
Average-size to Average-size	50% 95%	380 600	520 880

NOTES

1 The maximum signalling nodes delay is the sum of all cross-office delays involved.

2 All values are provisional.

5.3 National components of HSRC

The national components of the HSRC includes all national signalling nodes (e.g. SEP, SPR, STP) in the connection (but does not include the international switching centre in the country). The maximum number of SEPs, SPRs and STPs allowed are listed in Table 8.

The unavailability of each of the overall national components of the signalling network should not exceed the following totals per year:

– 20 minutes for the 50% case of average-size countries;

– 30 minutes for the 95% case of average-size countries and 50% case for large size countries; and

– 40 minutes for the 95% case of large-size countries.

TABLE 8/Q.709

Maximum number of SEPs, SPRs and STPs in national component

Country size	Percent of connections	Number of STPs	Number of SPRs	Number of SEPs
Large-size	50%	4	1	1
	95%	5	2	1
Average-size	50%	2	1	1
	95%	4	1	1

NOTES

1 Although the signalling component of the international switching centre in the country is not included in Table 8, it is included in the unavailability objectives.

2 The HSRC defines a unique path through the national and international networks, therefore when considering the overall unavailability of each national component, no account is taken of any standby path, if provided, in that national network. The values given are based on those for each component route-set as specified in 1.1/Q.706.

The maximum delay at the signalling nodes under normal conditions for each of the national components of a connection should not be worse than the values listed in Table 9.

6 Overall signalling delay for end-to-end signalling

The link-by-link signalling delay is applicable where messages are processed by each signalling point (e.g. during call establishment). The use of end-to-end signalling is intended to reduce the overall signalling delay.

From the HSRC and the values of message transfer times given for SEPs, SPRs and STPs, the overall signalling delay due to the node delays can be determined from Tables 7 and 9, for a given load in a given network. 50% delays and 95% delays are given in Table 10 for various combinations of large-size and average-size countries. Average signalling node delays at normal loading are assumed.

7 Influence of new SS No. 7 applications

7.1 Effects of database queries

The effect of database queries/responses on the overall signalling performance must be considered. Annex A provides information that will assist network designers in balancing the allowable signalling delay for link-by-link connections and the extra delay caused by database queries in order that the overall signalling performance is maintained.

TABLE 9/Q.709

Maximum delay at the signalling nodes for each national component

Country size	Percent of connections	Delay (ms)	
		Message type	
		Processing simple	Processing intensive
Large-size	50%	300	440
	95%	430	640
Average-size	50%	260	400
	95%	300	440

NOTES

1 The maximum signalling nodes delay is the sum of all cross-office delays involved.

2 All values are provisional.

TABLE 10/Q.709

Maximum overall delay at the signalling nodes

Country size	Percent of connections	Delay (ms)	
		Message type	
		Processing simple	Processing intensive
Large-size to Large-size	50%	900	1320
	95%	1270	1900
Large-size to Average-size	50%	900	1320
	95%	1180	1740
Average-size to Average-size	mean	9000	1320
	95%	1200	1760

NOTES

1 The maximum signalling nodes delay is the sum of all cross-office involved.

2 All values are provisional.

7.2 Effects of message length and other variables

All delay values used in this Recommendation have been based on the following assumptions:

- mean message length of 120 bits (i.e. TUP messages);
- link load of 0.2 Erlang;
- terrestrial links with basic error correction (BEC);
- no disturbances (i.e. error free).

As 5/Q.706 shows, changes in the above parameters may increase the basic delay values. It is the responsibility of the network provider to determine a compromise between

- higher delay values for each single network entity (e.g. links, STPs);
- network structure (e.g. numbers of STPs);
- desired performance (overall delay).

8 Remarks

8.1 The above values for signalling delays assumes a message length distribution as given in Table 2/Q.706 and Table 2/Q.725, with a mean message length of 15 octets. See 5/Q.706 for estimation of additional signalling delays introduced by longer message lengths, different propagation delays and different error correction methods.

8.2 When defining an overall signalling delay the propagation delay must be included. This delay cannot be completely neglected due to the geographical size of the HSRC (see Table 1/Q.41 and 3.3/Q.706).

Annex A

Database query considerations

(This annex forms an integral part of this Recommendation)

A.1 General

To assist network operators in the design of SS No. 7 networks so as to ensure meeting delay performance requirements when database query/response is part of call set-up, this annex provides formulae which indicate how the constituent component delays combine to yield the mean delay perceived by a subscriber. The impact of database query/responses (which will be referred to as database query) is explicitly taken into account in order to be able to calculate the Post-Selection Delay.

The impact of database queries on the mean Post-Selection Delay will depend on the proportion of calls invoking each of the available services, the number of database queries required to support each service and the time required to process each query.

A.2 Delay formulae

A.2.1 Calls without database interaction

Considering the simple case of circuit-switched connection involving N Signalling Points (SPs), including the local exchanges, M Signalling Transfer Points (STPs) and no database interaction, the mean Post-Selection Delay is given by

$$D_0(N) = \begin{cases} D_{sep} & if \ N = 1 \\ D_{sep1} + D_{sep2} + [N - 2] * D_{sp} + M * D_{stp} & if \ N \geq 2 \end{cases}$$

where

$D_0(N)$ mean call setup delay for a call involving no database query;

D_{sep} mean delay at the local exchange when $N = 1$;

D_{sep1} mean delay at the originating local exchange;

D_{sep2} mean delay at the terminating local exchange;

D_{sp} mean delay at intermediate transit (toll-trunk) exchanges; and

D_{stp} mean delay at an STP.

NOTE – The effect of processing global title translations a SCCP relay points is not taken into account.

It is convenient to relate the mean delay at local exchanges to the delay at intermediate transit exchanges:

$$D_{sep} \quad (1 + \delta_1 + \delta_2) * D_{sp}$$

$$D_{sep1} \quad (1 + \delta_1) * D_{sp}$$

$$D_{sep2} \quad (1 + \delta_2) * D_{sp}$$

where

δ_1 incremental proportion of delay attributable to the origination of an ISDN circuit-switched connection; and

δ_2 incremental proportion of delay attributable to the termination of an ISDN circuit-switched connection.

$D_0(N)$ is then given by:

$$D_0(N) = | N + \delta_1 + \delta_2 | * D_{sp} + M * D_{stp}$$

A.2.2 Calls including database interaction

Now considering the case where such an ISDN circuit-switched connection involves k database queries supporting a service application at a local or transit exchange (see Figure A.1), the mean Post-Selection Delay is given by:

$$D_k(N) = D_0(N) + k * D_{query}$$

where

k the number of database queries ($k = 0, 1, 2, 3, ...$);

$D_k(N)$ mean call setup delay for a call involving k database queries and N SPs; and

D_{query} mean query/response delay for a query to an SS No. 7 database node (including related delays at the signalling point initiating the query).

The overall mean Post-Selection Delay D is a weighted sum over all N and over all k:

$$D = \sum_N \gamma(N) * \sum_k [\alpha_k(N) * D_k(N)]$$

where

$\gamma(N)$ the fraction of circuit-switched connections involving N SPs

($0 \leq \gamma(N) \leq 1$ for each value of N and $\sum_N \gamma(N) = 1$; and

$\alpha_k(N)$ the fraction of the circuit-switched connections with N SPs that involve k database queries ($0 \leq \alpha_k(N) \leq 1$ for each value of k and $\sum_k \alpha_k(N) = 1$ for all N).

Introducing the database query factor α (see Table A.1) which denotes the average number of database queries/responses per call and is defined as follows:

$$\alpha = \sum_N \gamma(N) * \sum_k [\alpha_k(N) * k]$$

it can be shown that the overall mean Post-Selection Delay D is given by:

$$D = \left\{ \sum_N \gamma(N) * \{[N + \delta_1 + \delta_2] * D_{sp} + M * D_{stp}\} \right\} + \alpha * D_{query}.$$

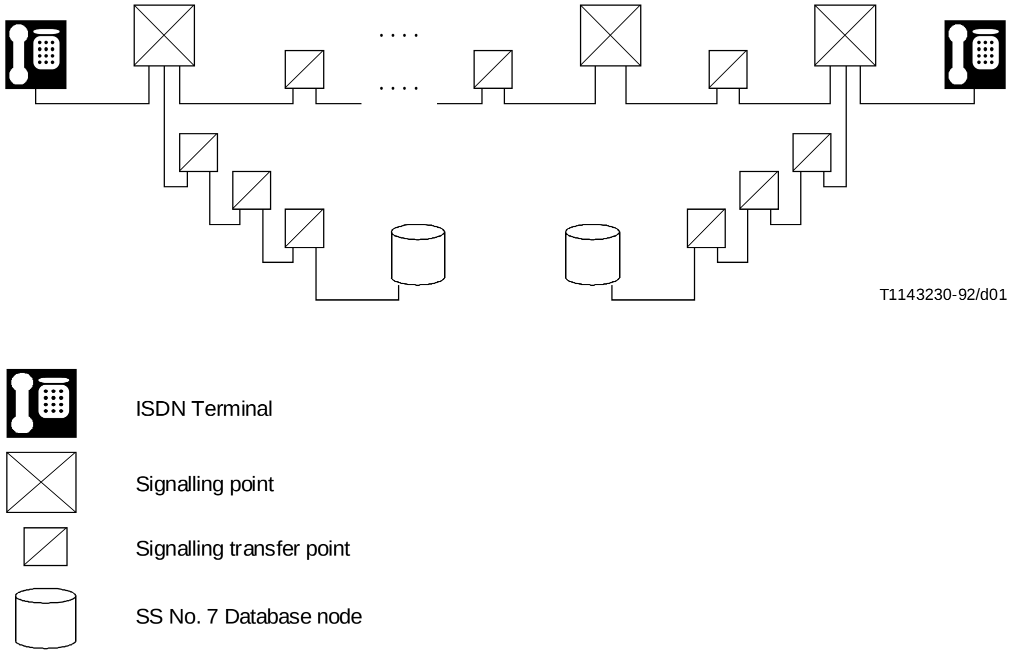

FIGURE A.1/Q.709

Generic reference connection with database access service at originating and terminating nodes

TABLE A.1/Q.709

Sample call mixes and database query factors

Fraction α_k of connections involving k database queries				Database query factor
α_0	α_1	α_2	α_3	α
100%	–	–	–	0.0
80%	20%	–	–	0.2
75%	20%	5%	–	0.3
30%	50%	20%	–	0.9
5%	70%	25%	–	1.2
–	60%	30%	10%	1.5

A.3 Application

Figure A.2 shows graphically how the mean increment in Post-Selection Delay varies as a function of the database query factor, for various possible values of D_{query}.

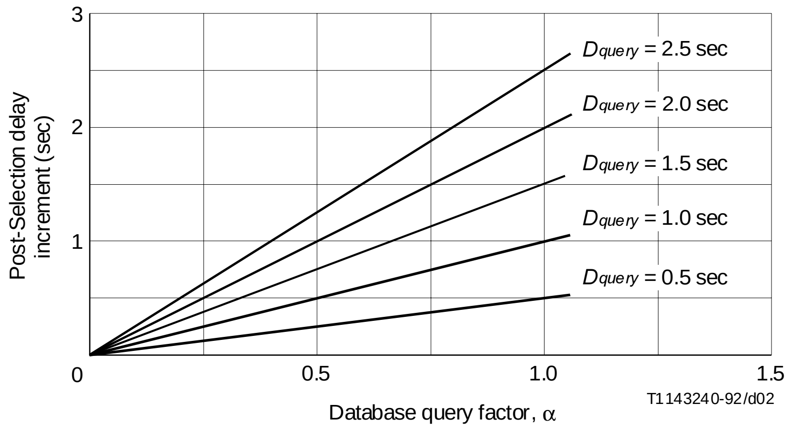

FIGURE A.2/Q.709

Mean increment in post-selection delay due to database queries

A.4 Reduction in User-Part delay allowance

The target objectives for mean Post-Selection Delay can be found in Recommendation E.721. As an example the impact of database queries on User-Part signalling delay is considered in Figure A.3.

In each case, the slope of the line is – α.

This analysis implies that with the introduction of IN and increasing values of the database query factor α, the User-Part delay allowance decreases. Such information must be carefully taken into account in planning new services and in designing and engineering the SS No. 7 network.

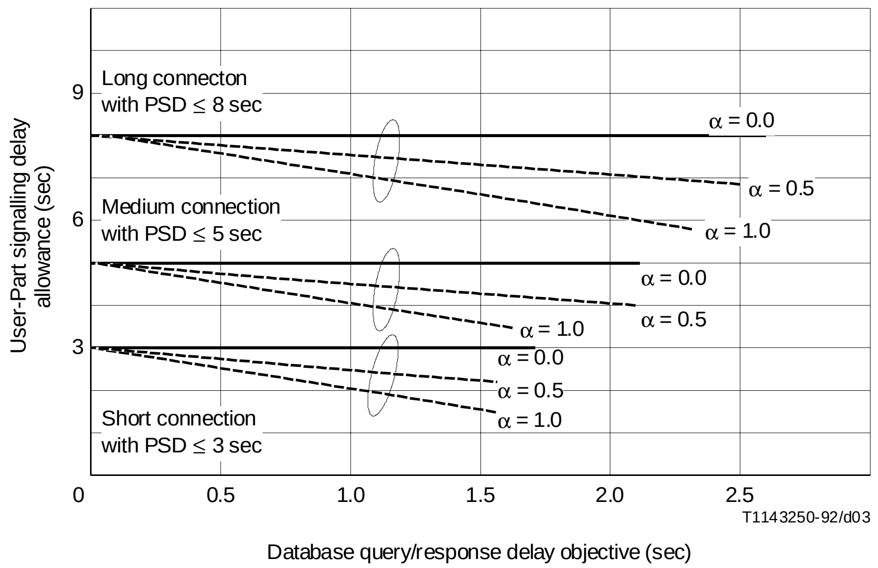

FIGURE A.3/Q.709

User-Part signalling delay allowance as a function of database query/response delay objective D_{query} and the database query factor α

References

[1] CCITT Recommendation *Network GOS parameters and target values for circuit-switched services in the evolving ISDN*, Rec. E.721.

[2] CCITT Recommendation *GOS parameters for SS No. 7 networks*, Rec. E.723.

[3] CCITT Recommendation *Network performance objectives for connection processing delays in an ISDN*, Rec. I.352.