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ITU-T

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OF ITU

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INTEGRATED SERVICES DIGITAL NETWORK (ISDN)

OVERALL NETWORK ASPECTS AND FUNCTIONS

NETWORK PERFORMANCE OBJECTIVES FOR CONNECTION PROCESSING DELAYS IN AN ISDN

ITU-T Recommendation I.352

(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 I.352 was revised by the ITU-T Study Group XVIII (1988-1993) and was approved by the WTSC (Helsinki, March 1-12, 1993).

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 Similarly, in this reform process, the CCIR and the IFRB have been replaced by the Radiocommunication Sector.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

NETWORK PERFORMANCE OBJECTIVES FOR CONNECTION PROCESSING DELAYS IN AN ISDN

(Melbourne, 1988; revised Helsinki, 1993)

1 General

1.1 Introduction

This Recommendation provides network performance objectives for connection processing delays. The parameter values specified include the effects of both congestion and network failures and apply for an exclusively ISDN connection established by means of CCITT protocols Q.931 (DSS 1) and Q.764 (ISUP).

The network performance objectives provided in this Recommendation are based on the concept of network performance which is defined in Recommendation I.350 (General aspects of Quality of Service and network performance in digital networks, including ISDN). In addition to Recommendation I.350 the following Recommendations also contain material that either provides background for or are relevant to this Recommendation:

I.324 ISDN Network Architecture

I.325 Reference configurations for ISDN connection types

Q.41 Mean one-way propagation time

Q.543 Digital exchange performance design objectives

Q.706 Message transfer part signalling performance

Q.709 Hypothetical signalling reference connection

Q.764 Signalling Procedures

Q.766 Performance objectives in the ISDN applications

Q.931 ISDN user-network interface layer 3 specification for basic call control

G.101 The transmission plan

E.172 ISDN routing plan

E.721 Network grade of service parameters and target values for circuit-switched services in the evolving ISDN

The relation with Recommendation E.721 is particularly important. The major distinctions between this Recommendation and Recommendation E.721 are:

– This Recommendation identifies network performance objectives observable at specified measurement points which are located at specified measurement points and include the effects of both congestion and network failures. Recommendation E.721 GOS values are intended to be used for network dimensioning and thus consider the network to be in a state where all network components are fully operational.

– Performance objectives of this Recommendation recommend the performance that worst case reference connections should achieve (see NOTE). On the other hand, Recommendation E.721 parameters are used for network dimensioning and therefore traffic weighted averages of the connection type are employed.

NOTE – Connections longer than the worst case reference connection are not covered by this Recommendation. Such very long connections may only apply in very unusual cases.

– The recommended values of this Recommendation apply for an exclusively ISDN connection established by means of CCITT protocols Q.931 (DSS 1) and Q.764 (ISUP). Recommendation E.721 recommended values allow for additional delays from non-ISUP established connections which may be present during the ISDN evolution.

1.2 Reference model

The reference model provided in Recommendation I.325 was used to provide a baseline reference configuration. The network portion boundaries defined in Recommendation I.325 correspond to the measurement points (MPs) used in this Recommendation as follows:

I.325	I.352
T_1 (S_1)	MPT_1
IB_1	MPI_1
IB_2	MPI_2
T_2 (S_2)	MPT_2

For the determination of values a worst case reference connection was used. Recommendations G.101 and G.709 were considered for this worst case reference connection. Annex A contains examples of worst case reference connections that can be used to test the objectives specified in this Recommendation.

Annex B provides an example for the calculation of the overall connection set-up delay.

NOTES

1 All values specified in this Recommendation were rounded after a calculation along that example.

2 This Recommendation does not take into account private networks. In case of private networks connected to the ISDN the recommended values refer to the interface at the T reference point. The interface at the S reference point applies when the S and T reference point is coincident.

1.3 Measurement

All parameter values are specified at measurement points. These values are measured at measurement points (exchange interface V_1 or V_4 at the S reference point or exchange interface V_3 at the T reference point and exchange interface A or B located at the national side of an ISC) using call processing performance-significant reference events as defined in this Recommendation for connections established using CCITT protocols Q.931 (DSS 1) and Q.764 (ISUP).

1.4 Network conditions

The values for delay given in this Recommendation include an allowance for the effects on delay that might be introduced by high traffic load during a nominal busy hour (see Note). Consideration was given to the possibility that individual busy hours might not be coincident. The values also include the effects of network component failures. The specified values do not apply under conditions of network unavailability. These delays are expressed in terms of mean and 95% probability values.

NOTE – In cases where the actual traffic load leads to an overload condition in the network, the recommended delay values are not covered by this Recommendation.

1.5 User delay

Values are provided for measurements made at a single measurement point as well as measurements made between two measurement points. This allows for calculations that would avoid inclusion of any delay that might be introduced by users or user equipment.

1.6 Allocation

Overall connection processing delays between interfaces at the S reference point or the T reference point can be divided into sub-values for national and the international network fabric. The national and the international network fabric is defined in Recommendation I.325.

1.7 Basic connection

Connection processing delays are only defined for a basic connection and therefore do not provide for any effects that might be introduced by supplementary services.

1.8 Phases

Connection processing delay values are specified for the connection set-up and disconnection phase.

2 Purpose

The purpose of this Recommendation is to provide values for connection processing delays that can be used as a basis for network planning and system design. Quality of Service information should be provided to the user after mapping network performance into user-oriented expressions.

3 Connection processing delays in ISDN circuit-switched connections

The values for the connection processing delay parameters have been determined, taking into account that:

- the calling access link;
- the connection processing at the originating local exchange;
- the connection processing at transit exchanges;
- the usage of signalling transfer points (STP);
- the internodal links;
- the connection processing at the terminating local exchange; and
- the connected access link

cause delay.

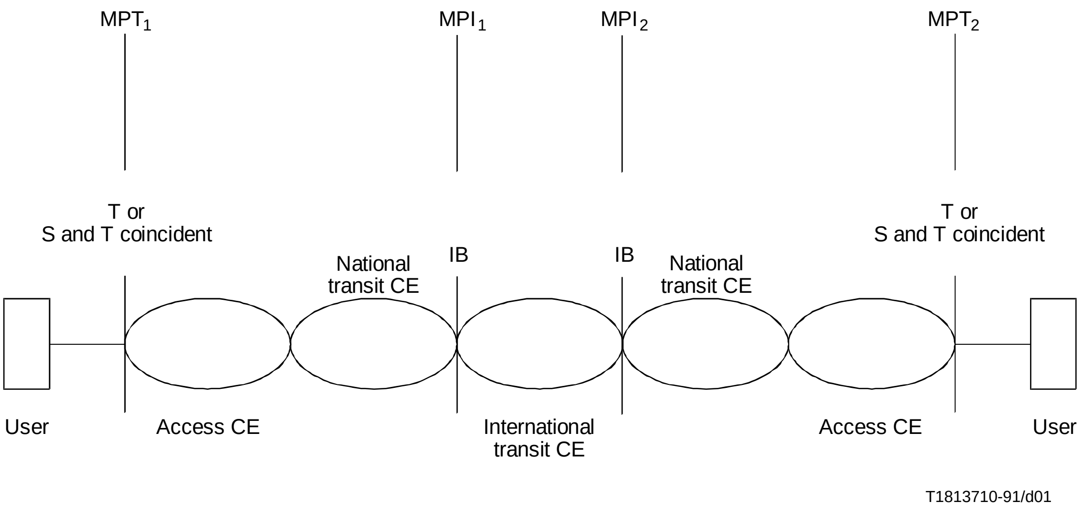
These values are representative for all terrestrial connections and also for connections involving a satellite in an internodal link allowing a smaller number of transit exchanges in that connection.

3.1 Connect phase parameters

3.1.1 Connection set-up delay

Connection set-up delay is defined first based on observations at a single measurement point, MP_i (See Note) as shown in Figure 1, and then between two measurement points (MP_i,MP_j). In the former case, the connection set-up delay includes the delay for all connection elements on the called user side of MP_i and the terminal device. In the latter case, the connection set-up delay includes only the delay between MP_i and MP_j. Connection set-up delay is defined using performance-significant reference events. Table 1 identifies the performance-significant reference events and the resulting call states for I.451/Q.931 connection processing messages. Table 2 identifies the performance-significant reference events and the resulting call states for the relating Signalling System No. 7 user part messages defined in Recommendation Q.764.

NOTE – MP_i is one of the following measurement points: MPT_1, MPI_1, MPI_2, MPT_2.



CE Connection element

FIGURE 1/I.352

General reference configuration

(based on the International ISDN reference configuration in Recommendation I.325)

3.1.1.1 Definition of connection set-up delay observed at a single measurement point

connection set-up delay at a single measurement point, MP_i, is defined using two call processing performance-significant reference events. Table 1 identifies the performance-significant reference events and the resulting call states for I.451/Q.931 connection processing messages. Table 2 identifies the performance-significant reference events and the resulting call states for the relating Signalling System No. 7 user part messages defined in Recommendation Q.764. Connection set-up delay is the length of time that starts when a SETUP or the last address information message creates a performance-significant reference event at MP_i, and ends when the corresponding CONNECT message returns and creates its performance-significant reference event at MP_i.

Connection set-up delay observed at a single measurement point = $(t_2 - t_1)$

where

t_1 is the time of occurrence starting performance-significant reference event

t_2 is the time of occurrence for the ending performance-significant reference event.

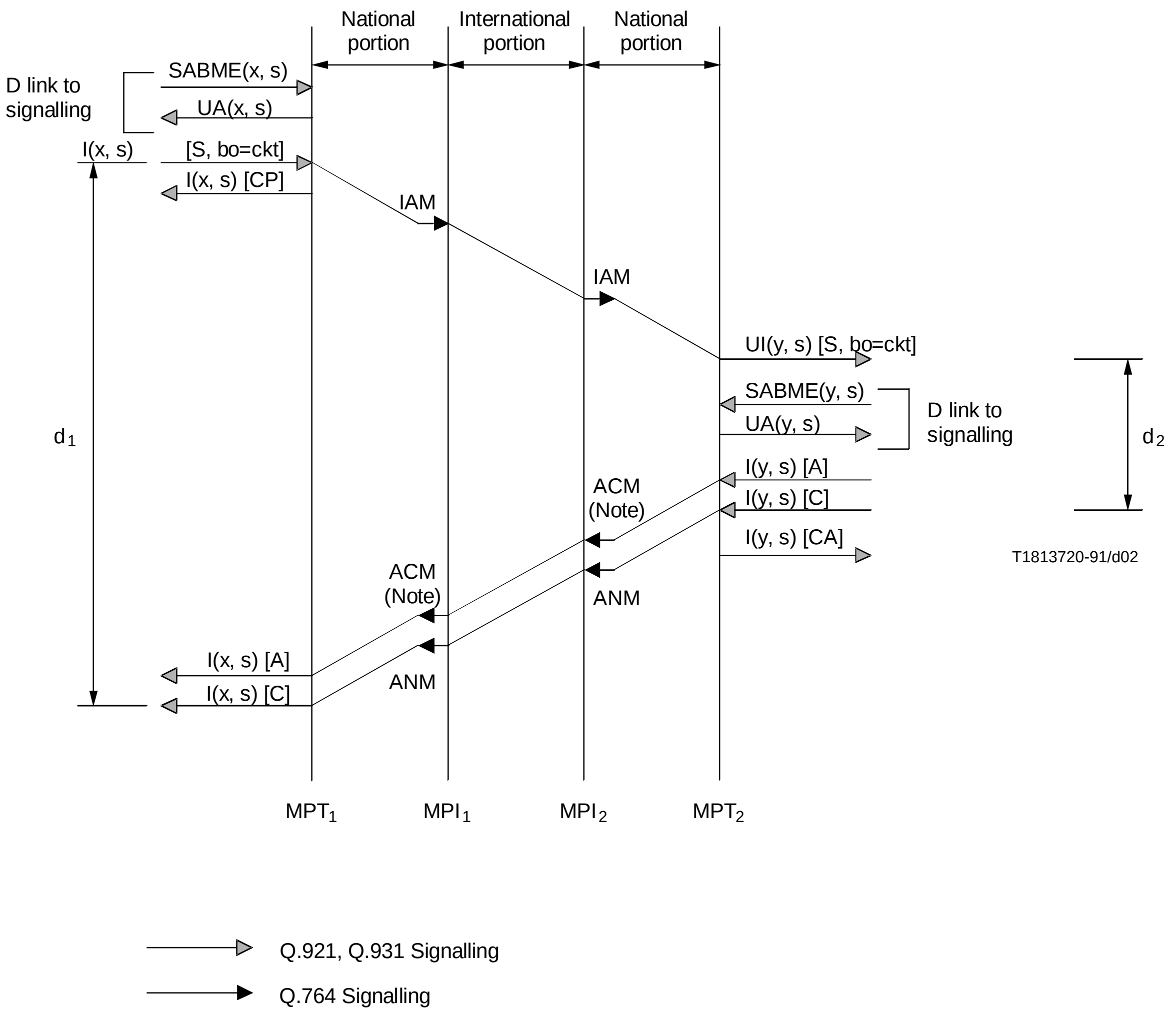
The transfer of the I.451/Q.931 messages and their corresponding user-part messages of Signalling System No. 7 is shown in Figure 2 along with measurement points. The specific performance-significant reference events used in measuring connection set-up delay are shown in Table 1.

NOTE – "Set-up" does not imply a through connection or capability for information transfer has been established.

TABLE 1/I.352

Performance-significant reference events for measuring connection set-up delay

Measurement point	Performance-significant reference event	
	Starting event code	Ending event code
MPT_1	P1a (en bloc)	P6b
MPT_1	P3 (overlap sending)	P6b
MPT_2	P1b	P6a
MPI_1	S1b	S3b
MPI_2	S1a	S3a
NOTE – En bloc and overlap sending options at the calling interface at the S or T reference point.		



NOTE – Needed if voice call.

FIGURE 2/I.352

Connection set-up delay

3.1.1.2 Definition of connection set-up delay between two measurement points

The connection set-up delay can be measured at one measurement point, MP_i, and then measured at another measurement point, MP_j, farther from the calling interface at the S or T interface. The difference in the values obtained is the connection set-up delay contributed by the connection elements between two measurement points.

Connection set-up delay between two measurement points = $(d_1 - d_2)$

where

d_1 is the connection set-up delay measured at MP_i

d_2 is the connection set-up delay measured at MP_j

The overall connection set-up delay is the connection set-up delay between the two at the S or T reference point interfaces, e.g. MP_i and MP_n in Figure 1. This overall connection delay excludes the called user response time. The connection set-up delay for a connection element is the connection set-up delay between the measurement points delimiting that connection element.

3.1.1.3 Connection set-up delay specification

The overall connection set-up delay should not exceed the values given in Table 2.

TABLE 2/I.352

Overall connection setup delay

Statistic	Connection setup delay
Mean	7500 ms[a)]
95%	8450 ms[a)]

a) Provisional values; the actual target values are for further study.

NOTES

1 The specified values could be met using the reference connections defined in Annex A.

2 Delays are specified for a nominal busy hour.

3 Connection set-up attempts which exceed a specified timeout value are excluded in computing these statistics and are counted separately as connection setup denials. These denials are for further study and will be contained in a seperate Recommendation.

4 In this table the values given are relevant to ISDN connection types given in Table 2/I.340.

5 Those message processing delays that are dependent on a user equipment network are not included. In addition, when transmitting a signal message defined in Recommendation Q.931 from the network to a user, before the message actually passes across the interface at the S or T reference point, it may have to wait in the exchange or signalling system while another message (signal or user packet) is being transmitted to the user. Since this waiting time depends on the volume of user packet (message) traffic over the D-channel, the resulting delay is beyond the responsibility of the network provider.

6 The delay objectives in the above table are applicable to connections provided exclusively over ISDNs established by means of CCITT protocols Q.931 (DSS 1) and Q.764 (ISUP), i.e. no interworking with other networks.

7 The connection setup and disconnect procedures in ISDNs for circuit mode voice and data are essentially the same. Therefore, the delay definitions are applicable for circuit mode voice and circuit mode data. The provisional values in the table are applicable for both circuit mode voice and circuit mode data with no interworking. However, the observed delay performance may not be identical to the values in the table due to delay caused by network architectural differences and interworking.

The set-up delay in the international network fabric should not exceed the values given in Table 3.

TABLE 3/I.352

Connection set-up delay for the international network fabric

Statistic	Connection setup delay
Mean	1700 ms[a)]
95%	2300 ms[a)]
[a)] Provisional values; the actual target values are for further study. NOTE – The delays are derived from Table 29/Q.543 and Table 4/Q.709 assuming a processing intensive message in the forward direction and a simple message in the backward direction.	

The connection set-up delay for the national network fabric should not exceed the values given in Table 4.

TABLE 4/I.352

Connection set-up delay for national network fabric (Note 1)

Statistic	Connection setup delay (Note 2)
Mean	2900 ms[a)]
95%	3600 ms[a)]
[a)] Provisional values; the actual target values are for further study. NOTES 1 The delays are derived from Table 29/Q.543 and Table 4/Q.709 assuming a processing intensive message in the forward direction and a simple message in the backward direction. 2 The connection setup delay values in the table are applicable to each national network fabric in the connection.	

3.1.2 Alerting delay (applicable in case of manual answering terminals and some automatic answering terminals)

Alerting delay is defined using an approach similar to that described in 3.1.1 for connection set-up delay. Alerting delay is defined using performance-significant reference events. Table 1 identifies the performance-significant reference events and the resulting call states for I.451/Q.931 connection processing messages. Table 2 identifies the performance-significant reference events and the resulting call states for the relating Signalling System No. 7 user part messages defined in Recommendation Q.764.

3.1.2.1 Definition of alerting delay observed at a single measurement point

alerting delay at a single measurement point, MP_i, is defined as the length of time that starts when a SETUP or the last address information message creates a performance-significant reference event at MP_i, and ends when the corresponding ALERTing message returns and creates its performance-significant reference event at MP_i.

Alerting delay observed at a single measurement point = ($t_2 - t_1$)

where

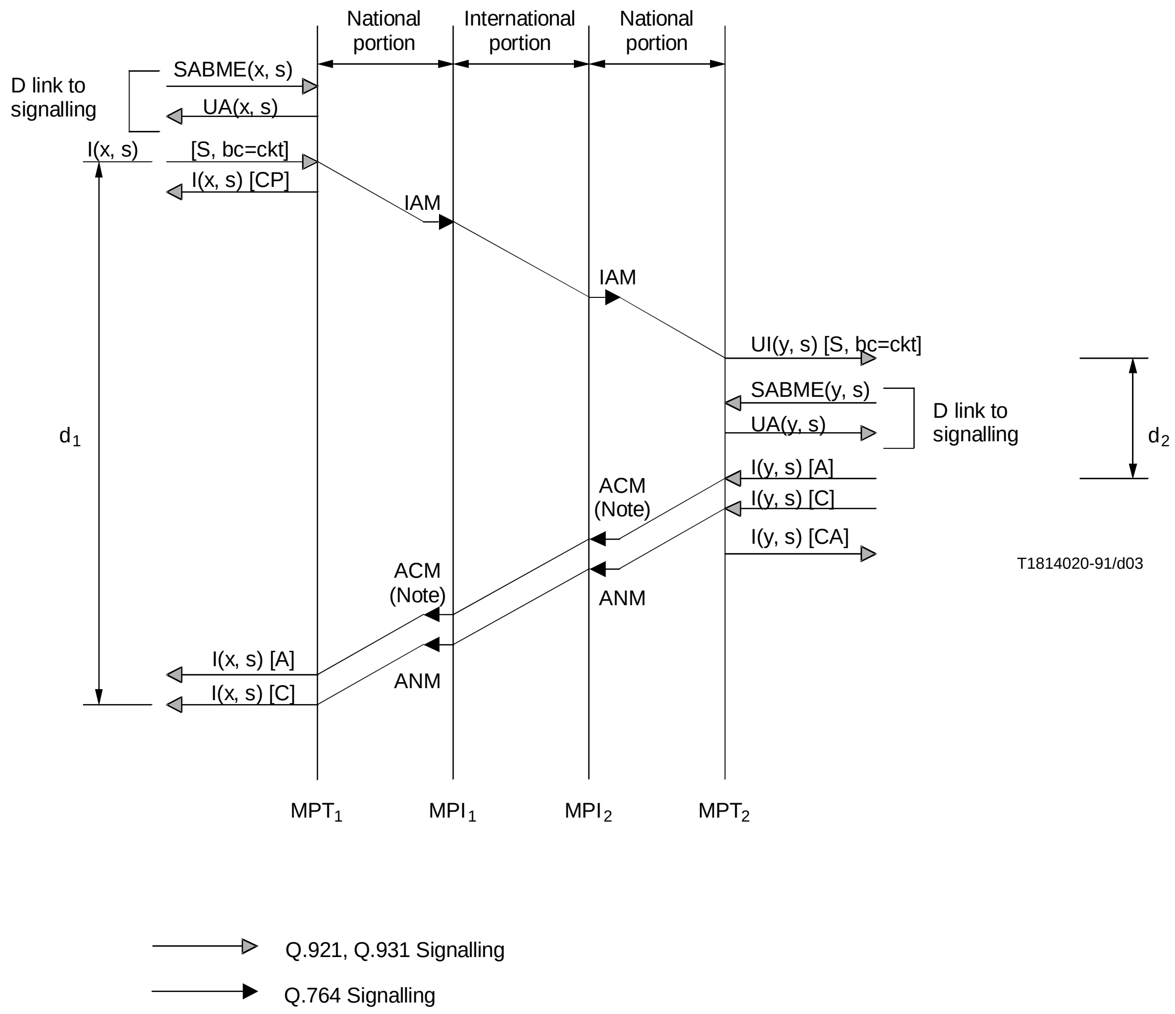
t_1 is the time of occurrence for the starting performance-significant reference event

t_2 is the time of occurrence for the ending performance-significant reference event.

The transfer of the I.451/Q.931 messages and their corresponding user-part messages of Signalling System No. 7 is shown in Figure 3 along with measurement points. The specific performance-significant reference events used in measuring alerting delay are shown in Table 5.

3.1.2.2 Definition of alerting delay between two measurement points

The alerting delay can be measured at one measurement point, MP_i, and then measured at another measurement point, MP_j, further from the calling interface at the S or T reference point. The difference in the values obtained is the alerting delay contributed by the connection elements between the two measurement points.



NOTE – Needed if voice call.

FIGURE 3/I.352

Alerting set-up delay

TABLE 5/I.352

Performance-significant reference events for measuring alerting delay

Measurement point	Performance-significant reference event	
	Starting event code	Ending event code
MPT_1	P1a (en bloc)	P5b
MPT_1	P2b (overlap sending)	P5b
MPT_2	P1b	P5a
MPI_1	S1b	S2b
MPI_2	S1a	S2a
NOTE – En bloc and overlap sending options at the calling S or T interface.		

Alerting delay between two measurements points = $d_1 - d_2$

where

d_1 is the alerting delay measured at MP_i

d_2 is the alerting delay measured at MP_j.

The overall alerting delay is the alerting delay between the two interfaces at the S or T reference point, MPT_1 and MPT_2 in Figure 1 for the connection types contained in Table 2/I.340. This overall alerting delay excludes the called user response time. The alerting delay for a connection element is the alerting delay between the measurement points delimiting that connection element.

3.1.2.3 Alerting delay specification

The overall alerting delay should not exceed the values given in Table 6.

The alerting delay for the international network fabric should not exceed the values given in Table 7.

The alerting delay for the national network fabric should not exceed the values given in Table 8.

3.2 Disconnect phase parameters

3.2.1 Disconnect delay

Disconnect definition is based only on a one-way message transport from the clearing party to the cleared party. Therefore, this parameter requires observations at two measurement points. Disconnect delay is defined using performance-significant reference events. Table 1 identifies the performance-significant reference events and the resulting call states for I.451/Q.931 connection processing messages. Table 2 identifies the performance-significant reference events and the resulting call states for the relating Signalling System No. 7 user part messages defined in Recommendation Q.764.

3.2.1.1 Definition of disconnect delay between two measurement points

Disconnect delay between two measurement points, MP_i and MP_j, is defined as the length of time that starts when a DISConnect message creates a performance-significant reference event at MP_i and ends when that DISConnect message creates a performance-significant reference event at MP_j, farther from the clearing party.

TABLE 6/I.352

Overall alerting delay

Statistic	Alerting delay
Mean	7500 ms[a)]
95%	8450 ms[a)]

a) Provisional values; the actual target values are for further study.

NOTES

1 The specified values could be met using the reference connections defined in Annex A.

2 Delays are specified for a nominal busy hour.

3 Connection set-up attempts which exceed a specified timeout value are excluded in computing these statistics and are counted separately as connection setup denials. These denials are for further study and will be contained in a seperate Recommendation.

4 In this table the values given are relevant to ISDN connection types given in Table 2/I.340.

5 Those message processing delays that are dependent on a user equipment network are not included. In addition, when transmitting a signal message defined in Recommendation Q.931 from the network to a user, before the message actually passes across the interface at the S or T reference point, it may have to wait in the exchange or signalling system while another message (signal or user packet) is being transmitted to the user. Since this waiting time depends on the volume of user packet (message) traffic over the D-channel, the resulting delay is beyond the responsibility of the network provider.

6 The delay objectives in the above table are applicable to connections provided exclusively over ISDNs established by means of CCITT protocols Q.931 (DSS 1) and Q.764 (ISUP), i.e. no interworking with other networks.

7 The connection setup and disconnect procedures in ISDNs for circuit mode voice and data are essentially the same. Therefore, the delay definitions are applicable for circuit mode voice and circuit mode data. The provisional values in the table are applicable for both circuit mode voice and circuit mode data with no interworking. However, the observed delay performance may not be identical to the values in the table due to delay caused by network architectural differences and interworking.

TABLE 7/I.352

Alerting delay for the international network fabric

Statistic	Alerting delay
Mean	1700 ms[a)]
95%	2300 ms[a)]

a) Provisional values; the actual target values are for further study.

NOTE – The delays are derived from Table 2/Q.709 assuming a processing intensive message in the forward direction and a simple message in the backward direction.

Disconnect delay between two measurement points = $(t_2 - t_1)$

where

t_1 is the time of occurrence for the performance-significant reference event at MP_i

t_2 is the time of occurrence for the performance-significant reference event at MP_j.

TABLE 8/I.352

Alerting delay for national network fabric (Note 1)

Statistic	Alerting delay (Note 2)
Mean	2900 ms[a)]
95%	3600 ms[a)]

a) Provisional values; the actual target values are for further study.

NOTES

1 The delays are derived from Table 29/Q.543 and Table 2/Q.709 assuming a processing intensive message in the forward direction and a simple message in the backward direction.

2 The alerting delay values in the table are applicable to each national network fabric in the connection.

The overall disconnect delay is the disconnect delay between two interfaces at the S or T reference point, e.g. MP_1 and MP_n in Figure 1 for the connection types contained in Table 2/I.340. The disconnect delay for a connection element is the disconnect delay between the measurement points delimiting that connection element. The transfer of the I.451/Q.931 messages and their corresponding user-part messages of Signalling System No. 7 is shown in Figure 4 along with measurement points. The specific performance-significant reference events used in measuring disconnect delay are shown in Table 9.

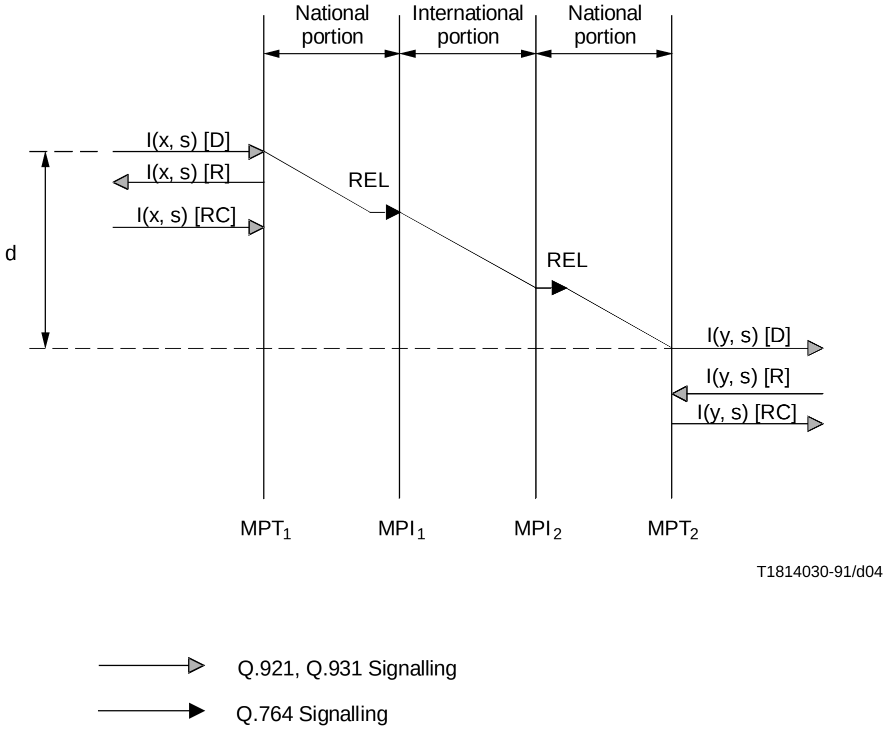


FIGURE 4/I.352

Disconnect delay

TABLE 9/I.352

Performance-significant reference events for measuring disconnect delay

Measurement point	Performance-significant reference event	
	Starting event code	Ending event code
MPT_1 and MPT_2	P8a (Clearing end)	P8b (Cleared end)
MPI_1 and MPI_2	S4b (National/International)	S4a (International/National)

3.2.1.2 Disconnect delay specification

The overall disconnect delay should not exceed the values given in Table 10.

The disconnect delay in the international network fabric should not exceed the values given in Table 11.

The disconnect delay for the national network fabric should not exceed the values given in Table 12.

TABLE 10/I.352

Overall disconnect delay

Statistic	Disconnect delay
Mean	3500 ms[a)]
95%	4250 ms[a)]

a) Provisional value; the actual target values are for further study.

NOTES

1 The specified values could be met using the reference connections defined in Annex A.

2 Delays are specified for a nominal busy hour.

3 In this table the values given are relevant to ISDN connection types given in Table 2/I.340.

4 The delay objectives in the above table are applicable to connections provided exclusively over ISDNs by means of CCITT protocols Q.931 (DSS 1) and Q.764 (ISUP), i.e. no interworking with other networks.

5 The connection setup and disconnect procedures in ISDNs for circuit mode voice and data are essentially the same. Therefore, the delay definitions are applicable for circuit mode voice and circuit mode data. The provisional values in the table are applicable for both circuit mode voice and circuit mode data with no interworking. However, the observed delay performance may not be identical to the values in the table due to delay caused by network architectural differences and interworking.

6 Connection disconnect attempts which exceed a specified timeout value are excluded in computing these statistics and are counted separately as connection disconnect denials. These denials are for further study and will be contained in a separate Recommendation.

TABLE 11/I.352

Disconnect delay for the international network fabric

Statistic	Disconnect delay
Mean	1000 ms[a)]
95%	1350 ms[a)]

a) Provisional values; the actual target values are for further study.

NOTE – The delays are derived from Table 2/Q.709 assuming in the forward direction a simple message.

TABLE 12/I.352

Disconnect delay for national network fabric (Note 1)

Statistic	Disconnect delay (Note 2)
Mean	1250 ms[a)]
95%	1750 ms[a)]

a) Provisional values; the actual target values are for further study.

NOTES

1 The delays are derived from Table 28/Q.543 and Table 4/Q.709 assuming in the forward direction a simple message.

2 The disconnect delay values in the table are applicable to each national network fabric in the connection.

3.2.2 Release delay

Release delay is defined only at the clearing party interface at the S or T reference point. Release delay is defined using performance-significant reference events. Table 1 identifies the performance-significant reference events and the resulting call states for I.451/Q.931 connection processing messages. Table 2 identifies the performance-significant reference events and the resulting call states for the relating Signalling System No. 7 user part messages defined in Recommendation Q.764.

3.2.2.1 Definition of release delay

Release delay is defined as the length of time that starts when a DISConnect message from the clearing party creates a performance-significant reference event at the clearing party interface at the S or T reference point and ends when the RELease message creates a performance-significant reference event at the same interface.

Release delay at the clearing party S or T interface = $(t_2 - t_1)$

where

t_1 is the time of occurrence for the starting performance-significant reference event

t_2 is the time of occurrence for the ending performance-significant reference event.

Since the release message sent by the exchange at the clearing end is only transported over the access connection element at that end, the distinction between overall delay and connection element delay is not relevant. The transfer of the I.451/Q.931 messages and their corresponding user-part messages of Signalling System No. 7 is shown in Figure 5 along with measurement points. The specific performance-significant reference events used in measuring release delay are shown in Table 13.

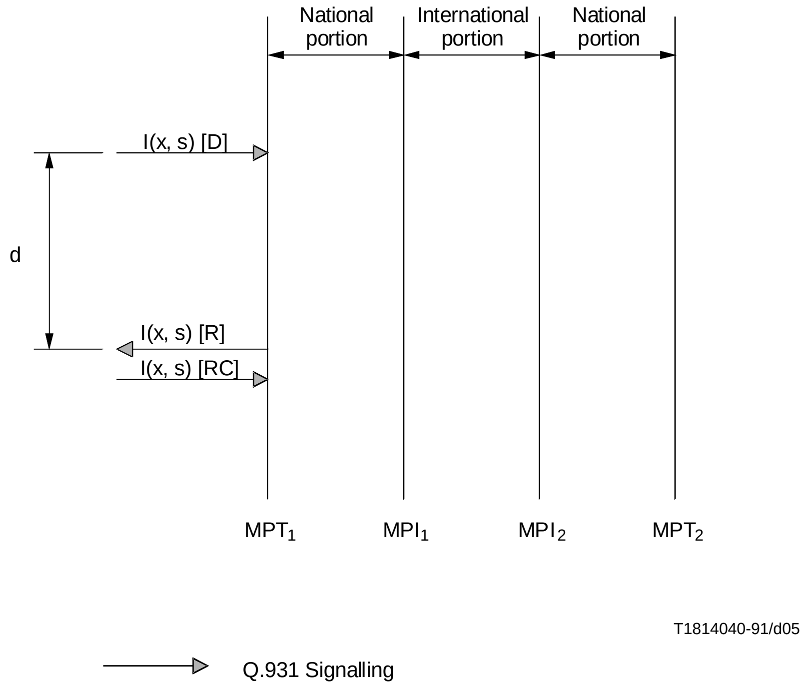


FIGURE 5/I.352

Release delay

TABLE 13/I.352

Performance-significant reference events for measuring release delay

Measurement point	Performance-significant reference event	
	Starting event code	Ending event code
MPT_1 or MPT_2 (Clearing party)	P8a	P8b
MPI_1 or MPI_2 (Cleared party)	Not applicable	Not applicable
MPI_1 or MPI_2	Not applicable	Not applicable

Annex A

Worst case reference connections for circuit switched connection types

(This annex forms an integral part of this Recommendation)

A.1 General

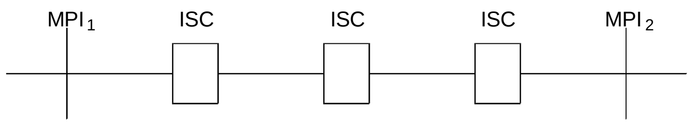
With the following worst case reference connections the performance objectives specified in this Recommendation will be met. The measurement point I (MPI) is located at the national side of an ISC.

A.2 Worst case reference connections

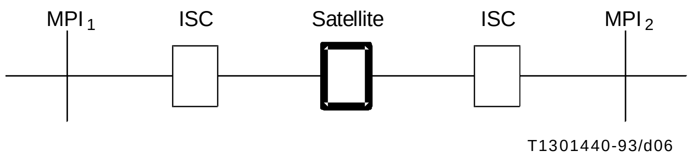
A.2.1 International network portion

The worst case reference connections for the international network portion are given in diagrams **a)** and **b)** of Figure A.1.

Within these worst case reference connections, up to four signalling transfer points (STP) might be included.



a) Worst case reference connection for the international network portion without a satellite link



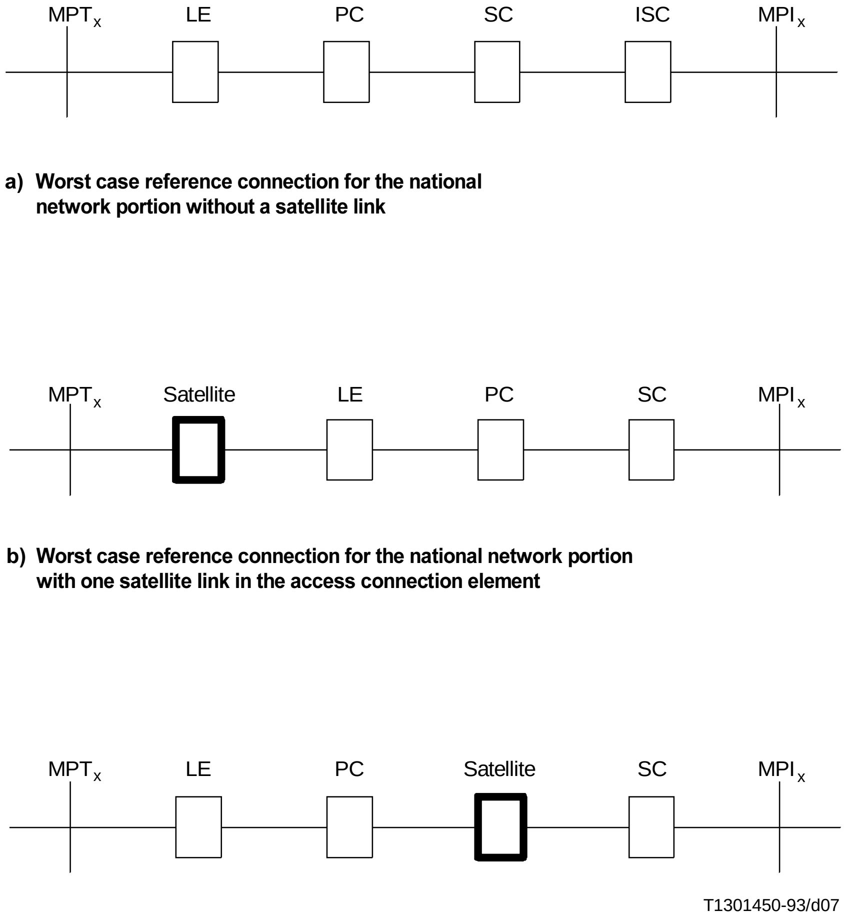
b) Worst case reference connection for the international network portion with one satellite link

FIGURE A.1/I.352

A.2.2 National network portion

The worst case reference connections for the national network portions are given in diagrams **a)**, **b)** and **c)** of Figure A.2.

Within these worst case reference connections up to five signalling transfer points (STP) might be included.



a) Worst case reference connection for the national network portion without a satellite link

b) Worst case reference connection for the national network portion with one satellite link in the access connection element

c) Worst case reference connection for the national network portion with one satellite link in the national transit connection element

FIGURE A.2/I.352

Annex B

Calculation of values of connection processing performance parameters

(This annex forms an integral part of this Recommendation)

B.1 Methodology

NOTE – For a more accurate determination of delay values a more sophisticated model should be used. This model shall take into consideration all relevant factors including:

- alternative routing;
- non-coincident busy hours;
- partially non-operational networks.

This model is for further study.

This annex describes the approach for calculation of the values (mean and 95 percentile) of the connection processing performance parameters.

It is considered for a network component i:

– the mean delay as t_{m_i};

– the 95 percentile delay as t_{95_i}; and

– the relation $t_{95_i} = t_{m_i} + k\sigma_i$;

– the standard deviation $\sigma_i = \frac{t_{95_i} - t_{m_i}}{k}$; and

– the variance $V_i = \sigma_i^2 = \left(\frac{t_{95_i} - t_{m_i}}{k} \right)^2$.

For a connection with n network components

i) the mean value is obtained by the summation of the individual mean values

$$T_{m_n} = \Sigma\, t_{m_i}$$

ii) the 95 percentile value is obtained as follows:

$$V_n = \sum_{i=1}^{i=n} V_i = \sum_{i=1}^{i=n} \left(\frac{t_{95i} - t_i}{k} \right)^2$$

$$\sigma_n = \sqrt{V_n} = \sqrt{\sum_{i=1}^{i=n} \left(\frac{t_{95_i} - t_{m_i}}{k} \right)^2} = \frac{1}{k} \sqrt{\sum_{i=1}^{i=n} (t_{95_i} - t_{m_i})^2}$$

$$T_{95_n} = T_{m_n} + k\sigma_n = T_{m_n} + \sqrt{\sum_{i=1}^{i=n} (t_{95_i} - t_{m_i})^2}$$

B.2 Example

The following example of the value of the overall connection setup delay with en-bloc dialling takes into consideration the delays specified in Recommendations 2.2/Q.41 and 2.3/Q.41, 2.4/Q.543, 4.3.4/Q.706 and in 4.2.3/Q.766. As the connection processing delays represent worst case situation the calculation is based on the assumption that all exchanges involved in the connection are in the load condition of reference load B which is defined in Recommendation Q.543.

The connection in Figure B.1 was used for the determination of values and represents the worst case reference connection for the application of ISDN.

The maximum number of signalling points (SP) and signalling transfer points (STP) in the worst case reference connection is given in Table B.1.

Table B.2 and Table B.3 provide parameters for the calculation of connection processing delays.

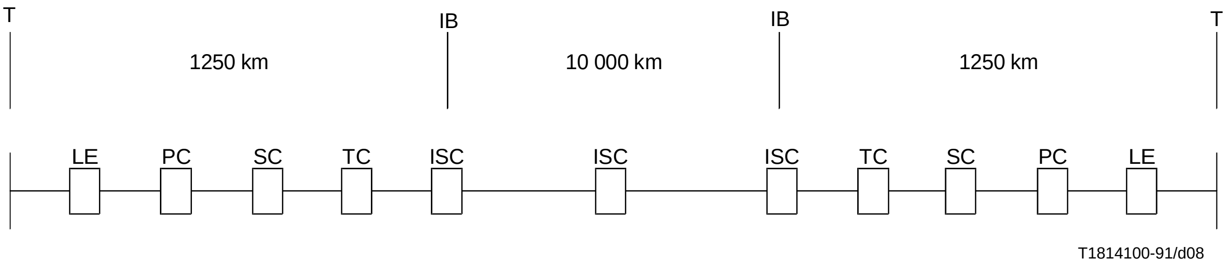


FIGURE B.1/I.352

Worth case reference connection

TABLE B.1/I.352

Maximum number of signalling points and signalling transfer points in the worst case reference connection

Network portion	Number of SPs	Number of STPs
International network portion	3	4
National network portion	4	5

TABLE B.2/I.352

Parameters for the calculation of connection processing delays

Network component	Parameter	Value	
		Mean	95%
Originating local exchange (LE)	Call setup delay (Table 30/Q.543)	800 ms	1000 ms
Transit exchange (PC, SC, TC, ISC)	IAM processing (Table 1/Q.766)	270 ms	540 ms
Terminating local exchange (LE)	Incoming call indication sending delay (Table 34/Q.543)	800 ms	1200 ms
Signalling transfer point (STP)	Message transfer time (Table 4/Q.706)	40 ms	80 ms
Transit exchange (PC, SC, TC, ISC)	ANS processing (Table 1/Q.766)	165 ms	330 ms
Originating local exchange (LE)	Signalling transfer delay (Table 28/Q.543)	350 ms	700 ms
Transmission links (12 500 km; bothway)	Transmission delay (Q.41)	200 ms	–

TABLE B.3/I.352

Calculation of connection processing delays

Network component		Parameter	Value	
Number	Type		T_{m_n}	T_{95_n}
1	Originating local exchange (LE)	Call setup delay (Table 30/Q.543)	800 ms	
9	Transit exchange (PC, SC, TC, ISC)	IAM processing (Table 1/Q.766)	2430 ms	
1	Terminating local exchange (LE)	Incoming call indication sending delay (Table 34/Q.543)	800 ms	
9	Transit exchange (PC, SC, TC, ISC)	ANS processing (Table 1/Q.766)	1485 ms	
2×14	Signalling transfer point (STP)	Message transfer time (Table 4/Q.706)	1120 ms	
1	Originating local exchange (LE)	Signalling transfer delay	350 ms	
1	Transmission links (12 500 km; bothway)	Transmission delay	200 ms	
	Connection with 11 exchanges and 14 STPs (12 500 km)	Overall connection setup delay	7185 ms	8311 ms