SECTION 4

CONNECTION TYPES

Recommendation I.340

ISDN CONNECTION TYPES

(Malaga-Torremolinos, 1984; amended at Melbourne, 1988)

1 General

The ISDN may be described by a limited set of user-network interfaces (refer to Recommendation I.411) and a limited set of ISDN connection types to support the telecommunication services described in the I.200-Series of Recommendations. This Recommendation identifies and defines these connection types which are a description of the lower layer functions (refer to Recommendation I.310) of the ISDN network needed to support the basic services.

This Recommendation should be considered in conjunction with other Recommendations in the I-Series, with particular reference to Recommendations I.120, I.200-Series, I.310, I.320, I.324, I.411 and I.412. For definitions of terms used in this Recommendation, refer to Recommendation I.112.

2 Basic concept of ISDN connection types

2.1 *Introduction*

An ISDN provides a set of network capabilities which enable telecommunication services to be offered to a user (refer to I.200-Series Recommendations).

ISDN connection types are a description, using the attribute method of Recommendation I.140, of the basic low layer functions (BLLFs) of the ISDN. The set of possible values of attributes is given in § 3. It is possible to select combinations of attribute values which are either impractical or of little use; therefore, a set of agreed connection types is given in § 3.

An ISDN connection is a connection established between ISDN reference points (see Recommendations I.310, I.410 and I.411). All ISDN connections are made to support a request for an ISDN service and are time dependent and of finite duration. All ISDN connections will fall under the category of one or other of the connection types. It follows therefore that an ISDN connection type is a time dependent description and an ISDN connection is an instance of a type.

2.2 *Purpose of international connection types*

The definition of a set of ISDN connection types provides the necessary input to identify the network capabilities of ISDNs. Other key requirements of an ISDN are contained in other I-Series Recommendations, in particular in Recommendations I.310, I.410 and I.411.

In addition to describing network capabilities of an ISDN, the identification of ISDN connection types facilitates the specification of network-to-network interfaces. It will also assist in the allocation of network performance parameters.

It should be noted that the user specifies only the service required while the network allocates resources to set up a connection of the specific type as necessary to support the requested service. It is further noted that for certain services additional functions (e.g. additional lower layer functions and or higher layer functions) may be required as depicted in Figure 1/I.340. For examples of such cases, refer to Recommendation I.310.

2.3 *Functions associated with ISDN connection types*

Any ISDN connection type involves an association of functions to support telecommunication services. These functions are fully described in Recommendation I.310.

Figure 1/I.340, (N), p.

2.4 *Applications of ISDN connection types*

Four situations have been identified thus far to which ISDN connection types apply:

— between two ISDN user-network interfaces, i.e. between S/T reference points (refer to Figure 2a/I.340);

(*Note* — There may be a need in certain cases to differentiate between the S and T reference points. This is for further study.)

— between an ISDN user-network interface and an interface to a specialized network resource (refer to Figure 2b/I.340));

— between an ISDN user-network interface and a network-to-network interface (refer to Figure 2c/I.340);

— between two ISDN-to-other network interfaces (refer to Figure 2d/I.340).

2.5 *ISDN connection involving several networks*

An ISDN connection may comprise a number of tandem network connections. Figure 3/I.340 shows an example in which each end network is an ISDN. The intermediate networks may or may not be ISDNs but they offer the appropriate network capabilities for the service supported by the (overall) ISDN connection. Other configurations are for further study.

In (overall) ISDN connections involving several networks, each network provides a part of the connection and may be categorized by different attribute values. In such cases, the characterization of the performance for the overall ISDN connection is for further study.

3 ISDN connection types and their attributes

3.1 *Attributes and their values*

ISDN connection types are characterized by a set of attributes. Each attribute has a set of admissible values. The definitions of these attributes are given in Recommendation I.140. Table 1/I.340 of this Recommendation lists the set of attributes and their possible values for connection types and connection elements. The concept of connection elements is explained in detail in § 4.

Figure 4/I.340 shows an example of three different ISDN connections distinguished by differing values for the attribute ‘‘topology’’ in their ISDN connection types. Values for the other attributes of the connection type may be the same, e.g. speech.

Figure 2/I.340, (N), p.2

Figure 3/I.340, (N), p.3

Figure 4/I.340, (N), p.4

The attributes which are associated with the ISDN connection types have a similarity to those used to define telecommunication services in Recommendations I.211 and I.212. However, the two sets of attributes differ in several important aspects. For example:

a) ISDN connection types represent the technical capabilities of the network and are a means to ensure defined performance and interworking between networks. Telecommunication services supported by the ISDN are the packages offered to users and the definition of their attributes is the means to standardize the service offerings world-wide.

b) Quality of service and commercial attributes are relevant to telecommunication services, whereas network performance, network operation and maintenance attributes are relevant to connection types.

3.2 *Rules of association for the attribute values of connection elements and connection types*

This section describes the relationship between the attribute values of connection elements and connection types (see Table 1/I.340). For each attribute the possible values recommended are listed. The definitions of the attributes and attribute values are contained in Recommendation I.140. In addition to the (possible) attribute values applicable to the connection elements, an association law is given (where appropriate) for each attribute to show how the value of the attribute for the overall connection type is obtained from the values of the attribute applicable to the connection elements.

H.T. [1T1.340]

TABLE 1/I.340

Values already identified for attributes for ISDN connection

elements and connection types

Attributes	Access connection element Overall connection type	Values for attributes {	
1 Information transfer mode	Circuit, packet	Circuit, packet	Circuit, packet
2 Information transfer rate			
Layer 1	64, 2×64, 384, 1536, 1920	{	
(16, 32), 64, 2×64, 384, 1536, 1920			
}	{		
(16, 32), 64, 2×64, 384, 1536, 1920			
}			
Layer 2	Throughput options for FS	Throughput options for FS	Throughput optio
Layer 3	Throughput options for FS	Throughput options for FS	Throughput optio
{			
3			
Information transfer susceptance			
}	{		
Speech processing equipment e.g. LRE, speech interpolation, μ/A conversion, echo suppression equipment, null			
}	{		
Speech processing equipment e.g. LRE, speech interpolation, μ/A conversion, echo suppression equipment, multisatellite hops, null			
}	{		
Unrestricted digital, 3.1 kHz audio, speech			
}			
4 Establishment of connection	{		
Switched, semi-permanent, permanent			
}	{		
Switched, semi-permanent, permanent			
}	{		
Switched, semi-permanent, permanent			
}			
5 Symmetry	{		
Unidirectional, bidirectional, symmetric, bidirectional asymmetric			
}	{		
Unidirectional, bidirectional, symmetric, bidirectional asymmetric			
}	{		
Unidirectional, bidirectional, symmetric, bidirectional asymmetric			
}			
6 Connection configuration			
Topology	{		
Point-to-point (simple, tandem or 2×64 parallel)			
}	{		
Point-to-point (simple, tandem or 2×64 parallel) multipoint			
}	{		
Local, national, international (simple or 2×64 parallel)			
}			
Uniformity	Uniform, non uniform	Uniform, non uniform	Not applicable
Dynamics	Not applicable	Not applicable	{
Concurrent, sequential, add/remove, symmetry and/or topology change			
}			
7 Structure			
Layer 1	{		
8 kHz integrity, 8 kHz integrity with RDTD, unstructured			
}	{		
8 kHz integrity, 8 kHz integrity with RDTD, unstructured			
}	{		
8 kHz integrity, 8 kHz integrity with RDTD, unstructured			
}			
Layer 2	SDU integrity, unstructured	SDU integrity, unstructured	SDU integrity, ur
Layer 3	SDU integrity, unstructured	SDU integrity, unstructured	SDU integrity, ur
8 Channel (rate)			

Information channel D(16), D(64), B(64), H 0(384), H 1 1(1536), H 1 2(1920) } Signalling channel D(16), D(64), D(16) + B(64), D(64) + B(64) } Common channel signalling system, packet }	{ 64, 1536, 1920, analogique { {	Not applicable	

Tableau 1/I.340 [1T1.340], p.5

Blanc

TABLE 1/I.340 *(cont.)*

<table>
<tr><td rowspan="2">Attributes</td><td colspan="3">Values for attributes</td></tr>
<tr><td>Access connection element

Overall connection type</td><td>{</td><td></td></tr>
<tr><td>{
9
Connection control protocol | ua)
}</td><td></td><td></td><td>Not applicable
{</td></tr>
<tr><td>Layer 1, Rec. I.430, Rec. I.431, Rec. Q.702, Rec. X.75 physical level | uc), Rec. X.25 physical level | uc)
}</td><td></td><td></td><td></td></tr>
<tr><td>Layer 2
Rec. I.441, Rec. X.25 link level | uc) | ud), or null
}</td><td>{

{</td><td></td><td></td></tr>
<tr><td>Rec. Q.703, Rec. X.75 link level | uc), Rec. X.25 link level | uc)
}</td><td></td><td></td><td></td></tr>
<tr><td>Layer 3
Rec. I.451, Rec. X.25 packet level | uc) | ud)
}</td><td>{

{</td><td></td><td></td></tr>
<tr><td>Rec. Q.704 + SCCP,
Rec. X.75 packet level,
Rec. Q.704 + ISUP,
Rec. X.25 packet level | uc), null
}</td><td></td><td></td><td></td></tr>
<tr><td>{
10
Information transfer coding protocol | ua)
}</td><td></td><td></td><td>Not applicable</td></tr>
<tr><td>Layer 1
Rec. I.430, Rec. I.431,
Rec. G.711
}</td><td>{

{</td><td></td><td></td></tr>
<tr><td>Rec. G.711, Rec. Q.702,
Rec. X.75 physical level | uc), Rec. X.25 physical level | uc)
}</td><td></td><td></td><td></td></tr>
<tr><td>Layer 2
Rec. I.441, Rec. X.25 link level | uc), or null
}</td><td>{

{</td><td></td><td></td></tr>
<tr><td>Rec. Q.703, Rec. X.75 link level | uc), Rec. X.25 link level | uc) or null
}</td><td></td><td></td><td></td></tr>
<tr><td>Layer 3
Rec. I.451, Rec. X.25 packet level | uc) | ud) or null
}</td><td>{

{</td><td></td><td></td></tr>
<tr><td>Rec. Q.704 + SCCP,
Rec. X.75 packet level | uc), Rec. Q.704 + ISUP, Rec. X.25 packet level | uc) or null
}</td><td></td><td></td><td></td></tr>
<tr><td>{
11
Network performance | ub)
}</td><td></td><td></td><td></td></tr>
<tr><td>a) Error performance</td><td>Rec. G.821</td><td>Rec. G.821</td><td>Rec. G.821</td></tr>
<tr><td>b) Slip performance</td><td>Rec. G.822</td><td>Rec. G.822</td><td>Rec. G.822</td></tr>
<tr><td>12 Network interworking</td><td>FS</td><td>FS</td><td>FS</td></tr>
<tr><td>13 Operations and management</td><td>FS</td><td>FS</td><td>FS</td></tr>
</table>

FS further study

a) Where there are two or more S/T interfaces, different values of access attributes (attributes 8, 9 and 10) may occur at each interface. Values need to be specified for each channel of the interface structure. The role of the access attributes in determining connection types is for further study. Interfaces to network specialized resources and to other networks are for furter study.

b) Examples of the additional performance attributes which may be defined are:

— call and packet processing delays;

— probability of call faillure due to congestion;

— probability of call failure due to network malfunction or packet mishandling;

— information transfer delay;

— error performance [including attributes 11 a) and 11 b)].

c) Use of Rec. X.25 and X.75 in ISDN can be found in Rec. X.31.

d) Packet connection establishment/release may be a two stage process: stage 1 the selection of a B-channel, stage 2 the setting up of a packet connection. For further details, see Rec. X.31.

Tableau 1/I.340 [2T1.340], p.6

3.2.1 *Information transfer mode*

Attribute values for connection elements

Circuit or packet.

Attribute values for overall connection type

Circuit or packet.

Association law

Due to the nature of current packet systems, the use of packet mode in any connection element would make the overall connection type a packet type.

3.2.2 *Information transfer rate (kbit/s)*

Attribute values for connection elements

16 or 32 or 64 or 2 × 64 or 384 or 1536 or 1920

(Values 16 and 32 are not allowed in the access connection element).

Attribute values for overall connection type

(16 or 32) or 64 or 2 × 64 or 384 or 1536 or 1920.

Association law

The value for the overall connection type will be equal to the lowest value of any of its connection elements.

3.2.3 *Information transfer susceptance*

Attribute values for connection elements

Speech processing functions (e.g. low rate encoding (LRE) equipment, speech interpolation, μ/A law conversion) and/or echo suppression functions and/or multiple satellite hops or null.

The exact means of specification of the attribute is for further study. One method would be an appropriate reference to a Recommendation detailing operational requirements in the ISDN.

Attribute values for overall connection types

Unrestricted digital information or 3.1 kHz audio or speech.

Association law

For an overall connection type to have the value *unrestricted digital* , no connection element may contain speech processing functions or echo suppression functions. Connection elements containing speech processing devices having the flexibility to change operation between speech and 64 kbit/s unrestricted would on the other hand be allowed to be a part of a number of different connection types.

For an overall connection type to have the value *3.1 kHz audio* , it may contain echo suppression functions (or it has to disable them prior to data transfer); it must however contain µ/law conversion equipment when appropriate.

For an overall connection type to have the value *speech* , it must contain µ/law conversion equipment and echo suppression functions when appropriate.

These matters are dealt with in more detail in Recommendation I.335.

3.2.4 *Establishment of connection*

Attribute values for connection elements

Switched or semi-permanent or permanent.

Attribute values for overall connection type

Switched or semi-permanent or permanent.

Association law

If all connection elements are permanent, then the overall connection type is permanent.

If any of the connection elements are switched, then the overall connection type is switched. If one or more of the connection elements are semi-permanent and none of the connection elements are switched, then the overall connection type is semi-permanent.

3.2.5 *Symmetry*

Attribute values for connection elements

Unidirectional or bidirectional symmetric or bidirectional asymmetric.

Attribute values for the overall connection type

Unidirectional or bidirectional symmetric or bidirectional asymmetric.

Association law

The overall symmetry can only be generated from the connection elements by analysis of the connection element values in the context of the architecture of the connection.

3.2.6 *Connection of configuration*

3.2.6.1 *Topology*

Attribute values for connection elements

Point-to-point (simple, tandem or 2×64 parallel), or multipoint.

(The access connection element may not be multipoint.)

Attribute values for the overall connection type

Local or national or international. (Each simple or 2×64 parallel.)

Association law

No association is possible.

3.2.6.2 *Uniformity*

Attribute values for connection elements

Uniform or non-uniform.

Attribute values for the overall connection type

Not applicable.

Association law

Not applicable.

3.2.6.3 *Dynamics*

Attribute values for connection elements

Not applicable.

Attribute values for the overall connection type

Concurrent or sequential or add/remove, or symmetry and/or topology change.

Association law

Not applicable.

3.2.7 *Structure*

Attribute values for connection elements

Layer 1: 8 kHz integrity or 8 kHz integrity with RDTD (Restricted Differential Time Delay) ' | or unstructured

Layer 2: Service data integrity or unstructured

Layer 3: Service data integrity or unstructured

Attribute values for the overall connection type

As per values for connection elements.

Association law

For further study.

3.2.8 *Channels*

3.2.8.1 *Information channel (rate)*

The term **RTTD** in the connection type context is defined as follows: This value applies when: i) at each point in a connection or connection element, the time slots are explicitly or implicitly demarcated for each information channel or an aggregate of information channels, and

ii) the information parts submitted to the time slots at the the transmitting end are delivered to the receiving end with a differential time delay or not more than 50 ms.

50 ms is a provisional value that needs to be confirmed. This value has to take into account the maximum differential time delay of an appropriate HRX or part thereof as defined in the G-Series Recommendations.

Attribute values for connection elements

Access connection element: D(16) or D(64) or B(64) or H_0(384) or $H_{1\d1}$(1536) or $H_{1\d2}$(1920)

Transit connection element: 64 kbit/s or equivalent in a higher order multiplex or packet system or analogue transmission.

Attribute values for the overall connection type

Not applicable

3.2.8.2 *Signalling channel (rate)*

Attribute values for connection elements

Access connection element: D(16) or D(64) or B(64) + D(16) or B(64) + D(64)

Transit connection element: common channel signalling system or packet

Attribute values for the overall connection type

Not applicable

3.2.9 *Connection control protocol*

Attribute values for connection elements

Access connection element:

Layer 1: I.430 or I.431

Layer 2: I.441 or I.441 + X.25 link level

Layer 3: I.451 or I.451 + X.25 packet level

Transit connection element:

Layer 1: Q.702 or X.75 physical level

Layer 2: Q.703 or X.75 link level or Q.703 + X.25 link level

Layer 3: Q.704 + SCCP or Q.704 + ISUP or X.75 packet level or Q.704 + SCCP + X.25 packet level or Q.704 + ISUP + X.25 packet level

Attribute values for the overall connection type

Not applicable.

3.2.10 *Information transfer coding/protocol*

Attribute values for connection elements

Access connection element:

Layer 1: I.430 or I.431 or I.430 + G.711 or I.431 + G.711

Layer 2: I.441 or X.25 link level or null

Layer 3: I.451 or X.25 link packet level or null

Transit connection element:

Layer 1: G.711 or G.702 or X.75 physical level

Layer 2: Q.703 or X.25 link level or X.75 link level or null

Layer 3: X.25 packet level or X.75 packet level or Q.704 + ISUP or null

Attribute values for the overall connection type

Not applicable.

3.2.11 *Network performance*

3.2.11.1 *Error performance*

Attribute values for connection elements

G.821

Attribute values for the overall connection type

G.821

Association law

G.821

3.2.11.2 *Slip performance*

Attribute values for connection elements

G.822

Attribute values for overall connection type

G.822

Association law

G.822

3.2.12 *Further attributes and attribute values*

Section 3.2 has outlined the relationships between those attributes values presently existing; the possibility for new values being added remains.

3.3 *Limited set of ISDN connection types*

From the given list of attributes and their possible values, a large number of connection types can be identified. However, some of these attributes are of a general or dominant nature and an initial set of ISDN connection types can be based on these dominant attributes.

Table 2/I.340 enumerates a limited set of connection types based on the following dominant attributes: information transfer mode, information transfer rate, information transfer susceptance, establishment of connection and symmetry. These connection types are intended to be sufficient to support the basic telecommunication services identified in the I.200-Series of Recommendations. Additional connection types are for further study.

4 Connection elements

The ISDN network architecture Recommendation I.324 explains how an ISDN connection type is made up of connection elements (CEs). This concept is illustrated in Figure 5/I.340 and this is valid for all connection types between S/T reference points. A particular ISDN connection may be local (i.e. only access connection elements are involved), national transit (i.e. involving access and national transit CEs), or international (i.e. involving all three kinds of CEs).

Current Recommendations allow collocation and non-collocation of each of the types of CRFs indicated in Figure 5/I.340. This is a national matter.

4.1 *Access connection element*

The access connection element is the portion of the connection from the S/T reference point to the local connection related function (CRF). In the case of permanent connection types an equivalent point to the local CRF needs to be defined.

4.2 *National transit connection element*

The national transit connection element is the portion of the connection between the local CRF and the international CRF. In the case of a national connection this would default to a ‘‘transit connection element’’, i.e. between two local CRFs, but could involve network elements from more than one network operator.

4.3 *International connection element*

The international connection element is the portion of the connection between the originating and destination international CRFs.

4.4 *Use of connection elements*

By using connection elements and attributes which have a layered nature, the construction of a connection type is more easily described. The use of different values for the same attribute in different connection elements allows for a greater degree of description and flexibility.

The connection element analysis may assist in the description of a complex and asymmetric ISDN connection. This is illustrated in Figure 6/I.340, in which the configuration attributes of topology, uniformity and dynamics for a connection type are described using the concept of connection elements.

Different connection elements which constitute an ISDN connection may have different sets of attributes. In this case the attributes across the connection are not homogeneous, and the available attributes of the connection are limited by the most restrictive set of attributes of all the connection elements of the connection.

H.T. [1T2.340]

TABLE 2/I.340
{
Set of ISDN connection types
}

ISDN connection type identity	Attributes { Additional attributes	

CT No.	ISDN CT category	1	2	3	4	5
A 1 A 2 A 3 64 kbit/s unrestricted digital } Unrestricted digital Unrestricted digital Unrestricted digital } Switched Semi-permanent permanent } Bidirectional symetric Bidirectional symetric Bidirectional symetric } Pt-pt multipoint Pt-pt multipoint Pt-pt multipoint }	{ Circuit Circuit Circuit { { { 8 kHz 8 kHz 8 kHz	64 64 64 B(64) B(64) B(64)	{ e)			
A 4 A 5 A 6	Speech	Circuit Circuit Circuit	64 64 64	Speech Speech Speech	Switched Semi-permanent Permanent	Bidirectional symetric Bidirectional symetric Bidirectional symetric
A 7 A 8 A 9	3.1 kHz audio	Circuit Circuit Circuit	64 64 64	3.1 kHz audio 3.1 kHz audio 3.1 kHz audio	Switched Semi-permanent Permanent	Bidirectional symetric Bidirectional symetric Bidirectional symetric

Tableau 2/I.340 [1T2.340], p.7

{
TABLE 2/I.340 *(cont.)*
}

ISDN connection type identity	Attributes	
	{ Additional attributes	

CT No.	ISDN CT category	1	2	3	4	5	6
A 10 Pt-pt multipoint +2×64 k }	 8 kHz RDTD	Circuit 2 × B	2×64	Unrestricted	Switched	Bidirectional symetric	{
A 11 Pt-pt multipoint +2×64 k }	Circuit 2×64 8 kHz RDTD	Circuit 2 × B	2×64	Unrestricted	Semi-permanent	Bidirectional symetric	{
A 12 Pt-pt multipoint +2×64 k }	 8 kHz RDTD	Circuit 2 × B	2×64	Unrestricted	Permanent	Bidirectional symetric	{
B 1 B 2	Packet	Packet Packet	64 (FS) 64 (FS)	Unrestricted Unrestricted	Switched Semi-permanent	Bidirectional symetric Bidirectional symetric	Pt-pt multipoint Pt-pt multipoint
C 1 C 2 C 3	Broadband | ud)	Circuit Circuit Circuit	384 384 384	Unrestricted Unrestricted Unrestricted	Switched Semi-permanent Permanent	Bidirectional symetric Bidirectional symetric Unidirectional | ub)	Pt-pt multipoint Pt-pt multipoint Pt-pt multipoint

Tableau 2/I.340 [2T2.340], p.8

{
TABLE 2/I.340 *(end)*
}

ISDN connection type identity		Attributes							
		{ Additional attributes							
CT No.	ISDN CT category	1	2	3	4	5	6	7	8
C 4	Broad-band | ud)	Circuit	1536	Unrestricted	Switched	Unidirectional | ub)	Pt-pt multipoint	8 kHz	H 1 1(1536)
C 5		Circuit	1536	Unrestricted	Semi-permanent	Unidirectional | ub)	Pt-pt multipoint	8 kHz	H 1 1(1536)
C 6		Circuit	1536	Unrestricted	Permanent	Unidirectional | ub)	Pt-pt multipoint	8 kHz	H 1 1(1536)
C 7		Circuit	1920	Unrestricted	Switched	Unidirectional | ub)	Pt-pt multipoint	8 kHz	H 1 2(1920)
C 8		Circuit	1920	Unrestricted	Semi-permanent	Unidirectional | ub)	Pt-pt multipoint	8 kHz	H 1 2(1920)
C 9		Circuit	1920	Unrestricted	Permanent	Unidirectional | ub)	Pt-pt multipoint	8 kHz	{
H 1 2(1920) }									

CT Connection type

FS Further study

I/W Interworking

O & M Operations and management

RDTD Restricted differential time delay

a) D(16, 64) for signalling.

b) Unidirectional: further study.

c) Parameters have to be based on network performance parameter values as described in Recommendations G.821, G.822 and others.

d) Some networks will not support these connection types until some future date; additionally, Recommendations are not yet available for the switching of H 0 and H 1 channels.

e) Overall connection control protocol is the resultant of the interactions of the access and inter-exchange connection control protocols.

Tableau 2/I.340 [3T2.340], p.9

Figure 5/I.340, (N), p.8

4.5 *Basic connection components*

A connection element is composed of basic connection components. These are identified by the appropriate functional groupings and delimiting reference points.

Two categories of basic connection components are considered:

— where CRFs are not included, e.g. transmission links (Figure 7/I.340 shows such a basic connection component for the digital subscriber line section);

— where CRFs are included, e.g. exchange connections as they are defined in Recommendation Q.513. (Figure 8/I.340 shows such a basic connection component for a circuit switched, 64 kbit/s, point-to-point connection in a local or combined exchange.)

When referencing to the relevant switching and transmission Recommendations, the basic connection components provides a bridge between the connection type and the physical network. The definition of appropriate rules for the selection of references is for further study.

5 Relationship between services and ISDN connection types

5.1 *General relationship*

Given a user request for a telecommunication service at the initiation of a call, the network must choose a connection of a connection type that supports the attributes of the service requested. This selection of a connection is effected at the time of call set-up as a routing function based on a table of options derived during the planning and implementation of the network. The options a network implements will be based on the capabilities needed to support the services the network intends to offer.

5.2 *Network capability to support a change in service during a call*

Recommendation I.231 identifies a bearer service alternate speech/64 kbit/s unrestricted which has a value of the information transfer capability attribute which can alternate.

When the user requests this service, this alterable attribute value should be identified in the signalling mesages during call set-up. During the call, the user will also use signalling messages to request a change in absolute value of this attribute when it is actually desired; and the network will confirm the request for change.

H.T. [T3.340]

a)

Topology

i)

Simple

ii)

Tandem

iii)

Parallel

iv)

Multipoint | ua)

v)

Others (for further study)

vi)

Combination of the above

b)

Uniformity

i)

Uniform (all connection elements identical)

ii)

Non-uniform (some connection elements different)

c)

Dynamics

i)

Concurrent (all connection elements established and released simultaneously)

ii)

Sequential (only one connection element established at a given time)

iii)

Add/remove (connection elements may be added and/or removed during a call)

iv)

Symmetry and/or topology change (the symmetry attribute value may be changed during a call).

Connection element

ISDN connection type

a) Each segment of the multipoint connection consists in general of several connection elements in tandem. The use of non-hierarchical networks, e.g. a satellite based network, may allow a reduction of the connection elements for each segment.

FIGURE 6/I.340

Description of the connection configuration attributes of an ISDN connection using the connection element analysis

H.T. [T1.350]

TABLE 1/I.350

Distinction between quality of service and network performance

Quality of service	Network performance
User oriented	Provider oriented
Service attribute	Connection element attribute

{
Focus on user-observable effects
}
Focus on planning, development (design), operations and maintenance
}
	{

{
Between (at) service access points
}
End-to-end or network connection elements capabilities
}
	{

Figure 6/I.340 (comme tableau) [T3.340], p.9

Blanc

Figure 7/I.340, (N), p.10

Figure 8/I.340, (N), p.11

Unless the change in service capability is requested by the user (and agreed to by the network) at the time of call establishment, a change in service request during a call may or may not be granted by the network. The user always has, of course, the option of terminating the call and establishing a new call with different service characteristics.

For service and operational reasons a rapid and reliable changeover is required and this should be considered in implementing the capability for change in service during a call.

When the connection elements/components have an inherent alterable feature which can be dynamically changed from the adjoining exchanges using out-of-band control signalling, then a rapid and reliable changeover can be achieved. The changes may involve disabling, bypassing or introduction of particular network functions (e.g. circuit multiplication equipment, A/μ law converters, echo control, digital pads). The inter-exchange signalling principles to support the alternate speech/64 kbit/s unrestricted ISDN bearer service are contained in Recommendation Q.764. The network capability to support a change in service during a call is for further study.

MONTAGE: PAGE 128 = PAGE BLANCHE

SECTION 5

PERFORMANCE OBJECTIVES

Recommendation I.350

GENERAL ASPECTS OF QUALITY OF SERVICE AND NETWORK PERFORMANCE IN DIGITAL NETWORKS, INCLUDING ISDN

(Melbourne, 1988)

1 General

1.1 *Purpose of Recommendation*

This Recommendation has been developed to:

— provide descriptions of Quality of Service and Network Performance;

— illustrate how the Quality of Service and the Network Performance concepts are applied in digital networks, including ISDNs;

— describe the features of, and the relationship between, these concepts;

— indicate and classify performance concerns for which parameters may be needed;

— identify generic performance parameters.

The generic term ‘‘performance’’ refers to Quality of Service and to Network Performance as they are defined in § 1.2.

1.2 *Descriptions of Quality of Service (QOS) and Network Performance (NP)*

1.2.1 *Description of Quality of Service*

QOS is defined in Recommendation G.106 *(Red Book)* | as follows: ‘‘Collective effect of service performances which determine the degree of satisfaction of a user of the service’’.

The note of Recommendation *(Red Book)* | underlines that the QOS is characterized by the combined aspects of:

— service support and service operability performance, and

— servability and service integrity performance.

The definition of Quality of Service in Recommendation G.106 *(Red Book)* | is a wide one encompassing many areas of work, including subjective customer satisfaction. However, within this Recommendation the aspects of Quality of Service that are covered are restricted to the identification of parameters that can be directly observed and measured at the point at which the service is accessed by the user. Other types of QOS parameters which are subjective in nature, i.e. depend upon user actions or subjective opinions, will not be specified in the I-Series Recommendations on QOS.

1.2.2 *Description of Network Performance*

Network Performance is a statement of the performance of the connection element or concatenation of connection elements employed to provide a service. It is defined and measured in terms of parameters which are meaningful to the network provider and are used for the purposes of system design, configuration, operation and maintenance. NP is defined independently of terminal performance and user actions.

network performance (NP) is defined as the ability of a network or network portion to provide the functions related to communications between users.

Note — The performance of a network and its component parts contributes to servability performance and service integrity performance as defined in Recommendation G.106 *(Red Book)* , and is characterized by a set of measurable and calculable parameters.

2 Purpose of QOS and NP

2.1 *General*

Bearer services and teleservices as described in the I.200-Series Recommendations are the objects which network and service providers offer to their customers. A major attribute of these services is the set of QOS parameters which a particular service offers. These parameters are user oriented and take into account the elements involved in a particular service as given in Figure 2/I.211.

Bearer services and teleservices are supported by a range of connection types, each of which comprises several connection elements. The performance of the connection types is characterized by a set of NP parameters. These parameters are network oriented.

Figure 1/I.350 illustrates how the concepts of QOS and NP are applied in the ISDN environment.

Figure 1/I.350, (N), p.

2.2 *Purpose of QOS*

A typical user is not concerned with how a particular service is provided, or with any of the aspects of the network's internal design. However, he is interested in comparing one service with another in terms of certain universal, user-oriented performance concerns which apply to any end-to-end service. Therefore from a user's point of view, Quality of Service is best expressed by parameters which:

— focus on user-perceivable effects, rather than their causes within the network;

— do not depend, in their definition, on assumptions about the network internal design;

— take into account all aspects of the service from the user's point of view which can be objectively measured at the service access point;

— may be assured to a user at the service access point by the service provider(s);

— are described in network independent terms and create a common language understandable by both the user and the service provider.

2.3 *Purpose of NP*

A network provider is concerned with the efficiency and effectiveness of the network, in providing services to customers. Therefore from a network provider's point of view, NP is best expressed by parameters which provide information for:

— system development;

— network planning, both nationally and internationally;

— operation and maintenance.

3 Principles for the development of QOS and NP parameters and values

3.1 *General principles*

3.1.1 *Distinction between QOS and NP*

The user oriented QOS parameters provide a valuable framework for network design, but they are not necessarily usable in specifying performance requirements for particular connections. Similarly, the NP parameters ultimately determine the (user observed) QOS, but they do not necessarily describe that quality in a way that is meaningful to users. Both types of parameters are needed, and their values must be quantitatively related if a network is to be effective in serving its users. The definition of QOS and NP parameters should make mapping of values clear in cases where there is not a simple one-to-one relationship between them.

Table 1/I.350 shows some of the characteristics which distinguish QOS and NP.

3.1.2 *Measurability of QOS and NP parameter values*

Due to separating QOS and NP, a number of general points should be noted when considering the development of parameters:

— the definition of QOS parameters should be clearly based on events and states observable at service access points and independent of the network processes and events which support the service;

— the definition of NP parameters should be clearly based on events and states observable at connection element boundaries, e.g. protocol specific interface signals;

— the use of events and states in the definition of parameters should provide for measurements at the boundaries identified above. Such measurements should be verifiable in accordance with generally accepted statistical techniques.

H.T. [T1.350]

TABLE 1/I.350

Distinction between quality of service and network performance

Quality of service	Network performance
User oriented	Provider oriented
Service attribute	Connection element attribute
{ Focus on user-observable effects } Focus on planning, development (design), operations and maintenance }	{
{ Between (at) service access points } End-to-end or network connection elements capabilities }	{

Tableau 1/I.350 [T1.350], p.

3.1.3 *Multiple network provider environments*

It should be recognized in the development of parameter values that services may be provided by multiple providers. In such an environment different levels of QOS may be supported. Therefore, in practice, users may experience a variety of ranges of QOS. It is thus important to establish minimum performance levels for each service and for connection elements providing international connections.

3.2 *QOS principles*

For the definition of parameters for QOS in the ISDN, the concept of bearer services and teleservices needs to be borne in mind. In particular, there is a difference between the kinds of parameters which would describe the QOS of a bearer service and that of a teleservice, since the point of observation of, or access to, the service is different in each case. Figure 1/I.350 illustrates this point.

In the case of teleservices the interface between the user and the service provider may be a man-machine interface. In the case of bearer services this interface corresponds to the S/T reference points. As a result, some of the parameters for describing the QOS of a teleservice will be different from those which describe the QOS of a bearer service.

In describing the QOS of teleservicess, the performance of the terminal equipment (TE) has to be taken into account. For a teleservice, there should be a mapping between the QOS of the teleservice and the performance of the customer equipment including the terminal and the overall (end-to-end) NP of the connection elements supporting this service.

For bearer service there should be mapping between the QOS of the bearer service and the overall (end-to-end) NP of connection elements supporting this service.

3.3 *NP principles*

When developing NP parameters the following points should be borne in mind:

— NP parameters must be measurable at the boundary of the network connection element(s) to which they are applied. The definitions should not be based on assumptions about either the internal characteristics of a network (or portions thereof), or the internal causes of impairments observed at the boundaries;

— the division of a network portion into sub-components should only be done if they must be specified separately in order to ensure satisfactory end-to-end performance or, where appropriate, to derive fair and reasonable allocations among providers. No network provider should bear a disproportionate cost in establishing and operating a service.

3.4 *Primary and derived performance parameters*

3.4.1 *Description*

primary performance parameter

A parameter or a measure of a parameter determined on the basis of direct observations of events at services access points or connection element boundaries.

derived performance parameter

A parameter or a measure of a parameter determined on the basis of observed values of one or more relevant primary performance parameters and decision thresholds for each relevant primary performance parameter.

3.4.2 *Relationship between primary and derived performance parameters*

A number of event types can be directly observed at service access points or connection element boundaries. Examples of such events are:

— the layer 3 protocol state transition associated with the transfer of a SETUP message or a DISCONNECT message across a connection element boundary;

— the correct receipt of an information bit (or a specified number of information bits) at an interface.

Parameters related to the time interval between specific events and the frequency of events can be measured. These directly measurable parameters or primary performance parameters describe the QOS (at service access points) or the NP (at connection element boundaries) during periods when the service or connection is available.

Derived performance parameters describe performance based on events which are defined as occurring when the value of a function of a primary performance parameter(s) crosses a particular threshold. These derived threshold events identify the transitions between the available and the unavailable states. Parameters related to the time interval between these derived threshold events and their frequency can be identified. These derived performance parameters describe the QOS and the NP for all time intervals; i.e. during periods when the service or connection is available or unavailable.

Note — Primary performance parameters are measured for all time intervals, since the transitions between available and unavailable states depend upon the value of these parameters. However, the values of primary performance parameters would not be specified for a service or connection in the unavailable state.

4 Generic performance parameters

Nine generic primary performance parameters are listed below. These have been developed as a result of the matrix approach described in Annex A. These parameters may be used in developing specific QOS and NP parameters:

— access speed;

— access accuracy;

— access dependability;

— information transfer speed;

— information transfer accuracy;

— information transfer dependability;

— disengagement speed;

— disengagement accuracy;

— disengagement dependability.

Section 3.4 defines derived performance parameters in addition to primary parameters. Derived performance parameters are determined utilizing a function of the primary performance parameter values. Recommendation G.821 defines one such function, which identifies transitions between available and unavailable states based on a threshold for severely errored seconds. The generic derived performance parameter associated with such a function is availability.

Examples of specific primary and derived performance parameters for bearer service QOS and those for circuit-switched and packet-switched NP are provided in Annex B.

ANNEX A

(to Recommendation I.350)

Method of identifying parameters

A.1 *The matrix approach*

The matrix provides a systematic method of identifying and organizing candidate network performance parameters with the objective of defining a concise set of parameters and, where appropriate, their QOS counterparts. This tool should be used as the basis for collection and evaluation of network performance parameters for digital networks, including ISDNs.

A.2 *3 × 3 matrix approach for network performance*

The 3 × 3 matrix approach for network performance is illustrated in Figure A-1/I.350. The main features are as follows:

1) Each row represents one of the three basic and distinct communication functions.

Note — The access function represents the connectionless as well as connection oriented services which are possible with ISDNs.

2) Each column represents one of the three mutually exclusive outcomes possible when a function is attempted.

3) The 3 × 3 matrix parameters are defined on the basis of events at connection element boundaries and are termed ‘‘primary performance parameters’’. ‘‘Derived performance parameters’’ are defined on the basis of a functional relationship of primary performance parameters, outage thresholds and an observation interval.

4) NP primary performance parameters should be defined so as to be measurable at the boundaries of the connection element(s) to which they apply. NP parameter definitions should not depend upon assumptions about impairment causes that are not detectable at the boundaries.

5) Availability is a derived performance parameter. Decisions on the appropriate primary performance parameters, outage threshold and algorithms for its definition require further detailed study.

Note — The following terminology problems are pointed out. Appropriate terms should be selected after further study:

a) the term ‘‘access’’ is used. However, the term ‘‘selection (of the connection type, the destination and facility)’’ has been proposed as an alternative.

b) The term ‘‘ dependability ´definition of dependability as used here is somewhat different from that in Recommendation G.106 *(Red Book)* . Alternative terms, ‘‘inserveability’’ and ‘‘refusal’’ are proposed.

c) The term ‘‘availability’’ is provisionally used. An alternative term ‘‘acceptability’’ has been proposed.

Figure A-1/I.350, (N), p.

A.3 *3 × 3 matrix approach for QOS*

The same 3 × 3 matrix approach as that described for network performance may be used for the related Quality of Service parameters.

QOS parameters should be defined so as to be measurable at service access points. QOS parameter definitions should not depend upon assumptions of impairment causes that are not detectable at the service access points.

Loss of service parameters are considered to be derived QOS parameters. An alternative matrix has been proposed and is still under consideration.

A.4 *Description of the basic communication functions*

A.4.1 *Access*

The access function begins upon issuance of an access request signal or its implied equivalent at the interface between a user and the communication network. It ends when either:

1) a ready for data or equivalent signal is issued to the calling users, or

2) at least one bit of user information is input to the network (after connection establishment in connection-oriented services).

It includes all activities traditionally associated with physical circuit establishment (e.g. dialling, switching, and ringing) as well as any activities performed at higher protocol layers.

A.4.2 *User information transfer*

The user information transfer begins on completion of the access function, and ends when the ‘‘disengagement request’’ terminating a communication session is issued. It includes all formatting, transmission, storage, error control and media conversion operations performed on the user information during this period, including necessary retransmission within the network.

A.4.3 *Disengagement*

There is a disengagement function associated with each participant in a communication session: each disengagement function begins on issuance of a disengagement request signal. The disengagement function ends, for each user, when the network resources dedicated to that user’s participation in the communication session have been released. Disengagement includes both physical circuit disconnection (when required) and higher-level protocol termination activities.

A.5 *Description of the performance*

A.5.1 *Speed*

Speed is the performance criterion that describes the time interval that is used to perform the function or the rate at which the function is performed. (The function may or may not be performed with the desired accuracy.)

A.5.2 *Accuracy*

Accuracy is the performance criterion that describes the degree of correctness with which the function is performed. (The function may or may not be performed with the desired speed.)

A.5.3 *Dependability*

Dependability is the performance criterion that describes the degree of certainty (or surety) with which the function is performed regardless of speed or accuracy, but within a given observation interval.

ANNEX B

(to Recommendation I.350)

Relationship between generic and possible specific QOS and NP parameters

This Annex illustrates the qualitative relationship between the generic parameters defined in this Recommendation and a candidate set of specific QOS and NP parameters. Tables B-1/I.350, B-2/I.350 and B-3/I.350 illustrate the relationship between the generic parameters and specific bearer service QOS, circuit-switched NP, and packet-switched NP parameters, respectively.

Blanc

TABLE B-1/I.350
{
**Qualitative relationship between generic performance parameters
and candidate bearer service QOS parameters**
}

{	{ {										
	Access speed	X									
Access accuracy		X									
Access dependability			X								
Information transfer speed	X	X									
Primary	Information transfer accuracy	X	X	X							
{ Information transfer dependability }									X		
Disengagement speed										X	
Disengagement accuracy	X										
	Disengagement dependability										
Derived	Availability										

Tableau B-1/I.350 [T2.350], ITALIENNE p.15

H.T. [T3.350]

TABLE B-2/I.350
{
Qualitative relationship between generic performance parameters and candidate circuit-switched NP parameters
}

{	{ {										
	Access speed	X	X								
Access accuracy			X								
Access dependability				X							
{ Information transfer speed }	X										
Primary	Information transfer accuracy	X	X	X							
{ Information transfer dependability }											
Disengagement speed									X	X	
Disengagement accuracy	X										
	Disengagement dependability										
Derived	Availability										

Tableau B-2/I.350 [T3.350] ITALIENNE, p.16

TABLE B-3/I.350

{

Qualitative relationship between generic performance parameters and candidate packet-switched NP parameters

}

{	{ {										
	Access speed	X									
Access accuracy		X									
Access dependability			X								
{ Information transfer speed }	X	X									
Primary	Information transfer accuracy	X	X	X							
{ Information transfer dependability }						X	X	X			
Disengagement speed									X		
Disengagement accuracy											
	Disengagement dependability										X
Derived	Availability										

Tableau B-3/I.350 [T4.350], ITALIENNE p.17

Recommendation I.351

RECOMMENDATIONS IN OTHER SERIES CONCERNING NETWORK PERFORMANCE | OBJECTIVES

THAT APPLY AT REFERENCE POINT T OF AN ISDN

(Melbourne, 1988)

The following Recommendations of the G-Series are applicable to reference point T of an ISDN:

G.821 Error performance of an international digital connection forming part of an integrated services digital network.

G.822 Controlled slip rate objectives on an international digital connection.

Recommendation I.352

NETWORK PERFORMANCE OBJECTIVES FOR CONNECTION PROCESSING DELAYS | IN AN ISDN

(Melbourne, 1988)

1 General

1.1 *Reference model*

This Recommendation provides network performance objectives for connection processing delays. The reference model provided in Recommendation I.340 was used to provide a baseline reference configuration. In addition, Recommendation Q.709 was taken into account in the determination of values.

Note — This Recommendation does not take into account the performance of private networks. In case of private networks connected to the ISDN, the recommended values refer to reference point T. Reference point S applies in cases where S and T are coincident.

1.2 *Measurement*

All parameter values are specified at network boundaries. These values are measured at the ISDN S/T reference points using all processing message transfer events (MTEs) (Recommendation Q.931 messages or the corresponding Signalling System No. 7 messages), where appropriate.

1.3 *Network conditions*

The values for delay given in this Recommendation include an allowance for the effects on delay that might be introduced during a nominal busy hour. 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.

1.4 *User delay*

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

1.5 *Allocation*

Overall connection processing delays between S/T reference points can be divided into sub-values for each connection element including the national and international portions.

1.6 *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 (see Figure 1/I.352).

Figure 1/I.352, (N), p.

1.7 *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 design objectives in 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 initially, based on observations at a single connection element boundary, B_i as shown in Figure 2/I.352, and then between two connection element boundaries ($B_{i, j}$). In the former case, the connection set-up delay includes the delay for all connection elements on the called user side of B_i and the terminal device. In the latter case, the connection set-up delay includes only the delay between B_i and B_j.

Figure 2/I.352, (N), p.

3.1.1.1 *Definition of connection set-up delay observed at a single connection element boundary*

connection set-up delay at a single connection element boundary, B↓i , is defined using two call processing message transfer events (MTEs). Table 1/I.352 identifies the message transfer events and the resulting call states for I.451(Q.931) connection processing messages. Table 2/I.352 identifies the message transfer events and the resulting call states for the relating Signalling System No. 7 user-part messages defined in Recommendation Q.762. Connection set-up delay is the length of time that starts when a

SETUP or the last address information message creates a message transfer event at B_i; and ends when the corresponding CONNECT message returns and creates its message transfer event at B_i.

Connection set-up delay observed at a single connection element boundary = (t_2 — t_1).

where

t_1 is the time of occurrence of the starting message transfer event

t_2 is the time of occurrence of the ending message transfer event.

The transfer of the I.451(I.931) messages and their corresponding user-part messages of Signalling System No. 7 is shown in Figure 3/I.352 along with connection element boundaries. The specific message transfer events used in measuring connection set-up delay are shown in Table 3/I.352.

Note — ‘‘Set-up’’ does not imply a through connection or that capability for information transfer has been established.

3.1.1.2 *Definition of connection set-up delay between two connection element boundaries*

The **connection set-up delay between two connection element boundaries** can be measured at one connection element boundary, B_1, and then measured at another boundary, B_2, from the distant calling S/T interface. The difference in the values obtained is the connection set-up delay contributed by the connection elements between two boundaries.

Connection set-up delay between two boundaries = (d_1 — d_2)

where

d_1 is the connection set-up delay at B_1,

d_2 is the connection set-up delay at B_2.

The overall connection set-up delay is the connection set-up delay between the two S/T interfaces, e.g. B_1 and B_n in Figure 2/I.352. 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 boundaries 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 4/I.352.

The allocation of the connection set-up delay among the elements of the connections are for further study.

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.

3.1.2.1 *Definition of alerting delay observed at a single connection element boundary*

alerting delay at a single element boundary, B↓i , is defined as the length of time that starts when a SETUP or the last address information message creates a message transfer event at B_i, and ends when the corresponding ALERTing message returns and creates its message transfer event at B_i.

Alerting delay observed at a single connection element boundary = (t_2 — t_1)

where

t_1 is the time of occurrence for the starting message transfer event,

t_2 is the time of occurrence for the ending message transfer event.

The specific message transer events used in measuring alerting delay are shown in Table 5/I.352.

H.T. [T1.352]

TABLE 1/I.352

Message transfer events based on Rec. I.451 layer 3 messages

No.	Layer 3 message	Message flow	Event	Resulting state
1	SET-UP	u - n	Entry	N1 (Call initiated)
2	SET-UP	n - u	Exit	N6 (Call present)
3	SET-UP ACKnowledge	u - n	Entry	N25 (Overlap receiving)
4	SET-UP ACKnowledge	n - u	Exit	N2 (Overlap sending)
5	INFOrmation	u - n	Entry	N2 (Overlap sending)
6	CALL PROCeeding	u - n	Entry	N9 (Incoming call proceeding)
7	CALL PROCeeding	n - u	Exit	N3 (Outgoing call proceeding)
8	ALERTing	u - n	Entry	N7 (Call receive)
9	ALERTing	n - u	Exit	N4 (Call delivered)
10	CONNect	u - n	Entry	N8 (Connect request)
11	CONNect	n - u	Exit	N10 (Active)
12	CONNect ACKnowledge	u - n	Entry	N10 (Active)
13	CONNect ACKnowledge	n - u	Exit	N10 (Active)
14	DISConnect	u - n	Entry	N11 (Disconnect request)
15	DISConnect	n - u	Exit	N12 (Disconnect indication)
16	RELease	n - u	Exit	N19 (Release request)
17	RELease COMplete	u - n	Entry	N0 (Null)
18	RELease COMplete	n - u	Exit	N0 (Null)

u - n user to network

n - u network to user

Note — The terminology for message flow is given in Rec. I.451.

Tableau 1/I.352 [T1.352], p.20

H.T. [T2.352]

TABLE 2/I.352

Message transfer events based on Rec. Q.764

No.	Signalling System No. 7 message	Direction a)	Event	Resulting state
S1	Initial address (IAM)	Outgoing	Entry	Wait for ACM (2)
S2	Initial address (IAM)	Incoming	Exit	Wait for OGC select (2)
S3	Address complete (ACM)	Outgoing	Exit	Wait for answer (3)
S4	Address complete (ACM)	Incoming	Entry	Wait for answer (5)
S5	Answer (ANS)	Outgoing	Exit	OGC answered (4)
S6	Answer (ANS)	Incoming	Entry	ICC answered (4)
S7	Release (REL)	Outgoing	Entry	Wait for RLC (7)
S8	Release (REL)	Incoming	Exit	Wait for RLC (9)
S9	Release complete (RLC)	Outgoing	Exit	Idle (0)
S10	Release complete (RLC)	Incoming	Entry	Idle (0)

OGC Outgoing trunk circuit

ICC Incoming trunk circuit

a) The connection processing control states have been divided into those used in incoming and outgoing circuit handling. The usage of the term direction in this contex refers to the direction of the connection

Tableau 2/I.352 [T2.352], p.21

Blanc

Figure 3/I.352, (N), p.30

H.T. [T3.352]

TABLE 3/I.352

Message transfer events for measuring connection set-up delay

Connection element boundary	Message transfer event Starting event number	 Ending event number
Calling S/T interface 1 (en bloc) or 5 (overlap sending) }	{ 11	
Called S/T interface	**S** 2	10

{
Access/national transit (originating)
}
	S1	S5

{
Access/national transit (terminating)
}
	S2	S6

{
National/international transit (originating)
}
	S2	S6

{
National/international transit (terminating)
}
	S1	S5

Note — En bloc and overlap sending options at the calling S/T interface.

Tableau 3/I.352 [T3.352], p.22

H.T. [T4.352]

TABLE 4/I.352

Overall connection set-up delay

ISDN connection type	Statistic	Connection set-up delay
{	Mean 95%	4500 ms | ua) 8350 ms[a)]

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

Note 1 — The values take into account worst case situations such as the longest length reference connection (27 500 km) as specified in Recommendation G.104.

The values observed will be dominated by the number of exchanges in a connection. For the moderate length reference connection (11 000 km), the observed values will be lower.

Note 2 — Delays are specified for a nominal busy hour.

Note 3 — Connection set-up attempts which exceed a specified timeout value are excluded in computing these statistics and are counted separately as connection set-up denials.

Note 4 — In this table, the relevant ISDN connection types given in Table 2/I.340 are specified.

Note 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 S/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.

Note 6 — The values take into account the additional signalling points for the 95% case of the hypothetical signalling reference connection in Recommendation Q.709.

Note 7 — The delay objectives in the table are primarily applicable to connections provided exclusively over ISDNs, i.e. no interworking.

Note 8 — The connection set-up and disconnected 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 tables are applicable for both circuit-mode voice and circuit-mode data with no interworking. However, the observed delay performance may not be identical due to network architectural differences and interworking.

Tableau 4/I.352 [T4.352], p.23

Blanc

H.T. [T5.352]

TABLEAU 5/I.352

Message transfer events for measuring alerting delay

Connection element boundary	Message transfer event Starting event number	Ending event number
Calling S/T interface 1 (en bloc) or 5 (overlap sending) }	{ **S** 9	
Called S/T interface	**S** 2	**S** 6

{
Access/national transit (originating)
}
	S1	S3

{
Access/national transit (terminating)
}
	S2	S4

{
National/international transit (originating)
}
	S2	S4

{
National/international transit (terminating)
}
	S1	S3

Note — En bloc and overlap sending options at the calling S/T interface.

Tableau 5/I.352 [T5.352], p.24

3.1.2.2 *Definition of alerting delay between two connection element boundaries*

The **alerting delay between two connection element boundaries** can be measured at one connection element boundary, B_i, and then measured at another boundary, B_j, further from the calling S/T interface. The difference in the values obtained is the alerting delay contributed by the connection elements between the two boundaries.

Alerting delay between two connection element boundaries = $(d_i — d_j)$

where

d_i is the alerting delay measured at B_i,

d_j is the alerting delay measured at B_j.

The overall alerting delay is the alerting delay between the two S/T interfaces, B_1 and B_n in Figure 1/I.352 for the reference configuration types in Recommendation 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 boundaries delimiting that connection element.

3.1.2.3 *Alerting delay specification*

The overall alerting delay should not exceed the values given in Table 6/I.352.

The allocation of the alerting delay among the elements of the connections are for further study.

H.T. [T6.352]
TABLE 6/I.352
Overall alerting delay

ISDN connection type	Statistic	Alerting delay
{	Mean 95%	4500 ms | ua) 8350 ms[a)]

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

Note 1 — The values take into account worst case situations such as the longest length reference connection (27 500 km) as specified in Recommendation G.104.

The values observed will be dominated by the number of exchanges in a connection. For the moderate length reference connection (11 000 km) the observed values will be lower.

Note 2 — Delays are specified for a nominal busy hour.

Note 3 — Connection set-up attempts which exceed a specified timeout value are excluded in computing these statistics and are counted separately as connection set-up denials.

Note 4 — In this table the relevant ISDN connection types given in Table 2/I.340 are specified.

Note 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 S/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.

Note 6 — The values take into account the additional signalling points for the 95% case of the hypothetical signalling reference connection in Recommendation Q.709.

Note 7 — The delay objectives in the table are primarily applicable to connections provided exclusively over ISDNs, i.e. no interworking.

Note 8 — The connection set-up 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 tables are applicable for both circuit-mode voice and circuit-mode data with no interworking. However, the observed delay performance may not be identical due to network architectural differences and interworking.

Tableau 6/I.352 [T6.352], p.

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 be cleared party. Therefore, this parameter requires observations at two connection element boundaries.

3.2.1.1 *Definition of disconnect delay between two connection element boundaries*

Disconnect delay between two connection element boundaries, B↓i and B↓j , is defined as the length of time that starts when a DISConnect message creates a message transfer event at B_i and ends when that DISConnect message creates a message transfer event at B_j, further from the clearing party S/T interface.

Disconnect delay between two connection element boundaries = $(t_2 — t_1)$

where

t_1 is the time of occurrence for the message transfer event at B_i,

t_2 is the time of occurrence for the message transfer event at B_j.

The overall disconnect delay is the disconnect delay between two S/T interfaces, B_1 and B_n in Figure 1/I.352 for the reference configuration types in Recommendation I.340. The disconnect delay for a connection element is the disconnect delay between the boundaries delimiting that connection element. The specific message transfer events used in measuring disconnect delay are shown in Table 7/I.352.

H.T. [T7.352]
TABLE 7/I.352
Message transfer events for measuring disconnect delay

Connection element(s)	{ Starting event number	Ending event number
S/T to S/T interface	14 (Clearing end)	15 (Cleared end)
National transit S8 (National/international transit) }	S7 (Access/national transit)	{
International transit S8 (National/international transit) } S7 (International/national transit) }	{ {	

Tableau 7/I.352 [T7.352], p.

3.2.1.2 *Disconnect delay specification*

The overall disconnect delay should not exceed the values given in Table 8/I.352.

The disconnect delay values for connection elements are for further study.

3.2.2 *Release delay*

Release delay is defined only at the clearing party S/T interface.

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 message transfer event at the clearing party S/T interface and ends when the RELease message creates a message transfer event at the same interface.

Release delay at the clearing part S/T interface = (t_2 — t_1)

where

t_1 is the time of occurrence for the starting message transfer event,

t_2 is the time of occurrence for the ending message transfer 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 specific message transfer events used in measuring release delay are shown in Table 9/I.352.

H.T. [T8.352]

TABLE 8/I.352

Disconnect delay

ISDN connection type	Statistic	Disconnect delay
{	Mean 95 %	2700 ms[a)] 4700 ms[a)]

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

Note 1 — The values take into account worst case situation such as the longest length reference connection (27 500 km) as specified in Recommendation G.104.

The values observed will be dominated by the number of exchanges in a connection. For the moderate length reference connection (11 000 km) the observed values will be lower.

Note 2 — Delays are specified for a nominal busy hour.

Note 3 — In this table the relevant ISDN connection types given in Table 2/I.340 are specified.

Note 4 — The values take into account the additional signalling points for the 95% case of the hypothetical signalling reference connection in Recommendation Q.709.

Note 5 — The delay objectives in the table are primarily applicable to connections provided exclusively over ISDNs, i.e. no interworking.

Note 6 — The connection set-up 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 tables are applicable for both circuit-mode voice and circuit-mode data with no interworking. However, the observed delay performance may not be identical due to network architectural differences and interworking.

Tableau 8/I.352 [T8.352], p.27

Blanc

H.T. [T9.352]
TABLE 9/I.352
Message transfer events for measuring release delay

Connection element boundary	Message transfer event	
	Starting event number	Ending event number
Clearing party S/T	14	16
Cleared party S/T	Not applicable	Not applicable
Access/National transit	Not applicable	Not applicable
{ National/international transit }	Not applicable	Not applicable

Tableau 9/I.352 [T9.352], p.28

3.2.2.2 *Release delay specification*

The release delay should not exceed the values given in Table 10/I.352.

H.T. [T10.352]
TABLE 10/I.352
Release delay

ISDN connection type	Statistic	Release delay
{	Mean 95%	300 ms | ua) 850 ms | ua)

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

Note 1 — The delay objectives in the table are primarily applicable to connections provided exclusively over ISDNs, i.e. no interworking.

Note 2 — The connection set-up 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 tables are applicable for both circuit-mode voice and circuit-mode data with no interworking. However, the observed delay performance may not be identical due to network architectural differences and interworking.

Tableau 10/I.352 [T10.352], p.29