INTERNATIONAL TELECOMMUNICATION UNION

ITU-T

TELECOMMUNICATION
STANDARDIZATION SECTOR
OF ITU

I.353

(08/96)

SERIES I: INTEGRATED SERVICES DIGITAL NETWORK

Overall network aspects and functions – Performance objectives

---

Reference events for defining ISDN and B-ISDN performance parameters

ITU-T Recommendation I.353

(Previously CCITT Recommendation)

ITU-T I-SERIES RECOMMENDATIONS

INTEGRATED SERVICES DIGITAL NETWORK

GENERAL STRUCTURE	I.100–I.199
Terminology	I.110–I.119
Description of ISDNs	I.120–I.129
General modelling methods	I.130–I.139
Telecommunication network and service attributes	I.140–I.149
General description of asynchronous transfer mode	I.150–I.199
SERVICE CAPABILITIES	I.200–I.299
Scope	I.200–I.209
General aspects of services in ISDN	I.210–I.219
Common aspects of services in the ISDN	I.220–I.229
Bearer services supported by an ISDN	I.230–I.239
Teleservices supported by an ISDN	I.240–I.249
Supplementary services in ISDN	I.250–I.299
OVERALL NETWORK ASPECTS AND FUNCTIONS	I.300–I.399
Network functional principles	I.310–I.319
Reference models	I.320–I.329
Numbering, addressing and routing	I.330–I.339
Connection types	I.340–I.349
Performance objectives	**I.350–I.359**
Protocol layer requirements	I.360–I.369
General network requirements and functions	I.370–I.399
ISDN USER-NETWORK INTERFACES	I.400–I.499
Application of I-series Recommendations to ISDN user-network interfaces	I.420–I.429
Layer 1 Recommendations	I.430–I.439
Layer 2 Recommendations	I.440–I.449
Layer 3 Recommendations	I.450–I.459
Multiplexing, rate adaption and support of existing interfaces	I.460–I.469
Aspects of ISDN affecting terminal requirements	I.470–I.499
INTERNETWORK INTERFACES	I.500–I.599
MAINTENANCE PRINCIPLES	I.600–I.699
B-ISDN EQUIPMENT ASPECTS	I.700–I.799
ATM equipment	I.730–I.749
Management of ATM equipment	I.750–I.799

For further details, please refer to ITU-T List of Recommendations.

ITU-T RECOMMENDATION I.353

REFERENCE EVENTS FOR DEFINING ISDN AND B-ISDN PERFORMANCE PARAMETERS

Summary

This Recommendation is one of the Recommendations (I.350, I.351 and I.353) that define general aspects of ISDN performance and provide a basis for the definition of specific performance parameters and values in other I-Series and G-Series Recommendations.

The ISDN performance parameters are defined in terms of reference events which can be observed at physical measurement points within an ISDN connection. This Recommendation defines the relevant measurement points and associated performance-significant ISDN reference events.

Source

ITU-T Recommendation I.353 was revised by ITU-T Study Group 13 (1993-1996) and was approved under the WTSC Resolution No. 1 procedure on the 27th of August 1996.

Keywords

B-ISDN, bit synchronization, entry event, errored bit, exit event, measurement point, performance, performance-significant reference event, reference event.

FOREWORD

ITU (International Telecommunication Union) is the United Nations Specialized Agency in the field of telecommunications. The ITU Telecommunication Standardization Sector (ITU-T) is a permanent organ of the ITU. 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, establishes the topics for study by the ITU-T Study Groups which, in their turn, produce Recommendations on these topics.

The approval of Recommendations by the Members of the ITU-T is covered by the procedure laid down in WTSC Resolution No. 1 (Helsinki, March 1-12, 1993).

In some areas of information technology which fall within ITU-T's purview, the necessary standards are prepared on a collaborative basis with ISO and IEC.

NOTE

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

CONTENTS

		Page
1	Scope	1
2	References	1
3	Terms and definitions	2
4	Abbreviations	4
5	Performance-significant reference events	5
5.1	Recommendation Q.931 (Recommendation I.451)	6
5.2	Recommendation Q.921	6
5.3	X.25 layer 2 (LAPB)	8
5.4	Recommendation Q.764	8
5.5	Frame switching	10
5.6	Frame relaying	10
5.7	Recommendations Q.2931 and Q.2971	10
5.8	Recommendation Q.2762	11
5.9	B-ISDN ATM layer	11
5.10	Unrestricted digital bearer services	13
	5.10.1 Performance-significant reference events	13
	5.10.2 The relevant bit of user information	13

Recommendation I.353

REFERENCE EVENTS FOR DEFINING ISDN AND B-ISDN PERFORMANCE PARAMETERS

(revised in 1996)

1 Scope

This Recommendation defines the measurement points where the performance of ISDNs and B-ISDNs should be evaluated. It defines the performance-significant reference events that can observed at those measurement points. Specifically, this Recommendation specifies the reference events used in evaluating:

– ISDN call processing performance.

– B-ISDN X.25 packet performance.

– Frame switching performance.

– Frame relaying performance.

– B-ISDN call processing performance.

– B-ISDN ATM cell transfer performance.

– Unrestricted digital bearer service performance.

2 References

The following Recommendations and other references contain provisions which, through reference in this text, constitute provisions of this Recommendation. At the time of publication, the editions indicated were valid. All Recommendations are subject to revision; all users of this Recommendation are therefore encouraged to investigate the possibility of applying the most recent edition of the Recommendations listed below. A list of the currently valid ITU-T Recommendations is regularly published.

[1] ITU-T Recommendation I.350 (1993), *General aspects of quality of service and network performance in digital networks, including ISDNs*.

[2] ITU-T Recommendation I.351 (1993), *Relationships among ISDN performance Recommendations*.

[3] ITU-T Recommendation I.356 (1996), *B-ISDN ATM layer cell transfer performance.*

[4] ITU-T Recommendation I.361 (1995), *B-ISDN ATM layer specification.*

[5] ITU-T Recommendation I.430 (1995), *Basic user-network interface – Layer 1 specification.*

[6] ITU-T Recommendation I.451 (1993), *ISDN user-network interface layer 3 specification for basic call control*.

[7] ITU-T Recommendation I.570 (1993), *Public/private ISDN interworking*.

[8] ITU-T Recommendation Q.764 (1993), *Signalling System No. 7 – ISDN user part signalling procedures*.

[9] ITU-T Recommendation Q.921 (1993), *ISDN user-network interface – Data link layer specification*.

[10] ITU-T Recommendation Q.931 (1993), *Digital subscriber Signalling System No. 1 (DSS 1) – ISDN user-network interface layer 3 specification for basic call control.*

[11] ITU-T Recommendation Q.2762 (1995), *General functions of messages and signals of the B-ISDN user part (B-ISUP) of Signalling System No. 7.*

[12] ITU-T Recommendation Q.2931 (1995), *Digital subscriber Signalling System No. 2 (DSS 2). User-network interface (UNI) layer 3 specification for basic call/connection control.*

[13] ITU-T Recommendation Q.2971 (1995), *Digital subscriber Signalling System No. 2 – User-network interface layer 3 specification for point-to-multipoint call/connection control.*

[14] ITU-T Recommendation X.25 (1996), *Interface between Data Terminal Equipment (DTE) and Data Circuit-terminating Equipment (DCE) for terminals operating in the packet mode and connected to public data networks by dedicated circuit.*

[15] ITU-T Recommendation X.75 (1995), *Packet-switched signalling system between public networks providing data transmission services.*

[16] CCITT Recommendation X.134 (1992), *Portion boundaries and packet layer reference events: basis for defining packet-switched performance parameters.*

3 Terms and definitions

For the purposes of ISDN performance Recommendations, the following definitions apply.

3.1 measurement point (MP): A measurement point is located at an interface that separates either customer equipment/customer network (CEQ) or a Switching/Signalling Node (SSN) from an attached transmission system at which ITU-recommended protocols can be observed.

NOTES

1 The term SSN collectively denotes any equipment that accesses the connection in the transport network under consideration.

2 With regard to the definitions of customer equipment and customer network, see Recommendations I.430 and I.570 respectively.

3 As defined, MPs exist at many physical interfaces in a connection. It is not the intention in these Recommendations to specify performance between arbitrary pairs of MPs – particularly pairs within a nation. These Recommendations will only specify the performance of portions delimited by MPTs and MPIs.

4 Recommendation I.356 locates MPs within the ATM interfaces, see 5.9.

3.2 measurement point T (MPT): A measurement point T is located at an interface associated with a T reference point. This interface separates CEQ from an attached digital section.

In order to delimit clearly the national portion and its allocation of performance, the MPT is located at the point that marks the limit of the public network operator's responsibility. This may be different from the ideal location for observing the ITU-recommended protocols. For example, in B-ISDN, the ideal MPs are within the ATM layer. Since a given ATM layer (VP and/or VC) is likely to terminate within CEQ, ATM events will not be directly observable at those termination points.

Two practical methods for measuring at the MPT are:

i) locating a physical test set at the MPT and replicating the relevant protocol layers outside of the CEQ; or

ii) approximating the performance at the MPT by observations made at the nearest convenient point within the network.

3.3 measurement point I (MPI): A measurement point I is located at an interface that terminates a transmission system at an International Switching Centre (ISC). The exact location of the MPI depends on the connection type and is specified, for each connection type, in the associated Network Performance Recommendation (see Note). For each MPT within a nation, the set of *associated MPIs* is the set of MPIs within the same nation. MPTs and individual associated MPIs delimit portions of an end-to-end ISDN connection for which performance objectives are specified[1].

NOTE – The MPT and MPI for B-ISDN are defined in 5.9.

3.4 ISDN reference event: An ISDN reference event is the transfer of a discrete unit of control or user information encoded in accordance with ITU-recommended protocols across an MP. Specified information units and associated resulting protocol states are identified by an event code used for reference in defining performance parameters. The resulting state in turn establishes which reference events can occur subsequently. Two classes of reference events are distinguished: exit events and entry events.

3.5 exit event: An exit event occurs when a unit of control or user information crosses the MP exiting the SSN or CEQ into the attached transmission system.

3.6 entry event: An entry event occurs when a unit of control or user information crosses the MP entering the SSN or CEQ from the attached transmission system.

If retransmissions occur, the exit event occurs with the first transmission and the entry event occurs with the last transmission.

NOTE – For practical measurement purposes, reference events can be observed at a physical location that differs from the actual MP. This physical location should, however, be as near as possible to the MP. In cases where reference events are monitored at a physical interface, the time of occurrence of an actual exit event can best be approximated by the observation of the first bit of the unit of control or user information out of the SSN or CEQ. The time of occurrence of an entry event can best be approximated by the observation of the last bit of the unit of control or user information into the SSN or CEQ.

Figures 1 and 2 illustrate these concepts.

---

[1] The differences in MPI location among connection types are a result of the need to ensure consistency between the emerging ISDN performance Recommendations and existing Recommendations that specify the performance of service-dedicated networks. As circuit mode, packet mode, and other transfer capabilities are more fully integrated into ISDNs, it may be possible to identify common measurement points.

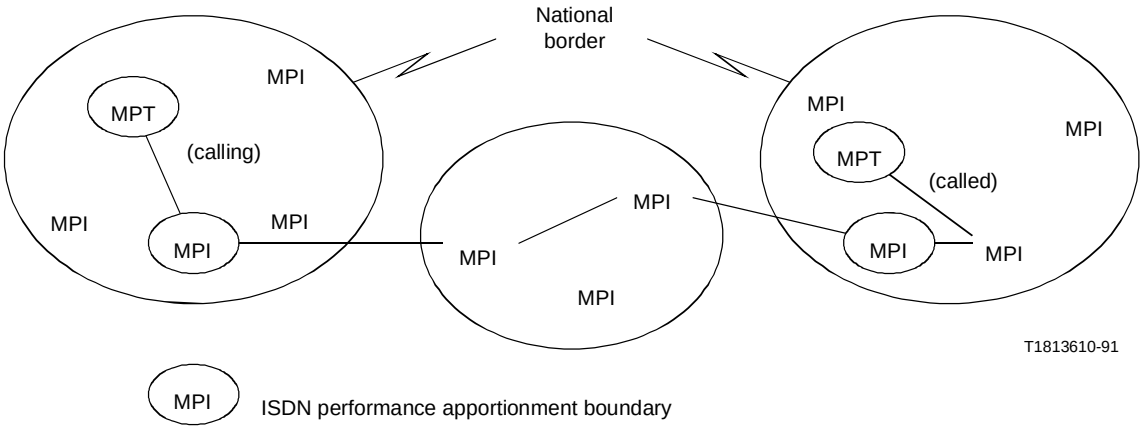


FIGURE 1/I.353

Example ISDN connection showing associated performance apportionment boundaries

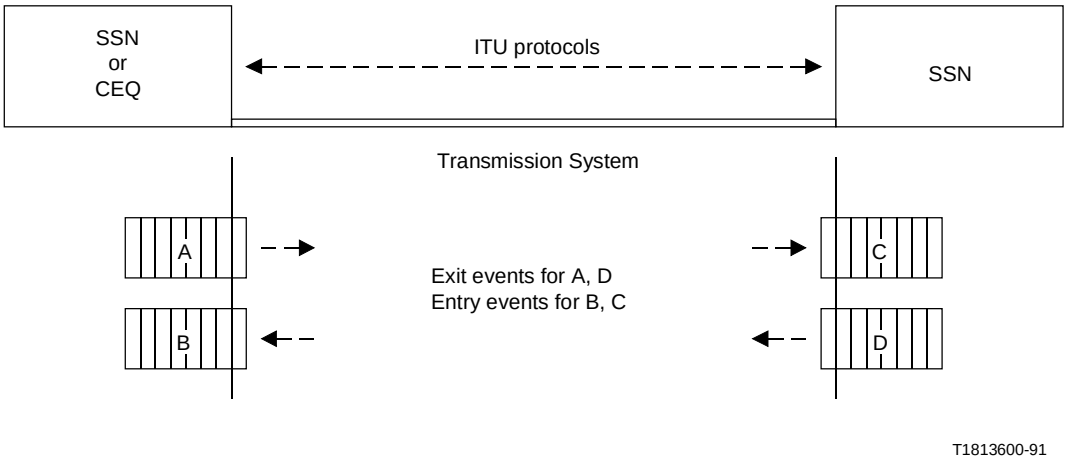


FIGURE 2/I.353

Entry and exit events

4 Abbreviations

For the purposes of this Recommendation the following abbreviations are used.

AAL ATM Adaptation Layer

ATM Asynchronous Transfer Mode

CEQ Customer equipment/customer network

HEC Header Error Control

ISC International Switching Centre

MP Measurement Point

MPI Measurement Point I

MPT Measurement Point T

SSN Switching/Signalling Node

VC Virtual Channel

VCI Virtual Channel Identifier

VP Virtual Path

VPI Virtual Path Identifier

5 Performance-significant reference events

Performance-significant reference events are those reference events useful in defining performance parameters. Table 1 identifies the Recommendations and subclauses of this Recommendation where the reference events useful for ISDN performance description are defined.

TABLE 1/I.353

References to information specifying performance-significant reference events

Protocol at MP	Reference
Rec. Q.931 (Rec. I.451)	5.1
Rec. Q.921	5.2
X.25 layer 3	Rec. X.134
X.25 layer 2 (LAPB)	5.3
Rec. X.75	Rec. X.134
Rec. Q.764	5.4
Frame switching	5.5
Frame relaying	5.6
Recs. Q.2931 and Q.2971	5.7
Rec. Q.2762	5.8
B-ISDN ATM layer	5.9
Unrestricted digital bearer services	5.10

In most cases, the definition of a performance-significant reference event depends on the interface state that results from the transfer of control or user information. If the resulting state is not the one listed in the relevant table, that reference event has not occurred. Aspects of the state other than those listed in these tables may change during entry or exit events, but those state changes are not viewed as having significance for performance description.

When the tables list more than one aspect of the state that might change as a result of a particular exit or entry event, each of those state changes represents distinct reference events that can be used in defining performance parameters. For example, in Table 1/X.134, event 9a would be used where the receipt of the data is relevant, and 9b would be used when the receipt of the acknowledgement is

relevant[2]. Event 26b would be used in association with permanent virtual circuits and 26a with other logical channels.

5.1 Recommendation Q.931 (Recommendation I.451)

Table 2 lists performance-significant reference events associated with the Q.931 protocol. The table entries are:

– event identification code;

– type of Q.931 layer 3 message transferred; and

– resulting state of the Q.931 layer 3 interface.

The unit of information transferred is the layer 2 frame carrying the Q.931 layer 3 message.

TABLE 2/I.353

Performance-significant reference events based on Q.931 (I.451) layer 3 message transfer

Code	Layer 3 message	Resulting state
P1a	SETUP	N1 (Call Initiated)
P1b	SETUP	N6 (Call Present)
P2a	SETUP ACKnowledge	N25 (Overlap Receiving)
P2b	SETUP ACKnowledge	N2 (Overlap Sending)
P3	INFOrmation	N2 (Overlap Sending)
P4a	CALL PROCeeding	N9 (Incoming Call Proceeding)
P4b	CALL PROCeeding	N3 (Outgoing Call Proceeding)
P5a	ALERTing	N7 (Call Receive)
P5b	ALERTing	N4 (Call Delivered)
P6a	CONNect	N8 (Connect Request)
P6b	CONNect	N10 (Active)
P7	CONNect ACKnowledge	N10 (Active)
P8a	DISConnect	N11 (Disconnect Request)
P8b	DISConnect	N12 (Disconnect Indication)
P9	RELease	N19 (Release Request)
P10	RELease COMplete	N0 (Null)
NOTE – Reference events coded "a" represent messages transferred from the user to the network. Reference events coded "b" represent messages transferred from the network to the user.		

5.2 Recommendation Q.921

Table 3 lists performance-significant reference events associated with the Q.921 protocol. The table entries are:

– event identification code;

---

[2] In the case of packet communications, the virtual connection section boundaries defined in Recommendation X.134 are the relevant measurement points.

– type of Q.921 layer 2 frame transferred; and

– resulting state of the Q.921 layer 2 interface.

The unit of information transferred is the layer 2 frame.

TABLE 3/I.353

Performance-significant reference events based on Q.921 layer 2 frame transfer

Code	Layer 2 frame	Resulting state (Note 1)
Q1a Q1b	I I	V(R) becomes N(S) + 1 V(A) becomes N(R)
Q2	RR	V(A) becomes N(R); PRB cleared
Q3	RNR	V(A) becomes N(R); PRB set
Q4	REJ	V(A) becomes N(R); PRB cleared
Q5	SABME	Awaiting Establishment
Q6	DM	TEI Assigned
Q7	UI	(Note 2)
Q8	DISC	Awaiting Release
Q9a Q9b	UA UA	Multiple Frame Established (Note 3) TEI Assigned (Note 4)
Q10	FRMR	Awaiting Establishment

I	Information
RR	Receiver Ready
RNR	Receiver Not Ready
REJ	Reject
SABME	Set Asynchronous Balanced Mode Extended
DM	Disconnect Mode
UI	Unnumbered Information
DISC	Disconnect
UA	Unnumbered Acknowledgement
FRMR	Frame Reject
V(R)	Receive State Variable
N(S)	Send Sequence Number
V(A)	Acknowledge State Variable
N(R)	Receive Sequence Number
PRB	Peer Receiver Busy
TEI	Terminal Endpoint Identifier

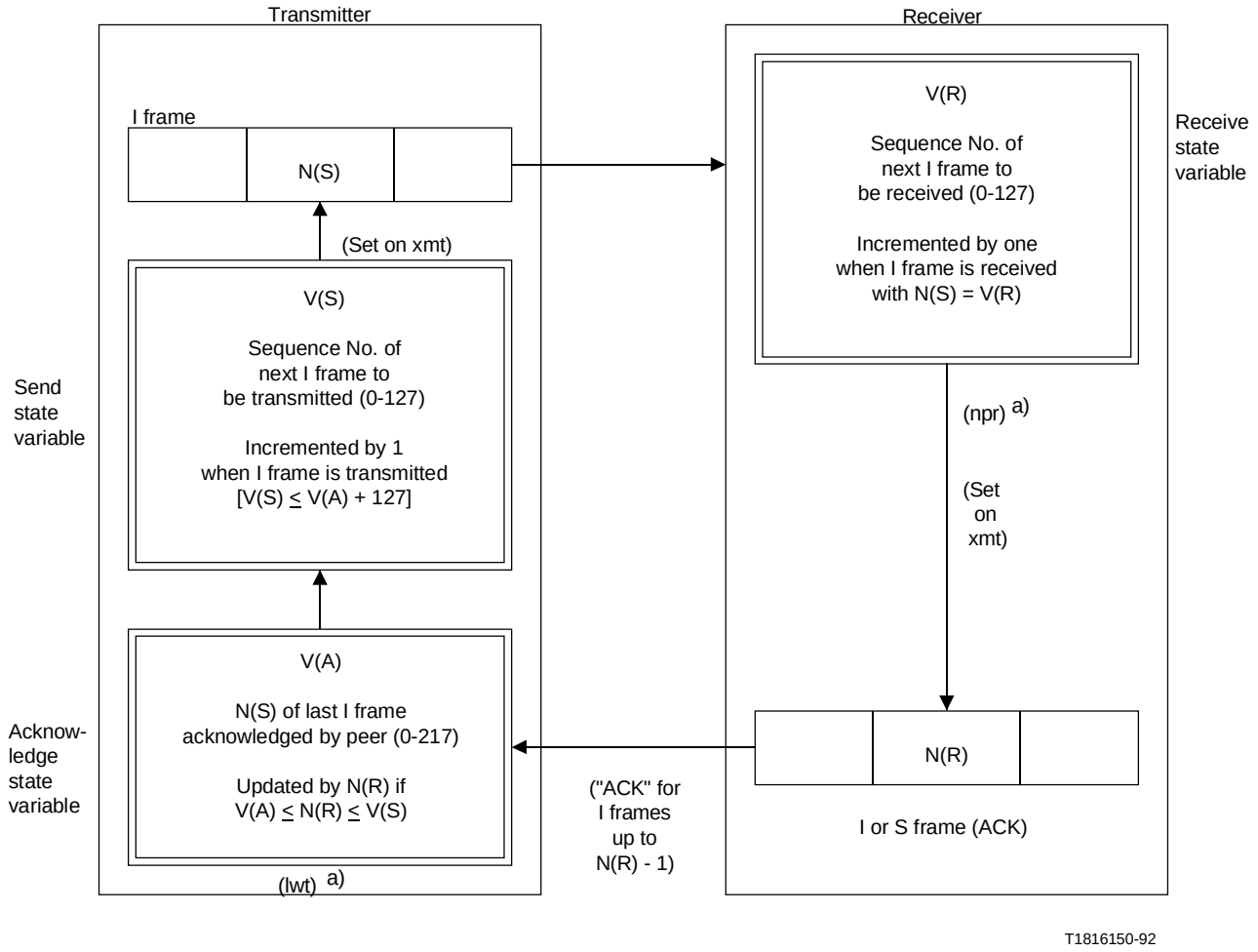
NOTES

1 Figure 3 defines the state variables used in frame flow control.

2 UI frames have no effect on the data link layer state variables defined in Recommendation Q.921. Their transmission and reception could be recorded by incrementing ancillary state variables if required for performance assessment purposes.

3 Q9a occurs in response to an SABME command. Q9b occurs in response to a DISC command.

4 Exchange Identification (XID) frames have no effect on the operational mode or state variables associated with data link layer entities.



a) Indicate corresponding Recommendation X.134 ancillary state variables.

FIGURE 3/I.353

Q.921 state variables used in frame flow control

5.3 X.25 layer 2 (LAPB)

Table 4 lists performance-significant reference events associated with the X.25 layer 2 (LAPB) protocol. The table entries are:

– event identification code;

– type of X.25 layer 2 (LAPB) frame transferred; and

– resulting state of the X.25 layer 2 interface.

The unit of information transferred is the layer 2 frame carrying the X.25 layer 3 message.

5.4 Recommendation Q.764

Table 5 lists performance-significant reference events associated with the Q.764 protocol. The table entries are:

– event identification code;

– type of Q.764 message transferred; and

– resulting state of the Q.764 interface, if applicable.

The unit of information transferred is the Q.764 message.

TABLE 4/I.353

Performance-significant reference events based on X.25 layer 2 (LAPB) frame transfer

Code	Layer 2 frame	Resulting state
B1a B1b	I I	V(R) becomes N(S) + 1 V(A) becomes N(R) (Note 1)
B2	RR	V(A) becomes N(R); PRB cleared (Note 1)
B3	RNR	V(A) becomes N(R); PRB set (Note 1)
B4	REJ	V(A) becomes N(R); PRB cleared (Note 1)
B5	SABM	Awaiting Establishment
B6	SABME	Awaiting Establishment
B7	DM	TEI Assigned
B8	DISC	Awaiting Release
B9a B9b	UA UA	Multiple Frame Established (Note 2) TEI Assigned (Note 2)
B10	FRMR	Awaiting Establishment

SABM Set Asynchronous Balanced Mode

NOTES

1 V(A) and PRB are ancillary state variables not explicitly defined in Recommendation X.25. With the appropriate notational changes, Figure 3 generally applies to the interpretation of Table 4.

2 B9a occurs in response to an SABM or SABME command. B9b occurs in response to a DISC command.

TABLE 5/I.353

Performance-significant reference events based on Q.764 message transfer

Code	Q.764 message	Resulting state
S1a S1b	Initial Address (IAM) Initial Address (IAM)	Wait for ACM Wait for OGC Select
S2a S2b	Address Complete (ACM) Address Complete (ACM)	Wait for Answer Wait for Answer
S3a S3b	Answer (ANS) Answer (ANS)	ICC Answered OGC Answered
S4a S4b	Release (REL) Release (REL)	Wait for RLC Wait for RLC
S5a S5b	Release Complete (RLC) Release Complete (RLC)	Idle Idle
S6a S6b	Circuit Reset Circuit Reset	– –
S7a S7b	Reset Reset	– –

OGC Outgoing trunk circuit

ICC Incoming trunk circuit

NOTE – Reference events coded "a" represent exit events. Reference events coded "b" represent entry events.

5.5 Frame switching

For further study.

5.6 Frame relaying

For further study.

5.7 Recommendations Q.2931 and Q.2971

Table 6 lists performance-significant reference events associated with the Q.2931 and Q.2971 protocols. The table entries are:

– event identification code;

– type of Q.2931 or Q.2971 message transferred.

The unit of information transferred is the Q.2931 or Q.2971 message.

TABLE 6/I.353

Performance-significant reference events based on Q.2931 and Q.2971 message transfer

Code	Q.2931/Q.2971 message
T1a T1b	SETUP (connection establishment) SETUP (connection establishment)
T2a T2b	CONNECT (connection establishment) CONNECT (connection establishment)
T3a T3b	RELEASE (connection release) RELEASE (connection release)
T4a T4b	RELEASE Complete (connection release confirmation) RELEASE Complete (connection release confirmation)
T5a T5b	ADD Party (additional party establishment) ADD Party (additional party establishment)
T6a T6b	ADD Party Ack (additional party confirmation) ADD Party Ack (additional party confirmation)
T7a T7b	DROP Party (party release) DROP Party (party release)
T8a T8b	DROP Party Ack (party release confirmation) DROP Party Ack (party release confirmation)
T9a T9b	ALERTING ALERTING
T10a T10b	PARTY ALERTING PARTY ALERTING
NOTE – Reference events coded "a" represent exit events. Reference events coded "b" represent entry events.	

5.8 Recommendation Q.2762

Table 7 lists performance-significant reference events associated with the Q.2762 protocol. The table entries are:

– event identification code;

– type of Q.2762 message transferred.

The unit of information transferred is the Q.2762 message.

TABLE 7/I.353

Performance-significant reference events based on Q.2762 message transfer

Code	Q.2762 message
U1a U1b	Initial Address Message (IAM-connection establishment) Initial Address Message (IAM-connection establishment)
U2a U2b	Answer (AN-connection establishment) Answer (AN-connection establishment)
U3a U3b	Release (REL-connection release) Release (REL-connection release)
U4a U4b	Release Complete (RLC-connection release confirmation) Release Complete (RLC-connection release confirmation)
U5a U5b	Initial Address Message (IAM-additional party establishment) Initial Address Message (IAM-additional party establishment)
U6a U6b	Answer (AN-additional party establishment) Answer (AN-additional party establishment)
U7a U7b	Release (REL-party release) Release (REL-party release)
U8a U8b	Release Complete (RLC-party release confirmation) Release Complete (RLC-party release confirmation)
U9a U9b	Address Complete (ACM) Address Complete (ACM)
NOTE – Reference events coded "a" represent exit events. Reference events coded "b" represent entry events.	

5.9 B-ISDN ATM layer

ATM cell transfer reference events are defined for a virtual connection. A VP is monitored at an MP where the VP layer is accessed, and a VC is monitored at an MP where the VC layer is accessed (see Figure 4). The MPs are above the (VP/VC) multiplexing and demultiplexing functions, but below any other (VP/VC) functions such as cell rate policing.

NOTE – For practical measurement purposes, ATM cell reference events can be observed at physical locations near the actual MP. See Note in 3.6 for further information.

In order to delimit clearly the national portion and its allocation of performance, the MPT for B-ISDN is located at the T_B reference point. This is different from the ideal location illustrated in Figure 4. Two practical methods for measuring at the B-ISDN MPT are:

i) locating a physical test set at the MPT and replicating the ATM protocol functions outside of the CEQ; or

ii) approximating the performance at the MPT by observations made within the network at the first point where the ATM layer is observable.

For broadband ISDN, the location of the MPI (Measurement Point I) is on the international side of the ISC (or frontier station, FS, if the FS accesses the ATM layer) at:

a) the last egress MP in a given country; and

b) the first ingress MP in a given country.

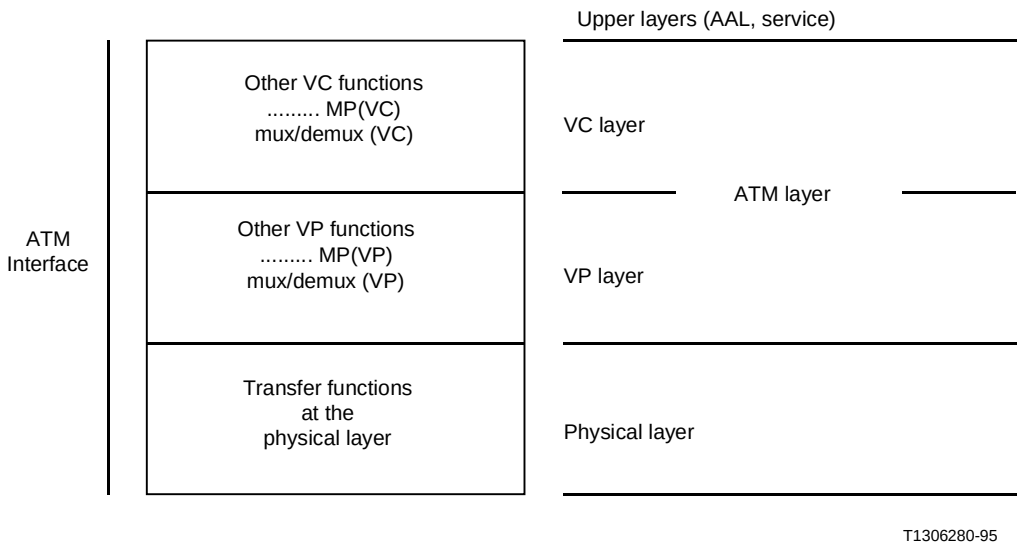


FIGURE 4/I.353

Location of ATM layer MPs within the ATM interface

The establishment of an MP on the national side of the ISC (or FS) and its performance allocation in the national portion are national matters, depending on the network topology of each country.

Cell exit events occur when a user information cell crosses an MP exiting the SSN or CEQ into the attached transmission system. Cell entry events occur when a user information cell crosses an MP entering the SSN or CEQ from the attached transmission system.

The only cells that create exit events and entry events for the specified virtual connection are those that cross a MP with the following properties:

- Standard physical layer procedures have delineated and approved the cell, including the HEC handling.
- The VPI or VPI/VCI (as appropriate) field corresponds to the monitored connection (after HEC handling).
- The payload type field indicates a user information cell (after HEC handling). Reference events for other cell types are for further study.

Table 8 lists performance-significant reference events associated with ATM cell transfer (for further study). The table entries are:

– event identification code;

– type of ATM layer cell transferred; and

– resulting state of the ATM layer interface.

Unassigned cells do not create cell reference events.

TABLE 8/I.353

Performance-significant reference events based on ATM layer cell transfer

Code	Cell type	Resulting state
A1	UI	For further study
UI User information NOTE – Table 8 is for further study.		

5.10 Unrestricted digital bearer services

5.10.1 Performance-significant reference events

A performance-significant reference event for unrestricted digital bearer services is the appearance of a relevant user information bit at a relevant boundary. The relevant boundary is the MP where performance is to be quantified. The unit of information transferred is one bit of user information. Additional events may be defined based on the specific structure of the transmitted bit stream, e.g. framing.

To communicate direction, entry events can be distinguished from exit events. Entry events are created when the bit is travelling across the MP into a switching node or a CEQ. Exit events are created when the bit is travelling across the MP out of a switching node or a CEQ.

In general, there are no protocol state changes associated with the user information transfer phase of unrestricted digital bearer services. Therefore, in identifying their reference events, state changes need not be discussed.

5.10.2 The relevant bit of user information

The ability to identify the relevant bit of user information is essential to the definition of the user information transfer parameters. Unrestricted digital bearer services accept a sequence of bits $\{a_i\}$ at one MP and deliver a sequence of bits $\{b_i\}$ at another MP. When measuring information transfer performance between those two boundaries the relevant bits are usually "corresponding" bits in the two sequences. The term "corresponding" has meaning if, and only if, there exists a large number N and other numbers m and d such that:

$$a_i = b_{i+d} \text{ for almost all integers } i, m \leq i \leq m + N \qquad (5\text{-}1)$$

where:

m is the index of the first bit in a sequence of N bits; and

d is the displacement in the index at the output MP.

Then for all i, $m \leq i \leq m + N$, bit b_{i+d} is said to correspond to bit a_i.

When the corresponding bits a_i and b_{i+d} are not equal, the bit b_{i+d} is said to be errored. When the corresponding bits a_i and b_{i+d} are equal, the bit b_{i+d} is said to be unerrored.

Before counting errored and unerrored bits in user information transfer measurement results it is advisable to adjust m, d and N in a way that maximizes N. However, m, d and N should also be chosen so that:

– equation (5-1) remains satisfied; and

– the large majority of bits at both the beginning and the end of the sequence $\{b_{m+d} .... b_{m+N+d}\}$ are unerrored.

If there are no *m, d and large N* for which equation (5-1) holds, this condition is referred to as *failure to synchronize*, or *no synch*. A period of no signal or failure to synchronize shall be considered a period of errored bits.

ITU-T RECOMMENDATIONS SERIES

Series A	Organization of the work of the ITU-T
Series B	Means of expression
Series C	General telecommunication statistics
Series D	General tariff principles
Series E	Telephone network and ISDN
Series F	Non-telephone telecommunication services
Series G	Transmission systems and media
Series H	Transmission of non-telephone signals
Series I	**Integrated services digital network**
Series J	Transmission of sound-programme and television signals
Series K	Protection against interference
Series L	Construction, installation and protection of cables and other elements of outside plant
Series M	Maintenance: international transmission systems, telephone circuits, telegraphy, facsimile and leased circuits
Series N	Maintenance: international sound-programme and television transmission circuits
Series O	Specifications of measuring equipment
Series P	Telephone transmission quality
Series Q	Switching and signalling
Series R	Telegraph transmission
Series S	Telegraph services terminal equipment
Series T	Terminal equipment and protocols for telematic services
Series U	Telegraph switching
Series V	Data communication over the telephone network
Series X	Data networks and open system communication
Series Z	Programming languages