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SERIES X: DATA NETWORKS AND OPEN SYSTEM
COMMUNICATION

Public data networks – Network aspects

**Performance for data networks providing
international frame relay SVC service**

ITU-T Recommendation X.145

(Previously CCITT Recommendation)

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

FOREWORD

The ITU-T (Telecommunication Standardization Sector) is a permanent organ of the International Telecommunication Union (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).

ITU-T Recommendation X.145 was prepared by ITU-T Study Group 7 (1993-1996) and was approved under the WTSC Resolution No. 1 procedure on the 5th of October 1996.

NOTE

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

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SUMMARY

This Recommendation defines those performance parameters needed to describe the performance of a frame relay Switched Virtual Connection (SVC) service. Only those parameters that are needed in addition to the frame relay PVC parameters of Recommendation X.144 are defined. These include call control delay and accuracy and dependability parameters as well as an expanded service availability definition.

**PERFORMANCE FOR DATA NETWORKS PROVIDING
INTERNATIONAL FRAME RELAY SVC SERVICE**

(Geneva, 1996)

1 Scope

The purpose of this Recommendation is to define a comprehensive basis for assessing the performance of frame relay SVC services providing telecommunication service in accordance with ITU-T Recommendations identified herein. This Recommendation defines parameters that may be used to describe the speed, accuracy and dependability of data networks when providing international frame relay switched service. The frame relay performance parameters of Recommendation X.144 are applicable to the information transfer phase of a switched frame relay connection and are included by reference in this Recommendation.

Performance is considered in the context of the 3×3 performance matrix defined in Recommendation X.134 (see Figure 1). Three protocol-independent data communication functions are identified in the matrix: access, user information transfer and disengagement. Each function is considered with respect to three general performance concerns (or “performance criteria”): speed, accuracy and dependability. This Recommendation defines a set of primary parameters that describe the speed, accuracy and dependability performance relative to each function.

The parameters defined in this Recommendation may be used to specify or measure the performance of end-to-end frame relay connections or connection portions as specified in Recommendation X.144.

The performance parameters defined in this Recommendation describe the speed, accuracy, dependability and availability of the access and disengagement phases provided by switched frame relay. Recommendation X.144 provides performance parameters that describe the information transfer phase of a switched frame relay connection. Other planned Recommendations will provide standard methods of measuring the frame transfer performance parameters of this Recommendation and specific design objectives for them.

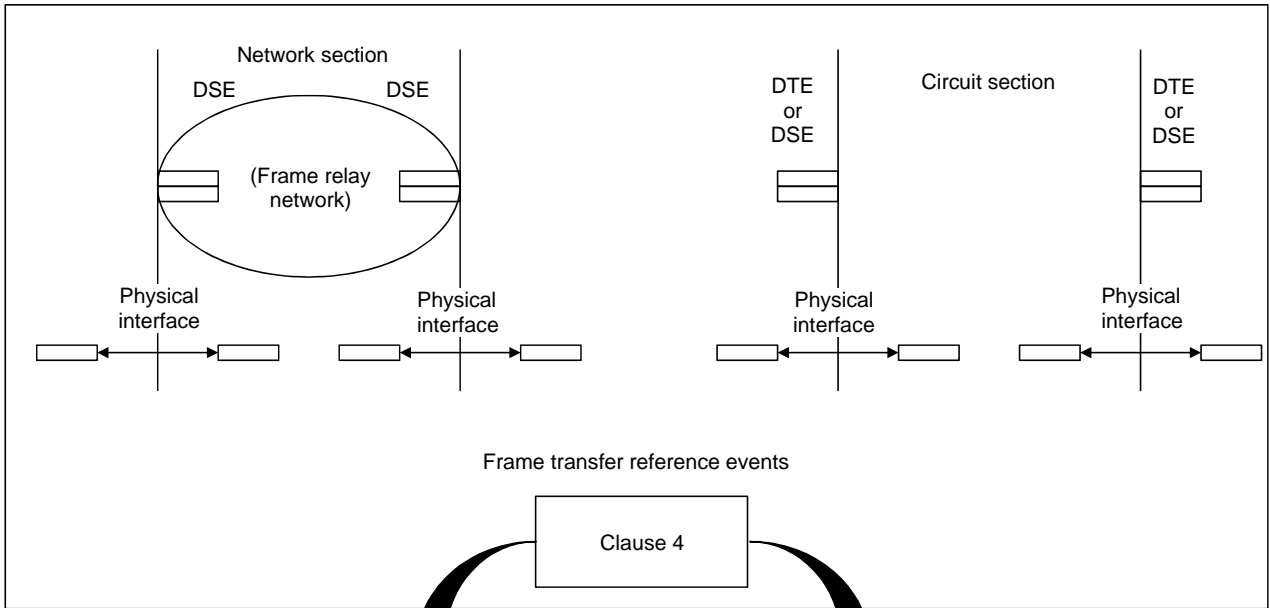
NOTE 1 – The parameters defined in this Recommendation may be augmented or modified based upon further study of the requirements of frame relay to be supported on networks.

NOTE 2 – The defined parameters are intended to characterize frame relay connections in the available state.

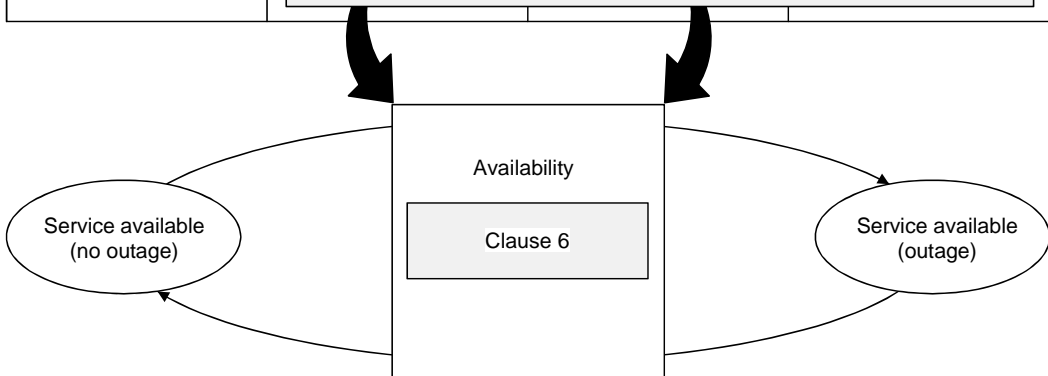
NOTE 3 – The parameters of this Recommendation are designed to measure the performance of network elements between pairs of section boundaries. However, users of this Recommendation should be aware that the behaviour of connection elements outside the pair of boundaries can adversely influence the measured performance of the elements between the boundaries.

This Recommendation is organized as follows:

- clause 2 presents references;
- clause 3 presents abbreviations;
- clause 4 defines a performance model and a set of frame transfer reference events (FEs) that provide a basis for performance parameter definition;
- clause 5 defines frame-based speed of service, accuracy and dependability parameters using the frame transfer reference events defined in clause 4;
- clause 6 defines the SVC availability parameters using the primary parameters defined in clause 5 and in clause 5/X.144.



Criterion / Function	Speed	Accuracy	Dependability
Access (call set-up)	Clause 5		
User information transfer	Clause 5/X.144		
Disengagement (call tear-down)	Clause 5		



T0723590-95/d01

FIGURE 1/X.145
Scope of Recommendation X.145

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 and other references 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 and other references listed below. A list of the currently valid ITU-T Recommendations is regularly published.

- [1] ITU-T Recommendation X.144 (1995), *User information transfer performance parameters for data networks providing international frame relay PVC service.*
- [2] ITU-T Recommendation X.36 (1995), *Interface between Data Terminal Equipment (DTE) and Data Circuit-terminating Equipment (DCE) for public data networks providing frame relay data transmission service by dedicated circuit.*
- [3] ITU-T Recommendation X.76 (1995), *Network-to-network interface between public data networks providing the frame relay data transmission service.*
- [4] CCITT Recommendation Q.922 (1992), *ISDN data link layer specification for frame mode bearer services.*
- [5] ITU-T Recommendation Q.933 (1995), *Signalling specification for frame mode basic call control.*
- [6] ITU-T Recommendation I.122 (1993), *Framework for frame mode bearer services.*
- [7] I.233-Series Recommendations, *Frame mode bearer services.*
- [8] CCITT Recommendation I.233.1 (1991), *ISDN frame relaying bearer service.*
- [9] CCITT Recommendation I.370 (1991), *Congestion management for the ISDN frame relaying bearer service.*

3 Abbreviations

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

ACS	Access Circuit Section
ANS	Access Network Section
B _c	Committed burst size
BCTDR	Bit-based Conformant Traffic Distortion Ratio
B _e	Excess burst size
BECN	Backward Explicit Congestion Notification
BLR	Bit-Loss Ratio
CEP	Connection set-up Error Probability
CFP	Connection set-up Failure Probability
CIR	Committed Information Rate
CLLM	Consolidated Link Layer Management
DE	Discard Eligible
DLCI	Data link Connection Identifier
DSE	Data Switching Exchange
DTE	Data Terminal Equipment
EFR	Extra Frame Rate
EIR	Excess Information Rate

FCTDR	Frame-based Conformant Traffic Distortion Ratio
FE	Frame layer reference event
FECN	Forward Explicit Congestion Notification
FLR	Frame Loss Ratio
FRS	Frame Relay SVC
HDLC	High-level Data Link Control
I	Information frame
ICS	Internetwork Circuit Section
ISDN	Integrated Services Digital Network
LAPF	Link Access Protocol Frame
MPI	Measurement Point I
MPT	Measurement Point T
MTBSO	Mean Time between Service Outages
MTTSR	Mean Time to Service Restoral
NE	Network Element
NNI	Network-to-Network Interface
NT	Network Termination
PDEP	Premature Disconnect Event Probability
PDSP	Premature Disconnect Stimulus Probability
PVC	Permanent Virtual Circuit
RBER	Residual Bit-Error Ratio
RE	Reference Event
RFER	Residual Frame-Error Ratio
SA	Service Availability
SABME	Set Asynchronous Balanced Mode Extended
SF	Switching Function
SN	Switching Node
SVC	Switched Virtual Connection
TE	Terminal Equipment
TNS	Transit Network Section
UA	Unnumbered Acknowledgement
UI	Unnumbered Information
UNI	User-to-Network Interface

4 Performance model and frame relay SVC reference events

The performance model for this Recommendation is that of Recommendation X.144 (as presented in clause 4/X.144). For completeness, this performance model is illustrated by Figures 2 and 3 in 4.1.

As there are some differences in the treatment of User-to-Network Interface (UNI) versus network-to-network interface layer 3 control messages in switched frame relay services, this Recommendation utilizes the terms MPT and MPI to distinguish between boundaries at a UNI or NNI respectively.

Performance-significant reference events are reference events useful in defining performance parameters. Table 1 provides references to information, either in this Recommendation or in other Recommendations, that collectively define a relevant set of frame relay SVC service performance-significant reference events.

TABLE 1/X.145

References to Recommendations specifying frame relay SVC performance-significant reference events

Recommendation/protocol	Relevant boundary	
	MPT	MPI
Rec. X.76	Not applicable	4.2.1/X.145
Annex A/Q.933 (Rec. X.36)	4.2.2/X.145	Not applicable

4.1 Performance model

Figures 2 and 3, corresponding to Figures 2/X.144 and 3/X.144, illustrate the performance model used in this Recommendation. In Figure 2, the boundaries at the DTEs are MPT boundaries and the boundaries delimiting the international portion are MPI boundaries.

The terms MPT and MPI represent a T measurement (or monitoring) point and an international measurement (or monitoring) point, respectively. The concept of a measurement (or monitoring) point is that of a point where standardized protocol reference events may be observed. Figure 3 illustrates this concept.

4.2 Frame relay SVC reference events

4.2.1 Recommendation X.76

Table 2a lists performance-significant X.76 message transfer reference events associated with an MPI boundary. For each layer 3 message, codes are given. Each code ends in either an “a” or “b”. All codes which end in an “a” represent exit reference events and all codes which end in a “b” represent entry reference events. The unit of information used in defining the time of occurrence of these reference events is the layer 2 (HDLC) frame that carries the layer 3 message across the relevant boundary.

4.2.2 Annex A/Q.933 (Recommendation X.36)

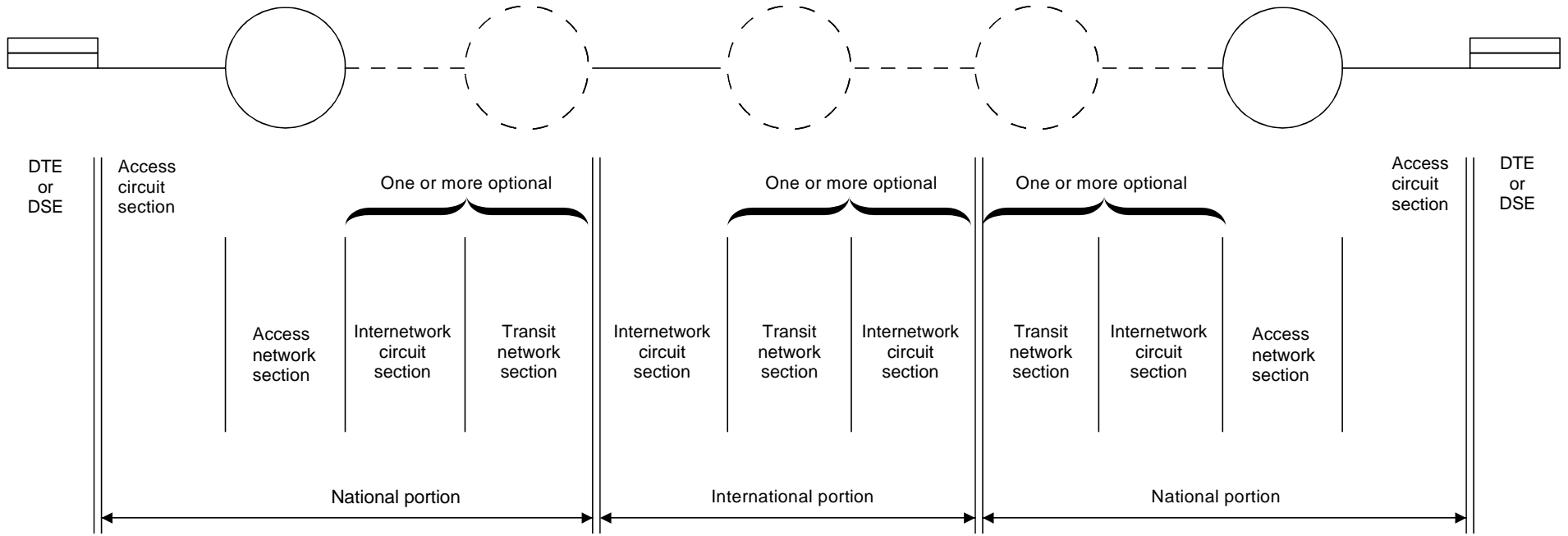
Table 2b lists performance-significant Annex A/Q.933 (Recommendation X.36) message transfer reference events associated with an MPT boundary. Each layer 3 message code ends in either an “a” or “b”. Codes ending in an “a” represent exit reference events; codes ending in a “b” represent entry reference events. The unit of information used in defining the time of occurrence of these reference events is the layer 2 (HDLC) frame that carries the layer 3 message across the relevant boundary.

5 Access and disengagement parameters

Speed of service parameters are based on reference events that occur during the course of normal network operations. Thus, connection set-up delay – defined in 5.1.1 – is only relevant for connections that are correctly established. The accuracy and dependability parameters in 5.2 address the issue of abnormal network operation.

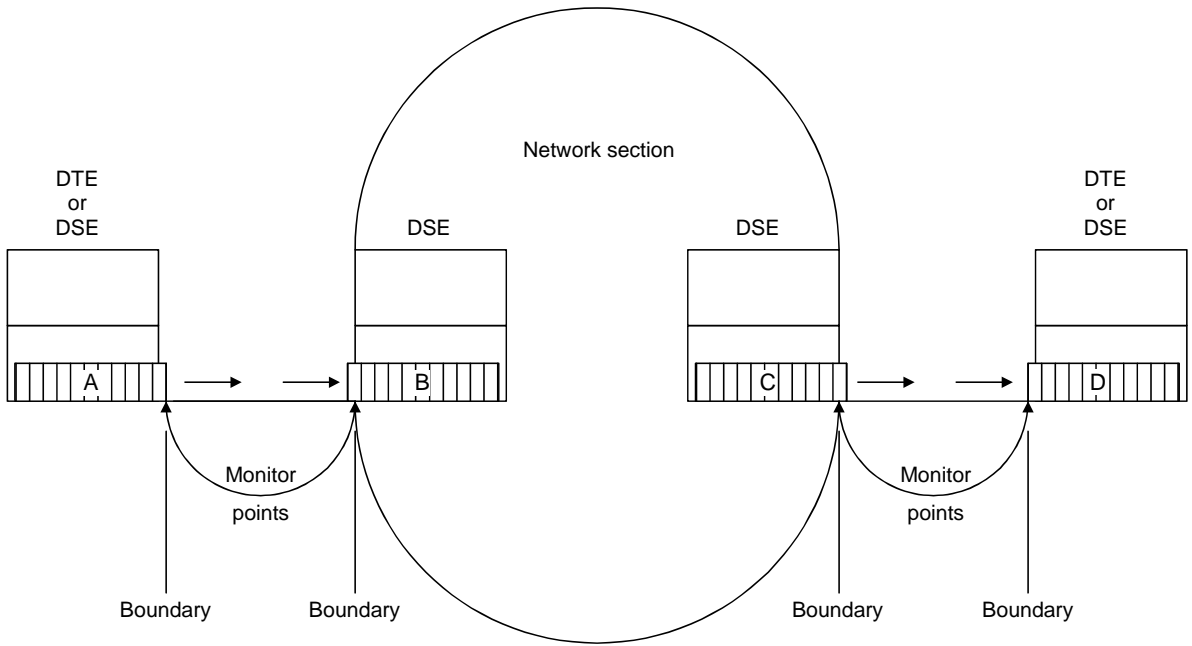
5.1 Speed of service parameters

This subclause defines speed of service parameters for digital connections provided using frame relay SVC service. These parameters can be measured or estimated at any pair of boundaries delimiting a portion or concatenation of portions.



T0723600-95/d02

FIGURE 2/X.145
Portions of an international virtual connection



T0723610-95/d03

NOTE 1 – Frame exit events for A and C.

NOTE 2 – Frame entry events for B and D.

FIGURE 3/X.145
Example transfer reference events

TABLE 2a/X.145

Frame relay SVC performance-significant reference events (FEs) based on X.76 layer 3 message transfer at an MPI boundary

FE code	Layer 3 message
S1a b	SETUP (S) SETUP (S)
S2a b	ALERTing (A) ALERTing (A)
S3a b	CALL PROCEEDing (CP) CALL PROCEEDing (CP)
S4a b	CONNect (C) CONNect (C)
S5a b	PROGress PROGress
S6a b	RELease (R) RELease (R)
S7a b	RELease COMplete (RC) RELease COMplete (RC)

TABLE 2b/X.145

Frame relay SVC performance-significant reference events (FEs) based on Annex A/Q.933 (Recommendation X.36) layer 3 message transfer at an MPT boundary

FE code	Layer 3 message
P1a b	SETUP (S) SETUP (S)
P2a b	ALERTing (A) ALERTing (A)
P3a b	CALL PROCEEDing (CP) CALL PROCEEDing (CP)
P4a b	CONNect (C) CONNect (C)
P5	PROGress
P6	RELease (R)
P7	RELease COMplete (RC)
P8	CONNect ACKnowledge (CA)
P9a b	DISConnect (D) DISConnect (D)

5.1.1 Connection set-up delay

Connection set-up delay applies to frame relay SVC service. Figure 4 illustrates the reference events used in defining this parameter. Connection set-up delay is defined first at a single boundary and then between pairs of boundaries.

5.1.1.1 Definition of connection set-up delay at a single boundary

Connection set-up delay at a single boundary, B_i is defined using two reference events. It is the interval of time between the occurrence of a reference event for a SETUP message at B_i and the occurrence of the corresponding reference event caused by the returning CONNect message at B_i .

Connection set-up delay at a single boundary = $t_2 - t_1$,

where:

t_1 is the time of occurrence of the starting reference event; and

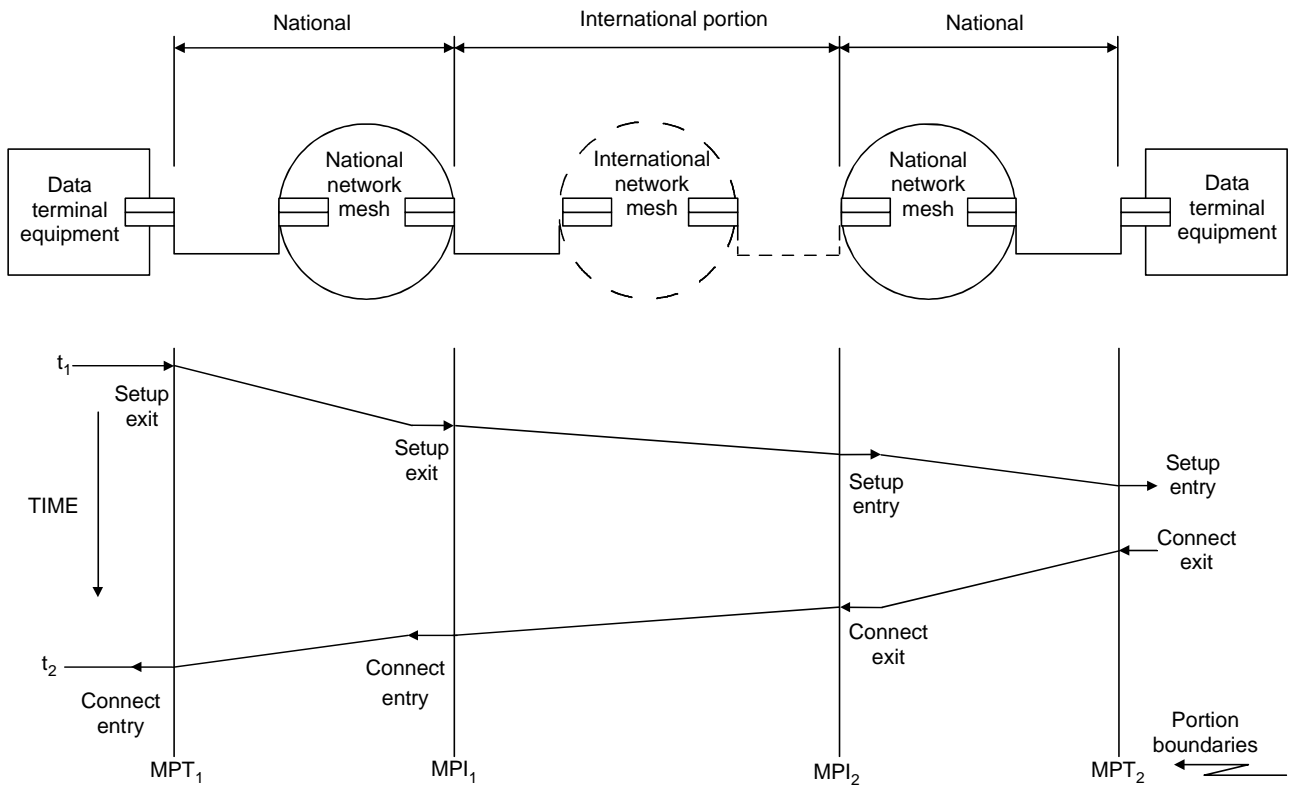
t_2 is the time of occurrence of the ending reference event.

The specific reference events used in defining connection set-up delay at a single boundary are shown in Table 3.

TABLE 3/X.145

Reference events used in defining connection set-up delay at a single boundary

Boundary	Starting reference event	Ending reference event
MPT ₁	P1a (Setup, exit)	P4b (Connect, entry)
MPT ₂	P1b (Setup, entry)	P4a (Connect, exit)
MPI ₁	P1a (Setup, exit)	P4b (Connect, entry)
MPI ₂	P1b (Setup, entry)	P4a (Connect, exit)



T0723620-95/d04

FIGURE 4/X.145
Connection set-up delay at the MPT₁ boundary

5.1.1.2 Definition of connection set-up delay between two boundaries

To assess network performances, it is necessary to determine the connection set-up delay attributable to the portions between two boundaries, B_i and B_j, where B_i is an arbitrary boundary and B_j is a boundary farther from the calling entity. The connection set-up delay between two boundaries is the (positive) difference between the delays at each individual boundary. This definition thus excludes the called entity's response time.

Connection set-up delay between two boundaries = $d_1 - d_2$,

where:

d_1 is the connection set-up delay measured at B_i, and

d_2 is the connection set-up delay measured at B_j.

5.1.2 Disconnect delay

Disconnect delay is a one-way delay based on the transport of a disconnect message from the clearing to the cleared party. This parameter therefore requires observation of reference events at two boundaries.

The disconnect delay between two boundaries is the (positive) difference between the occurrence of corresponding reference events at each individual boundary.

Disconnect delay between two boundaries = $t_2 - t_1$,

where:

t_1 is the time of occurrence of the starting reference event at B_i , and

t_2 is the time of occurrence of the ending reference event at B_j .

End-to-end disconnect delay is the disconnect delay between the two MPT boundaries (shown in Figure 5). The reference events used to define disconnect delay are given in Table 4.

TABLE 4/X.145

Reference events used in defining disconnect delay

Boundary	Reference event
MPT ₁	P9a (Disconnect, exit)
MPT ₂	P9b (Disconnect, entry)
MPI ₁	P9a (Disconnect, exit)
MPI ₂	P9b (Disconnect, entry)

5.1.3 Release delay

Release delay is the time between the sending of a Disconnect message by a DTE to the network and the receipt by the same DTE of either a corresponding RElease or RElease COMplete message. This parameter has significance to end-users. Table 5 gives the starting and ending reference events for this parameter.

TABLE 5/X.145

Reference events for release delay

Starting reference event	Ending reference event
P9a (Disconnect, exit)	P6 Release, or P7 Release Complete

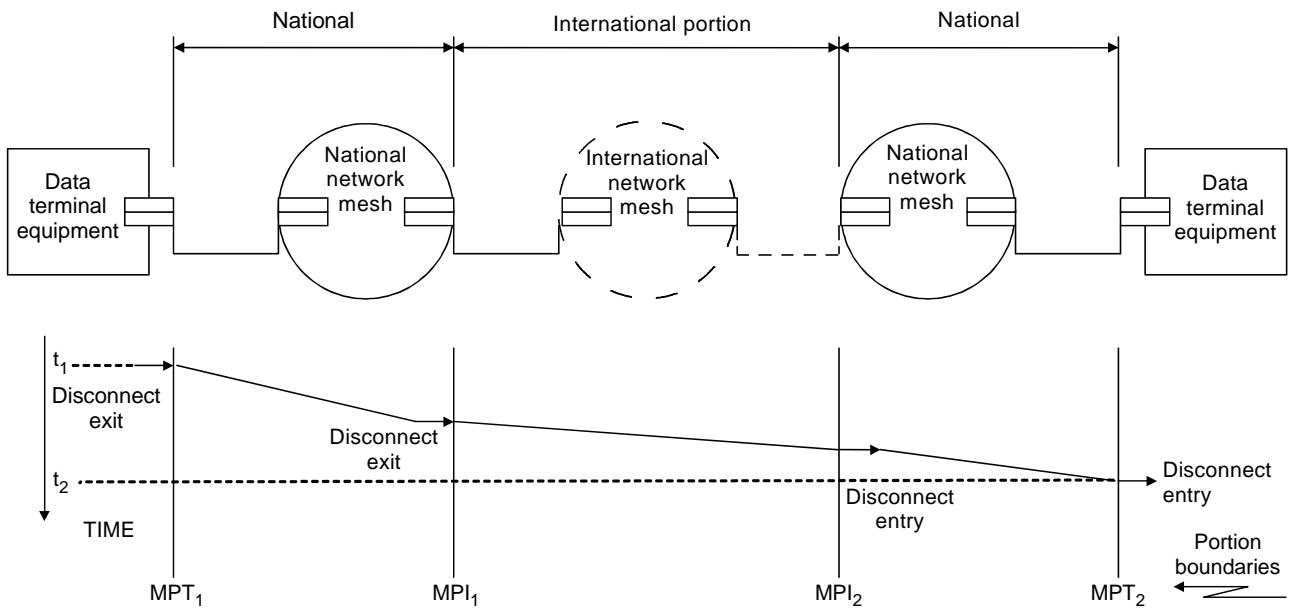
5.2 Accuracy and dependability parameters

This subclause defines accuracy and dependability parameters for digital connections provided using frame relay SVC service. These accuracy and dependability parameters can be measured or estimated at any pair of boundaries delimiting a portion or concatenation of portions.

Two access phase parameters, connection set-up error probability and connection set-up failure probability, are defined in 5.2.1. Subclause 5.2.2 defines two premature disconnect parameters, and 5.2.3 defines connection clearing failure probability.

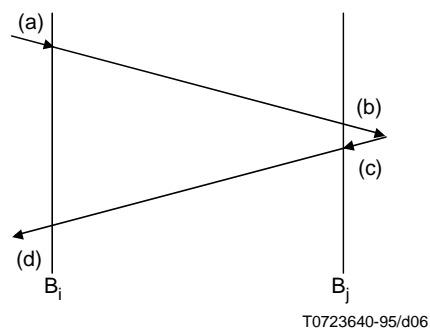
5.2.1 Connection set-up parameters

Connection set-up error and connection set-up failure are defined between pairs of portion boundaries (B_i , B_j). B_j is one of the set of boundaries to which the connection set-up attempt can properly be routed. Figure 6 identifies the sequence of four particular events that occur at these boundaries during a successful connection set-up. A connection set-up attempt over this portion is a sequential occurrence of corresponding events (a, b, c, d) prior to expiration of the appropriate timer, T301 or T303. Connection set-up errors and connection set-up failures within this portion are defined below. Any other unsuccessful connection set-up attempt is caused by elements outside the portion.



T0723630-95/d05

FIGURE 5/X.145
End-to-end disconnect delay



T0723640-95/d06

FIGURE 6/X.145
Reference events occurring during
successful connection set-up

5.2.1.1 Connection set-up error probability

Connection set-up error probability applies to frame relay SVC switched connection types. This parameter is used to measure the accuracy of the general user function of access in public frame relay SVC switched services conforming to the Recommendations identified in clause 2.

Connection set-up error probability is defined as the ratio of total connection set-up attempts that result in connection set-up error to the total connection set-up attempts in a population of interest.

Connection set-up error is distinguished from successful connection set-up by the fact that the intended called user is not contacted and not committed to the user information transfer session during the connection set-up attempt.

With reference to Figure 6, a connection set-up error is defined to occur on any connection set-up attempt in which event (d) occurs, but event (c) does not occur at an appropriate boundary prior to expiration of the appropriate timer, T301 or T303.

Connection set-up error is essentially the case of a network-caused “wrong number”. It occurs when the network responds to a valid connection request by erroneously establishing a connection to a destination TE other than the one designated in the connection request, and does not correct the error prior to entry to the user information transfer state. It may be caused, for example, by network operator administrative or maintenance actions.

The specific reference events used in measuring successful connection set-up at each portion boundary are those identified in Tables 6a and 6b.

TABLE 6a/X.145

Reference events (FEs) at B_i occurring during successful frame relay SVC connection set-up

Boundary, B _i	FE	
	(a)	(d)
MPT ₁	P1a (SETUP exit)	P6b (CONNECT entry)
MPI ₁	S1a (SETUP exit)	S4b (CONNECT entry)
MPI ₂	S1b (SETUP entry)	S4a (CONNECT exit)
MPT ₂	Not applicable	Not applicable

TABLE 6b/X.145

Reference events (FEs) at B_j occurring during successful frame relay SVC connection set-up

Boundary, B _j	FE	
	(b)	(c)
MPT ₁	Not applicable	Not applicable
MPI ₁	S1a (SETUP exit)	S4b (CONNECT entry)
MPI ₂	S1b (SETUP entry)	S4a (CONNECT exit)
MPT ₂	P1b (SETUP entry)	P4a (CONNECT exit)

5.2.1.2 Connection set-up failure probability

Connection set-up failure probability applies to frame relay SVC switched connection types. This parameter is used to measure the dependability of the general function of access in public frame relay SVC switched services conforming to the Recommendations identified in clause 2.

Connection set-up failure probability is defined as the ratio of total connection set-up attempts that result in connection set-up failure to the total connection set-up attempts in a population of interest.

With reference to Figure 6, connection set-up failure is defined to occur on any connection set-up attempt in which either one of the following outcomes is observed prior to expiration of the appropriate timer, T301 or T303:

- both events, (b) and (d) do not occur;
- events (b) and (c) occur, but event (d) does not.

Connection set-up attempts that are cleared by the portion as a result of incorrect performance on non-performance on the part of an entity outside the portion are excluded.

Excluded connection attempts

A connection set-up attempt can also fail as a result of user blocking. Such failures are excluded from network performance measurement. Examples of user blocking include the following:

- the called user issues a message to reject the call set-up attempt;
- the CONNect message (P4b) reference event fails to occur at the originating MPT boundary due to the lack of a CONNect message (P4a) reference event at the terminating MPT boundary;
- the called user delays excessively in generating the CONNect message (P4a) reference event during the connection period, with the result that a connection is not established before the time-out;
- all channels at the called TE are in use.

5.2.2 Premature disconnect parameters

Premature disconnect event probability and premature disconnect stimulus probability are related parameters used to describe the dependability of user information transfer in public frame relay SVC services conforming to the Recommendations identified in clause 2. These parameters apply to the switched connection capabilities of frame relay SVC services.

Certain events, called inbound disconnect stimuli, may be received by the portion. The receipt of an inbound disconnect stimuli by a portion followed by the clearing of the connection by that portion indicates proper portion behaviour; no premature disconnect or premature disconnect stimulus event has occurred. For frame relay SVC service, the inbound disconnect stimuli are Disconnect messages and indications of link failure outside the portion.

5.2.2.1 Premature disconnect event

In the absence of an inbound disconnect stimulus, the transmission out of the portion of an outbound FE from Table 7 determines a premature disconnect event for that portion.

5.2.2.2 Definition of premature disconnect event probability

The premature disconnect event probability for a portion is the probability, in any given second, that the portion experiences a premature disconnect event.

TABLE 7/X.145

Reference events (FEs) defining frame relay SVC premature disconnect event probability

Boundary	Reference event
MPT	P9a (DISCONNECT entry)
MPI	S6a (RELEASE exit) S6b (RELEASE entry) S7a (RELease COMplete, exit) S7b (RELease COMplete, entry)

5.2.2.3 Premature disconnect stimulus event

A **premature disconnect stimulus event** is an event that causes a portion to issue a message from Table 7 that, in the absence of the premature disconnect stimulus, would be considered a premature disconnect event for the portion. Receipt of a Release or RELease COMplete message are the two events that are identified as premature disconnect stimulus events for the receiving portion. The receipt by a portion of a premature disconnect stimulus may cause it to disconnect the connection.

5.2.2.4 Definition of premature disconnect stimulus probability

The premature disconnect stimulus probability of a portion at a boundary is the probability per connection second of a premature disconnect stimulus being generated within that portion and transferred across a portion boundary.

Receipt of a premature disconnect stimulus may result in the connection being disconnected and then re-established.

5.2.3 Connection clearing failure probability

Connection clearing failure probability applies to frame relay SVC switched connection types. This parameter is used to measure the accuracy and dependability of disengagement in frame relay SVC services conforming to the Recommendations identified in clause 2.

Connection clearing failure probability is defined as the ratio of total connection clearing failures to the total connection clearing attempts in a population of interest.

Connection clearing failure is defined with reference to events at the boundaries of a portion (B_i , B_j). A connection clearing attempt occurs when a DISConnect or RELease message enters the portion creating a reference event at B_i . A connection clearing failure occurs when no corresponding connection clearing reference event occurs at B_j within X seconds.

NOTE – The value of X is for further study.

The relevant reference events used in measuring connection clearing failure probability at each portion boundary are those identified in Tables 8a and 8b.

TABLE 8a/X.145

Starting reference events (FEs) at B_i used in defining frame relay SVC connection clearing failure probability

Boundary, B_i	Starting FE
MPT ₁	P7a (DISCONNECT exit)
MPI ₁	S6a (Release, exit) or S7a (RELease COMplete, exit)
MPI ₂	S6b (Release, entry) or S7b (RELease COMplete, entry)
MPT ₂	Not applicable

6 Availability

This clause specifies SVC availability parameters for the section types defined in clause 5. A two-state model provides a basis for describing overall SVC service availability. A specified availability function compares the values for a set of “supported” primary parameters with corresponding outage thresholds to classify the service as “available” (no service outage) or “unavailable” (service outage) during successive observation periods. This clause specifies the SVC availability function and defines the SVC availability parameters that characterize the resulting binary random process.

TABLE 8b/X.145

Reference events (FEs) at B_j whose non-occurrence is used in defining frame relay SVC connection clearing failure probability

Boundary, B_j	Non-occurring FE
MPT ₁	Not applicable
MPI ₁	S6a (Release, exit) or S7a (RELease COMplete, exit)
MPI ₂	S6b (Release, entry) or S7b (RELease COMplete, entry)
MPT ₂	P9b (DISCONNECT entry)

Two availability parameters are defined in clause 6: SVC service availability and mean time between SVC service outages. Each parameter can be applied to any basic section of an end-to-end connection.

6.1 SVC availability function

To define frame relay SVC availability, two additional outage criteria are specified in conjunction with the outage criteria of Recommendation X.144. The full set of frame relay SVC decision parameters and their outage thresholds are listed in Table 9.

TABLE 9/X.145

Outage criteria for the availability decision parameters

Availability decision parameters	Criteria
FLR _c (Note 1): User information frame loss ratio for a population of frames with DE = 0 when all DE = 0 frames conform with the CIR	FLR _c > C ₁
FLR _c (Note 2): User information frame loss ratio for a population of frames input with DE = 1 when all input DE = 1 frames conform with the EIR and all DE = 0 frames conform with the CIR	FLR _c > C ₂
RFER – Residual Frame-Error Ratio	RFER > C ₃
EFR – Extra Frame Rate	EFR > C ₄
Connection set-up Error Probability (CEP) and Connection set-up Failure Probability (CFP)	CEP + CFP > C ₅
Premature Disconnect Probability (PDP) and Premature Disconnect Stimulus Probability (PDSP)	PDP + PDSP > C ₆
NOTE 1 – Applicable as an availability decision parameter only when CIR > 0. If high FLR is observed, the offered DE = 0 traffic should be reduced to CIR before judging the availability state.	
NOTE 2 – Applicable as an availability decision parameter only when CIR = 0 and there are no DE = 0 frames. If high FLR is observed, the offered DE = 1 traffic should be reduced to EIR before judging the availability state.	
NOTE 3 – The connection section (or set of sections) may also be considered unavailable if the underlying physical layer at either section boundary is unavailable (no signal, alarm condition, etc.) due to causes within the connection section(s).	

Performance is considered independently with respect to each availability decision parameter. If the value of the parameter is equal to or better than the defined outage threshold, performance relative to that parameter is defined to be acceptable. If the value of the parameter is worse than the threshold, performance relative to that parameter is defined to be unacceptable.

A set of connection sections bounded by boundaries B_i and B_j is defined to be **available** (or to be in the available state) if the performance is acceptable relative to all decision parameters.

A set of connection sections bounded by boundaries B_i and B_j is defined to be **unavailable** (or to be in the unavailable state) if the performance of one or more of the decision criteria is unacceptable.

The intervals during which a connection section or concatenated set of connection sections is unavailable are identified by the superposition of the unacceptable performance periods for all decision parameters as illustrated in Figure 7/X.144.

In order to exclude transient impairments from being considered as periods of unavailability, a single test of the availability state must be five minutes or longer. In order to reduce the probability of state transitions during a test of the current availability state, each test should be less than 20 minutes.

6.2 SVC availability parameters

Two availability parameters are defined: SVC Service Availability (SA) and Mean Time between SVC Service Outages (MTBSO).

6.2.1 Definition of SVC service availability

Service availability as defined in clause 6 applies to SVC services. The **SVC service availability** is the long-term percentage of scheduled service time in which a section or concatenated set of sections is available.

Scheduled service time for a SVC is the time during which the network provider has agreed to make that SVC available for service. Typically, the scheduled service is 24 hours per day, seven days a week¹⁾.

6.2.2 Definition of mean time between SVC service outages

Mean time between service outages as defined in clause 6 applies to SVC services. The **mean time between SVC service outages** is the average duration of any continuous interval during which the SVC section or concatenated set of sections is available. Consecutive intervals of scheduled service time are concatenated.

6.2.3 Related parameters

Four other parameters are commonly used in describing availability performance. These are generally defined as follows:

- **Mean Time to Service Restoral (MTTSR)** is the average duration of unavailable service time intervals;
- **failure rate (λ)** is the average number of transitions from the available state to the unavailable state per unit available time;
- **restoral rate (μ)** is the average number of transitions from the unavailable state to the available state per unit unavailable time;
- **unavailability (U)** is the long-term ratio of unavailable service time to scheduled service time, expressed as a percentage.

Under the exponential distribution assumption of failure and restoration, the mathematical values for any of these parameters may be estimated from the values for Service Availability (SA) and Mean Time between Service Outages (MTBSO) as summarized in Figure 8/X.144.

¹⁾ Other scheduled service times may be specified in some networks.

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