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SERIES X: DATA NETWORKS AND OPEN SYSTEM
COMMUNICATIONS

Public data networks – Network aspects

**Connection establishment and disengagement
performance parameters for public Frame Relay
data networks providing SVC services**

ITU-T Recommendation X.145

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ITU-T Recommendation X.145

Connection establishment and disengagement performance parameters for public Frame Relay data networks providing SVC services

Summary

This Recommendation defines performance parameters for quantifying the connection establishment and disengagement performance of a frame relay Switched Virtual Connection (SVC) service. These include call control delay and accuracy and dependability parameters. The defined parameters are used in combination with the user information transfer performance parameters defined in ITU-T Rec. X.144 to fully quantify SVC service performance.

This revision was undertaken to take account of the development of ITU-T Rec. X.147 which specifies network availability objective values together with techniques for assessing frame relay network availability. Information previously pertaining to SVC availability has been moved to ITU-T Rec. X.147.

Source

ITU-T Recommendation X.145 was approved by ITU-T Study Group 17 (2001-2004) under the ITU-T Recommendation A.8 procedure on 29 October 2003.

FOREWORD

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The World Telecommunication Standardization Assembly (WTSA), which meets every four years, establishes the topics for study by the ITU-T study groups which, in turn, produce Recommendations on these topics.

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ITU-T Recommendation X.145

Connection establishment and disengagement performance parameters for public Frame Relay data networks providing SVC services

1 Scope

The purpose of this Recommendation is to define performance parameters for quantifying the connection establishment and disengagement performance of a frame relay Switched Virtual Connection (SVC) service. These include call control delay and accuracy and dependability parameters. The defined parameters are used in combination with the user information transfer performance parameters defined in ITU-T Rec. X.144 to fully quantify SVC service performance.

These parameters may be used to describe the speed, accuracy and dependability of data networks when providing an international frame relay SVC service. The user information transfer performance parameters defined in ITU-T Rec. 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 ITU-T Rec. X.140 (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 ITU-T Rec. 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.

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.

2 References

The following ITU-T 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; 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. The reference to a document within this Recommendation does not give it, as a stand-alone document, the status of a Recommendation.

- ITU-T Recommendation X.36 (2003), *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.*
- ITU-T Recommendation X.76 (2003), *Network-to-network interface between public networks providing PVC and/or SVC frame relay data transmission service.*
- ITU-T Recommendation X.140 (1992), *General quality of service parameters for communication via public data networks.*
- ITU-T Recommendation X.144 (2003), *User information transfer performance parameters for public frame relay data networks.*
- ITU-T Recommendation X.147 (2003), *Frame Relay network availability.*

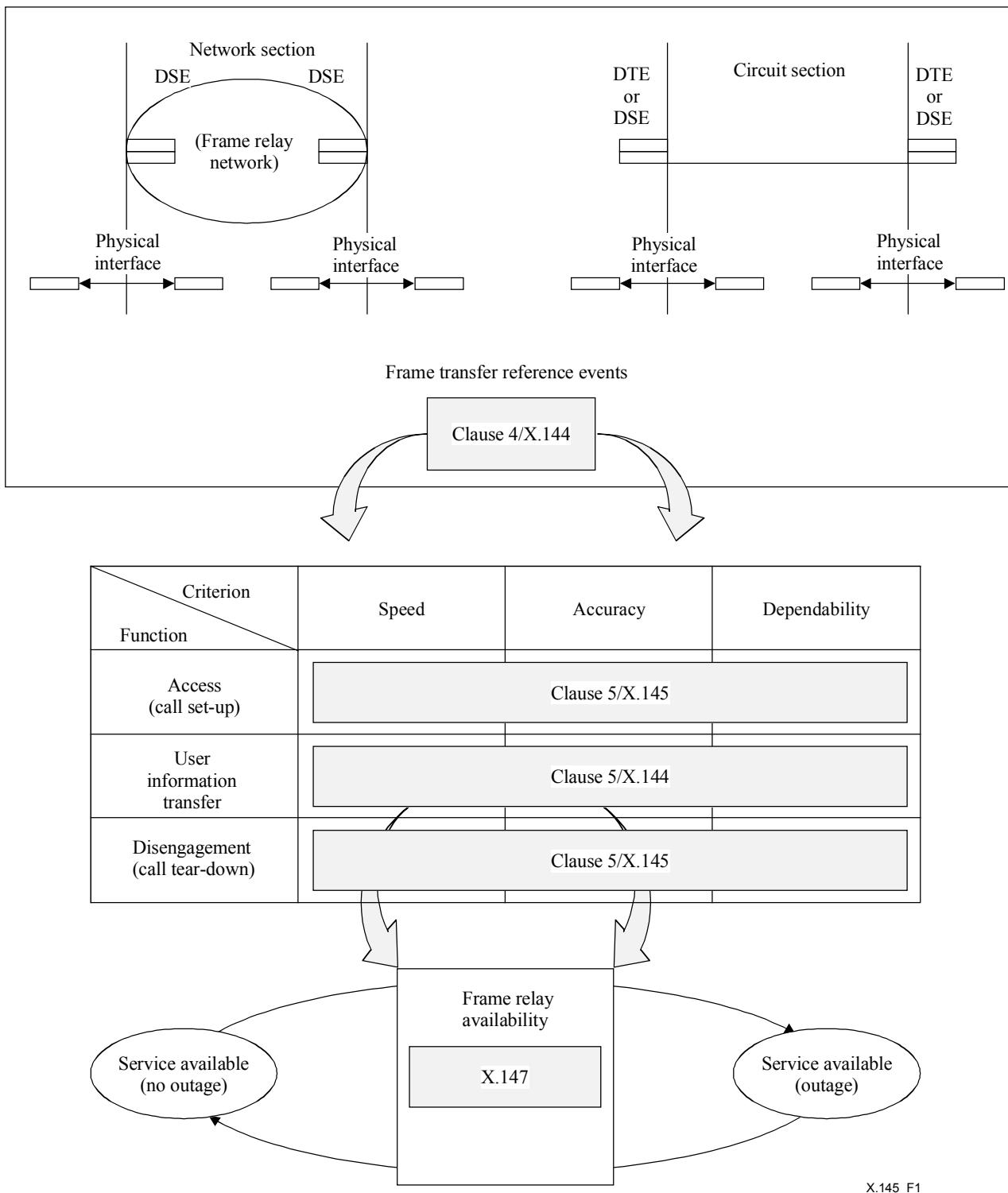


Figure 1/X.145 – Scope of ITU-T Rec. X.145

3 Abbreviations

This Recommendation uses the following abbreviations:

| | |
|-----|------------------------|
| ACS | Access Circuit Section |
| ANS | Access Network Section |
| Bc | Committed burst size |

| | |
|-------|---|
| BCTDR | Bit-based Conformant Traffic Distortion Ratio |
| Be | 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 identical to that defined in clause 4/X.144. For completeness, this performance model is illustrated in Figures 2 and 3.

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 |
| ITU-T Rec. X.76 | Not applicable | 4.2.1/X.145 |
| ITU-T 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 ITU-T Rec. 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 ITU-T Rec. X.36

Table 2b lists performance-significant 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 clause 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.

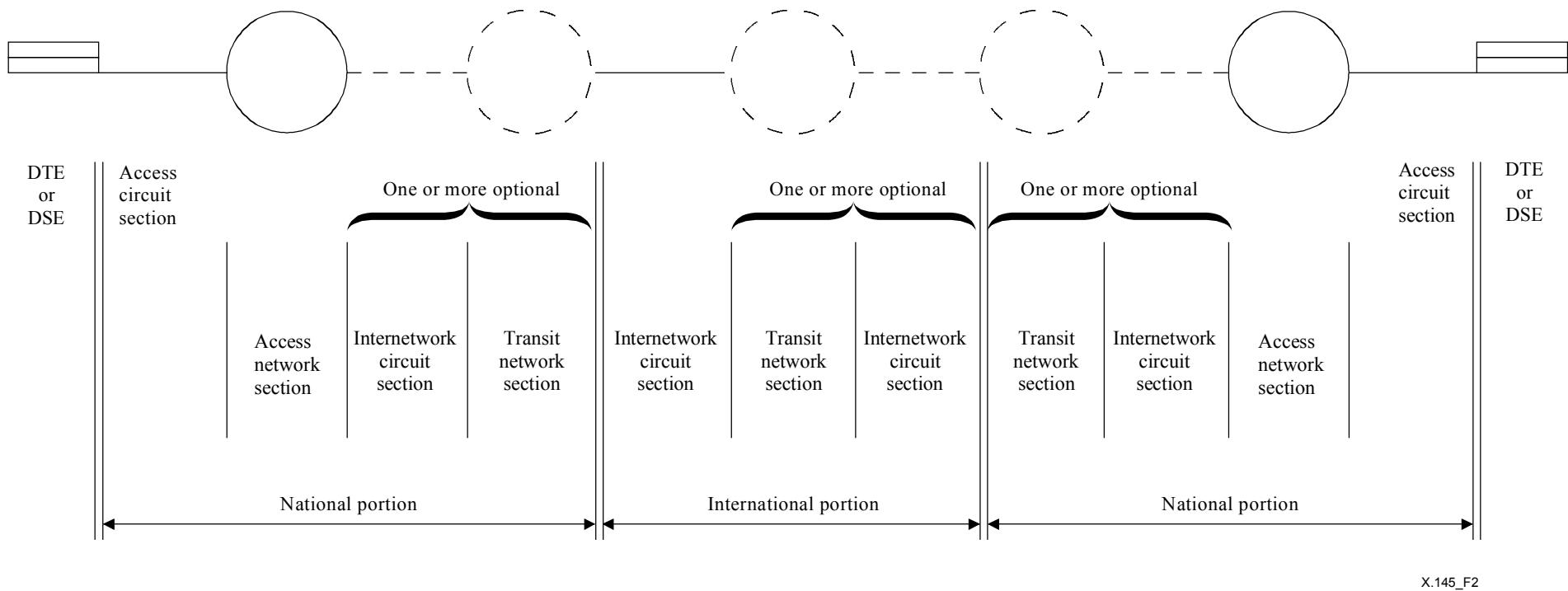
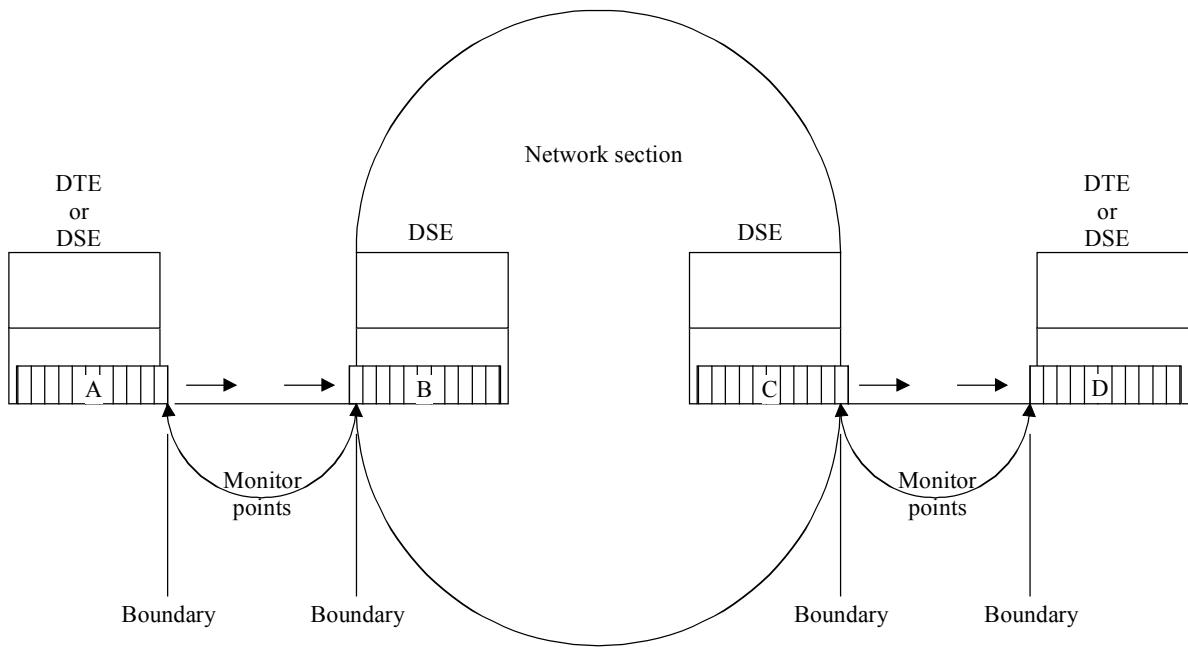


Figure 2/X.145 – Portions of an international virtual connection



X.145_F3

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 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) |

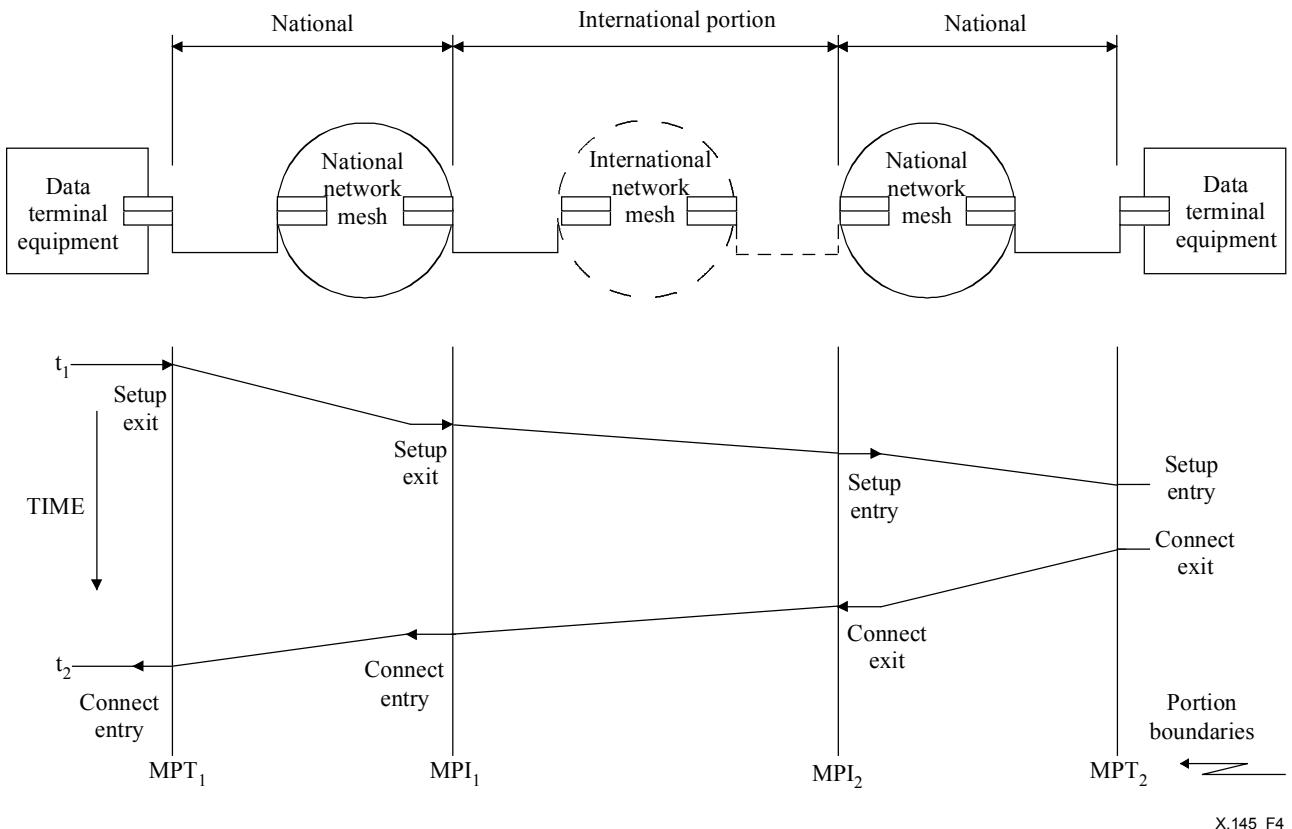


Figure 4/X.145 – Connection set-up delay at the MPT_1 boundary

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 |

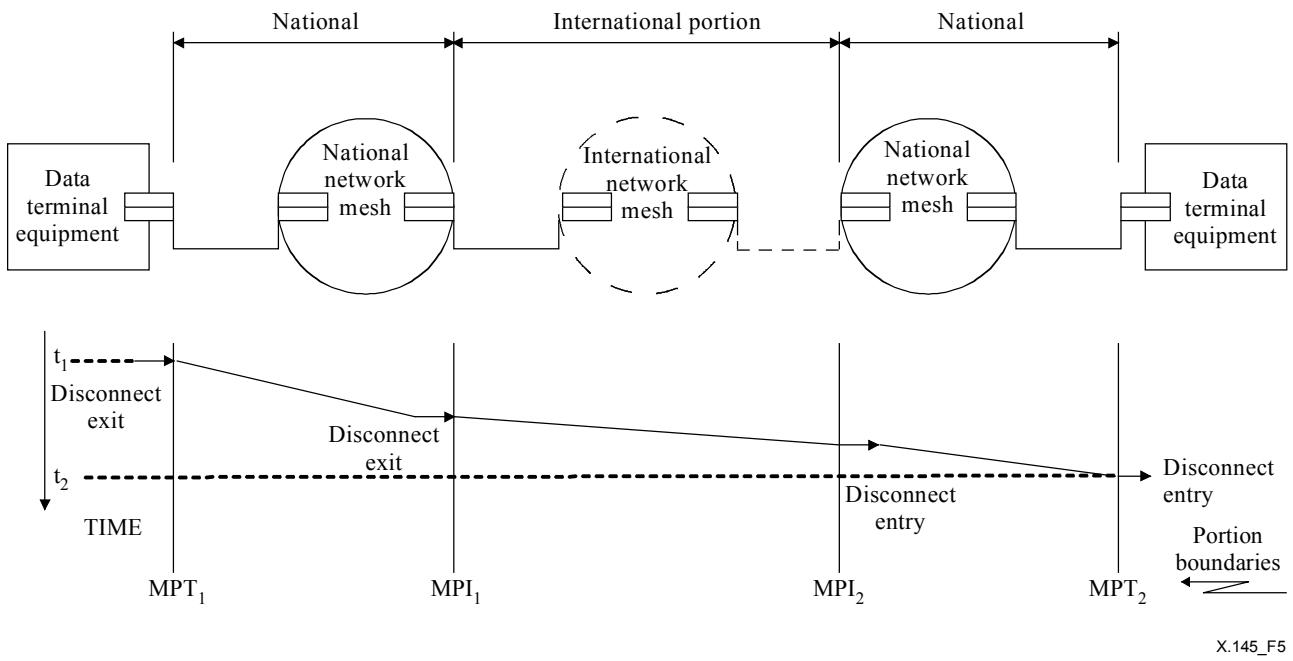
5.2 Accuracy and dependability parameters

This clause 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.

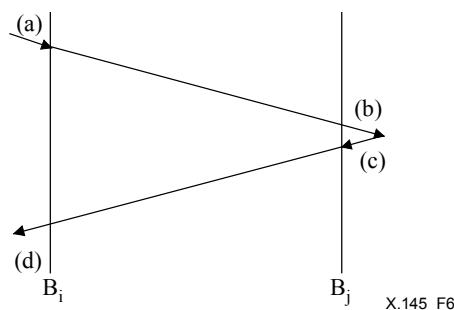
Two access phase parameters, connection set-up error probability and connection set-up failure probability, are defined in 5.2.1. Clause 5.2.2 defines two premature disconnect parameters, and 5.2.3 defines connection clearing failure probability.

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.



X.145_F5

Figure 5/X.145 – End-to-end disconnect delay

x.145_F6

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 Table 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 |

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) |

SERIES OF ITU-T RECOMMENDATIONS

- Series A Organization of the work of ITU-T
- Series B Means of expression: definitions, symbols, classification
- Series C General telecommunication statistics
- Series D General tariff principles
- Series E Overall network operation, telephone service, service operation and human factors
- Series F Non-telephone telecommunication services
- Series G Transmission systems and media, digital systems and networks
- Series H Audiovisual and multimedia systems
- Series I Integrated services digital network
- Series J Cable networks and transmission of television, sound programme and other multimedia signals
- Series K Protection against interference
- Series L Construction, installation and protection of cables and other elements of outside plant
- Series M TMN and network 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, telephone installations, local line networks
- Series Q Switching and signalling
- Series R Telegraph transmission
- Series S Telegraph services terminal equipment
- Series T Terminals for telematic services
- Series U Telegraph switching
- Series V Data communication over the telephone network
- Series X Data networks and open system communications**
- Series Y Global information infrastructure, Internet protocol aspects and Next Generation Networks
- Series Z Languages and general software aspects for telecommunication systems