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ATIS-0100513.2003(R2013)

Frame Relay Data Communication Service -Access, User Information Transfer, Disengagement, and Availability Performance Parameters

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ATIS-0100513.2003(R2013), *Frame Relay Data Communication Service – Access, User Information Transfer, Disengagement, and Availability Performance Parameters*

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American National Standard for Telecommunications

Frame Relay Data Communication Service – Access, User Information Transfer, Disengagement, and Availability Performance Parameters

Secretariat

Alliance for Telecommunications Industry Solutions

Approved February 28, 2003

American National Standards Institute, Inc.

Abstract

This standard defines performance for Frame Relay permanent and switched virtual connections, including availability, using both parameters and objectives. Information transfer objectives are presented in quality of service classes.

Foreword

The information contained in this Foreword is not part of this American National Standard (ANS) and has not been processed in accordance with ANSI's requirements for an ANS. As such, this Foreword may contain material that has not been subjected to public review or a consensus process. In addition, it does not contain requirements necessary for conformance to the standard.

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ANSI guidelines specify two categories of requirements: mandatory and recommendation. The mandatory requirements are designated by the word *shall* and recommendations by the word *should*. Where both a mandatory requirement and a recommendation are specified for the same criterion, the recommendation represents a goal currently identifiable as having distinct compatibility or performance advantages.

Suggestions for improvement of this standard are welcome. They should be sent to the Alliance for Telecommunications Industry Solutions, T1 Secretariat, 1200 G Street NW, Suite 500, Washington, DC 20005.

This standard was processed and approved for submittal to ANSI by Accredited Standards Committee on Telecommunications, T1. Committee approval of the standard does not necessarily imply that all members voted for its approval. At the time it approved this standard, the T1 Committee had the following members:

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American National Standard
for Telecommunications –

Frame Relay Data Communication Service – Access, User Information Transfer, Disengagement, and Availability Performance Parameters

1 Purpose and Scope

This standard defines speed, accuracy, dependability, and availability parameters that may be used in specifying and assessing the performance of public frame relay data communication services. The defined parameters apply to end-to-end, point-to-point frame relay connections[1] and to specified portions of such connections when provided in accordance with the American National Standards specified in clause 2.

This standard also defines frame relay service classes with their associated delay and loss parameters, together with allocations to frame relay networks. The frame relay service classes may be used to describe the information transfer phase of data networks when providing national frame relay service (either permanent virtual connection service or switched virtual connection service). Three frame relay performance parameters – frame transfer delay, frame delay jitter, and committed frame loss ratio – are used to characterize the various frame relay service classes.

The performance parameters and frame relay service classes defined in this standard are intended to be used in the planning of national frame relay services. The intended users of this standard include frame relay service providers, equipment manufacturers, and end users. This standard may be used: (1) by service providers in the planning, development, and assessment of frame relay services that meet user performance needs; (2) by equipment manufacturers as performance metrics that will affect equipment design; and (3) by users in evaluating performance.

The scope of this standard is summarized in Figure 1. The frame relay performance parameters are defined on the basis of frame transfer reference events that may be observed at physical interfaces associated with specified boundaries. For comparability and completeness, frame relay performance is considered in the context of the 3x3 performance matrix defined in ANSI X3.102-1992. Three protocol-independent data communication functions are identified in the matrix: (1) access, (2) user information transfer, and (3) disengagement. Each function is considered with respect to three general performance concerns (or "performance criteria"): speed, accuracy, and dependability. An associated two-state model provides a basis for describing permanent virtual circuit (PVC) service availability.

The performance parameters defined in this standard describe the speed, accuracy, dependability, and availability of frame relay networks.

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[1] In the context of this standard, a frame relay connection (denoted hereafter, unless noted otherwise, by the term *connection*) refers to a virtual connection established between two specified end points.

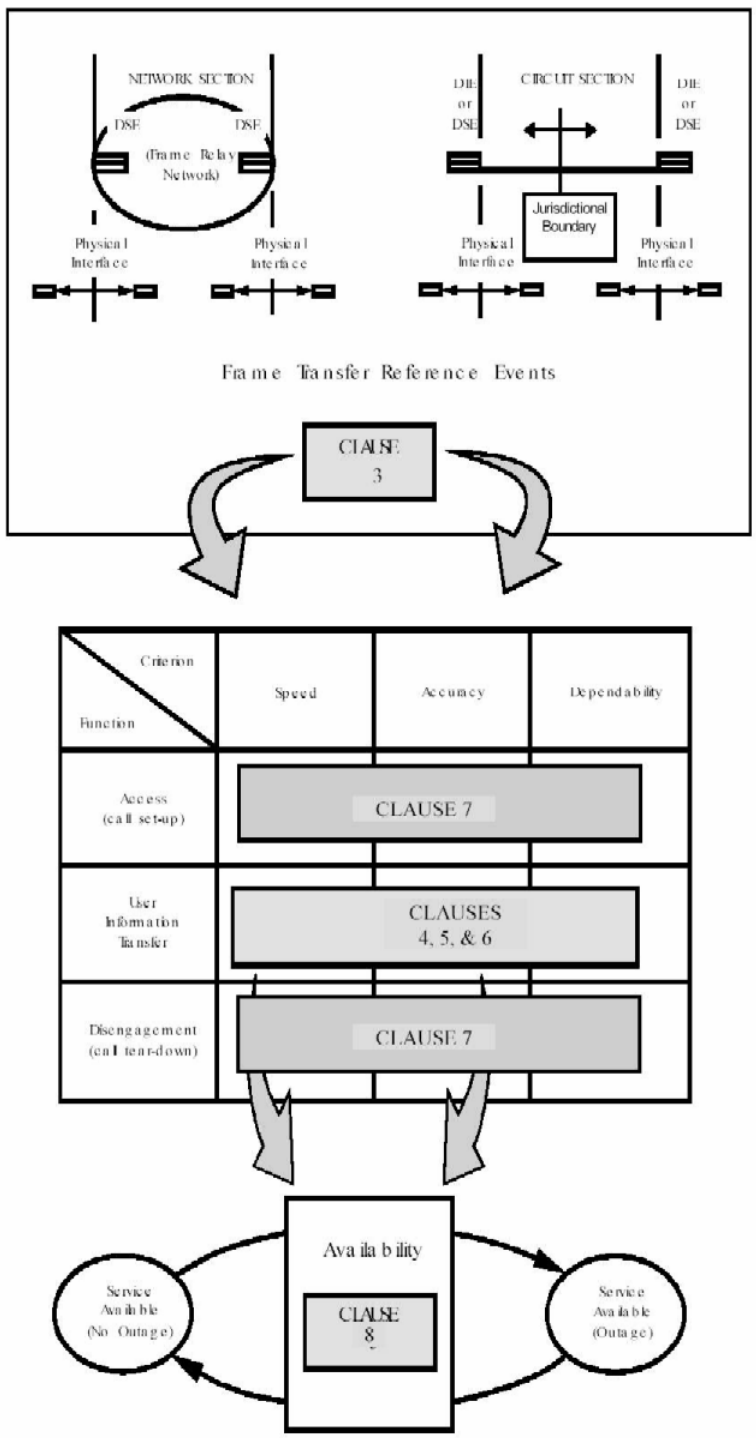

Figure 1 - Scope of T1.513-2003

NOTES

0 The parameters defined in this standard may be augmented or modified based upon further study of the requirements of the services to be supported on frame relay networks.

0 The speed, accuracy, and dependability parameters are intended to characterize frame relay connections in the available state.

0 The parameters of this standard are designed to measure the performance of network elements between two section boundaries. However, users of this standard should be aware that the behavior of connection elements outside the pair of boundaries can negatively influence the measured performance of the elements between the boundaries. Examples are described in Annex F.

This standard is organized as follows:

– Clause 2 presents the normative references;
– Clause 3 defines a performance model and a set of frame transfer reference events (FEs) that provide a basis for performance parameter definition;
– Clause 4 defines frame-based speed of service, accuracy, and dependability parameters for the information transfer phase using the FEs defined in clause 3;
– Clause 5 defines quality of services classes for the information transfer phase;
– Clause 6 provides allocation rules for the objectives of the classes of clause 5;
– Clause 7 defines frame-based speed of service, accuracy, and dependability parameters for the access and disengagement phases using the FEs defined in clause 3;
– Clause 8 defines the PVC availability parameters using the primary parameters defined in clause 4;
– Annex A presents a test for judging traffic conformance for performance assessment purposes;
– Annex B defines bit-based accuracy and dependability parameters associated with the transfer of user information in frame relay services;
– Annex C provides a glossary of acronyms;
– Annex D provides information on sampling estimation of the PVC availability parameters;
– Annex E discusses the performance effects of network indications of congestion and makes general recommendations for controlling these effects;
– Annex F identifies effects of external connection elements on measured performance;
– Annex G presents relationships between Frame Relay and ATM performance for Frame Relay PVCs supported by an ATM network; and
– Annex H is the Bibliography.

2 Normative References

The following standards contain provisions which, through reference in this text, constitute provisions of this American National Standard. At the time of publication, the editions indicated were valid. All standards are subject to revision, and parties to agreements based on this American National Standard are encouraged to investigate the possibility of applying the most recent editions of the standards indicated below.

T1.511-2003, *B-ISDN ATM layer cell transfer performance*.[2]

T1.606a-1992 (R1997), *Integrated Services Digital Network (ISDN) – Architectural framework and service description for frame-relaying bearer service (congestion management and frame size)* [Supplement to T1.606-1990 (R1996)].[2]

T1.617-1991 (R1997), *Integrated Services Digital Network (ISDN) – Signaling specification for frame relay bearer service for Digital Subscriber Signaling System Number 1 (DSS1)*.[2]

T1.617a-1994, *Integrated Services Digital Network (ISDN) – Signaling specification for frame relay bearer service for Digital Subscriber Signaling System Number 1 (DSS1) (Protocol Encapsulation and PICS)* [Supplement to T1.617-1991 (R1997)].[2]

T1.618-1991 (R2003), *Integrated Services Digital Network (ISDN) – Core aspects of frame protocol for use with frame relay bearer service*.[2]

T1.634-1993 (R2001), *Frame relaying service specific convergence sublayer (FR-SSCS)*.[2]

ITU-T Recommendation I.363 (03/93), *B-ISDN ATM adaptation layer specification*.[3]

ITU-T Recommendation X.36 (04/95), *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 (04/95), *Network-to-network interface between public data networks providing frame relay data transmission service*.[3]

3 Generic Performance Model

This clause defines a generic frame relay service performance model composed of four basic connection sections: 1) the access circuit section; 2) the internetwork circuit section; 3) the access network section; and 4) the transit network section. These four basic connection sections are defined in 3.1. They provide a set of building blocks with which any end-to-end connection can be represented. Each of the performance parameters defined herein can be applied to the unidirectional transfer of user information on a connection section or a concatenated set of connection sections.

This clause also specifies a set of frame transfer reference events that provide a basis for performance parameter definition. These reference events are derived from and are consistent with relevant ANSI frame relay service and protocol standards. The reference events are specified in 3.2.

> NOTE – A planned supplement to T1.513-2003 for specification of design objectives (see clause 1) will adapt the generic performance model defined in this clause to provide a jurisdictional basis for the specification and apportionment of frame relay user information transfer performance. The generic model defined in this clause partitions an end-to-end connection into basic sections and defines a set of performance-significant reference events that may be observed at the section boundaries. The performance specification model will add jurisdictional boundaries, define associated access and transit connection portions, and adapt the generic reference event definitions for application at the jurisdictional boundaries. Direct measurement of performance at the defined jursidictional boundaries will not always be practical. Section boundaries (defined in 3.1) may serve as practical surrogates for the jurisdictional boundaries in many cases.

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[2] This document is available from the Alliance for Telecommunications Industry Solutions, 1200 G Street N.W., Suite 500, Washington, DC 20005. <http://www.atis.org>

[3] This document is available from the International Telecommunications Union. < http://www.itu.int/ITU-T/ >

This document provides parameters for quantifying performance at the top of the data link (i.e., frame) layer service access point (SAP). Quantitative relationships between frame layer network performance and the performance of layers below and above the frame layer are for further study.

3.1 Components of an end-to-end connection

In the context of this standard, an end-to-end connection is composed of sections as defined below. The defined terms are shown in Figure 2.

3.1.1 circuit section: Either an access circuit section or an internetwork circuit section.

3.1.1.1 access circuit section (ACS): The physical circuit or set of circuits connecting a Data Terminal Equipment (DTE)[4] to the (local) Data Switching Exchange (DSE). It does not include any parts of the DTE or DSE.

3.1.1.2 internetwork circuit section (ICS): The physical circuit or set of circuits connecting a DSE in one network with a DSE in a different network. It does not include any parts of either DSE.

3.1.2 network section: The network components that provide the connection between two circuit sections. A network section may be either an access network section or a transit network section.

3.1.2.1 access network section (ANS): A network section connected to (at least) one access circuit section.

3.1.2.2 transit network section (TNS): A network section between two internetwork circuit sections.

3.1.3 basic section of a connection: A general term for an access circuit section, an internetwork circuit section, an access network section, or a transit network section.

3.1.4 section boundary: The boundary that separates a network section from the adjacent circuit section, or separates an access circuit section from the adjacent DTE. (Also called *boundary*.)

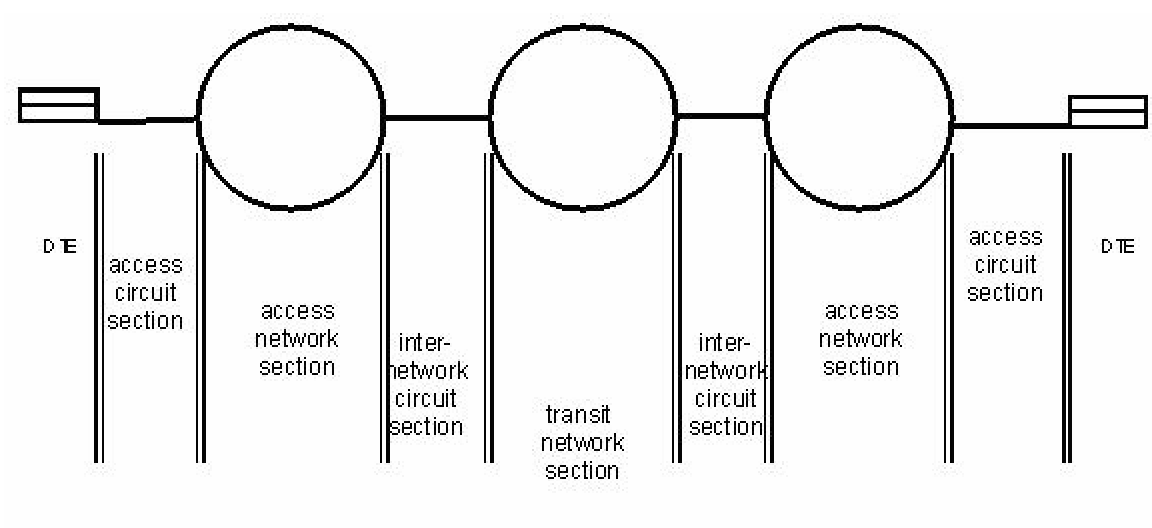

Figure 2 - Sections of a national virtual connection

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4 In the context of this standard, routers are considered as DTE.

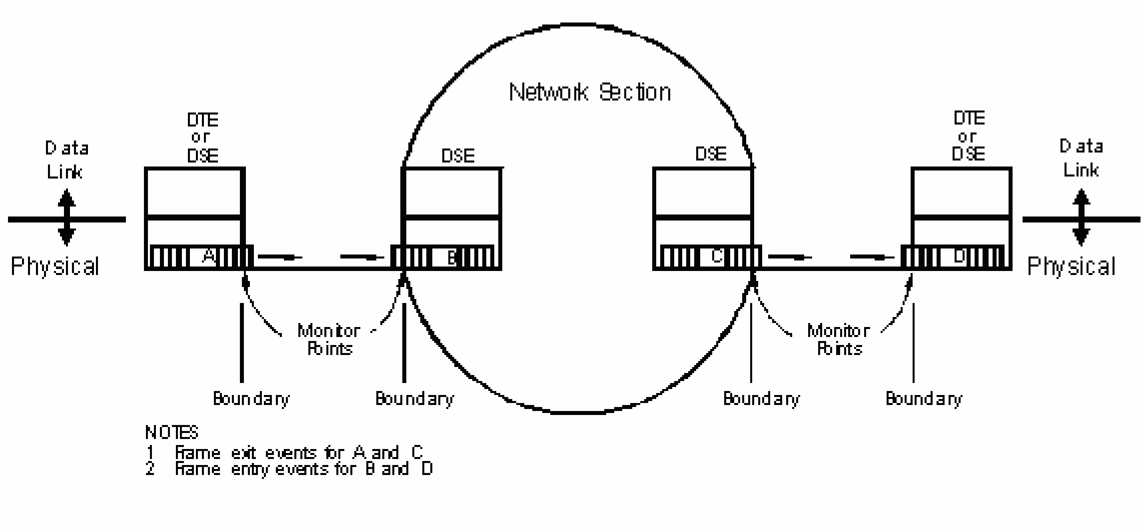


Figure 3 - Example frame transfer reference events

3.2 Frame transfer reference events

In the context of this standard, the following definitions apply on a specified connection. The defined terms are illustrated in Figure 3.

3.2.1 Frame transfer reference event: The event that occurs when all of three of the following conditions occur:

) A frame crosses a section boundary;

) The frame is identified as a user information frame; and

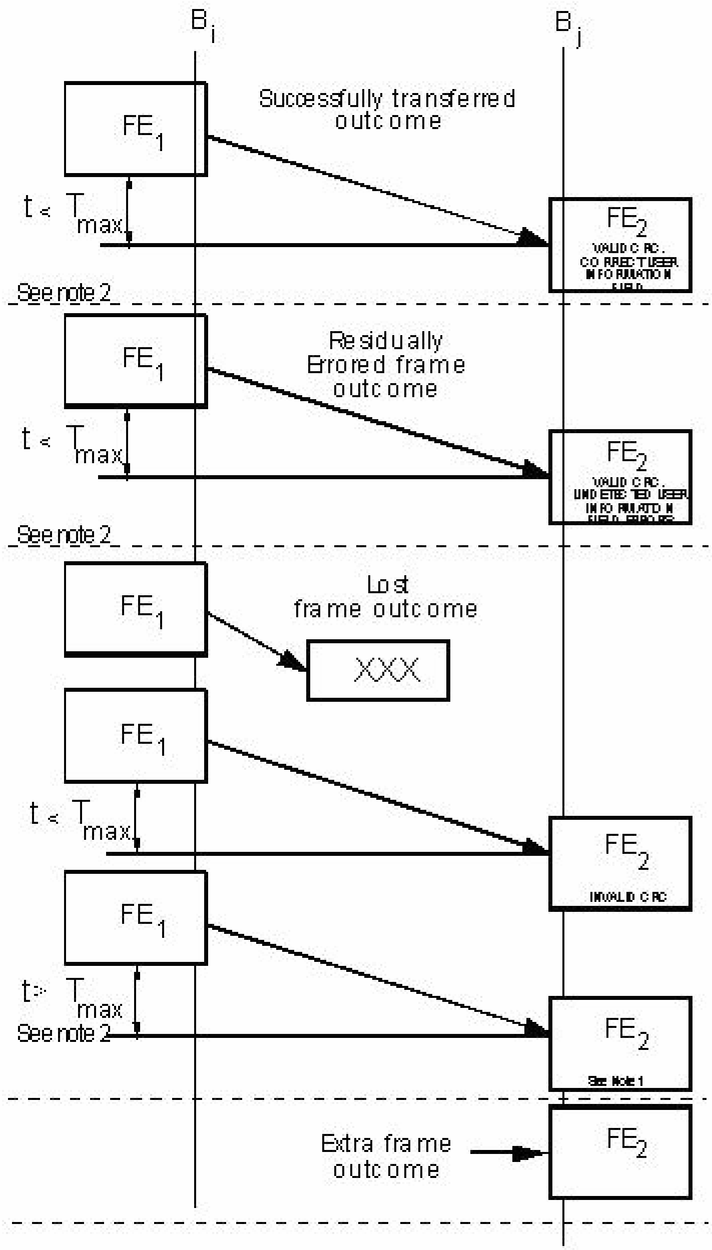
) The DLCI field indicates that the frame belongs to this connection.

Frame transfer reference events can be observed at the physical boundaries terminating a circuit section.

Two classes of frame transfer reference events are defined:

3.2.1.1 frame entry event: A frame transfer reference event that corresponds to a frame entering a network section (from a circuit section) or a frame entering a DTE (from an access circuit section). The time of occurrence of a frame transfer entry event is defined to coincide with the time at which the last bit of the closing flag of the frame crosses the boundary into the network section or DTE.

3.2.1.2 frame exit event: A frame transfer reference event that corresponds to a frame exiting a network section (to a circuit section) or a frame exiting a DTE (to an access circuit section). The time of occurrence of a frame transfer exit event is defined to coincide with the time at which the first bit of the address field of the frame crosses the boundary out of the network section or DTE.



Notes 1) Outcome occurs independently of CRC validity
2) the variable t denotes elapsed time

Figure 4 - Frame transfer outcomes

3.3 Frame transfer outcomes

In the following, it is assumed that the sequence of frames on a connection is preserved. Two events on a connection are said to be *corresponding* if they can be related to the same source frame.

By considering two frame transfer reference events -- FE_1 and FE_2 at B_i and B_j,[5] respectively -- four basic frame transfer outcomes may be defined. A transmitted frame is either *successfully transferred*, *lost*, or *residually errored*. A received frame for which no corresponding transmitted frame exists is said to be *extra*. Extra frames can occur as a result of errors in the address of a frame from a different connection.[6] Figure 4 illustrates the four basic frame transfer outcome definitions.

3.3.1 Successful frame transfer outcome

A successful frame transfer outcome occurs when an FE_2 corresponding to FE_1 happens within a specified time T_{max} after FE_1, and: (a) the Cyclical Redundancy Check (CRC) of the received frame is valid; and (b) the binary content of the user information field of the received frame conforms exactly with that of the corresponding transmitted frame. T_{max} is a time limit beyond which a frame is assumed, for performance assessment purposes, to be lost.

NOTE – The value of T_{max} is for further study.

3.3.2 Residually errored frame outcome

A residually errored frame outcome occurs when an FE_2 corresponding to FE_1 happens within a specified time T_{max} of FE_1 and the CRC of the received frame is valid, but the binary content of the received frame user information field differs from that of the corresponding transmitted frame (i.e., one or more bit errors exist in the received frame user information field).

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[5] Unless otherwise noted in this standard, boundaries B_i and B_j, refer respectively to the frame input and frame output boundaries delimiting an arbitrary connection section or concatenated set of connection sections. Performance parameters are defined with respect to a unidirectional transfer of frames.

[6] Missequenced or duplicated frames are not anticipated. If an unanticipated network mechanism creates these events, measurement systems may categorize them as combinations of lost, residually errored, or extra frame outcomes.

3.3.3 Lost frame outcome

A lost frame outcome occurs when an FE_2 fails to happen within time T_{max} of the corresponding FE_1 or the CRC of the received frame is invalid. The value of T_{max} is the same as that used in the definition of the successfully transferred frame outcome.

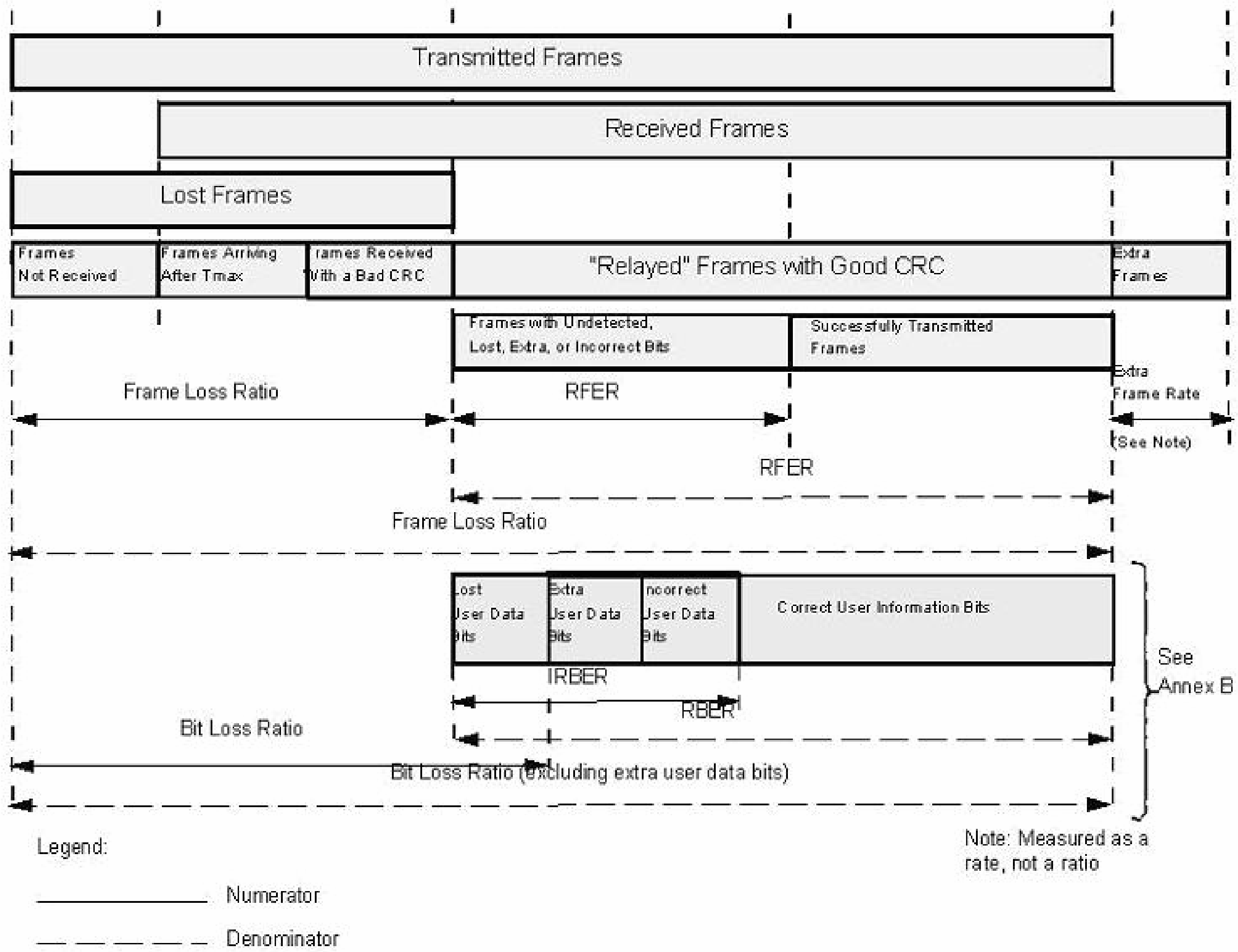

Figure 5 - Statisical populations used in defining selected accuracy and dependability parameters

3.3.4 Extra frame outcome

An extra frame outcome occurs when an FE_2 happens without a corresponding FE_1.

3.4 Frame Relay SVC Reference Events

3.4.1 ITU-T Recommendation X.76

Table 1a lists performance-significant message transfer reference events (defined in ITU-T Recommendation X.76) associated with an INI 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; 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.

Table 1a - Frame Relay SVC Performance Significant Reference Events (FEs) based on ITU-T Recommendation X.76 Layer 3 Message Transfer at an INI boundary

FE Code	Layer 3 Message
S1 a	SETUP (S)
b	SETUP (S)
S2 a	ALERTing (A)
b	ALERTing (A)
S3 a	CALL PROCeeding (CP)
b	CALL PROCeeding (CP)
S4 a	CONNect (C)
b	CONNect (C)
S5 a	PROGress
b	PROGress
S6 a	RELease (R)
b	RELease (R)
S7 a	RELease COMplete (RC)
b	RELease COMplete (RC)

3.4.2 ITU-T Recommendation X.36

Table 1b lists performance-significant message transfer reference events (defined in ITU-T Recommendation X.36) associated with a UNI 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.

Table 1b - Frame Relay SVC Performance-Significant Reference Events (FEs) based on ITU-T Recommendation X.36 Layer 3 Message Transfer at a UNI boundary

FE Code	Layer 3 Message
P1 a	SETUP (S)
b	SETUP (S)
P2 a	ALERTing (A)
b	ALERTing (A)
P3 a	CALL PROCeeding (CP)
b	CALL PROCeeding (CP)
P4 a	CONNect (C)
b	CONNect (C)
P5	PROGress
P6	RELease (R)
P7	RELease COMplete (RC)
P8	CONNect ACKnowledge (CA)
P9 a	DISConnect (D)
b	DISConnect (D)

4 Frame performance parameters

This clause defines speed of service, accuracy, and dependability parameters associated with the transfer of user information (user information frame transfer delay, user information frame loss ratio, residual frame error ratio, extra frame rate, and frame-based conformant traffic distortion ratio), as well as access and disengagement. All parameters may be estimated on the basis of observations at the section boundaries. Figure 5 shows the statistical populations used to calculate selected accuracy and dependability parameters.[7]

NOTE – Annex B defines three supplementary, bit-based accuracy and dependability parameters associated with the transfer of user information in frame relay services: 1) user information bit loss ratio; 2) residual bit error ratio; and 3) bit-based conformant traffic distortion ratio. These parameters are relatable to the frame-based parameters defined in clause 4 (see Figure 5).

4.1 User information frame transfer delay

The user information frame transfer delay (FTD) is defined as:

$$FTD = t_2 - t_1$$

where, in a specified population:

7 As shown in Figure 5, a successfully transferred or residually errored frame outcome is referred to as a "relayed frame."

t_1 is the time of occurrence for the first FE;

t_2 is the time of occurrence for the second FE; and

$t_2 - t_1 \leq T_{max}$.

The end-to-end user information frame transfer delay is the one-way delay between DTE boundaries (for example, B_1 and B_n in Figure 6).

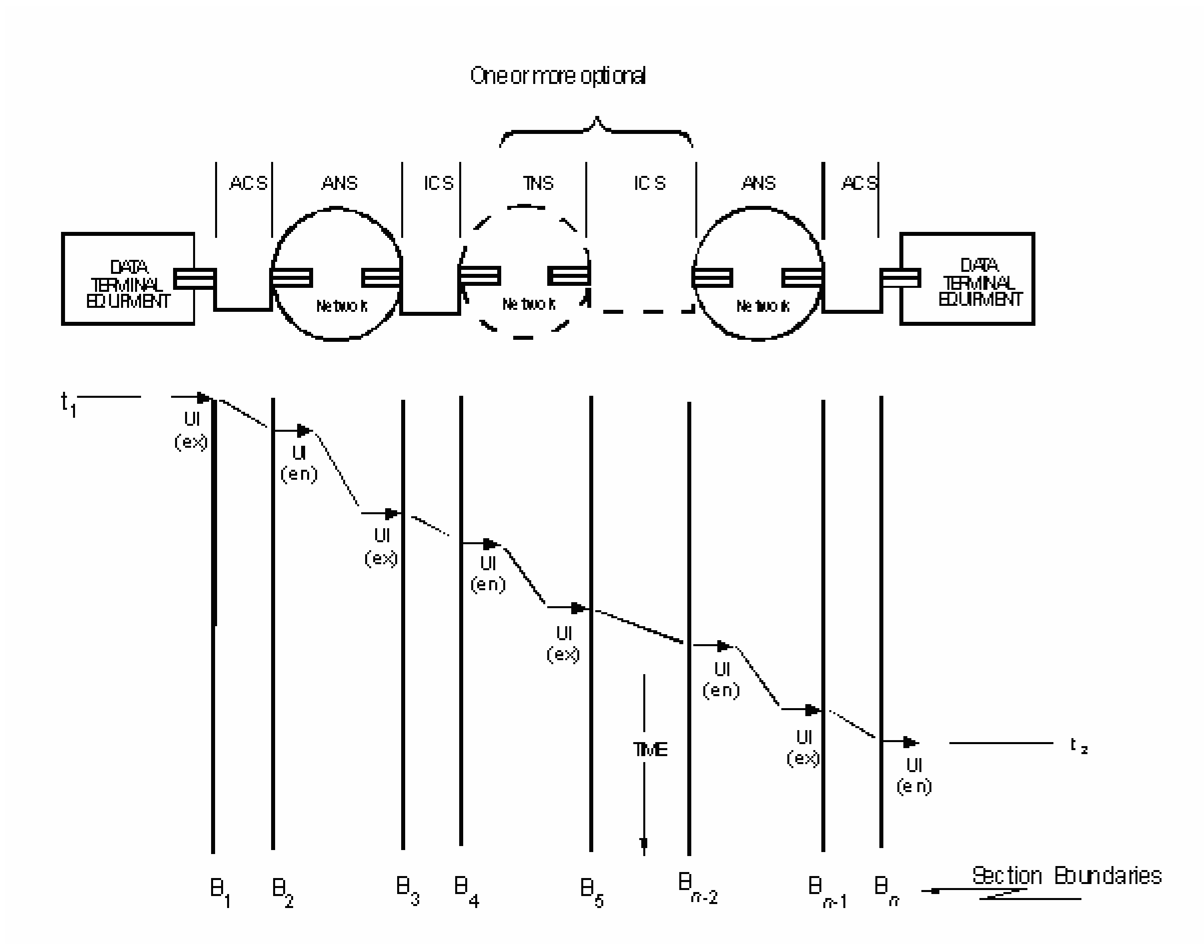

Figure 6 - User information frame transfer delay events

4.2 User information frame loss ratio

The user information frame loss ratio (FLR) is defined as:

$$FLR = \frac{F_L}{F_L + F_R + F_S}$$

where, in a specified population:

F_S is the total number of successfully transferred frame outcomes;

F_L is the total number of lost frame outcomes; and

F_R is the total number of residually errored frame outcomes.

Two special cases are of particular interest, FLR_c, and FRL_e.

4.2.1 FLR_c

The FLR for frames marked DE=0 should remain relatively constant as long as the total DE=0 traffic does not exceed the $CIR=B_c /T$. If the total DE=0 traffic exceeds the CIR, some DE=0 frames may be immediately discarded or converted to DE=1 frames, and the FLR for DE=0 traffic may increase.[8]

FLR_c is defined as the FLR for a population of frames with DE=0 when all DE=0 frames are conforming with the CIR. If the network accepts all conforming frames in accordance with the test described in annex A, FLR_c is the probability that a DE=0 frame accepted as conforming will subsequently be lost. Conformance with the CIR is judged using the test described in annex A.

NOTE – DE=0 frames successfully relayed with the DE bit changed to DE=1 are counted as F_s outcomes in the calculation of FLR_c.

4.2.2 FLR_e

Frames can be marked DE=1 either before or immediately after crossing the input section boundary. The loss performance for all such frames should remain relatively constant as long as the total DE=1 traffic does not exceed the $EIR=B_e /T$. If the total DE=1 traffic exceeds the EIR, some DE=1 frames may be immediately discarded, and the loss ratio for DE=1 traffic may increase. [8]

FLR_e is defined as the FLR 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. If the network accepts all conforming frames in accordance with the test described in Annex A, FLR_e is the probability that an input DE=1 frame accepted as conforming will subsequently be lost. Conformance with EIR and CIR is judged using the test described in Annex A.

For evaluation purposes, as there is no precise way of quantifying the amount of DE=0 traffic that the network converts to DE=1, the FLR_e parameter is defined only in terms of frames input as DE=1. As long as the total DE=1 traffic does not exceed the EIR, it is expected that network marked DE=1 traffic will experience loss ratios similar to FLR_e.

[8] The rate at which FLR increases when offered traffic exceeds CIR and EIR may vary among network providers. Some network providers explicity offer to transport this extra traffic. Such offerings may have an increased probability of congestion notification, delays, or bursts of loss.

4.3 Residual frame error ratio

The residual frame error ratio (RFER)[9] is defined as:

$$RFER = \frac{F_R}{F_R + F_S}$$

where, in a specified population:

F_S is the total number of successfully transferred frame outcomes; and

F_R is the total number of residually errored frame outcomes.

4.4 Extra frame rate

The extra frame rate (EFR) is defined as:

$$EFR = \frac{F_E}{T_{EFR}}$$

where:

F_E is the total number of extra frame outcomes observed during a specified time interval T_{EFR}.

This rate may be expressed as the number of extra frame outcomes per connection second.[10]

4.5 Frame-based conformant traffic distortion ratio

Network-caused frame clumping or excess marking of conforming traffic as DE=1 can result in frame loss in downstream network elements. Therefore, the frame-based conformant traffic distortion ratio (FCTDR) is defined to help in diagnosing problems with FLR.

The relationship between FCTDR and downstream FLR depends strongly on how network providers collaborate to meet their (implied) end-to-end CIR and EIR commitments. In some cases, a downstream network may deliberately provision a larger B_c and B_e, or smaller T, to compensate for upstream frame clumping. Also FCTDR may not be relevant for terminating devices that do not care about either the burstiness of arrivals or the DE status of frames received. For both these reasons, standards for FCTDR performance may not be established.

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9 This accuracy parameter refers to the residual (i.e., undetected) user information frame errors caused by transmission or switching impairments introduced on a specified connection.

10 By definition, an *extra frame* is a received frame that has no corresponding transmitted frame on that connection. Extra frames on a particular connection can be caused by an undetected error in the address of a frame originated on a different connection, or by an incorrectly programmed translation of addresses for frames originated on a different connection. Since neither of these mechanisms has a direct relation to the number of frames transmitted on the observed connection, this performance parameter cannot be expressed as a ratio of frame counts, but only as a rate.

Frames conforming to CIR at an input boundary (B_i) may be lost, clumped, or tagged as DE=1 so that the number of frames conforming to CIR at the output boundary (B_j) is reduced. The frame-based conformant traffic distortion ratio for DE=0 traffic ($FCTDR_c$) measures the reduction in conforming traffic due to only clumping or tagging.

The $FCTDR_c$ parameter is defined as follows:

Let $\{A_1, A_2, \ldots, A_N\}$ denote a sequence of N frames, all input with DE=0, conforming to CIR at B_i, and all relayed to B_j.

$$\text{Let } F_n = \begin{cases} 1 & \text{if frame } A_n \text{ is nonconforming to } \hat{CIR} \text{ at } B_i \text{ or is marked DE = 1 at } B_j' \\ 0 & \text{otherwise} \end{cases}$$

Then:

$$FCTDR_c = \frac{1}{N}\sum_{n=1}^{N} F_n$$

CÎR is the modification of CIR described in Annex A.

Frames conforming to EIR at an input boundary (B_i) may be lost or clumped so that the total number of frames conforming to EIR at the output boundary (B_j) is reduced. The frame-based conformant traffic distortion ratio for DE=1 traffic ($FCTDR_e$) measures the reduction in conforming traffic due only to clumping.

The $FCTDR_e$ parameter is defined as follows:

Let $\{A_1, A_2, \ldots, A_N\}$ denote a sequence of N frames, all input with DE=1, conforming to EIR at B_i, and all relayed to B_j.

$$\text{Let } F_n = \begin{cases} 1 & \text{if frame } A_n \text{ is nonconforming to } \hat{EIR} \text{ at } B_j' \\ 0 & \text{otherwise} \end{cases}$$

$$FCTDR_e = \frac{1}{N}\sum_{n=1}^{N} F_n$$

EÎR is the modification of EIR described in Annex A.

4.6 Frame Delay Jitter

Frame Delay Jitter (FDJ) is defined as the maximum Frame Transfer Delay (FTD_{max}) minus the minimum Frame Transfer Delay (FTD_{min}) during a given measurement interval, consisting of a statistically significant number of delay measurements (N).

$$FDJ = FTD_{\max} - FTD_{\min}$$

where:

– FTD_{max} is the maximum FTD recorded during a measurement interval of N delay measurements

- FTD_{min} is the minimum FTD recorded during a measurement interval of N delay measurements
- N is the number of FTD measurements made to give a statistically significant representation of the FTD performance. N must be chosen to be at least 1000 (see NOTE below).

  NOTE - This number of 1000 observations will ensure that the 99.5 percentile of delay is observed at least 99% of the time. The suggested measurement interval is five (5) minutes. It is desirable that the observations be distributed uniformly across the measurement interval.

4.7 Frame flow related parameters

The need for network performance parameters describing the achievable flow of frames in a connection is for further study. Such parameters will be needed if flow control mechanisms are implemented in frame relay networks. One useful parameter could be the (positive) difference between the negotiated committed information rate and the actual information transfer rate. Measures of specific flow control mechanisms may also be of value.

NOTE – Annex E discusses performance effects associated with network indications of congestion (i.e., FECN, BECN, CLLM) and makes general recommendations for controlling these effects.

5 National Network Performance Objectives and Quality of Service (QoS) Classes

Table 2 specifies end-to-end national versions of the Frame Relay QoS classes specified in Table 1 of ITU-T Recommendation X.146. Apportionment rules for these national end-to-end objectives are given in clause 6. Any of the QoS classes in Table 2 may be requested for a specific PVC or SVC, but only one such QoS class may be requested per virtual connection. As QoS class 0 has no specified numeric objectives, it is sometimes referred to as the "unspecified" class.

Table 2/T1.513-2003 – National Frame relay service classes

Class	Network support	FLR_C	FTD (ms)	FDJ (ms)
0	Mandatory, default class	No upper bound specified on FLR_C. But FLR_C will have a practical upper bound and will not be arbitrarily bad.	No upper bound specified on FTD. But delay will have a practical upper bound and will not be arbitrarily large.	NOT APPLICABLE
1	Mandatory	Value $< 3.4 \times 10^{-4}$, and 95th percentile of weighted 15-minute values $< 1 \times 10^{-3}$.	95th percentile $<$ 138 ms.	95th percentile < 30 ms (see Note 7 and Note 8)
2	Optional	Value $< 1 \times 10^{-5}$, and 95th percentile of weighted 15-minute values $< 3.4 \times 10^{-5}$.	95th percentile $<$ 138 ms.	95th percentile < 10 ms (see Note 7 and Note 9)
3	Optional	Value $< 1 \times 10^{-5}$, and 95th percentile of weighted 15-minute values $< 3.4 \times 10^{-5}$.	95th percentile $<$ 50 ms.	95th percentile < 10 ms (see Note 7 and Note 9)

NOTE 1 – All values are provisional and they need not be met by networks until they are revised (up or down) based on real operational experience.

NOTE 2 – The FTD objectives apply edge-to-edge, excluding the access circuit sections.

NOTE 3 – Basic frame relay service guarantees apply to all service level classes (i.e., minimum service availability requirements).

NOTE 4 – For FTD performance, all service classes apply to frames of size 256 (i.e., to frames with user information fields of 256 octets). If frames of size 128 are used to estimate compliance with these objectives, then the following tighter 95th percentile objectives for FTD should be used: 130 ms for classes 1 and 2, and 45 ms for class 3.

NOTE 5 – Classes 2 and 3 may be characterized by service availability levels higher than those of basic frame relay service.

NOTE 6 – For frame relay PVC connections, a one-month interval should be used to evaluate the FLR_c objective.

NOTE 7 – The allocated FDJs sum to more than the end-to-end FDJ, because FDJ accumulates similarly to the standard deviation of roughly independent random variables. When independently random variables are summed, the resulting standard deviation is roughly the square root of the sum of the squares.

NOTE 8: Certain applications (e.g., voice) need a FDJ requirement and therefore such a requirement is included in Class 1. However, it is recognized that there are other applications that could use class 1 (e.g., file transfer) that do not need a FDJ requirement.

NOTE 9: It is assumed that there are no satellites in the national portion. If a satellite is present, the FTD objectives will not apply.

5.1 Nature of the network performance objectives

These FLR_c objectives apply to all offered frame relay frames within the CIR (regardless of size). These objectives do not include the performance of DTEs or private networks.

5.2 Standardized Frame Size for FTD performance measurement

Clocking delay of both access circuit sections and inter-network circuit sections can be a significant component of the end-to-end frame transfer delay, in particular if large frames or low-speed circuit sections are in place.

A standardized frame size (length of information field in frame relay frame) of 256 octets is to be used for making FTD performance measurements. This ensures that the clocking delay component is not significant, and that the clocking delay contribution is not variable between different performance measurement implementations.

> NOTE – It is recognized that FTD performance measurements might be made using a frame size of 128 octets, in which case the objective values are modified accordingly (see Note 4 of Table 2).

5.3 Frame relay service class support

Table 2 specifies four frame relay service classes. For each QoS class, four items are specified. First, the level of network support, either mandatory or optional, is specified. Next, the committed frame loss ratio, FLR_C, if applicable, and its mean value and 95%-tiles. Thirdly, the requirements on the frame transfer delay -- FTD (in milliseconds) -- are given for each QoS class. Finally, FDJ requirements (in milliseconds) are given. These frame relay QoS classes apply to both frame relay PVC and frame relay SVC. User signalling of frame relay service class at a UNI is contained in Recommendation X.36. Signalling of frame relay service class at the NNI is contained in ITU-T Recommendation X.76.

The notations of mandatory, default class, and optional in the network support column have the following interpretations:

- Any network supporting these frame relay service classes must support both class 0 and class 1.
- Class 0 corresponds to current frame relay implementations and is thus denoted as the default class.
- Use of the default service class is defined in ITU-T Recommendations X.36 and X.76.
- Lastly, networks supporting these frame relay service classes may, at their discretion, elect to support the optional classes 2 or 3. Users selecting class 2 or class 3 may be subject to additional restrictions of the service provider not explicitly mentioned in this Recommendation.

6 Allocation of QoS Class Objectives

This clause defines methods for allocating the performance objectives specified in the QoS classes of clause 5 to the participating networks. As the objectives in the QoS classes in clause 5 exclude the performance of the access circuit section, this aspect is discussed first in 6.2 after the introduction of route length in 6.1. Subsequently, 6.3 and 6.4 discuss the means by which the QoS class objectives of clause 5 for FTD and FLR_C, respectively, are to be allocated nationally. Subclause 6.3 also contains the formula for the FTD of an access circuit section. Finally, 6.5 contains a discussion of the rule for allocating FDJ.

Both "complexity" and "distance" when allocating FTD are considered in formulating the allocation rules. The term *complexity* denotes network effects that increase delay as more switching and queuing stages are encountered. *Distance* means those network effects not directly related to additional switching or queuing.

It should be noted that, since the levels of the various FLR_c objectives in the frame relay QoS classes are in the range of 10^{-5} to 10^{-3}, the major effect on FLR_c is due to buffer management (i.e., complexity). Thus, route length is not used as a factor in the allocation of FLR_c.

6.1 Route length calculation

Route length (R_{km}) is used in place of "distance" in allocating some of the FTD performance objectives. If D_{km} is the air-route distance between the portion boundaries, then the route length is calculated as follows (this is the same calculation as found in ITU-T Recommendation G.826):

– if $D_{km} < 1000$ km, then $R_{km} = 1.5 \times D_{km}$;

– if 1000 km $\leq D_{km} \leq$ 1200 km, then R_{km} = 1500 km;

– if $D_{km} > 1200$ km, then $R_{km} = 1.25 \times D_{km}$.

This rule does not apply if there is a satellite in the portion.

6.2 Access circuit section FTD

For FTD, the contribution of the access circuit section could be significant, depending on both its length and its nominal access line rate. The following formula quantifies the access circuit section's contribution to FTD.

The following notation is used:

– AR stands for the access line rate of the access circuit section in bits per second;

– FTD_a is the respective contribution of an access circuit section to the end-to-end frame transfer delay in milliseconds; and

– R_a stands for the calculated route length of the access circuit section in kilometers.

The multiplier of 0.005 ms/km comes from ITU-T Recommendation Table A.1/G.114, and allows for delay in repeaters and regenerators. Additionally, a frame size of 256 octets, with 5 octets of overhead (a two-octet address field, a 16-bit cyclic redundancy check, and one flag) and 40 insertion bits for transparency is assumed.

The FTD associated with an access circuit section is:

$$FTD_a \ \text{ms} = \frac{(256 \times 8 + 5 \times 8 + 40) \ \text{bits}}{(AR / 1000) \ \text{bit} \cdot \text{s}^{-1}} + R_a \ \text{km} \times 0.005 \ \text{ms} \cdot \text{km}^{-1}$$

6.3 Frame delay allocation

For allocating FTD, the following rules apply:

- For Classes 1 and 2, each Frame switch is allowed an allocation of 6.55 ms of delay, and the route mileage (in kilometres) is allowed 0.005 ms/km of propagation delay.
- For Class 3, each Frame switch is allowed an allocation of 1.65 ms of delay, and the route mileage (in kilometres) is allowed 0.005 ms/km of propagation delay.
- Each network shall interpret its FTD allocation as an upper 99%-tile.

6.4 Frame loss allocation

For allocating FLR_c, the following rules apply:

- For Class 1, each Frame switch is allowed an allocated overall FLR_c of 1.9×10^{-5} with an upper 99.72%-tile of loss of 5.7×10^{-5}.[11]
- For Classes 2 and 3, each Frame switch is allowed an allocated overall FLR_c of 5.7×10^{-7} with an upper 99.72%-tile of loss of 1.9×10^{-6}.
- For Class 1, a network with N Frame switches shall have an overall FLR_c objective of N x (1.9×10^{-5}), and a [100 x (0.9972^N)]%-tile of N x (5.7×10^{-5}).
- For Classes 2 and 3, a network with N Frame switches shall have an overall FLR_c objective of N x (5.7×10^{-7}), and a [100 x (0.9972^N)]%-tile of N x (1.9×10^{-6}).

6.5 Frame delay jitter allocation

For allocating FDJ, the following rules apply:

- For Class 1, originating or terminating Frame switches are allowed an allocation of 15 ms of FDJ; all other Frame switches are allowed an allocation of 5 ms of FDJ.
- For Classes 2 and 3, originating or terminating Frame switches are allowed an allocation of 4 ms of FDJ; all other Frame switches are allowed an allocation of 2 ms of FDJ.
- A network's FDJ allocation is the square root of the sum of squares of the FDJ of each contributing switch in the network.
- Each network shall interpret its FDJ allocation as an upper 99%-tile.

7 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 7.1.1 – is only relevant for connections that are correctly established. The accuracy and dependability parameters in 7.2 address the issue of abnormal network operation.

[11] The fractional percentiles (such as 99.72%-tile) used in the various allocation rules are the result of statistical calculations.

7.1 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.

7.1.1 Connection set-up delay

Connection Set-up delay applies to Frame Relay SVC service. Figure 7 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.

7.1.1.1 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.

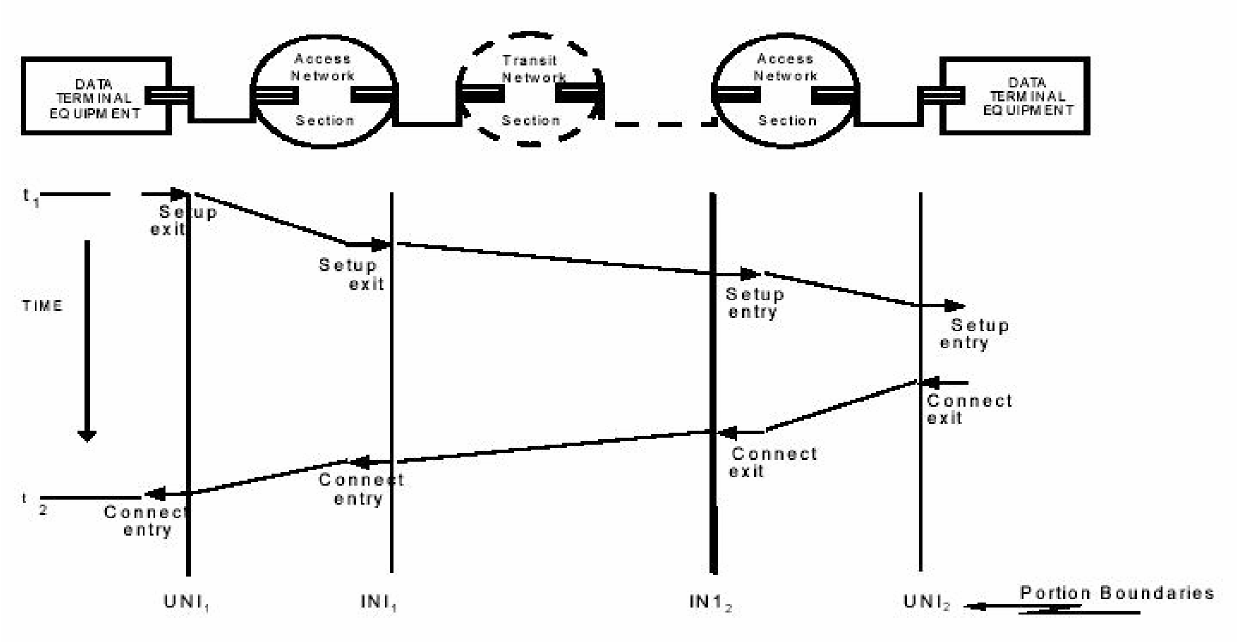

Figure 7 - Connection set-up delay example

Table 3 - Reference Events Used in Defining Connection Set-up Delay at a Single Boundary

Boundary	Starting Reference Event	Ending Reference Event
UNI_1	P1a (Setup, exit)	P4b (Connect, entry)
UNI_2	P1b (Setup, entry)	P4a (Connect, exit)
INI_1	S1a (Setup, exit)	S4b (Connect, entry)
INI_2	S1b (Setup, entry)	S4a (Connect, exit)

7.1.1.2 Definition of connection set-up delay between two boundaries

To assess network performance, 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.

7.1.2 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 UNI boundaries (shown in Figure 8). The reference events used to define disconnect delay are given in Table 4.

Table 4 - Reference events used in defining disconnect delay

Boundary	Reference Event
UNI_1	P9a (Disconnect, exit)
UNI_2	P9b (Disconnect, entry)
UNI_1	P9a (Disconnect, exit)
UNI_2	P9b (Disconnect, entry)

7.1.3 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.

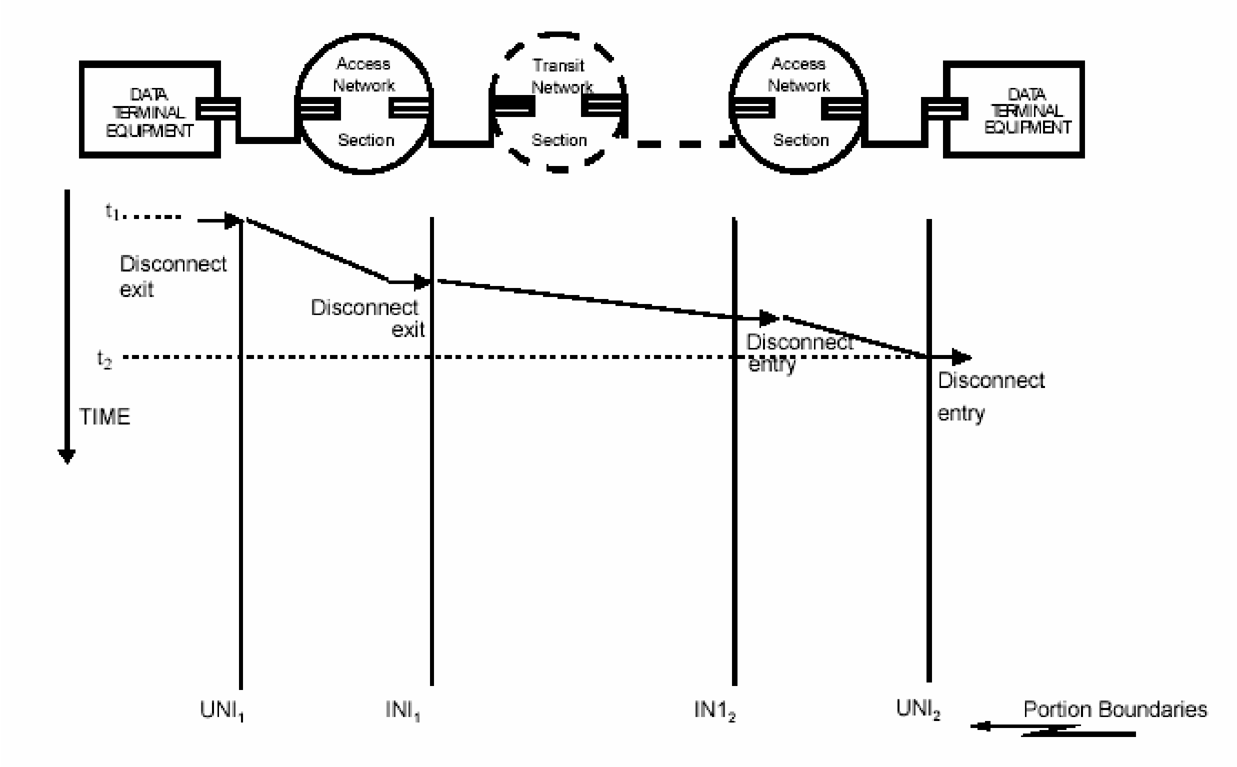

Figure 8 - End-to-end disconnect delay

Table 5 - Reference Events for Release Delay

Starting Reference Event	**Ending Reference Event**
P9a (Disconnect, exit)	P6 Release, or P7 RELease COMplete

7.2 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 7.2.1. Subclause 7.2.2 defines two premature disconnect parameters, and 7.2.3 defines connection clearing failure probability.

7.2.1 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 9 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.

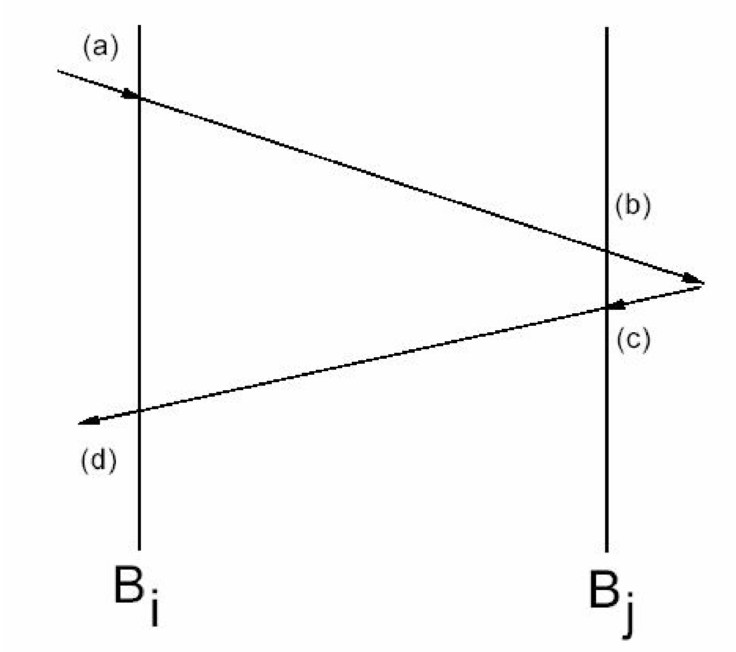

Figure 9 - Successful connection setup

7.2.1.1 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 standards 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 9, 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 - Reference events (FEs) at B_i occurring during successful Frame Relay SVC connection set-up

Boundary, B_i	FE	
	(a)	(d)
UNI_1	P1a (SETUP exit)	P6b (CONNECT entry)
INI_1	S1a (SETUP exit)	S4b (CONNECT entry)
INI_2	S1b (SETUP entry)	S4a (CONNECT exit)
UNI_2	Not Applicable	Not Applicable

Table 6b - Reference events (FEs) at B_j occurring during successful Frame Relay SVC connection set-up

Boundary, B_j	FE	
	(b)	(c)
UNI_1	Not Applicable	Not Applicable
INI_1	S1a (SETUP exit)	S4b (CONNECT entry)
INI_2	S1b (SETUP entry)	S4a (CONNECT exit)
UNI_2	P1b (SETUP entry)	P4a (CONNECT exit)

7.2.1.2 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 Recommendations X.36 and X.76 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 9, 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:

0) Both events (b) and (d) do not occur; or

0) 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 or nonperformance on the part of an entity outside the portion are excluded.

7.2.1.2.1 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 UNI boundary due to the lack of a CONNect message (P4a) reference event at the terminating UNI 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 timeout; and

) All channels at the called TE are in use.

7.2.2 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 ITU-T 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 behavior; 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.

7.2.2.1 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.

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

Boundary	Reference Event
UNI	P9a (DISCONNECT entry)
INI	S6a (RELEASE exit) S6b (RELEASE entry) S7a (RELease COMplete, exit) S7b (RELease COMplete, entry)

7.2.2.3 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.

7.2.2.4 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 reestablished.

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

Boundary, B_i	Starting FE
UNI_1	P7a (DISCONNECT exit)
INI_1	S6a (Release, exit) or S7a (RELease COMplete, exit)
INI_2	S6b (Release, entry) or S7b (RELease COMplete, entry)
UNI_2	N/A

Table 8b - 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**
UNI_1	N/A
INI_1	S6a (Release, exit) or S7a (RELease COMplete, exit)
INI_2	S6b (Release, entry) or S7b (RELease COMplete, entry)
UNI_2	P9b (DISCONNECT entry)

8 Availability

This clause specifies PVC AND SVC availability parameters for the section types defined in 3.1. A two-state model provides a basis for describing overall PVC AND 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 PVC AND SVC availability function and defines the PVC AND SVC availability parameters that characterize the resulting binary random process.

Four availability parameters are defined in clause 6:

0. PVC service availability;
0. SVC service availability;
0. Mean time between PVC service outages; and
0. Mean time between SVC service outages.

Each parameter can be applied to any basic section of an end-to-end connection.

For both PVC and SVC availability, 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 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.

The set of connection sections bounded by 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 four decision criteria is unacceptable.

The intervals during which a connection section or concatenated set of connection sections are unavailable are identified by superimposing the unacceptable performance periods for all decision parameters as illustrated in Figure 10.

In order to exclude transient impairments from being considered as periods of unavailability, a single test of the availability state must be 5 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.

8.1 PVC availability function

Four performance parameters, defined in clause 4, are used in computing the PVC availability:

0. User information frame loss ratio (for offered traffic conforming with the CIR);
0. User information frame loss ratio (for offered traffic conforming with EIR);
0. Residual frame error ratio; and
0. Extra frame rate.

These parameters are called the availability decision parameters. Each decision parameter is associated with an outage threshold. These decision parameters and their outage thresholds are listed in Table 9.

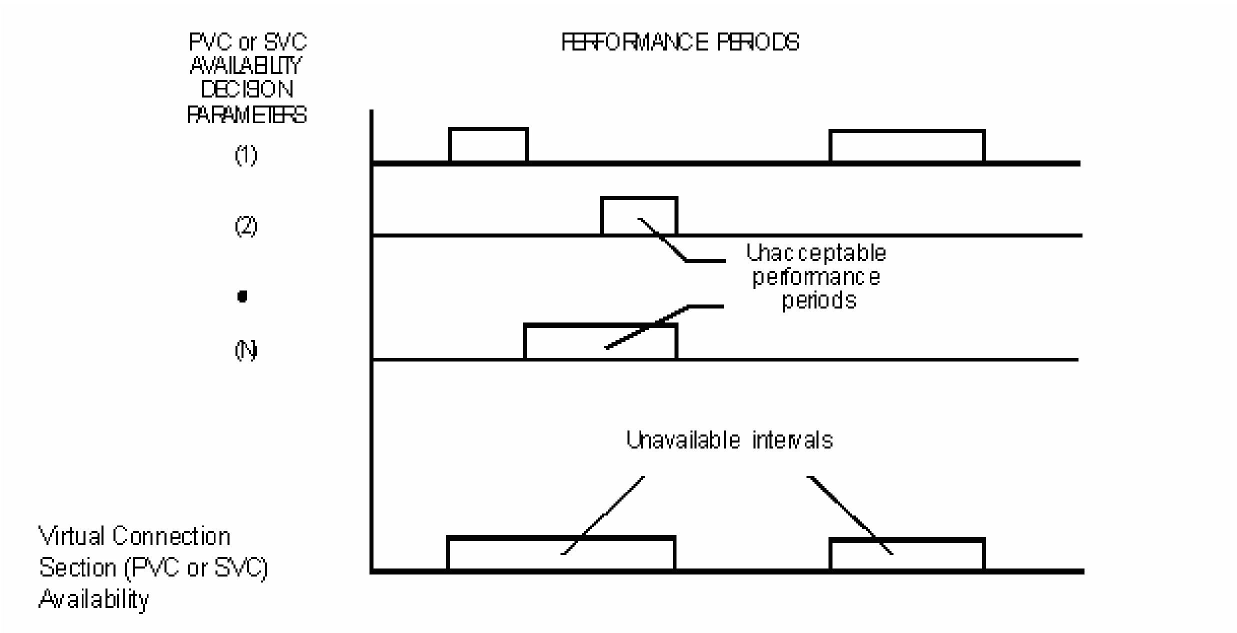

Figure 10 - Determination of virtual connection section availability states

Table 9 - Outage criteria for the PVC availability decision parameters

Availability decision parameters	Criteria
FLR_c [1)] – User information frame loss ratio for frames with DE=0 when all input DE=0 frames conform with the CIR	$FLR_c > C_1$
FLR_e [2)] – User information frame loss ratio for frames input with DE=1 when all input DE=1 frames conform with the EIR and all DE=0 frames conform with the CIR	$FLR_e > C_2$
REFR – Residual frame error ratio	$RFER > C_3$
EFR – Extra frame rate	$EFR > C_4$

[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.

[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.

NOTES

1 The threshold values C1 = 10 (percent), C2 = 25 (percent), C3 = 1 (percent), C4 = 1/300 (extra frames per connection second) are provisional and for further study.

2 The connection section (or set of sections) may also be considered unavailable if the physical layer at either section boundary is unavailable (no signal, alarm condition, etc.) due to causes within the section(s).

8.2 PVC availability parameters

Two availability parameters are defined: PVC service availability (SA) and mean time between PVC service outages (MTBSO).

8.2.1 Definition of PVC service availability

SA as defined in 8.2 applies to PVC services. The *PVC service availability* is the long-term percentage of scheduled service time in which a connection section or concatenated set of connection sections is available.

Scheduled service time for a PVC is the time during which the network providers have agreed to make that PVC available for service. Typically, the scheduled service is 24 hours per day, 7 days a week.[12]

8.2.2 Definition of mean time between PVC service outages

MTBSO as defined in 8.2 applies to PVC services. The *mean time between PVC service outages* is the average duration of any continuous interval during which the PVC section or concatenated set of sections is available. Consecutive intervals of scheduled service time are concatenated.

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[12] Other scheduled service times may be specified in some networks.

8.3 SVC availability function

To define Frame Relay SVC availability, two additional outage criteria are specified in conjunction with the outage criteria for PVC availability. The full set of Frame Relay SVC decision parameters and their outage thresholds are listed in Table 10.

Table 10 – Outage criteria for the SVC availability decision parameters

Availability decision parameters	Criteria
FLR_c 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_e 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	$FLR_e>C_2$
REFR – 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)	$PDP+PDSP>C_6$

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.

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 -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).

8.4 SVC availability parameters

Two availability parameters are defined: SVC SA and MTBSO.

8.4.1 Definition of SVC service availability

SA as defined in 8.4 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, 7 days a week.[13]

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[13] Other scheduled service times may be specified in some networks.

8.4.2 Definition of mean time between SVC service outages

MTBSO as defined in 8.4 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.

8.5 Related parameters

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

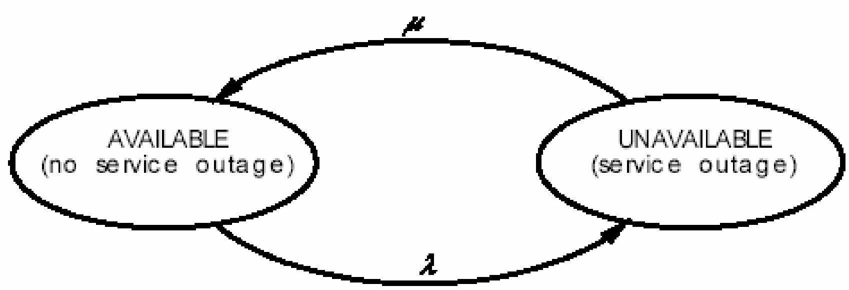
) Mean time to service restoral (*MTTSR)* is the average duration of unavailable service time intervals;

) 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 SA and MTBSO as summarized in Figure 11.



(a) State diagram

$$MTBSO = \frac{1}{\lambda} \qquad MTTSR = \frac{1}{\mu}$$

$$SA = 100\left[\frac{MTBSO}{MTBSO + MTTSR}\right] = 100\left[\frac{\mu}{\lambda + \mu}\right]$$

$$U = 100 - SA = 100\left[\frac{MTTSR}{MTBSO + MTTSR}\right] = 100\left[\frac{\lambda}{\lambda + \mu}\right]$$

(b) Parameter relationships

Figure 11 - Basic availability model and parameters

Annex A
(normative)

A Conformance test for performance evaluation

A.1 Motivation

There are no standards for how networks should determine conformance with CIR and EIR. All reasonable network implementations that normally admit B_c and B_e traffic in T time units are acceptable. However, FLR_c and FLR_e (in subclauses 4.2.1 and 4.2.2), FCTDR (see 4.5) and availability (see clause 5) all require the notion of conformance. For the purposes of evaluating FLR_c, FLR_e, FCTDR, and availability performance in a standard way, it is necessary to have a standard way of determining conformance.

This annex provides the standard test to be used in determining frame relay traffic conformance for the above performance assessment purposes. The test, called the double dangerous bridge (DDB), was selected because it is believed to be more stringent than any network's implementation of conformance testing in traffic enforcement.

Since networks are allowed to discard (or mark as DE) all frames in excess of CIR or EIR, it is usually desirable that such frames not be counted against a measurement of FLR or FCTDR. The DDB is believed to be at least as stringent in determining conformance as any reasonable frame relay conformance test Therefore any frame stream determined by the DDB to be completely conforming will be accepted as completely conforming by any reasonable network. Every frame in those streams should, in principle, be accepted by the network without discard or marking. Thus, frame streams determined to be completely conforming by the DDB are useful for estimating the frame loss performance within a network while avoiding the allowable effects of traffic enforcement.

For the subscriber's benefit, network providers may carry traffic beyond the negotiated CIR and EIR. However, because there is no standardized way in which this extra capacity is offered, this standard does not include performance measures for such offerings. Users of this capacity should be aware that there may be an accompanying increased probability of FECNs, BECNs, CLLMs, frame loss, delay, and conformance distortion.

A.2 Limited application

This normative definition of the DDB should only be used for the performance evaluation purposes described above. It is not a standard for implementation within frame relay networks. However, designs for traffic enforcement can be compared with the DDB to confirm that they are less stringent and more accepting than the DDB. As defined, the DDB is believed to be so stringent that no practical enforcement policy should reject frames approved by the DDB.

A.3 DDB definition

The DDB algorithm computes the total number of user data bits in a sliding window of time duration T. Two comparisons are made with B_x, where B_x is either B_c or B_e, depending on whether the CIR or EIR is being evaluated. The first compares the total number of user data bits included in information frames for which the first bit of the frame is within the current window, and the second compares the total number of user data bits included in information frames for which the last bit of the frame is within the current window. If either of these numbers exceeds B_x, a frame in the window is declared nonconforming. It is clear from this description that the DDB never allows more than B_x data bits into any T window and this is not true for any (currently) known traffic enforcement policy. Furthermore, with some small assumptions about traffic enforcement, the maximally stringent nature of the DDB can be rigorously demonstrated.

An implementation of the DDB is shown in Figure A.1. The DDB can be implemented in alternative ways; however, any such implementation must yield the same decisions about conformance as the algorithm presented here.

Two total counts are calculated for a frame stream at the specified boundary:

) The variable *count_fbw* is the total cumulative count of user data bits in frames whose first bits are in the T window. The variable *fbw_list* is the list of frames with their first bits in the current T window; and

) The variable *count_lbw* is the total cumulative count of user data bits in frames whose last bits are in the T window. The variable *lbw_list* is the list of frames with their last bits in the current T window.

If B_x is exceeded by either of these two counts, the Figure A.1 implementation of the DDB declares the most recent frame into the T window as a nonconforming frame.

NOTE – In evaluating FLR_c, FLR_e, and availability, the counts of nonconforming frames and data bits in those frames are not relevant. What is relevant is only whether the DDB determines the entire stream to be conforming.

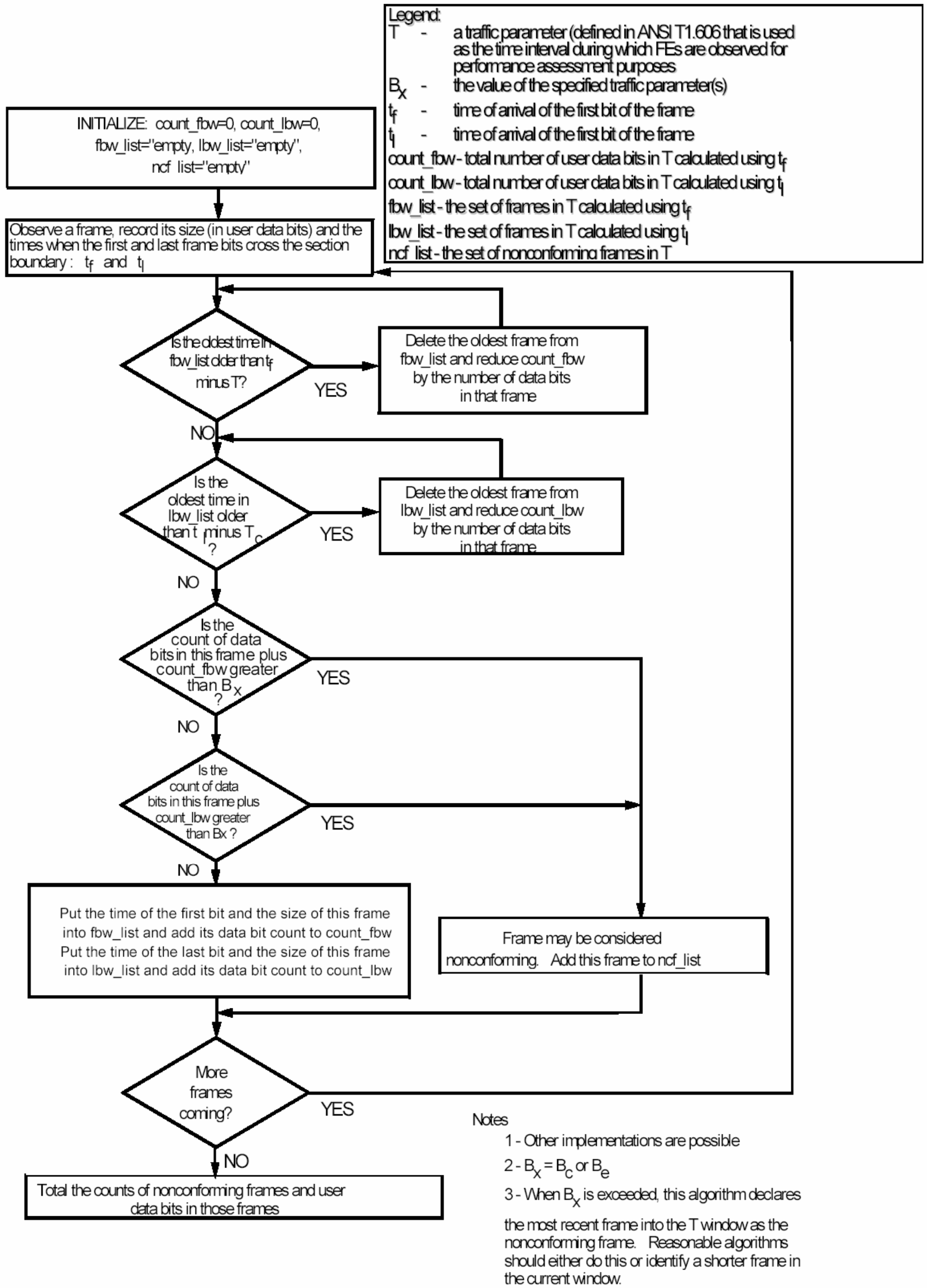


Figure A.1 - Double dangerous bridge implementation

A.4 Using the DDB in evaluating FCTDR

FCTDR compares the amount of conforming traffic at a downstream interface with the amount of conforming traffic at an upstream interface. The determination of whether a traffic stream is conformant at a downstream interface should allow for some frame clumping in the upstream elements. A parameter, ε, called the "frame clumping tolerance" can be used to make this allowance.

For a given connection, consider the flow of user information frames between two boundaries delimiting a set of concatenated connection sections. Let T continue to refer to the time interval over which B_X (representing B_c for CIR and B_e for EIR) is evaluated at the input boundary. To allow for a reasonable amount of delay variation in evaluating FCTDR, traffic conformance at the output boundary should be compared using a modified T, CIR, and EIR:

$E\hat{I}R = T - \varepsilon$

$C\hat{I}R = B_c / E\hat{I}R$

$E\hat{I}R = B_e / E\hat{I}R$

$(0 < \varepsilon < T)$

NOTE – The specification of ε is for further study.

Annex B

(normative)

B Bit-based accuracy and dependability parameters

This annex defines three bit-based protocol-specific accuracy and dependability parameters associated with the transfer of user information in frame relay services: 1) user information bit loss ratio; 2) residual bit error ratio; and 3) bit-based conformant traffic distortion ratio. These parameters supplement the corresponding frame-based parameters (user information frame loss ratio, residual frame error ratio, and frame-based conformant traffic distortion ratio) defined in clause 4. Figure 6 shows the statistical populations used to calculate these accuracy and dependability parameters.

NOTE – Unless otherwise stated, the relevant conditions stipulated in clauses 1-4 apply in Annex B.

B.1 User information bit loss ratio

The user information bit loss ratio (BLR) is defined as:

$$BLR = \frac{B_L + B_M}{B_S + B_R + B_L + B_M}$$

where, in a specified population:

B_S is the total number of user information bits in successfully transferred frame outcomes,

B_R is the total number of user information bits in residually errored frame outcomes,

B_L is the total number of user information bits in lost frame outcomes, and

B_M is the total number of residually lost (i.e., missing) user information bits in residually errored frame outcomes.

Two special cases are of particular interest, and are addressed in B.1.1 and B.1.2.

B.1.1 BLR_c

BLR_c is defined as the BLR for a population of frames with DE=0 when all DE=0 frames conform with the CIR.

B.1.2 BLR_e

BLR_e is defined as the BLR 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.

B.2 Residual bit error ratio

Residual bit error ratio (*RBER*)[14] is defined as:

$$RBER = \frac{B_M + B_I + B_E}{B_C + B_M + B_I + B_E}$$

where, in a specified population:

> B_C is the total number of correct user information bits in either successfully transferred or residually errored frame outcomes;
>
> B_M is the total number of residually lost (i.e., missing) user information bits in residually errored frame outcomes;
>
> B_I is the total number of residually incorrect (i.e., inverted) user information bits in residually errored frame outcomes; and
>
> B_E is the total number of residually extra (i.e., additional) user information bits in residually errored frame outcomes.

In practice, it is not possible in all cases to distinguish residually incorrect, residually lost, and residually extra user information bit occurrences without detailed knowledge of the problems within the boundaries.

B.3 Bit-based conformant traffic distortion ratio

The $BCTDR_c$ parameter is defined as follows:

> Let $\{A_1, A_2, \ldots, A_N\}$ denote a sequence of N frames all input with DE=0 and conforming to CIR at B_i , and all relayed to B_j.

Let:

$$F_n = \begin{cases} 1 & \text{if frame } A_n \text{ is nonconforming to CÎR or is marked DE = 1 at } B_j' \\ 0 & \text{otherwise} \end{cases}$$

Let N_A denote the total number of user information bits in frames $\{A_1, A_2, \ldots, A_N\}$.

Let b_n denote the number of user information bits in frame A_n (n = 1, 2, ..., N).

Then:

$$BCTDR_c = \frac{1}{N_A} \sum_{n=1}^{N} F_n b_n$$

CÎR is the modification of CIR as described in Annex A.

---

[14] This accuracy parameter refers to the residual (i.e., undetected) user information bit errors caused by transmission or switching impairments introduced on a specified virtual connection.

The $BCTDR_e$ parameter is defined as follows:

Let $\{A_1, A_2, \ldots, A_N\}$ denote a sequence of N frames all input with DE=1 and conforming to EIR at B_i , and all relayed to B_j.

Let:

$$F_n = \begin{cases} 1 & \text{if frame } A_n \text{ is nonconforming to E\^{I}R at } B_j, \\ 0 & \text{otherwise} \end{cases}$$

Let N_A denote the total number of user information bits in frames $\{A_1, A_2, \ldots, A_N\}$.

Let b_n denote the number of user information bits in frame A_n (n = 1, 2, ..., N).

Then:

$$BCTDR_e = \frac{1}{N_A} \sum_{n=1}^{N} F_n b_n$$

EÎR is the modification of CIR as described in Annex A.

The bit-based conformant traffic distortion ratio for DE=1 traffic is defined as:

$$BCTDR_e = \frac{1}{N_A} \sum_{n=1}^{N} F_n b_n$$

where,

$$F_n = \begin{cases} 1 & \text{if frame } A_n \text{ is nonconforming to E\^{I}R at } B_j' \\ 0 & \text{otherwise} \end{cases}$$

$\{A_1, A_2, \ldots, A_N\}$ denotes a sequence of N frames, all input with DE=1, conforming to EIR at B_i, and are all relayed to B_j.

EÎR is the modification of EIR as described in Annex A, b_n is the number of user information bits in frame A_n (n = 1, 2, ..., N), and

$$N_A = \sum_{n=1}^{N} b_n \quad ,$$

is the total number of user information bits in frames $\{A_1, A_2, \ldots, A_N\}$.

NOTE – The need for objectives for $BCTDR_e$ is for further study.

Annex C

(informative)

C Glossary of Abbreviations & Acronyms

λ	Rate of transition to the Unavailable state
AAL	ATM Adaptation Layer
ACS	Access Circuit Section
ANS	Access Network Section
ANSI	American National Standards Institute
ATM	Asynchronous Transfer Mode
B_c	Committed burst size
BCTDR	Bit-based Conformant Traffic Distortion Ratio
B_e	Excess burst size
BECN	Backward Explicit Congestion Notification
BER	Bit Error Ratio
BLR	Bit Loss Ratio
CEP	Connection set-up Error Probability
CER	Cell Error Ratio
CFP	Connection set-up Failure Probability
CIR	Committed Information Rate
CLLM	Consolidated Link Layer Management
CLR	Cell Loss Ratio
CMR	Cell Misintertion Rate
CPE	Customer Premises Equipment
CRC	Cyclical Redundancy Check
CTD	Cell Transfer Delay
DDB	Double Dangerous Bridge
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
FDJ	Frame Delay Jitter
FE	Frame layer reference Event
FECN	Forward Explicit Congestion Notification
FLR	Frame Loss Ratio
FR-ATM	Frame Relay and ATM
FRS	Frame Relay SVC
FTD	Frame Transfer Delay
HDLC	High Level Data Link Control

I	Information frame
ICS	Internetwork Circuit Section
INI	Inter-Network Interface
ISDN	Integrated Services Digital Network
IWF	Interworking Function
LAPF	Link Access Protocol Frame
MP	Measurement Point
MTBSO	Mean Time Between Service Outages
MTTSR	Mean Time To Service Restoral
NE	Network Element
NNI	Network-to-Network Interface
NT	Network Termination
OAM	Operations, Administration and Maintenance
PCR	Peak Cell Rate
PVC	Permanent Virtual Circuit
QoS	Quality of Service
RBER	Residual Bit Error Ratio
RE	Reference Event
RFER	Residual Frame Error Ratio
SA	Service Availability
SABME	Set Asynchronous Balance Mode Extended
SAP	Service Access Point
SECBR	Severely Errored Cell Block Ratio
SF	Switching Function
SN	Switching Node
SVC	Switched Virtual Circuit
T	Time interval over which B_c and B_e are defined (see ITU-T X.36)
TE	Terminal Equipment
TNS	Transit Network Section
UA	Unnumbered Acknowledgement
UI	Unnumbered Information
UNI	User-to-Network Interface
VCI	Virtual Channel Identifiers
μ	Rate of transition to the Available state

Annex D

(informative)

D Sampling estimation of PVC availability parameters

D.1 A minimal test for PVC service availability

The definition of permanent virtual circuit (PVC) service availability requires that observed performance for all four decision parameters be compared with outage thresholds. A single success of the following test is defined to be sufficient for declaring the PVC section available. A single failure of a section to meet any of the four individual criteria is defined to be sufficient for declaring the PVC section unavailable. This test and its decision criteria are defined to be the minimum criteria necessary to sample the availability of the section.

The minimal availability test can be performed in either direction across the section by equipment and components outside the section. To ensure the availability test does not fail as a result of insufficient or excessive input, for 5 minutes attempt to maintain DE=0 traffic conforming with CIR, if CIR>0, and DE=1 traffic conforming to EIR, if CIR=0. There are three criteria for deciding if the test has failed or succeeded:

3. For:
   . (CIR > 0): The test fails if the FLR_C is greater than N_1;
   . (CIR = 0): The test fails if the FLR_e is greater than N_2;
3. The test fails if the RFER is greater than N_3; and
3. The test fails if the EFR is greater than N_4.

If a section passes the test for all decision criteria, the test is successful, and the PVC supported by the section is considered to have been available during the test. If the section fails the test for one or more decision criteria, the PVC supported by the section is considered to have been unavailable during the test.

Minimal availability tests may be run consecutively when offered traffic is continuous. For PVCs with substantial idle time, unbiased determination of SA and MTBSO values may require rigorous sampling plans. Examples are provided in D.2 and D.3.

D.2 Procedures for estimating PVC service availability

A sufficient estimate of PVC service availability percentage can be computed as follows: based on an a priori estimate of the service availability, choose sample size *s*, not less than 300. Choose s testing times during scheduled service time and distribute them across a long measurement period (for instance, 6 months). Because of the expected durations of service outages, choose no two testing times closer together than 7 hours (this serves to keep the observations uncorrelated). The testing times should be uniformly distributed across the scheduled service time. At each predetermined testing time, perform the availability test described in D.1. If the test fails, the section is declared unavailable for that sample. Otherwise, the section is declared available. The estimate of the PVC service availability percentage is the number of times the section was declared available, multiplied by 100, and divided by the total number of samples.

D.3 Procedures for estimating mean time between PVC service outages

A sufficient estimate of the mean time between PVC service outage parameter can be computed by conducting consecutive availability performance samples and by counting the observed changes from the available state to the unavailable state.

Prior to performing any tests, choose *k* disjoint intervals of time each not less than 30 minutes nor more than 3 hours. The total amount of time in the *k* intervals should exceed three times the a priori estimate of mean time between PVC service outages. For the duration of each predefined interval, conduct consecutive availability performance samples. The amount of time observed in the available state will be added to a cumulative counter called *A*. The number of observed transitions from the available state to the unavailable state will be accumulated in a counter called *F*.[15]

For each predefined interval:

) *If all the consecutive availability samples succeed*, then add the total length of the interval to *A*. Do not change the cumulative value of *F*.

) *If the first availability sample succeeds and any subsequent sample in the interval fails*, increase *F* by one. Add to *A* the total length of all availability samples prior to the first failure. Following the first failed availability sample the remaining time in the interval may be discarded without testing its availability.

) *If the first availability sample fails*, assume that the state transition occurred before the interval began. Add nothing to the count of observed availability time, *A*. Add nothing to the cumulative count of observed state changes, *F*. The remaining time in the interval may be discarded without testing its availability.

After the results of every predefined interval have been accumulated, the ratio, *A/F*, is an estimate of the mean time between PVC service outages. A statistically more precise estimate can be obtained by increasing the number of observed intervals, *k.*

The estimate of mean time between PVC service outages assumes that, if an outage begins during an availability performance sample, either this sample or the following sample will decide that the section is unavailable. This is a reasonable assumption since service outages, in contrast to transient failures, will last more than 5 minutes.

Discarding the remainder of the interval following a failed availability sample is both practical and statistically justifiable. The PVC section must return to the available state before any more available time can be accumulated and before any more transitions to the unavailable state can be observed. First, the expected time to restore PVC service may be large with respect to the remaining time in the interval. It can be inappropriate and counterproductive to continue testing a failed or congested network section. Second, if transitions to the unavailable state are statistically independent, then discarding the remainder of the interval, which may include time in the available state, will not bias the result.[16] The only consequence of discontinuing the test is the loss of testing time. To minimize that loss, the test intervals should be short with respect to the sum of the expected time to restore PVC service and the expected time between PVC service outages. Thus each test should be no longer than 3 hours.

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[15] Each counter is initially set to zero.

[16] If outages tend to be clustered, discontinuing a test following a transition to the unavailable state will tend to overestimate the mean time between service outages. If outages tend to be negatively clustered, discontinuing a test following a transition to the unavailable state will tend to underestimate the mean time between service outages.

There are two sources of bias in the estimation procedure described in this clause. First, if an outage begins during the last availability sample of the interval, that transition may or may not cause the sample to fail. If it does not fail, the state transition is missed and the mean time between PVC service outages is overestimated. Second, a state transition to the unavailable state during the first availability sample of the interval may or may not cause that sample to fail. According to the estimation procedure, if the sample does fail, the interval will be discarded, the state transition is missed, and the mean time between PVC service outages is overestimated. These edge effects can be minimized by increasing the length of each interval, consequently increasing the number of availability samples, and thus decreasing the effect of the first and last sample outcomes as a proportion of the total sampled outcomes. A minimum recommended interval length is 30 minutes, using 5-minute availability samples.

Alternatively, both biases can be corrected by replacing instruction a) in this clause with:

) *If all of the consecutive availability samples succeed*, then add the total length of the interval to A. Take one additional availability sample immediately following the interval. If that sample fails, increase F by one. If that sample succeeds, do not change F. The length of the additional sample has no effect on A.

This modification identifies any state transitions that occurred during the last sample of the interval and eliminates the first source of bias. It also counts certain transitions that occurred outside of the interval. These transitions are counted with the same probability as the probability that the second source of bias inappropriately discards transitions. Thus this modified procedure corrects both sources of bias. Using this modification, the mean time between PVC service outages can be more accurately estimated.

Annex E

(informative)

E Congestion notification

E.1 The effects of FECN, BECN, and CLLM on performance

Network providers can use FECN and BECN bits and/or CLLM frames to signal information about the utilization of network resources, thus helping users avoid or mitigate the effects of congestion. Some DTEs or applications may automatically respond to FECNs, BECNs, and/or CLLMs by reducing or smoothing the offered frame traffic more than the *a priori* traffic descriptors require. Thus, a network's use of FECN, BECN, and CLLM may impact directly on the throughput and performance observed by end users.

E.2 Controlling the effects on performance

Neither the network's use of FECN, BECN, and CLLM nor the appropriate user response is standardized. Thus, at the current time, there is no way to standardize limits on the use of these performance-significant signals. In the meantime, the following recommendations can be made:

– If a network provider expects its users to respond to FECN, BECN, or CLLM by temporarily reducing or smoothing their offered traffic more than the *a priori* descriptors require, these network providers should:

) Precisely define how users should respond;[17]

) Establish limits for the frequency and duration of such periods; and

) Explain what additional risk the user is facing by ignoring these periods.

Users should determine their network provider's interpretation of FECN, BECN, and CLLM, and then they should attempt to optimize their responses to these signals.

In lieu of specific information about how to respond to FECN, BECN, and CLLM, or in lieu of limits on their use, users completely conforming to their *a priori* traffic descriptors may assume that network performance objectives (FTD, FLR, etc.) will be applicable independently of FECNs, BECNs, and CLLMs. (See Annex F, which identifies effects of external connection elements on measured performance.)

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[17] Note that some network providers also ask that users respond to lost frames by initiating or extending periods of load reduction.

Annex F

(informative)

F Effects of external connection elements on measured performance

The parameters of this standard are designed to measure the performance of network elements between two section boundaries. However, users of this standard should be aware that the behavior of connection elements outside the pair of boundaries can negatively influence the measured performance of the elements between the boundaries. Two important examples are:

) *Unanticipated simultaneous bursting on an access line*. There may be occasions where simultaneous bursting from the set of connections on an access circuit section exceeds the physical capacity of the line. In accepting this set of connections, the network provider and subscriber anticipated limited or negative time correlation among bursts of frames, but for unanticipated reasons this assumption does not hold true. During such events, the apparent performance of the network between section boundaries will be degraded and in particular these events may result in increased numbers of FECNs, BECNs, and CLLMs (see Annex E), increased frame loss ratio (FLR), increased frame transfer delay (FTD), increased frame-based conformant traffic distortion ratio (FCTDR), or some combination of these effects.

) *Use of "oversubscribed" access lines*. Particularly when PVCs are involved, network providers may allow a subscriber to establish multiple connections on an access circuit section with a total CIR greater than its physical capacity. This allows the subscriber to take advantage of the fact that not all of their connections will be active simultaneously. However, the apparent performance of the network between section boundaries will be degraded if the subscriber attempts to make use of this oversubscription. In particular, attempts to fully utilize this overbooking may result in increased numbers of FECNs, BECNs, and CLLMs (see Annex E), increased FLR, increased FTD, increased FCTDR, or some combination of these effects. In the worst case, attempts to fully use this oversubscription may appear as unavailability.

Annex G

(normative)

G Some relations between frame-level and ATM-level performance parameters

G.1 Scope

This annex develops some relations between the frame-level performance parameters defined in the body of this standard and the ATM-level performance parameters defined in T1.511-2003. These performance relationships are based on the Frame Relay and ATM (FR-ATM) network interworking scenario -- see Figure G.1(a) -- and the FR-ATM service interworking scenario -- see Figure G.1(b) -- identified and developed in T1.634-1993 (R2001) and more fully developed in T1.634-1993 (R2001) and clause 6 of ITU-T Recommendation I.363. The relationships developed in this annex between the ATM-level and Frame-level performance parameters may be used as a basis for establishing performance objectives for Frame Relay when supported over, or interworked with, ATM.

G.2 Motivation for relating frame-level and ATM-level and performance parameters

A suitable relation between the network performance parameters for frame transfer and cell transfer should allow determination of end-to-end performance for the two interworking scenarios identified in Figure G.1. Furthermore, for a connection segment that supports frame relay service over ATM technology, such a relation should also allow the estimation of a connection segment's frame-level performance from a measurement of the connection segment's ATM-level performance.

Referring to Figure G.1, an end-to-end (or CPE-to-CPE) virtual connection could be partitioned into two or more "connection segments" by using a Measurement Point (MP) near each IWF. The end-to-end performance of such a virtual connection could be estimated by measuring the performance of each connection segment, and then suitably combining the performance impairments measured on each connection segment. Since some of these connection segments use frame-oriented technology and others use ATM-oriented technology, the determination of end-to-end network performance by this approach requires a suitable means for relating the performance parameters based on these two technologies.

On a given connection segment where ATM technology is used to support frame relay service, it can be operationally useful to establish the relation between that segment's ATM-oriented delay, loss and error performance characteristics, and their impact on the analogous frame-oriented performance characteristics.

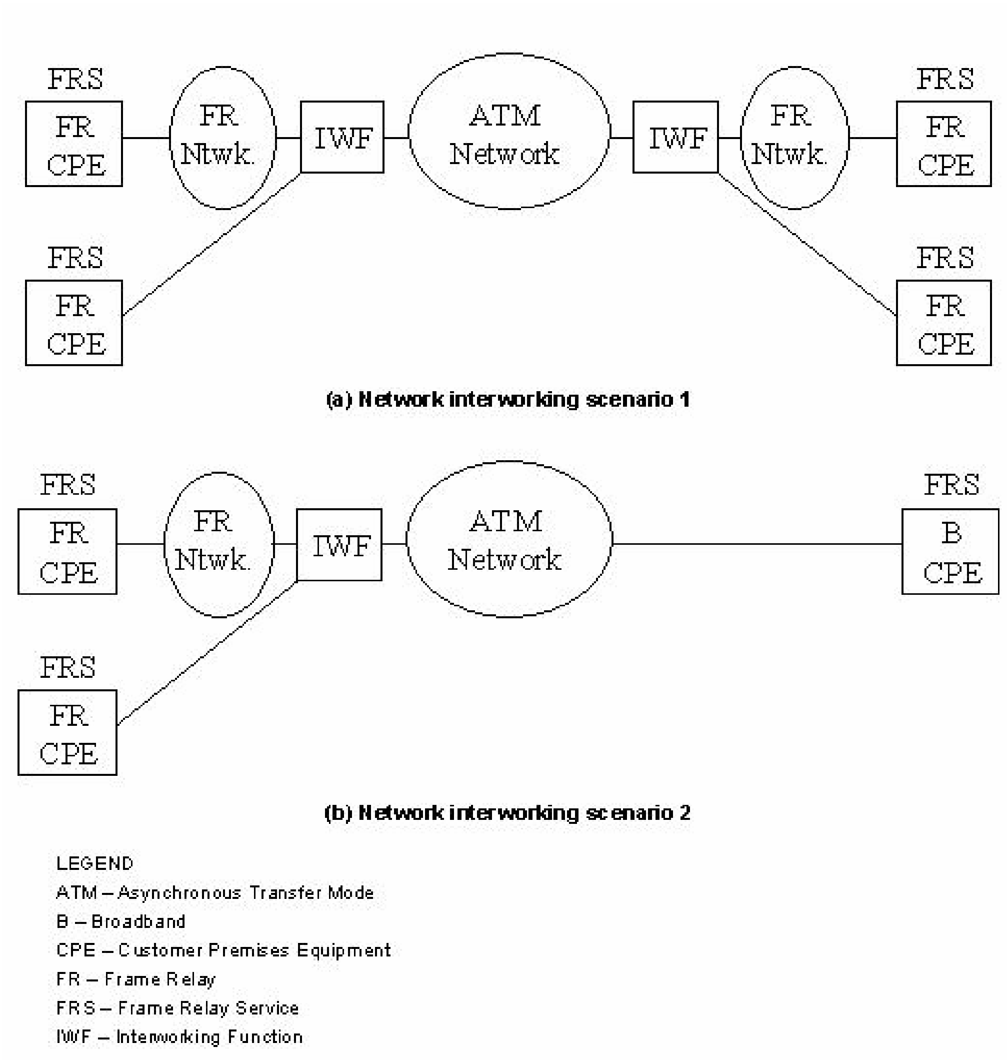

Figure G.1 - Some FR-ATM interworking scenarios

G.3 Frame relay parameters considered

The relevant Frame-level parameters[18] include:

) User information frame transfer delay (FTD);

) User information frame loss ratio (FLR);

) Residual frame error ratio (RFER); and

) Extra frame rate (EFR).

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18 The frame-based conformant traffic distortion ratio and potential frame flow related parameters are not considered in this annex.

At least two factors influence correlation of FTD with Cell Transfer Delay (CTD). First, the FR-ATM interworking scenarios provide for the mapping (also called multiplexing) of FR-level Data Link Channel Identifiers (DLCIs) to ATM-level Virtual Channel Identifiers (VCIs). Two types of mapping schemes have been discussed, those which map one DLCI to one VCI (called 1-to-1 multiplexing), and those which map a number of DLCIs to one VCI (called N-to-1 multiplexing).

The type of mapping scheme can influence the relation between CTD and FTD because the N-to-1 mapping scheme could include the buffering of information from several DLCIs before an opportunity exists for their transmission over the one designated VCI. Furthermore, some of a VCI's information transfer capacity can be used to transfer OAM cells in addition to User Information cells. If a VCI is transferring both OAM cells and User Information cells that bear frame relay service information, some consideration must be given to identifying the capacity that is available for these User Information cells even though the impact on FTD of OAM cell transfer is likely to be quite small.

The FLR can be related to the Cell Loss Ratio (CLR) and other performance parameters when either the frame size is known or a nominal frame size is assumed. This is discussed further in G.4 of this annex.

The RFER can be related to the Cell Error Ratio (CER) when either the frame size is known or a nominal frame size is assumed. However, development of this relation involves consideration of the frame-level CRC's breakdown during its error detection task. This relationship is for further study.

The EFR is conceptually analogous to the Cell Misinsertion Rate (CMR). The reference events for each of these parameters can be caused by either an undetected/miscorrected error in the channel identifier field (i.e., DLCI or VPI-VCI) or an incorrectly programmed translation of channel identifier labels.

G.4 Relation between FR and ATM user information loss parameters

Consider now the relation between the user information frame loss ratio (FLR), the cell loss ratio (CLR) and other relevant performance parameters. A frame length of F_{cells} or an equivalent F_{bits} is assumed[19].

The FLR is defined over a connection segment delimited by two MPs as the ratio of the number of lost frame outcomes to the number of lost, successfully transferred, and residually errored frame outcomes. The denominator of this ratio can be viewed as representing the total number of frames transmitted onto a given connection segment during a time period of interest. Our approach is to first estimate the probability of frame loss under each of several identified mechanisms; next, equate each such probability to the ratio of the number of frames lost under a specific mechanism to the total number of frames transmitted onto the connection segment during a common period of interest, and finally, sum the probabilities over all identified mechanisms.

A lost frame outcome occurs on a connection segment either when a frame entry event fails to happen within a specified time interval T_{max} after the corresponding frame exit event, or when the CRC of the received frame corresponding to the frame entry event is invalid. Consistent with this definition, five mechanisms that result in frame loss can be identified;

a) Frame loss due to burst impairment events involving multiple bit errors, cell losses, and/or misinserted cells.

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[19] Since 1 cell requires 53 octets, F_{bits} = 424 x F_{cells}, where F_{bits} represents the total number of bits needed to transport the frame at the ATM level. F_{cells} is determined from the frame length and the fact that AAL5 is used to transport FR frames. Up to 48 octets of FR information would be contained in each cell used to transport a given frame, and the last cell used for that frame would contain 8 octets of AAL5-specific information.

b) Frame loss due to (background) random, single-bit errors.

c) Frame loss due to (background) loss of a constituent cell or cells (e.g., cell-level buffer overflow).

d) Frame loss due to (background) misinsertion of a cell.

e) Frame loss due to frame-level processing failure (e.g., frame-level buffer overflow or frame-level processor saturation).

Mechanism a) accounts for the impact of all burst impairments that are visible at the ATM level, while mechanisms b), c), and d) account for the independent impacts of the background impairment types that are visible at the ATM level and that remain after burst impairments are counted and removed. Mechanism e) accounts for impairments (of both burst and background types) that are caused strictly at the frame level, and hence not visible at the cell level. Take these 5 mechanisms to be independent. Then applying the approach just cited, the FLR on a particular connection segment during a specific time period is represented as:

(1) $FLR = FLR_{burst} + FLR_{error} + FLR_{CLR} + FLR_{CMR} + FLR_{frame}$

where FLR_{burst} is the FLR due to burst impairment events, FLR_{error} is the FLR due to random, single-bit errors, FLR_{CLR} is the FLR due to loss of constituent cells, FLR_{CMR} is the FLR due to misinserted cells and FLR_{frame} is the FLR due to frame-level processing failure. The remainder of this sub-clause considers the FLR component due to each of these mechanisms.

G.4.1 Burst-type impairments

Consider first the probability of frame loss due to burst-type impairments. The Severely Errored Cell Block Ratio (SECBR), as measured on a given connection segment over a time period of interest, can be used to bound the probability of occurrence during that period of burst-type impairments involving bit errors, cell losses and/or misinserted cells. It remains to relate the length of a frame, F_{cells} ,to the length of a cell block, B_{cells} [20]. Three cases will be considered here: (R2013)

a) $F_{cells} << B_{cells}$;

b) $F_{cells} >> B_{cells}$; and

c) $F_{cells} \sim B_{cells}$.

NOTE – If only frames of size 512 or less are supported, then only the first case is applicable.

If F_{cells} is significantly smaller than B_{cells}, then the fraction of frames that are impacted by burst-type impairments is approximated by the fraction of cell blocks that are severely errored (i.e., the SECBR). Hence:

(2a) $FLR_{burst} = SECBR$

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20 The length of the cell block identified in ITU-T Recommendation I.356 is related to the peak cell rate (PCR). The minimum length is 128 cells and the maximum length is 32,768 cells. Assuming a maximum frame length of 512 octets, 5 octets of overhead, and AAL5, the number of frames contained in one cell block of 128 cells is (128 x 48 – 8)/(512+5) = 12 frames, and the number of frames contained in one cell block of 32,768 cells is 3014 frames.

However, if F_{cells} is significantly larger than B_{cells}, then any one of (F_{cells}/B_{cells}) cell blocks[21] would, if severely errored, impact a given frame. The probability that a frame of such length is not so impacted is:

$(1 – SECBR)^{Fcells/Bcells}$.

The FLR due to this mechanism is the logical complement of this, namely the probability that a frame of such length does experience one or more SECBs, which is :

(2b) $FLR_{burst} = 1 – (1 – SECBR)^{Fcells/Bcells}$

If F_{cells} and B_{cells} are about equal, then a single SECB would generally impact two frames, and so:

(2c) $FLR_{burst} = 2\ SECBR$

We observe that an alternative approach for estimating the impact at frame level of burst-type impairments would be to use a physical level parameter such as the number of Severely Errored Seconds per day or the time spent per day executing protection switches. The appropriateness of this alternative is for further study.

G.4.2 Single-bit errors

Consider next the probability of frame loss due to independently occurring, single-bit errors. Take the probability of a single-bit error to be as given by the Bit Error Ratio (BER). The probability that a frame F_{bits} bits in length does not experience a random, single-bit error is:

$(1 – BER)^{Fbits}$

The FLR due to this mechanism is the logical complement of this, namely the probability that such a frame does experience one or more random, single-bit errors, which is:

(3) $FLR_{error} = 1 – (1 – BER)^{Fbits}$

We observe that relations could in principle be established first between physical-level bit error parameters and CER, and then between the CER and this FLR_{error}.

G.4.3 Cell losses

Consider next the probability of frame loss due to independently occurring cell losses. Take the probability of a single cell's loss to be as given by the CLR. The probability that a frame F_{cells} in length does not experience a lost cell is:

$(1 – CLR)^{Fcells}$

The FLR due to this mechanism is the logical complement of this, namely the probability that such a frame does experience one or more cell losses, which is:

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21 Or more precisely, [F_{cells}/B_{cells}] where [x] denotes the smallest integer which is greater than or equal to x.

(4) $FLR_{CLR} = 1 – (1 – CLR)^{Fcells}$

G.4.4 Misinserted cells

Consider the probability of frame loss due to a randomly occurring misinserted cell. If the CMR and the Peak Cell Rate (PCR) applicable to the ATM connection are known, then the fraction of received cells that are misinserted is CMR/PCR. Take this fraction to be the probability that a single cell is misinserted. The probability that a frame F_{cells} in length does not experience a misinserted cell is:

$$(1 – CMR/PCR)^{Fcells}$$

The FLR due to this mechanism is the logical complement of this, namely the probability that such a frame does experience one or more cell losses, which is:

(5) $FLR_{CMR} = 1 – (1 – CMR/PCR)^{Fcells}$

G.4.5 Frame-level processing failures

Finally consider the probability of frame loss due to frame-level processing failure. This is dependent upon processes above the physical and ATM levels, and hence is beyond the scope of this annex. The resulting FLR_{frame} would be estimated by frame-based methods and substituted into equation (1), together with the results of equations (2), (3), (4), and (5).

Annex H

(informative)

H Bibliography

T1.504-1998 (R2002), *Packet-switched data communication service – Performance parameters, measurements methods and objectives*.[2]

T1.517-1995 (R2001), *Integrated Services Digital Network (ISDN) – Performance parameters and objectives*.[2]

T1.606-1990 (R1996), *Integrated Services Digital Network (ISDN) – Architectural framework and service description for frame-relaying bearer service*. [2]

T1.606b-1993, *Integrated Services Digital Network (ISDN) – Architectural framework and service description for frame-relaying bearer service (network-to-network interface requirements)* [Supplement to T1.606-1990 (R1996) and T1.606a-1992 (R1997)].[2]

T1.633-1993, *Frame relaying bearer service interworking*.[2]

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

ITU-T Recommendation X.144 (04/95), *User information transfer performance parameters for data networks providing international frame relay PVC service*. [3]

ITU-T Recommendation X.145, *Performance parameters for data networks providing international frame relay SVC service*. [3]

ANSI X3.102-1992, *Information Systems – Data communication systems and services – User-oriented performance parameters*.[22]

[22] This standard was withdrawn as an American National Standard on September 23, 1997. Please contact the Secretariat for more recent information.