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American National Standard for Telecommunications

Network Performance Parameters for Dedicated Digital Services -- Definitions and Measurements

Secretariat

Alliance for Telecommunications Industry Solutions

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American National Standards Institute, Inc.

Abstract

This standard applies to Layer 1, dedicated digital services, which are characterized by established transmission paths (i.e., no access or disengagement functions). Therefore, this standard defines performance parameters relevant to the information transfer phase only. This standard provides a list of the performance parameters and measurement methods needed by users, vendors, and providers of dedicated digital communications services, to characterize the user-observable performance of these services (i.e., it does not address the causes of errors). It also provides a formula for arriving at the thresholds of performance that will indicate the transitions between the available and unavailable states. A given service will only reference those parameters or thresholds that are applicable to that service. The network-specific parameters are for performance allocation and network control. End users may use the concepts developed in this standard to measure end-user-to-end-user performance and availability.

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.

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Table of Contents

Table of Figures

Table of Tables

American National Standard
for Telecommunications –

Network Performance Parameters for Dedicated Digital Services – Definitions and Measurements

1   Scope, Purpose, and Application

This standard applies to Layer 1, dedicated digital services, which are characterized by established transmission paths (i.e., no access or disengagement functions). Therefore, this standard defines performance parameters relevant to the information transfer phase only. Also, parameters such as absolute delay -- although recognized as important to user applications -- are not specified as they are not expected, on a connection basis, to change significantly over time. Specific dedicated digital services are defined in separate ANSI Standards -- i.e., T1.102-1993 (R1999), T1.105-2001, T1.107-2002, T1.410-2001, etc. This standard provides a list of the performance parameters and measurement methods needed by users, vendors, and providers of dedicated digital communications services, to characterize the user-observable performance of these services (i.e., it does not address the causes of errors). It also provides a formula for arriving at the thresholds of performance that will indicate the transitions between the available and unavailable states. A given service will only reference those parameters or thresholds that are applicable to that service. The network-specific parameters are for performance allocation and network control. Standard performance parameter definitions and standard measurement methods are provided to ensure an understanding of:

–   Measured performance values;

–   Performance allocation among network elements; and

–   Compatibility of performance measurements among network users, providers, and equipment vendors.

This document provides the framework for a companion document, T1.510-1999, *Network performance parameters for dedicated digital services*, which contains numerical specifications and allocations for the parameters and measurements discussed in this standard.

End users may use the concepts developed in this standard to measure end-user-to-end-user performance and availability.

2   Normative References

The following standard contains provisions, which, through reference in this text, constitute provisions of this American National Standard. At the time of publication, the edition indicated was 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.

T1.510-1999, *Network Performance Parameters for Dedicated Digital Services for Rates Up to and Including DS3 – Specifications.*[1]

3 Abbreviations, Acronyms, and Definitions

3.1 Abbreviations & Acronyms

ANSI	American National Standards Institute
ATIS	Alliance for Telecommunications Industry Solutions
BBE	Background Block Error
BBER	Background Block Error Ratio
BER	Bit Error Ratio
BLER	Block Error Ratio
DS1-	Digital Signal Level 1
DS3	Digital Signal Level 3
ES	Errored Second
ESF	Extended Superframe Format
FEBE	Far-End Block Error
INI	Inter-Network Interface
ITU-T	International Telecommunication Union – Telecommunication Standardization Sector
LEC	Local Exchange Carrier
NI	Network Interface
POT	Point of Termination
PRM	Performance Report Message
SDH	Synchronous Digital Hierarchy
SDP	Severly Disturbed Period
SEP	Severely Errored Period
SES	Severely Errored Second
SEUT	Severely Errored Unit of Time
SONET	Synchronous Optical NETwork
UAS	Unavailable Second

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[1] 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>

3.2   Definitions

3.2.1   Absolute delay: The total time between the instant a bit enters the network and the instant a corresponding bit exits the network.[2]

3.2.2   Background block error (BBE): An errored block not occurring as part of an SES.

3.2.3   Background block error ratio (BBER): The ratio of Background Block Errors (BBE) to total blocks in available time during a fixed measurement interval. No blocks that occur during an SES shall be used for the computation of BBER

3.2.4   Block: A set of consecutive bits associated with the connection. Each bit belongs to one and only one block.

3.2.5   Bit error: A bit is said to be in error when it is transferred from the source to the destination within the assigned time slot, but the delivered bit is of a different value than that sent by the source.

3.2.6   Block error: A block is said to be in error when at least one bit error occurs in that block when it is transferred from the source to the destination within the time slot assigned.

3.2.7   Errored unit of time: A specified period of time, during which bits are transferred from a source to a destination, that contains at least one bit in error.

3.2.8   Inter-network interface (INI): The point of demarcation between networks when service is provided across multiple networks.[3]

3.2.9   Network interface (NI): The point of demarcation between the carrier facilities and the customer's[4] installation.

3.2.10   Performance anomalies: A discrepancy between actual and desired characteristics of an item. An anomaly may or may not affect the ability of an item to perform a required function.

3.2.11   Performance defects: A limited interruption in the ability of an item to perform a required function. Successive anomalies causing a decrease in the ability of an item to perform a required function are considered a defect.

3.2.12   Performance failures: A failure is the termination of the ability of an item to perform a required function.

3.2.13   Performance primitives: Basic error events or other performance-related occurrences that may be detected by monitoring a digital signal.

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2 *Delay* is an inherent characteristic of an established dedicated digital service connection. *Absolute delay* is largely dependent on the technology used to provide the service (i.e., on terrestrial connections the absolute delay can be expected to be less than 50 ms as opposed to a satellite connection where absolute delays of 300 ms can be expected). Although absolute delay on a digital service may not change significantly from the time of installation, changes in absolute delay can be experienced over time, due to factors such as changes in the terrestrial technology used to provide the service or a switch to diverse routed protection on a large self-healing ring. These delay changes are generally less than the difference between terrestrial and satellite given above.

3 Where a point of termination (POT) exists, it coincides with an INI.

4 Customer, in this definition, refers to the end user.

3.2.14 Severely errored unit of time (SEUT): A specified period of time, during which bits are transferred from a source to a destination, where $\geq 30\%$[5] of the blocks received are errored, or at least one severely disturbed period (SDP) occurred. An SDP occurs when over a period of time equivalent to four contiguous blocks or 1 ms (whichever is larger), all the contiguous blocks are affected by a high bit error density of $\geq 10^{-2}$. This definition applies for a specified block size.

> NOTE – Where a suitable block is not available, an alternate definition can be used: A specified period of time, during which bits are transferred from a source to a destination, where a bit error ratio (see 6.1) worse than 10^{-3} occurs.

3.2.15 Severely errored period (SEP): A sequence of consecutive SEUT lasting 3 units of time (typically seconds) or more while the service is available. The sequence is terminated by a unit of time, equal to the unit of time for the SEUT, which is not an SEUT.

3.2.16 Severely errored second (SES): An SES is an SEUT where the unit of time equals one second.

4   Functional Reference Models

The performance parameters for dedicated digital networks shall be specified in terms of the reference models in Figure 1. End-to-end performance -- Figure 1(a) -- shall be specified from NI-to-NI with performance allocated for NI-to-INI and INI-to-INI. Figure 1(a) applies to point-to-point configurations and Figure 1(b) applies to point-to-multipoint configurations. Since connections may or may not span multiple networks, INIs are shown as dashed lines. There is the possibility that each segment may be comprised of transport from several providers. T1.TR.51-1996 provides details of an alternate model that may be operational where transport is obtained from more than one provider in a segment. For intranetwork connections (no INIs), end-to-end parameters shall apply. Since dedicated digital services are characterized by established connections (i.e., no access or disengagement phases) with a constant rate of data transfer, entry and exit events consist solely of user information bits crossing a network interface.

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[5] The errored block threshold for defining an SES (SEUT where the unit of time is 1 second) for SDH sections is different from 30% and typically lower.
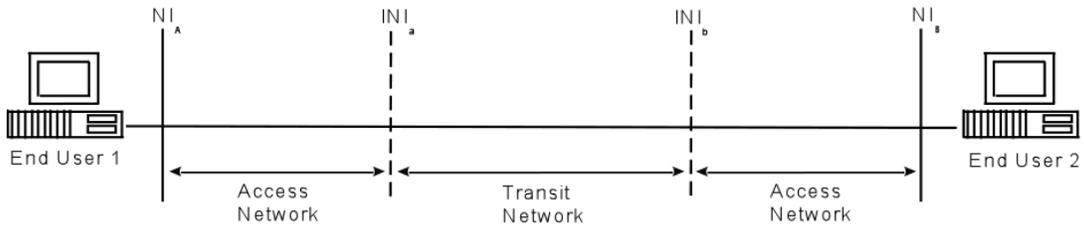
a) Point-to-point dedicated digital service
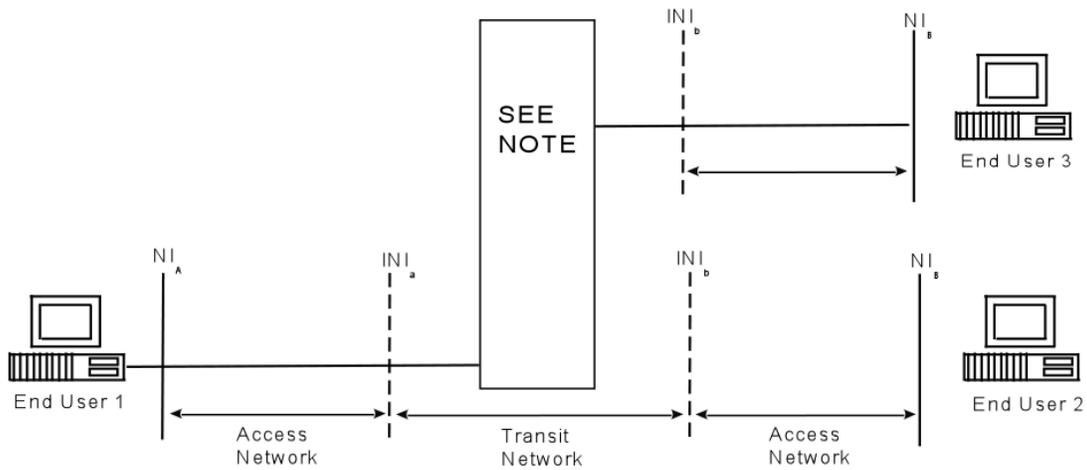
Note: The multipoint node can be located within either the access or the transit segments of the network.

b) Point-to-multipoint dedicated digital service

Legend:

NI -   Network interface

INI -   Inter-network interface: INIs are present only when the service is provided across multiple networks. Where a point-of-termination (POT) exists, it will coincide with an INI.

Figure 1 – Reference models

5   Performance Parameters

Performance parameters are derived by the processing of performance primitives used to define performance events.

5.1   Accuracy parameters

a) *Bit error ratio (BER):* The ratio of the number of bit errors to the total number of bits transmitted in a given time interval. Bit Error Ratio is used in this standard to establish threshold values in defining performance parameters.

b) *Block error ratio (BLER):* The ratio of the blocks that contain at least one bit in error to the total number of blocks transmitted in a given time interval.

c) *Errored unit of time measure:* The number or percent of errored units of time in a specified period. See 3.2.7 with the unit of time being 1 second.

d) *Severely Errored Unit of Time Measure:* The number or percent of SEUT in a specified period. An example of a severely errored unit of time is a Severely Errored Second (SES): a 1-second interval having $\geq 30\%$[6] of the blocks received errored, or at least one severely disturbed period.

e) *Severely Errored Period Measure:* The number of SEP events in available time, divided by the total available time in seconds.

5.2   Availability parameters

An end-to-end digital service can be analyzed based on the Network Functional Reference Model (refer to Figure 1) in which an end-to-end transmission path is broken down into sections demarcated by jurisdictional boundaries: INIs (Inter-Network Interfaces) and NIs (Network Interfaces). End-to-end performance (including availability) shall be specified from NI to NI with performance allocated for NI-to-INI (access network, e.g., LECs) and INI-to-INI (transit network, e.g., Inter-exchange carriers).

Thus, Availability measures shall be defined between two points along the transmission path.

Service between two specified points is assumed to be in the available state, unless a transition to the unavailable state is observed without a subsequent transition to the available state. The transitions between the available and unavailable states are defined as follows:

a) *Transition to the unavailable state:* This transition occurs at the beginning of the period of time when one or more of the following criteria[7] is true:

1)   BLER worse than 10^{n_B}, for X_B number of consecutive observation periods of N_B duration.

2)   More than X_t, number of consecutive severely errored units of time.

b) *Transitions to the available state*: This transition occurs at the beginning of the period of time when all of the following criteria[7] are true:

1)   BLER better than or equal to 10^{n_B}, for X_B number of consecutive observation periods of N_B duration.

2) X_t, number of consecutive units of time without a severely errored unit of time.

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[6] The errored block threshold for defining an SES for SDH sections is different from 30% and typically lower.

[7] Only that subset of these criteria specified for a given service shall be considered.

Availability parameters are defined as follows:

1) *Mean time between unavailable states:* This is the average duration of available state intervals over a specified period of time.

2) *Percent service availability:* This term represents the percent of time the service is in the available state over a specified period of time.

5.2.1 Availability definitions

With reference to Figure 1(a), the following Availability Parameters are defined:

$A^{uni}_{(a,b)}$:   unidirectional availability for $INI_a \rightarrow INI_b$;

$A^{uni}_{(b,a)}$:   unidirectional availability for $INI_b \rightarrow INI_a$;

$A^{uni}_{(A,B)}$:   unidirectional availability for $NI_A \rightarrow NI_B$;

$A^{uni}_{(B,A)}$:   unidirectional availability for $NI_B \rightarrow NI_A$.

$A^{uni}_{(A,a)}$:   unidirectional availability for $NI_A \rightarrow INI_a$; and

$A^{uni}_{(a,A)}$:   unidirectional availability for $INI_a \rightarrow NI_A$.

Interactive services are bi-directional in nature and are unusable (i.e., unavailable) if either direction of transport is unavailable. For services that are bi-directional, end-to-end bi-directional service availability is defined as:

$A^{bi}_{(AB)}$:   bidirectional availability for $NI_A \leftrightarrow NI_B$

where

$$A^{bi}_{(AB)} = A^{uni}_{(A,B)} \cap A^{uni}_{(B,A)}$$

and $\cap$ is the Intersection operator.

Note that bi-directional availability is end-to-end and cannot be allocated.

5.2.2 Determination of bidirectional availability

There must be some method to determine the periods of time when both directions of a bidirectional service are in the available state. One method of providing this functionality is to require time-stamping of the transitions to available and unavailable states as a new feature. Another method is to implement the bidirectional UAS register as specified in ITU-T Recommendation G.784.[8] Additional methods to assess bidirectional availability are for further study.

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[8] For the title and availability information of this cross-reference, see Annex A

6 Measurements

6.1 Measurement purposes

The following measurements and tests are made to verify long-term service performance:

a) *Acceptance tests:* These measurements verify that the value of the performance parameters are within prescribed limits after the completion of a new service installation. The measurements for these tests are performed on an out-of-service basis.

b) *Trouble verification tests:* These tests verify the need for maintenance activity, in response to a trouble report. The measurements for these tests are performed on either an in-service or an out-of-service basis.

c) *Repair verification tests:* These tests verify that the values of the performance parameters are within the prescribed limits after completion of a repair activity. The measurements for these tests are generally performed on an out-of-service basis.

d) *Service monitoring:* These measurements verify that the values of the performance parameters are within the prescribed limits. These in-service measurements are performed on a continuous or periodic basis.

e) *Characterization measurements:* These measurements collect data for determining the performance of a specific population (defined by rate, facility type, and other characteristics). These measurements are performed on either an in-service or an out-of-service basis.

6.2 Types of measurements

The parameters can be measured in the following ways:

a) *Inservice measurements:* These measurements are performed without disturbing user information transmissions; and

b) *Out-of-service measurements:* These measurements require the service to be made unavailable to the user.

6.3 Performance determination

Performance determination is based on the following relationships:

a) Z number of intervals of length Q are examined where:

   1) Z is an integer value; and

   2) Q is an interval of time or a fixed number of bits corresponding to the event under consideration.

c) For each interval Q examined, a determination is made as to whether a threshold value W for the event has been exceeded where W is a threshold of transmission bit or block errors over interval Q corresponding to the event under consideration;

d) Performance for the parameter under consideration is determined by the number of intervals (events) Y, out of Z intervals examined, which cross the threshold W.

Table 1 shows the relationship of the accuracy events to the intervals and thresholds.

Table 1 – Relationship of the accuracy events to the intervals and thresholds

Event	Interval (Q)	Threshold (W)
Errored Unit of Time	Unit time	Zero Errors
Errored Block	Block length (time or number of bits)	Zero Errors
Severely Errored Unit of Time	Unit time	Block error count over interval Q corresponding to 30% (see Note) errored blocks (where a suitable block is not available, 10^{-3} BER) or 1 SDP
Severely Errored Period	3 unit times while in the available state	100% SEUT (a non-SEUT stops the sequence)

NOTE - The errored block threshold for defining an SES (SEUT where the unit of time is 1 second) for SDH sections is different from 30% and typically lower.

6.4 In-service measurement of availability

With availability defined in Availability parameters above, the monitoring points should be at INIs and NIs.

6.4.1 Measuring availability between two INIs

To measure Availability between INIs[9], monitoring points are at the INI located at both ends of the transit portion of the transmission path. As shown in Figure 2, each end has two monitoring points: one for transmitting and one for receiving. Four monitoring points are available for measuring unidirectional availability performances.
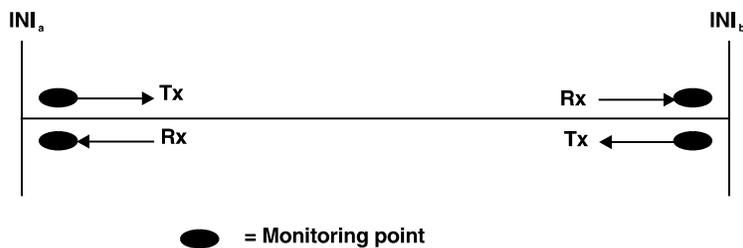
Figure 2 – Monitoring points for availability between two INIs

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[9] Multiple INIs are possible within the transit portion. The monitoring points shown in Figure 2 are applicable to any pair of INIs.

Measuring availability from NI-to-NI

Similarly, the Availability from NI to NI (see Figure 3), could be measured using test access points at A, B, F, and H. However, in some instances, A, B, F, and H are not accessible to the service provider. For these situations, availability can only be measured if a Far-End Monitoring Capability is supported by the customer premise equipment. With only monitoring point C, D, E, and G accessible, performance primitives required for availability measurements (e.g., ES, SES, etc.) in the incoming direction are reported to the far-end via special messages embedded within the signal format (see T1.231-1997). Examples include the far-end block error (FEBE) indicators in SONET and DS3 C-bit applications, and the performance report message (PRM) in DS1-ESF. With such capability built into a transmission signal, part of the monitoring functions (derivation, storage, thresholding, and reporting of performance primitives and parameters) for transmission performance observed at the far-end can be provided at the near-end.
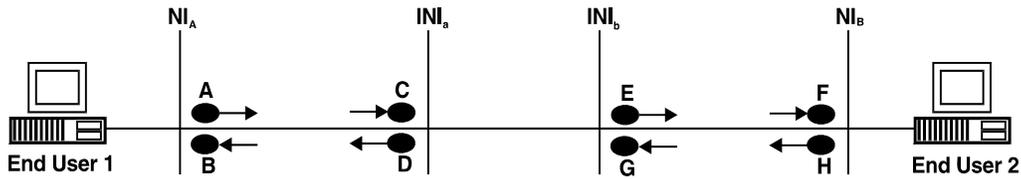

Figure 3 – Monitoring points for availability from NI-to-NI

Annex A

(informative)

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[10] This document is available from the International Telecommunications Union.
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