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American National Standard for Telecommunications

Network Performance Parameters for Circuit-Switched 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 circuit-switched digital services, and provides and defines the performance parameters and measurements needed by users, vendors, and providers of circuit-switched digital services, to characterize the user-observable performance of these services (i.e., it does not address the causes of errors). It also includes parameters to be considered in determining whether or not a service is in the available or unavailable state. A given service will only reference those parameters or thresholds applicable to that service. The network-specific parameters are for performance allocation and network control. Standard performance parameter definitions and measurements 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 framework information for T1.517-1995 (R2001), *Integrated services digital network (ISDN) – Performance parameters and objectives,* which contains numerical specifications and allocations for the parameters and measurements discussed in this standard.

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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Network Performance Parameters for Circuit-Switched Digital Services – Definitions and Measurements

1 Scope, Purpose, and Application

This standard applies to circuit-switched digital services, and provides and defines the performance parameters and measurements needed by users, vendors, and providers of circuit-switched digital services, to characterize the user-observable performance of these services (i.e., it does not address the causes of errors). It also includes parameters to be considered in determining whether or not a service is in the available or unavailable state. A given service will only reference those parameters or thresholds applicable to that service. The network-specific parameters are for performance allocation and network control. Standard performance parameter definitions and measurements 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 framework information for T1.517-1995 (R2001), *Integrated services digital network (ISDN) – Performance parameters and objectives,*which contains numerical specifications and allocations for the parameters and measurements discussed in this standard. The service objectives specified in this companion document will be based on measurements made during the available state (i.e., measurements made during the unavailable state will be excluded from performance calculations) and are applicable to both directions of transmission.

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.

T1.503-2001, *Network Performance Parameters for Dedicated Digital Services - Definitions and Measurements*.[1]

[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 Abbreviations, Acronyms, and Definitions

3.1 Abbreviations & Acronyms

adp	access denial probability
ANSI	American National Standards Institute
ATIS	Alliance for Telecommunications Industry Solutions
BER	Bit Error Ratio
BLER	Block Error Ratio
ES	Errored Second
EUT	Errored Unit of Time
iap	incorrect access probability
INI	Inter-Network Interface
ITU-T	International Telecommunication Union – Telecommunication Standardization Sector
LATA	Local Access and Transport Area
NI	Network Interface
pdp	premature disconnect probability
pdsp	premature disconnect stimulus probability
POT	Point of Termination
SEP	Severely Errored Period
SEUT	Severely Errored Unit of Time

3.2 Definitions

3.2.1 Access request: A signal[2] sent to a network for the purpose of initiating the establishment of a network connection.

3.2.2 Alerting indicator: A signal indicating that an alerting signal is being sent to an addressed user.

3.2.3 Alerting signal: A signal from the network toward the addressed user indicating the presence of an incoming call.

3.2.4 Answer indicator: A signal indicating acceptance of the call by the addressed user.

3.2.5 Connection establishment: The establishment of the capability for the transmission of user information.

3.2.6 Disengagement request: A signal to a network for the purpose of initiating the termination of an established connection.

3.2.7 Premature disconnect: The termination of an established connection where the termination is not initiated by either of the connected end-users.

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[2] In this standard, a signal may take the form of a message.

3.2.8 Premature disconnect stimulus: The untimely occurrence of an event or a combination of events that, according to the protocol, should result in a disconnection. In addition, the occurrence of one or more of the following criteria generated between the portion boundaries is defined to be a premature disconnect stimulus:

a) Bit error ratio worse than 10^{n_b}, for X_b number of consecutive observation periods of N_b duration;

b) Block error ratio worse than 10^{n_B}, for X_B number of consecutive observation periods of N_B duration;

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

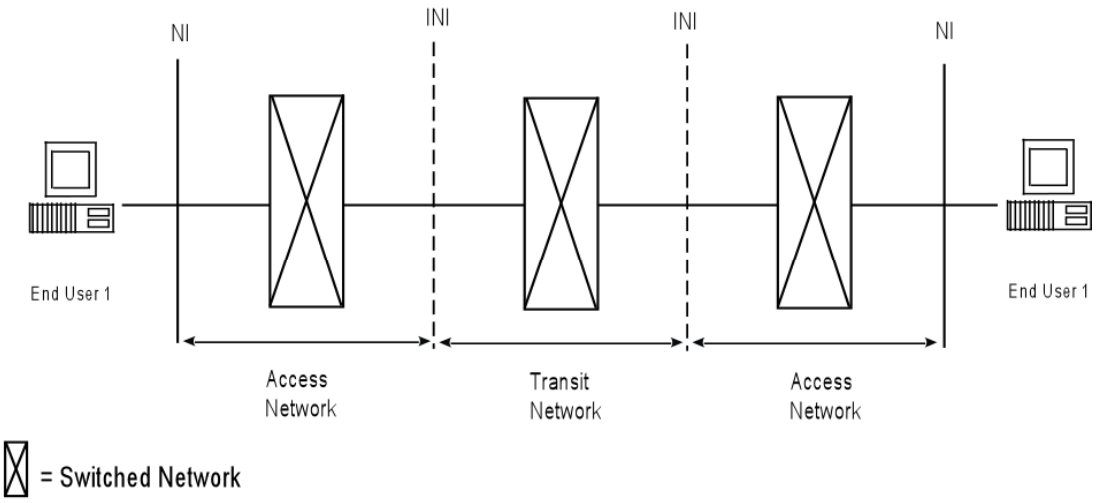
Receipt of a premature disconnect stimulus may result in a connection being disconnected and then reestablished.

NOTE – Only that subset of these criteria specified for a given service shall be considered.

3.2.9 Request acknowledgment: A signal from a network in response to an access request, indicating the network's readiness to accept address information.

4 Functional reference model

The performance parameters for circuit-switched digital connections shall be specified in terms of the reference model in Figure 1. End-to-end performance shall be specified from NI-to-NI with performance allocated for NI-to-INI and INI-to-INI. Since connections may or may not span multiple networks, INIs are shown within dashed lines. For intra-network connections (no INIs), end-to-end parameters apply.



NOTES

1. The exchange-carrier switch or the interexchange carrier network may not be in the circuit. However, at least one switch must be in the network.
2. NI – Network Interface
3. INI – Inter-Network Interface: INIs are only present when the service is provided across multiple networks. Where a point of termination (POT) exists, it will coincide with an INI.
4. 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.

Figure 1 – Functional reference model – Inter-LATA network

5 Measurements

5.1 Types of measurements

The parameters can be measured in the following ways:

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

b) *In-service measurements:* These measurements are performed without disturbing user information transmissions. The measurements may not be available to the service providers.

5.2 Measurement purposes

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

a) *Acceptance tests:* These tests verify that the value of performance parameters are within prescribed limits after 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 out-of-service basis.

c) *Repair verification tests:* These tests verify that the values of the performance parameters are within 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 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 bit rate, facility, type, and other characteristics). These measurements are performed on either an in-service or out-of-service basis.

6 Performance parameters

Circuit-switched digital services are characterized by three phases: the access phase, the information transfer phase, and the disengagement phase.

a) *Access phase:* The access phase includes all those activities that are required for the establishment of a switched digital connection. The access phase begins with an access request and ends with connection establishment.

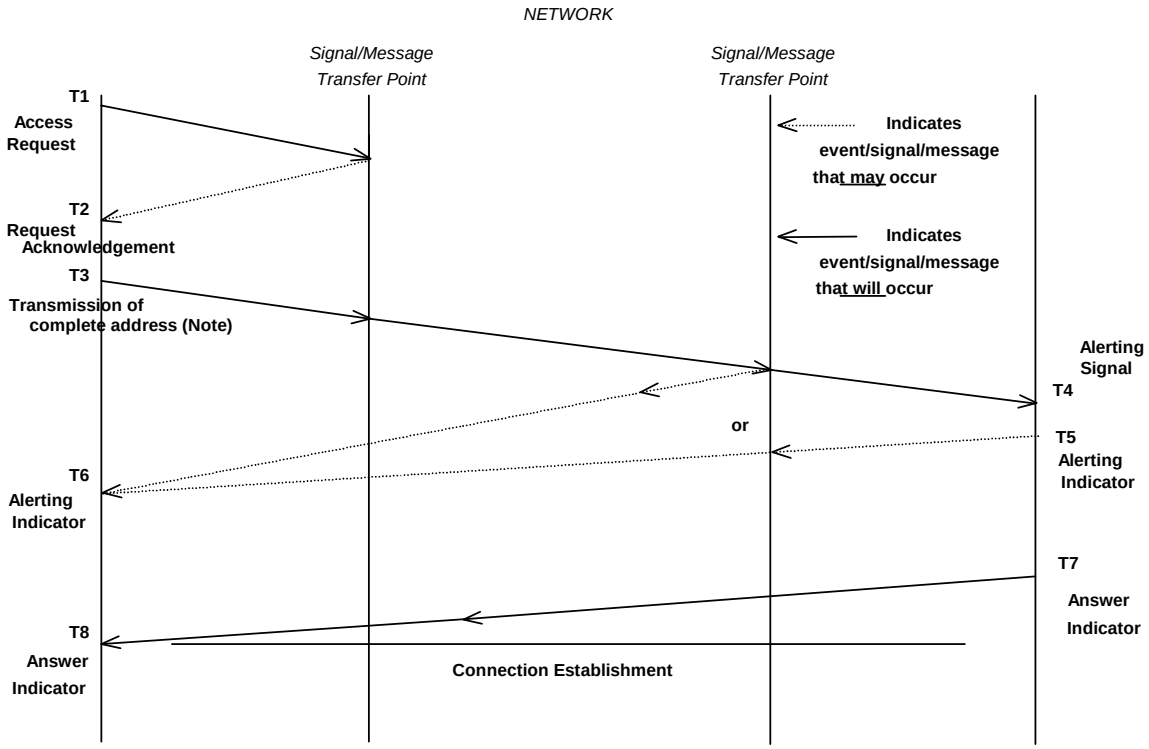
b) *Information transfer phase:* The information transfer phase begins at connection establishment and ends with a disengagement request.

c) *Disengagement phase:* The disengagement phase includes all those activities that are required for the termination of a switched digital connection. The disengagement phase begins with a disengagement request and ends when the network is ready to respond to a new user access request.

Parameters are measured at the network interface and are described in terms of defined interface events. These parameters, being network-specific, only describe network performance.

6.1 Access phase performance parameters

The access phase performance parameters are defined in this subsection. Delay calculations are made only on successful events and exclude any user-dependent delay. The event sequences for these parameters are shown in Figure 2.



NOTE – When the complete address is included with the Access Request, T1 and T3 are coincident.

PARAMETER MEASUREMENTS

The Request Acknowledgment Delay is (T2-T1). The Request Acknowledgment Delay may only be measured when the Request Acknowledgment signal/message is present.

The Alerting Indicator Delay is (T6-T3). The Alerting Indicator Delay may only be measured when the Alerting Indicator signal/message is present. In cases where the Alerting Indicator is provided external to the network under measure, the time (T5-T4) shall be subtracted from the measured value.

The Connection Establishment Delay is (T8-T3) – (T7-T4).

Figure 2 – Access phase event sequence

Following are the access phase performance parameters:

a) *Request acknowledgment delay:* This parameter is the time between the transmission of an access request and the receipt of the request acknowledgment.

NOTE – In all cases where the addressing information is sent with the access request, request acknowledgment delay is not measured separately.

b) *Alerting indicator delay:* This parameter is the time between the transmission of the complete address and the receipt of the alerting indicator. Since an alerting indicator is not always provided, this parameter is not always measurable.

c) *Connection establishment delay:* This parameter is the time between the transmission of the complete address and the connection establishment, which may be indicated by a connection establishment signal.

d) *Incorrect access probability:* This parameter is the ratio of the number of access attempts that result in incorrect access to total access attempts. Incorrect access occurs when a connection is established to a user other than the one intended. Incorrect addressing is excluded.

e) *Access denial probability:* This parameter is the ratio of the total access phase attempts that are unsuccessful to the total number of access phase attempts. An access phase attempt is unsuccessful (access denial) when any of the following events are observed:

   1) The request acknowledgment delay exceeds S1 units of time;

   2) The connection establishment delay exceeds S2 units of time; or

   3) An indication of denied access is received.

6.2 Information transfer phase performance parameters

6.2.1 Parameter definitions

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

b) *Block error ratio (BLER):* This parameter is 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:* This parameter is the number or percent of errored units of time in a specified period.

d) *Severely errored unit of time measure:* This parameter is the number or percent of severely errored units of time in a specified period.

e) *Variation in mean one-way absolute delay:* This parameter is the variation in one-way absolute delay between connections between the same end points, stated in terms of an interval of time.

f) *Premature disconnect probability:* This parameter is the ratio of the number of premature disconnects (cut-offs) to the total number of successful accesses.

g) *Premature disconnect stimulus probability:* The number of premature stimulus events per unit time over a specified period.

6.2.2 Accuracy performance determination

The accuracy performance events and parameters are:

Events	***Parameters***
Bit error	*Bit error ratio (BER)*
Block error	*Block error ratio (BLER)*
Errored Unit of Time (EUT)	*Errored unit of time measure*
Severely Errored Unit of Time (SEUT)	*Severely errored unit of time measure*
Severely Errored Period (SEP)	*Severely errored period measure*

NOTE - Definitions for these events and parameters are found in T1.503-2002.

6.2.2.1 Single measurement period procedure

This procedure is typically used in the design of trouble and repair verification tests. Performance determination for accuracy parameter is based on the following relationships:

a) *Z* number of intervals of length *Q* (on a single connection) are examined, where *Z* is an integer value and *Q* is an interval of time or a fixed number of bits corresponding to the event under consideration.

b) 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.

c) To determine the performance for the parameter under consideration, measure a total of *Z* intervals of length *Q* and count the number of intervals where the number of transmission bit or block errors crosses the threshold *W*. The number of intervals counted is *Y* and the performance is the value *Y*/*Z*.

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

Table 1 – Relationship of the accuracy event 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.

6.2.2.2 Multiple measurement period procedures

These procedures shall be used for service monitoring and characterization measurements (i.e., service performance acceptability).

Measurements are made for each of a number of continuous fixed-length time intervals. Performance is specified in terms of the ratio of intervals having parameter values within the limits established for a single interval to the total number of intervals examined.

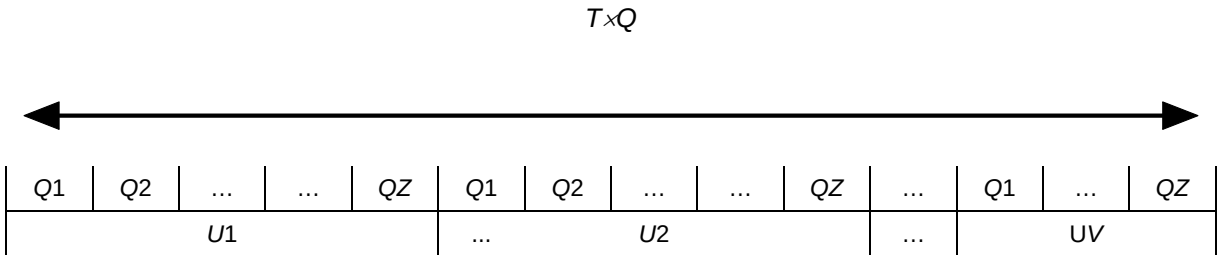
This procedure is based on the following relationships:

a) *V* number of intervals of length *U* are examined, where *V* is an integer value and *U* is an interval of *Z* contiguous intervals of length *Q* or a fixed number of bits *Z* x *Q*, (if *Q* represents a fixed number of bits) corresponding to the parameter under consideration.

b) For each interval *U,* a determination is made as to whether a threshold value *L* for the parameter has been exceeded, where *L* is a threshold value for the measurement *Y*.

c) To determine the performance for the parameter under consideration, measure *Y* over a total of *V* intervals (each comprised of *Z* intervals of length *Q*) and count the number of intervals where *Y* exceeds *L*. The number of intervals counted is *P* and the performance is the value *P*/*V*.

Figure 3 shows the relationship between time intervals *Q* and *U*.



Q = An interval of time or fixed number of bits corresponding to the parameter under consideration.

Z = An integer number of interval *Q* contained within the interval *U.*

U = An interval containing *Z* contiguous intervals of length *Q.*

V = An integer number of intervals, *U*, examined.

$T = V \times Z.$

$T \times Q$ = Total test interval in units of time or bits.

Figure 3 – Interval relationships

P/*V* represents the fraction of continuous intervals *U* that have less than, or equal to, the threshold value of *L* intervals of length *Q* that cross the threshold *W*.

Optionally, in conjunction with the above procedure, performance for the parameter under consideration may be evaluated over the cumulative measurement period based on the following relationship:

a) *T* number of intervals of length *Q* are examined. *T* is an integer value where $T = V \times Z$. (The intervals examined are the same as those in Procedure (a) in this subclause).

b) In this procedure, performance for the parameter under consideration is determined by the number of intervals *R* out of *T* intervals examined that cross the threshold *W*.

Example 1:

Percent (P_c) of 5 minute intervals with > 0 ES over 20 hours total test time. The total test time consists of 240 - possibly non-contiguous - 5 minute intervals.

q = threshold for *Q* intervals crossing event threshold *W*

v = number of *U* intervals where *q* is exceeded

Q = 1 second (event base interval)
W = *0* errors (event threshold)

Z = 300 event intervals
U = sample size = *Q x 300* =300 seconds (5 minutes)
q = *0* (*U* interval threshold)

V = 240 samples
T = total event intervals = *V x Z* = 72000
Total test size = *T x Q* = 72000 seconds (20 hours)

Therefore:

P_c = v*100/V *where, for example, P could be 5%* of 5minute intervals with 1 or more ES

Example 2:

Percent (P_c) of *Q* intervals crossing event threshold *W* over total 20 hour test time. The total test time consists of 240 - possibly non-contiguous - 5 minute intervals.

Q = 1 second (event base interval)
W = *0* errors (event threshold)

Z = 300 event intervals
U = sample size = *Q x 300* =300 seconds (5 minutes)
T = total event intervals = *V x Z* = 72000

R = number of *Q* intervals crossing event threshold *W* in *T* event intervals

Therefore:

P_c = *R*100/T* where, for example, P could be 0.01% ES

6.3 Disengagement phase performance parameters

These parameters are defined as follows:

a) *Disengagement delay:* Disengagement delay is the time between the initiation of a disengagement and receipt of a disengagement indication by the far end (e.g., the network is capable of responding to a new access request).

b) *Release delay:* Release delay is the time between the generation of an initial disengagement request and the receipt, by the initiator of the disengagement request, of a disengagement

indication (this parameter has significance to end-users, but is not one for which network performance objectives will be set).

c) *Unsuccessful disengagement probability:* This term represents the ratio of the number of unsuccessful disengagements to the total number of disengagement attempts.

The event sequences for disengagement and release delay are shown in Figure 4:

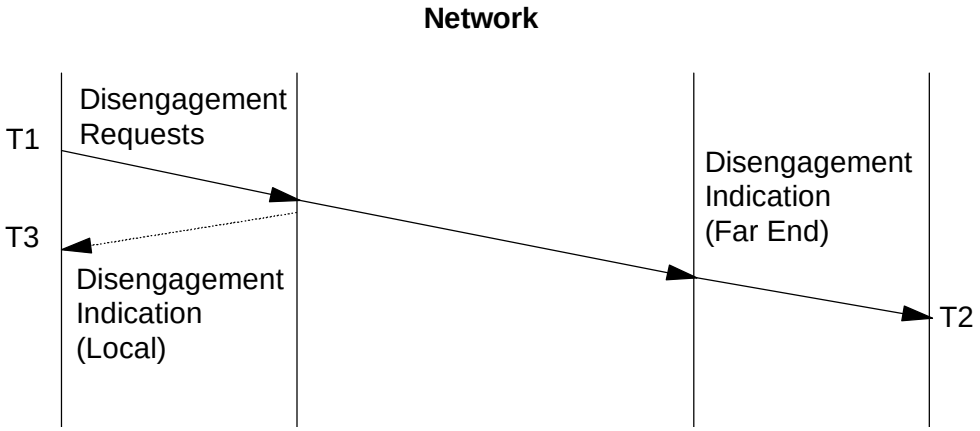


Figure 4 – Disengagement and release sequences

6.4 Availability parameters

This clause specifies availability parameters for the portions defined in clause 4. Two availability parameters -- service availability and mean time between service outages -- are defined.

A two-state model provides a basis for describing overall circuit-switched service availability. The values of (unspecified) combinations constructed from the access phase or information transfer phase parameters with, in the case of the “state-based” version, corresponding outage thresholds are used to classify the service as "available" (no service outage) or "unavailable" (service outage) during scheduled service time. The set of constructed combinations and any outage thresholds are called an *availability function*. Parameters that are typically used in an availability function are given in this subclause. Examples of both “state-based” and “transition-based” availability functions are presented in Tables 2 and 3, respectively.

Performance parameters typically used in constructing availability functions:

a) Incorrect access probability;

b) Access denial probability;

c) Bit error ratio;

d) Block error ratio;

e) Errored unit of time measure;

f) Severely errored unit of time measure;

g) Premature disconnect probability; and

h) Premature disconnect stimulus probability.

6.4.1 Example availability functions

Table 2 – Example of a state-based availability function

Availability decision parameters	Outage criteria
incorrect access probability (iap) access denial probability (adp)	$iap+adp>C_1$
premature disconnect probability (pdp) premature disconnect stimulus probability (pdsp)	$pdp+pdsp>C_2$

Performance is considered independently for each outage criteria. An interval of time over which the outage criteria are evaluated is specified. If the outage criteria is met over this interval of time, then the performance relative to that outage criteria is unacceptable (for the observed interval of time). If the outage criteria is not met, then the performance relative to that outage criteria is acceptable (for the observed interval of time).

The portion is defined to be available (or to be in the available state) if the performance relative to all outage criteria is acceptable.

The portion is defined to be unavailable (or to be in the unavailable state) if the performance relative to any outage criteria is unacceptable.

The intervals during which a portion is unavailable are identified by superimposing the unacceptable performance intervals for all outage criteria.

Table 3 – Example of a transition-based availability function

Performance Parameter	Entry to the Unavailable State	Return to the Available State
Severely Errored Unit of Time (SEUT)	10 consecutive SEUT periods	10 consecutive non-SEUT periods

A portion is either assumed to be in the available state due to the lack of an observation of an entry to the unavailable state, or because of the observation of a return to the available state.

A portion is in the unavailable state when an entry to the unavailable state has been observed and no succeeding return to the available state has been observed.

6.4.2 Definition of service availability

The service availability for a portion is the long-term percentage of scheduled service time in which that portion is available.

6.4.3 Definition of mean time between service outages

The mean time between service outages for a portion is the average duration of any continuous interval during which the portion is available. Consecutive intervals of scheduled service time are concatenated. Availability performance objectives can be used as an aid in designing, developing, and maintaining the networks providing switched digital services. They can also be used to design terminal equipment, to facilitate service planning and as guidance for other standards organizations.

Annex A

(informative)

A Bibliography

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