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ATIS-0100027.2010(R2015)

Availability – A Guide to Consistent Definitions

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American National Standard for Telecommunications

AVAILABILITY – A GUIDE TO CONSISTENT DEFINITIONS

Alliance for Telecommunications Industry Solutions

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American National Standards Institute, Inc.

Abstract

In order for service providers, vendors or customers of the network to develop an SLA that includes the availability metric, the definition of availability must be agreed upon and a method for estimation developed. This Technical Report (TR) will describe the components of the definition of "Availability" that should be present. The purpose is to stimulate consistency in the manner which availability is defined in various standards documents. Additionally, the TR will describe an ITU-T (International Telecommunication Union – Telecommunication Standardization Sector) proposed "Universal" definition for compatibility. And finally, the TMForum's SLA Management Handbook [GB917] should also be consulted since it provides additional guidance.

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.

The Alliance for Telecommunication Industry Solutions (ATIS) serves the public through improved understanding between providers, customers, and manufacturers. The Network Performance, Reliability, and Quality of Service Committee (PRQC) develops and recommends standards, requirements, and technical reports related to the performance, reliability, and associated security aspects of communications networks, as well as the processing of voice, audio, data, image, and video signals, and their multimedia integration. PRQC also develops and recommends positions on, and foster consistency with, standards and related subjects under consideration in other North American and international standards bodies.

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 document are welcome. They should be sent to the Alliance for Telecommunications Industry Solutions, PRQC , 1200 G Street NW, Suite 500, Washington, DC 20005.

At the time it approved this document, PRQC, which is responsible for the development of this Standard, had the following members:

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1   SCOPE

Availability is a key measure in Service Level Agreements (SLAs) between service providers and their customers as well as their vendors and suppliers. Metrics for estimating IP packet layer availability [Y.1540] and service level availability [ATIS-0100025] have received considerable attention in various standards bodies.

In order for service providers, vendors or customers of the network to develop an SLA that includes the availability metric, the definition of availability must be agreed upon and a method for estimation developed. This Technical Report (TR) will describe the components of the definition of "Availability" that should be present. The purpose is to stimulate consistency in the manner which availability is defined in various standards documents. Additionally, the TR will describe an ITU-T (International Telecommunication Union – Telecommunication Standardization Sector) proposed "Universal" definition for compatibility. And finally, the TMForum's SLA Management Handbook [GB917] should also be consulted since it provides additional guidance.

2   NORMATIVE REFERENCES

The following documents 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 and technical reports 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.

2.1   ATIS References[1]

[ATIS-0100016] - *End-to-End Service Availability: General Definition*, ATIS Technical Report ATIS-0100016, 2008.

[ATIS-0100020] - *Quantifying the Impact on IP Service Availability from Network Element Outages*, ATIS Technical Report ATIS-0100020, 2008,

[ATIS-0100025] - *A Methodology for Estimating the Availability of Access IP Routers in Terms of Customer Facing Line Card Availability*, ATIS Technical Report ATIS-0100025.

[ATIS-0100008] – *DPM Metric for Transactional Services such as VoIP*, American National Standard ATIS-0100008.2007

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[1] This document is available from the Alliance for Telecommunications Industry Solutions (ATIS), 1200 G Street N.W., Suite 500, Washington, DC 20005. < https://www.atis.org/docstore/default.aspx >

2.2 ITU References[2]

[Y.1540] - *Internet protocol aspects – Quality of service and network performance – Internet protocol data communication service - IP packet transfer and availability performance parameters*, ITU-T Recommendation Y.1540, November 2007.

[Y.1561] - *Performance and availability parameters for MPLS networks*, ITU-T Recommendation Y.1561, May 2004.

[Y.1563] - *Ethernet frame transfer and availability performance*, ITU-T Recommendation Y.1563, January 2009.

2.3 Reference Literature

[Becker, et al] - Becker, R. A., Clark, L. A., and Lambert, D., "Events Defined by Duration and Severity, With an Application to Network Reliability", *Technometrics*, August 1998, p. 177-189.

[MEF 10.2] MEF Technical Specification 10.2 Ethernet Services Attributes Phase 2, Oct 2009

[GB917] GB917, *SLA Management Handbook*, Release 2.5, Telemanagement Forum

3 ACRONYMS, & ABBREVIATIONS

3.1 Acronyms & Abbreviations

ATIS	Alliance for Telecommunications Industry Solutions
IP	Internet Protocol
ITU	International Telecommunication Union
ITU-T	International Telecommunication Union - Telecommunications
MPLS	Multi-Protocol Label Switching
MEF	MetroEthernet Forum
PRQC	Performance, Reliability, & Quality Committee
QOS	Quality of Service
SLA	Service Level Agreement
STP	Signal Transfer Point

4 AVAILABILITY – AN INTRODUCTION

Various standards bodies have wrestled with the application of availability in telecommunications. Previous PRQC contributions have presented initial examinations of these efforts. They provided examples of availability definitions discussed in standards bodies (ITU-T Recommendations E.800, Y.1540, and Y.1561) and in the technical literature. This Technical Report provides a synthesis of this material into a guide for consistency, which can be used to characterize an availability definition. In the guide, the key elements that should be included in any definition are clearly enumerated.

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

5 GUIDE

The general concept and theoretical definitions provide the key points for the guide. Definitions of availability should address these concepts. Foremost is the understanding that availability is related to time, in particular a proportion of time. Second is the notion that the subject of the definition is in one of two states, "functioning" or "not functioning". Third is the understanding of the definition type as it relates to its application. Availability definitions should include descriptions of the following four areas:

- Definition type

- Subject of definition

- Time

- Functioning definition.

These four concepts are described in the following subsections.

5.1 Definition Type

In general, an availability definition has one of two purposes:

- Prediction or
- Estimation.

An availability definition for the purpose of prediction is used to quantify availability based on a model while one for the purpose of estimation is used to quantify availability as a measurement. With reference to the general theoretical definitions,

- an *availability definition for prediction* describes models or formulas that are theoretic in nature, while

- an *availability definition for estimation* describes formulas and methodologies used to measure and calculate an observed value.

Definitions of availability for purposes of prediction are often used for the reliability engineering of telecommunications systems and networks and in the structuring of Service Level Agreements (SLAs) for those networks. Definitions of availability for purposes of estimation are often used to monitor telecommunications systems and networks and in the verifying that SLAs are being met.

5.2 Subject of Definition

The subject of the definition specifies the object for which availability is predicted or estimated.

5.2.1 Subject Type

Within telecommunications, the two major subject types for defining availability are:

- Equipment and
- Service/Network.

The two are linked together and often confused. If equipment is not functioning, then service is often not functioning. However, redundancies in telecommunications networks often allow service to be

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unimpaired if equipment is not functioning. It is also possible that service is initially impacted, but restored before the equipment that caused the service interruption is repaired or replaced.

If service is not functioning, then some piece of equipment is often not functioning. The primary cause of service failures is equipment failure. However, service may not be functioning even when all equipment is functioning. Here are two examples:

- A network experiences traffic overload causing performance to be degraded to the point that service is considered not functional. In this case, all equipment is functional but service is not.
- Transmission between nodes of a wireless network is not functioning because of interference. Again all equipment is functional but service is not.

The choice of Equipment versus Service availability has a great effect on the other characteristics of the definition.

If the definition is to be applied to Equipment, then Equipment can be subdivided in a variety of ways including:

- Hardware versus Software
- Different types of systems (e.g. switch, cell site, Signaling Transfer Point - STP)
- Different types of equipment (e.g., card, capacitor, diode).

Each type could have its own definition of functionality.

5.2.2 Subject Scope

Subject scope defines how broadly the definition is extended across a network. If the subject type is equipment, the subject could include all equipment of a certain type, a certain manufacturer, or a certain region of the network. If the subject is a service, the subject could be end-to-end or it could be restricted to a certain portion of the service (e.g. access, backbone transport).

5.3   Time

Time is a critical element in the definition of availability. There are two major time characteristics for a definition:

- Scope of the definition with respect to time
- Atomic level of time in the definition.

5.3.1 Scope of Time

The first decision with respect to time is the scope of time to which the definition applies. The definition can be applied to a defined time window (e.g., average availability) or as a limit as time approaches infinity (e.g., limiting average availability or limiting availability). This decision is generally linked to the definition type. Definitions for availability as time approaches infinity are used almost exclusively for purposes of prediction. Definitions for availability with respect to a window of time could be used for purposes of prediction, but are generally used for the purpose of estimating availability from measurements in a specific time window. If the definition is to be applied to a time window, the definition must specify the need to provide the scope limits in the definition (e.g., the definition is for availability from time T_1 to T_2).

Scheduled down time is a time interval agreed upon by both the Subscriber and Service Provider during which a service may be disabled by the Service Provider. This time interval should not be used in calculations of availability or unavailability.

5.3.2   Atomic Level of Time

Theoretically, availability *A(t)* is defined for a moment in time *t* as described in the general theoretical definitions. This moment is the atomic level of time in the definition, the smallest unit of time. In the most theoretical definitions, the atomic level is instantaneous time with zero length. Some definitions utilize instantaneous time as the atomic level.

Example: The *Technometrics* paper "Events Defined by Duration and Severity, With an Application to Network Reliability" by Richard A. Becker, Linda A. Clark, and Diane Lambert [Becker, et al] describes statistical techniques for identifying time periods of poor network performance. The authors use the probability of a call being blocked as the metric of interest for network performance. A connection between two endpoints is considered unavailable when blocking probability exceeds a given threshold. Blocking probability is estimated as a continuous function over time using weighted logistic regression to fit a smoothed curve to the blocking data. This function gives blocking probability at any moment in time and by comparison to the threshold gives availability at any moment in time.

However, more commonly, definitions of availability are constructed based on atomic levels of time with length greater than 0. Generally, the scope of the definition is subdivided into smaller time units. The functionality definition is applied within these smaller time units. These smaller time units provide the atomic level of time in the definition.

Example: ITU-T Recommendation Y.1540 provides a definition of an estimate of average or mean availability for IP service. A given window of time [T_1, T_2] is divided into a number of time intervals of length T_{av}. The functionality definition is applied to each atomic level of time T_{av}. Basically, instantaneous availability at a time *t* has been replaced by an estimate of availability within a small time slice around the time *t*.

5.4   Functioning Definition

At any moment in time, the subject of the availability definition is in one of two states, functional or not functional. The definition of when the subject is in one of these two states is generally the most complex part of the availability definition. Functionality must be considered with respect to the subject's interaction with its environment. To do this, the means by which the subject interacts and the sequence of events in this interaction must be considered. The availability definition requires that this interaction be converted into a meaningful quantifiable metric associated with functionality.

Example: ITU-T Recommendation Y.1540 describes the availability of IP service. IP service interacts with its environment via sequences of packets. Measurements of the numbers of packets transmitted and lost are taken within the atomic level window. The ratio of packets lost to packets transmitted provides the meaningful metric associated with functionality. Service is considered functional (non-functional) within the atomic level window when this ratio is lower (greater) than a specified threshold.

Hysteresis is a potential characteristic of an availability definition. The characteristic is generally encountered in the functionality component of the definition. The presence of hysteresis means that the determination of functionality at any moment depends not just on an evaluation of measurements at that time, but also on prior time periods as well.

Example: ITU-T Recommendation Y1561 provides an availability definition for Multi-Protocol Label Switching (MPLS) service. It is similar to the Y.1540 definition in many ways:

- It uses packet streams as the means of interaction with its environment.
- It relies on measurements of numbers of packets transmitted and lost as the basis for quantifying functionality.
- It calculates a ratio of lost packets to packets transmitted within an atomic time period.

However, instead of comparing each ratio within an atomic level time period separately as in Y.1540, 10 consecutive atomic time periods with ratios above a specified threshold are required to declare the service non-functional across the 10 time periods; otherwise the service is considered functional across all 10 time periods. Once a non-functional period is declared, each subsequent atomic time window is non-functional until 10 consecutive atomic time periods below the threshold are encountered. In this way, the determination of functionality at any moment depends not only on measurements within that moment's atomic time period, but also on those atomic time periods near it in time.

Quality of Service (QOS) may affect how the parameters associated with the criteria for functioning vs. non-functioning are set. The availability definition may be configured to express differences of availability for different levels of QOS. Generally this is done within the functionality definition. One way for QOS to be expressed is to have different thresholds for different QOS levels. In both the Y.1540 and Y.1561 examples above, services with a lower QOS could find higher lost packet rates more acceptable. Therefore, such low QOS services could have higher thresholds to express this difference in functionality for lower QOS.

However, other means could also be used to configure QOS differences. In the Y.1561 example, a definition in which only 5 atomic level period ratios are required to declare non-functionality places a more stringent requirement on functionality. So, using a consecutive time period requirement less than 10 could be used for availability definitions of higher QOS while a consecutive time period requirement greater than 10 could be used for lower QOS.

In general (particularly in a point-to-point situation), availability definitions are based on a binary state: the subject is either functional or not functional. However, it can be difficult to make such a binary assessment for complex systems or services (that are not necessarily point-to-point). In such cases, the binary state non-functional (0) or functional (1) can be extended to the range of values from 0 to 1 inclusive. This range can be interpreted as expressing partial outage of the subject or as a probabilistic assessment of the functionality of the subject. The measurements can be made in a number of ways – packet loss, severely-errored seconds, line card availability, completed connections, etc. Some examples of methodologies associated with multipoint services follow:

Example1: ATIS Technical Report ATIS-0100020, [ATIS-0100020],"Quantifying the Impact on IP Service Availability from Network Element Outages" defines availability in terms of the weighted fraction of time that the service is not in an outage state. The weights (fraction of service lost during an outage) express functionality in terms of partial outage.

Example 2: The ATIS Technical Report – "A Methodology for Estimating the Availability of Access IP Routers in Terms of Customer Facing Line Card Availability" provides a methodology for estimating network availability for any service by examining a key hardware component's (line cards) "up time"[ATIS-0100025]. By examining the hardware "up-time" as a surrogate of the service availability, one essentially considers a fraction of the service unavailable when an end user is isolated from the network by a line card failure.

Example 3: The ATIS Technical Report – "DPM Metric for Transactional Services such as VoIP" [ATIS-0100008] provides a metric that takes advantage of customer billing record (CBR) information to estimate defects per million (DPM) that is directly related to availability.

6   UNIVERSAL METHOD

During 2008, ITU-T was finalizing the contents of Y.1563, "Ethernet frame transfer and availability performance", which was issued in January 2009. The following table shows comparisons of particular aspects of the methods described in ITU-T Y.1540, Y.1561, Y.1563 and the Metro-Ethernet Forum (MEF) 10.2. Additionally, a generic "Universal" method is illustrated that is compatible with all of the methods. The table comes from a presentation made to the MEF Aligning Availability ad hoc group and

is included in this Technical Report to illustrate the similarities of the various standardized methods of measuring availability.

The "Universal" method is an estimation technique (type aspect) that is looking at a particular service (subject aspect). It describes parameters to be used for the time aspect and the functioning definition aspect. The left hand column of the following table provides a description for the estimation parameters for the four standards documents listed and the Universal Method. In the body of the table, the parameter names are shown (if applicable) and if a value is recommended, it is included. If the value is not shown in the table, it is still under study or to be determined by the customer and service provider. More detailed descriptions of the methods and parameters are in the sections following the table.

Table 1 - Comparison of Availability Calculation Methods

	Y.1540	Y.1561	MEF 10.2	Y.1563	Universal
Loss threshold for the transition: available → unavailable	- 0.75	S_1 0.15	C_u	S_1 0.5	S_1
Loss threshold for the transition: unavailable → available	- 0.75	S_1 0.15	C_a	S_1 0.5	S_2
Length of the atomic measurement interval, the loss threshold refers to	T_{av} 5 min	T_{lb} 1 s	delta t	T_{av} 1 s	T_{lb}
Minimal number of samples (packets) for a decision	M_{av} 1000	M_{lb}	-	-	M_{lb}
Number of atomic measurement intervals the decision is based on	1	**10**	n	**10**	n
Is the window sliding? (no:0 yes:1)	0	**1**	0	1	Optional, **SW** = 0 or 1
Availability performance objective requirement	-	-	**A**	-	-

	Y.1540	Y.1561	MEF 10.2	Y.1563	Universal
Measurement interval, the requirement refers to	-	-	**T**	-	-
Time interval the decision is made for	$1*T_{av}$	$1*T_{lb}$	$n*delta\ t$	$1*T_{av}$ <u>1 s</u>	$(1-SW)*(n-1)*T_{lb} + T_{lb}$
Time interval the transition is based on	$1*T_{av}$	$10*T_{lb}$	$n*delta\ t$	$10*T_{av}$ <u>10 s</u>	$n*T_{lb}$
Is there a hysteresis? May current availability status affect the next status?	*no*	*yes*	*yes*	*yes*	*yes*

6.1   Y.1540

ITU-T Rec. Y.1540 defines the IP packet transfer and availability performance parameters.

- IP service availability function: The IP service is available on an end-to-end basis if the packet loss ratio for that end-to-end case is smaller than a given threshold.

    - If IPLR > $c_1 \rightarrow$ unavailable state

    - If IPLR <= $c_1 \rightarrow$ available state

    - The minimum number of packets that should be used in evaluating the IP service availability function is M_{av}

    - The minimum duration of an interval of time during which the IP service availability function is to be evaluated is T_{av}

- Percent IP service unavailability (PIU): The percentage of total scheduled IP service time (the percentage of T_{av} intervals) that is (are) categorized as unavailable using the IP service availability function.

- Percent IP service availability (PIA) The percentage of total scheduled IP service time (the percentage of T_{av} intervals) that is (are) categorized as available using the IP service availability function.

6.2   Y.1561

ITU-T Rec. Y.1561 defines the performance and availability parameters for MPLS networks. It is noted, that connection-oriented services require a more continuous packet transfer than other packet services.

- A severe loss block (SLB) outcome occurs for a block of packets observed during time interval T_{lb} at ingress MP_0 when the ratio of lost packets at egress MP_i to total packets in the block exceeds s_1.

–Evaluation of successive blocks (time intervals) should be non-overlapping.

–The minimum number of packets that should be used in evaluating the severe loss block outcome is M_{lb}.

- MPLS service availability function

  –The onset of unavailability begins with the occurrence of ten consecutive SLBs. These ten seconds are part of unavailable time.

  –A period of unavailability ends with the occurrence of ten consecutive seconds, none of which are SLB. These ten seconds are part of available time.

  –The ten-second criteria are supported using a sliding window with one-second granularity.

- Percent MPLS service unavailability (PIU): The percentage of total scheduled service time that is categorized as unavailable using the MPLS service availability function.

- Percent MPLS service availability (PIA): The percentage of total scheduled service time that is categorized as available using the MPLS service availability function.

6.3 Y1563

ITU-T Rec. Y.1563 defines the performance and availability parameters for Ethernet service. The Ethernet service availability definition is based on a model which uses two states corresponding to the ability or inability of the network to sustain the service in the available state. Transitions between the states of the model are governed by the occurrence of patterns of severe errored seconds in the Ethernet layer (SESETH). This Recommendation views availability from the network perspective, where availability performance is characterized independently of user behaviour.

- A severe errored second (SESETH) outcome occurs for a block of frames observed during a one-second interval at ingress MP0 when the corresponding FLR (i.e., the ratio of lost frames tototal frames in the block) at egress MPi exceeds s1.
- A provisional value s1 of 0.5 is proposed, and different values may also be chosen depending on the class of service (CoS).

- Evaluation of successive one-second intervals is non-overlapping.A period of unavailable time begins at the onset of 10 consecutive SESETH outcomes. The corresponding period of time is considered to be part of unavailable time. During the unavailable time period, the Ethernet network is in unavailable state. A new period of available time begins at the onset of 10 consecutive non-SESETH outcomes. The corresponding period of time is considered to be part of available time. During the available time period, the Ethernet network is in available state.
- All 10-second intervals evaluated for state determination must be entirely composed of scheduled service time (the time interval when the service is intended to be operational, and is usually specified in a service agreement). This means that all seconds of scheduled service time are evaluated at least once for state determination purposes.
- Because an Ethernet service is bidirectional, an Ethernet network is in the unavailable state if either one, or both directions, are in the unavailable state. The unidirectional availability can be measured by the criteria mentioned above.

6.4 MEF 10.2

The Metro Ethernet Forum document 10.2 [MEF 10.2] (Ethernet Services Attributes Phase 2) defines the performance parameters for Ethernet Virtual Connections. The MEF is currently revising this document to align the definition with the definitions currently existing in ITU documentation. Since changes may be made in future versions of the MEF document, the following paragraphs reflect the contents of the current (10.2) version.

- Availability Performance is the percentage of time within a specified time interval during which the Frame Loss Ratio Performance is small

- Informally, Availability Performance is based on Service Frame loss during a *sequence (of length 'n')* of consecutive small time intervals (delta t).

  - If the previous sequence was defined as available, and if the frame loss is high (C_u) for each small time interval in the current sequence, then the current sequence is defined as unavailable. Otherwise the current sequence is defined as available.

- On the other hand, if the previous sequence was defined as unavailable, and if frame loss is low (C_a) for each small time interval in the current sequence, then the current sequence is defined as available. Otherwise, the current sequence is defined as unavailable.

- The values of C_u and C_a could be different; however, alignment with other definitions would make them equal.

- For bi-directional services, both directions must be available for the service to be available.

- For multi-point services, a specified subset of pairs of end-points must be available for the service to be considered available.

6.5 Universal Method

A universal Ethernet (packet technology) availability function definition is described below:

- A severe loss block (SLB) outcome occurs for a block of packets observed during time interval $\mathbf{T_{lb}}$ at ingress MP_0 when the ratio of lost packets at egress MP_i to total packets in the block exceeds $\mathbf{s_1}$.

  - Evaluation of successive blocks (time intervals) should be non-overlapping.

  - The minimum number of packets that should be used in evaluating the severe loss block outcome is $\mathbf{M_{lb}}$.

- A severe non-loss block (SNLB) outcome occurs for a block of packets observed during time interval $\mathbf{T_{lb}}$ at ingress MP_0 when the ratio of lost packets at egress MP_i to total packets in the block not more than $\mathbf{s_2}$.

  - Evaluation of successive blocks (time intervals) should be non-overlapping.

  - The minimum number of packets that should be used in evaluating the severe non-loss block outcome is $\mathbf{M_{lb}}$.

- Ethernet (packet) service availability function

  - The onset of unavailability begins with the occurrence of $\mathbf{n}$ consecutive SLBs. These n times T_{lb} time intervals are part of unavailable time.

- Depending upon the service that is being evaluated for availability, if bi-directional traffic is required for the service to operate properly, the availability function should evaluate both directions.

- For multi-point services, a specified subset of pairs of end-points must be available for the service to be considered available.

- The inclusion of separate parameters (S_1 and S_2) is largely for historical purposes; $S_1 \le S_2$ and for alignment with ITU definitions, the values would be equal.