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SERIES Y: GLOBAL INFORMATION
INFRASTRUCTURE, INTERNET PROTOCOL ASPECTS
AND NEXT-GENERATION NETWORKS

Internet protocol aspects – Quality of service and network
performance

Ethernet frame transfer and availability performance

Recommendation ITU-T Y.1563



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Recommendation ITU-T Y.1563

Ethernet frame transfer and availability performance

Summary

Recommendation ITU-T Y.1563 defines parameters that may be used in specifying and assessing the performance of speed, accuracy, dependability and availability of Ethernet frame transfer of an Ethernet communication service. The defined parameters apply to end-to-end, point-to-point connections and multipoint connectivity in the Ethernet layer and to the network portions that provide, or contribute to the provision of, such service in accordance with the normative references specified in clause 2.

Source

Recommendation ITU-T Y.1563 was approved on 13 January 2009 by ITU-T Study Group 12 (2009-2012) under Recommendation ITU-T A.8 procedures.

FOREWORD

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

The approval of ITU-T Recommendations is covered by the procedure laid down in WTSA Resolution 1.

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Recommendation ITU-T Y.1563

Ethernet frame transfer and availability performance

1 Scope

This Recommendation defines parameters that may be used in specifying and assessing the performance of speed, accuracy, dependability and availability of Ethernet frame transfer on an Ethernet network. It provides a simple set of constructs (terms, definitions and illustrations) and the semantics that allow the performance parameters to be applied to Ethernet networks in many useful ways.

This Recommendation describes Ethernet networks in terms of basic sections, such as networks and links, and measurement points at the boundaries between them. These descriptive terms and concepts have been developed and refined over a series of Recommendations addressing various networking technologies (e.g., ATM, IP, MPLS), and applied to Ethernet technology in this Recommendation. Ethernet networks described using these basic sections (and a few well-known concepts in the networking industry) can be related to Ethernet layer networks defined in [ITU-T G.8010] (architecture of Ethernet layer networks) and Ethernet services defined in [b-ITU-T G.8011]. [ITU-T G.8010] provides a functional specification of Ethernet bridges as defined in [b-IEEE 802.1D] and [b-IEEE 802.1Q]. Appendix VI provides the relationship.

The defined parameters apply to networks that provide, or contribute to the provision of, Ethernet services in accordance with the normative references specified in clause 2.

It applies to point-to-point Ethernet topologies and to point-to-multipoint Ethernet topologies. Multipoint-to-multipoint topologies which add a greater level of complexity are left for further study.

The scope of this Recommendation is summarized in Figure 1. The Ethernet network performance parameters are defined on the basis of Ethernet frame transfer reference events that may be observed at measurement points (MPs) associated with specified functional and jurisdictional boundaries. For comparability and completeness, Ethernet network performance is considered in the context of the 3×3 performance matrix defined in [b-ITU-T I.350]. Three protocol-independent communication functions are identified in the matrix: access, user information transfer and disengagement. Each function is considered with respect to three general performance concerns (or "performance criteria"): speed, accuracy and dependability. An associated two-state model provides a basis for describing Ethernet network availability.

Access and disengagement phases are beyond the scope of this Recommendation. In particular, additional Ethernet frames associated to MAC learning procedures are not considered in this Recommendation, since they are related to the access phase.

Figure 1

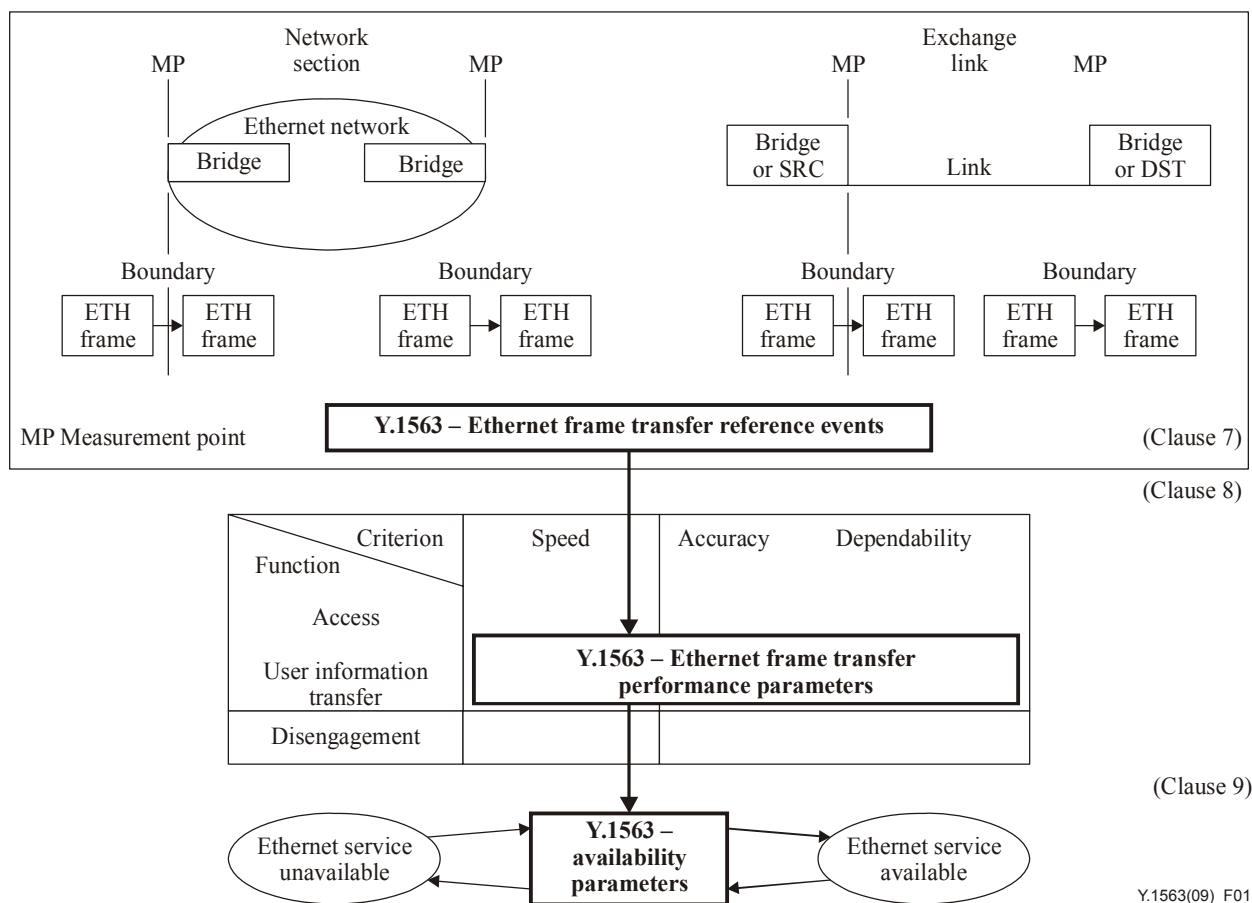


Figure 1 – Scope of this Recommendation

The objectives associated with the Ethernet user information transfer performance parameters are for further study. Another Recommendation will specify these performance objectives.

The end-to-end performance of Ethernet networks providing access and disengagement functions and higher-layer transport capabilities (e.g., Internet Protocol) may be addressed in separate Recommendations.

This Recommendation is structured as follows: Clause 1 specifies its scope. Clause 2 specifies its normative references. Clause 3 lists the terms used and/or defined in this Recommendation. Clause 4 provides a list of abbreviations. Clause 6 illustrates the layered model that creates the context for Ethernet performance specification. Clause 7 defines the model used for Ethernet performance, including network sections and measurement points, reference events and outcomes. Clause 8 uses this model to define Ethernet frame transfer performance parameters. Clause 9 then defines Ethernet service availability parameters. Appendix I describes the implications of sampling large multicast groups on performance parameters definitions and possibly the associated objectives. Appendix II provides alternative parameters which use the framework of point-to-point parameters at registered destinations of a multicast group defined in this Recommendation. Appendix III proposes to harmonize terminologies for frame delay and frame delay variation metrics developed by ITU-T and MEF. Appendix IV describes different networking opportunities making use of Ethernet technology. Finally, Appendix V presents OAM measurement considerations, and Appendix VI addresses the mapping to alternate descriptive terms for Ethernet architectures in [ITU-T G.8010].

NOTE 1 – The speed, accuracy and dependability parameters of this Recommendation are intended to characterize Ethernet service in the available state.

However, no measurements of these parameters made during periods of unavailable time are ever used for determining long-term frame transfer performance, and mechanisms must be established to exclude all performance measurement results collected during unavailable periods from any estimations of long-term Ethernet frame performance parameters.

NOTE 2 – The parameters of this Recommendation are designed to characterize the performance of service provided by network elements between specified section boundaries. However, users of this Recommendation should be aware that network elements outside the specified boundaries can sometimes influence the measured performance of the elements between the boundaries.

NOTE 3 – The parameters defined in this Recommendation can also be applied to any subset of the Ethernet frames offered to a given set of network equipment. Methods for aggregating performance over a set of network equipment or over an entire network are outside of the scope of this Recommendation.

NOTE 4 – The word "provisional", as used in this Recommendation, means that there is agreement on the stability of the value referenced, but that the value may change following further study, or on the basis of real network operational experience.

2 References

The following ITU-T Recommendations and other references contain provisions which, through reference in this text, constitute provisions of this Recommendation. At the time of publication, the editions indicated were valid. All Recommendations and other references are subject to revision; users of this Recommendation are therefore encouraged to investigate the possibility of applying the most recent edition of the Recommendations and other references listed below. A list of the currently valid ITU-T Recommendations is regularly published. The reference to a document within this Recommendation does not give it, as a stand-alone document, the status of a Recommendation.

- | | |
|-----------------|--|
| [ITU-T G.805] | Recommendation ITU-T G.805 (2000), <i>Generic functional architecture of transport networks</i> . |
| [ITU-T G.809] | Recommendation ITU-T G.809 (2003), <i>Functional architecture of connectionless layer networks</i> . |
| [ITU-T G.8010] | Recommendation ITU-T G.8010/Y.1306 (2004), <i>Architecture of Ethernet layer networks</i> . |
| [IEEE 802.1ad] | IEEE 802.1ad (2005), <i>IEEE Standard for Local and metropolitan area networks – Virtual Bridged Local Area Networks – Amendment 4: Provider Bridges</i> . |
| [IEEE 802.1ag] | IEEE 802.1ag (2007), <i>IEEE Standard for Local and metropolitan area networks – Virtual Bridged Local Area Networks – Amendment 5: Connectivity Fault Management</i> . |
| [IEEE 802.1ah] | IEEE 802.1ah (2008), <i>IEEE Standard for Local and metropolitan area networks – Virtual Bridged Local Area Networks – Amendment 6: Provider Backbone Bridges</i> . |
| [IEEE 802.3] | IEEE 802.3 (2002), <i>IEEE Standard for Information technology – Telecommunications and Information Exchange Between Systems – Local and Metropolitan Area Networks – Specific Requirements – Part 3: Carrier Sense Multiple Access with Collision Detection (CSMA/CD) Access Method and Physical Layer Specifications</i> . |
| [IETF RFC 3393] | IETF RFC 3393 (2002), <i>IP Packet Delay Variation Metric for IP Performance Metrics (IPPM)</i> . |
| [MEF 10.1] | MEF 10.1 (2006), <i>Ethernet Services Attributes Phase 2</i> . |

3 Definitions

3.1 Terms defined elsewhere

This Recommendation uses the following terms defined elsewhere:

- 3.1.1 **connection**: [ITU-T G.805].
- 3.1.2 **connection point**: [ITU-T G.805].
- 3.1.3 **Ethernet frame (equivalent to MAC frame)**: [IEEE 802.3].
- 3.1.4 **flow**: [ITU-T G.809].
- 3.1.5 **link**: [ITU-T G.805].

3.2 Terms defined in this Recommendation

This Recommendation defines the following terms in clauses 7, 8 and 9:

- 3.2.1 **comparative group delivery ratio**
- 3.2.2 **comparative group loss ratio**
- 3.2.3 **delay variation range over group**
- 3.2.4 **frame delay variation**
- 3.2.5 **frame error ratio**
- 3.2.6 **frame loss ratio**
- 3.2.7 **frame reference event**
- 3.2.8 **frame transfer delay**
- 3.2.9 **global mean transfer delay**
- 3.2.10 **group loss ratio**
- 3.2.11 **group mean transfer delay**
- 3.2.12 **loss ratio range over group**
- 3.2.13 **mean Ethernet frame transfer delay**
- 3.2.14 **mean transfer delay range over group**
- 3.2.15 **median Ethernet frame transfer delay**
- 3.2.16 **minimum Ethernet frame transfer delay**
- 3.2.17 **maximum Ethernet frame transfer delay**
- 3.2.18 **multicast group**: A multicast group is a set of bridges or end points which have been configured to receive frames sent to a given Ethernet multicast address, or which belong to the same VLAN. This set of bridges and their associated egress measurement points provide a key qualification to the point-to-multipoint population of interest.
- 3.2.19 **percent Ethernet service availability**
- 3.2.20 **percent Ethernet service unavailability**
- 3.2.21 **severe errored second**
- 3.2.22 **spurious Ethernet frame rate**

4 Abbreviations and acronyms

This Recommendation uses the following abbreviations and acronyms:

ATM	Asynchronous Transfer Mode
CCM	Continuity Check Message
CE	Customer Edge
DST	Destination customer edge
EL	Exchange Link
EPL	Ethernet Private Line
EPLAN	Ethernet Private Local Area Network
ETY	Ethernet physical layer network
EVC	Ethernet Virtual Connection
EVPL	Ethernet Virtual Private Line
EVPLAN	Ethernet Virtual Private Local Area Network
FCS	Frame Check Sequence
FDV	Frame Delay Variation
FER	Frame Error Ratio
FLR	Frame Loss Ratio
FRE	Frame Reference Event
FTD	Frame Transfer Delay
GFP	Generic Framing Procedure
IFDV	Inter-Frame Delay Variation
IPDV	Internet Protocol Packet Delay Variation
IP	Internet Protocol
IPTV	Internet Protocol Television
LAN	Local Area Network
LOC	Loss of Continuity
MAC	Media Access Control
MEG	Maintenance Entity Group
MEP	Maintenance End Point
MMG	Mismerge (defect)
MP	Measurement Point
MPLS	MultiProtocol Label Switching
NNI	Network-to-Network Interface
NS	Network Section
NSE	Network Section Ensemble
OAM	Operation, Administration and Maintenance
OTN	Optical Transport Network

PDH	Plesiochronous Digital Hierarchy
PE	Provider Edge
PEA	Percent Ethernet service Availability
PEU	Percent Ethernet service Unavailability
$R_{\max}$	Maximum number of successful frames at all destinations in a group, $\max(R_n)$
R_n	Number of successful frames at destination n , with respect to a population of interest
RSTP	Rapid Spanning Tree Protocol
S	the number of frames a Source transmits that constitute the population of interest
SDH	Synchronous Digital Hierarchy
SLS	Service Level Specification
SRC	Source Customer edge
STP	Spanning Tree Protocol
TCP	Transmission Control Protocol
$T_{\max}$	Maximum Ethernet frame delay beyond which the frame is declared to be lost
T_{POI}	Interval of time corresponding to transmission of the Population Of Interest
$T_{R,n}$	Interval corresponding to reception of the population of interest at destination n
UNI	User-to-Network Interface
VID	Virtual local area network Identifier
VLAN	Virtual Local Area Network

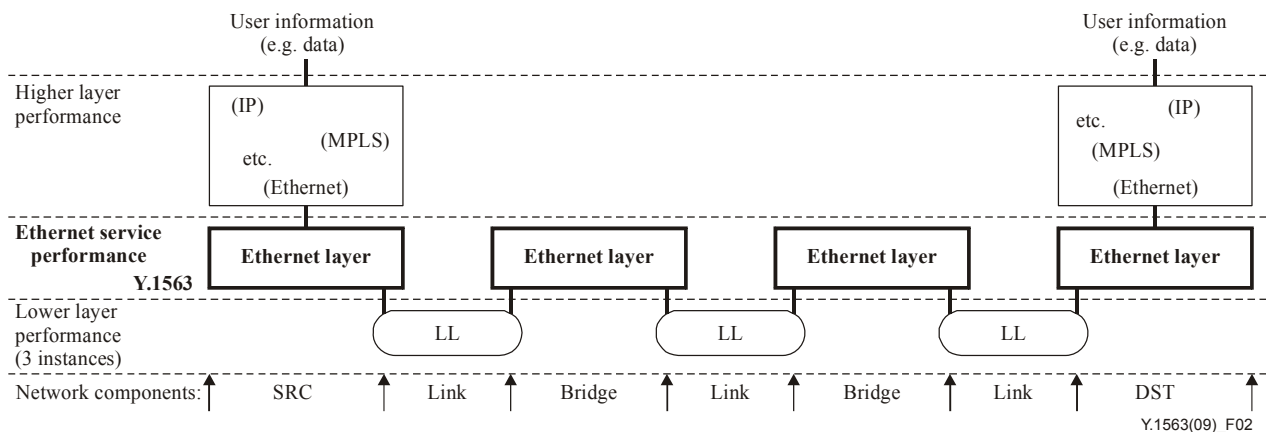
5 Conventions

None.

6 Layered model of performance for Ethernet service

Figure 2 illustrates the layered nature of the performance of Ethernet service. The performance provided to Ethernet service users depends on the performance of other layers:

- Lower layers that provide (via "links") connection-oriented or connectionless transport supporting the Ethernet layer. Links are terminated at points where Ethernet frames are forwarded (i.e., "bridges", "SRC" and "DST") and thus have no end-to-end significance. Links may involve different types of technologies, for example, SDH, OTN, PDH, MPLS, ATM and ETY.
- The Ethernet layer that provides transport of Ethernet frames. The Ethernet layer has end-to-end significance for a given pair of source and destination MAC addresses, possibly within the scope of an Ethernet virtual local area network (VLAN).
- Higher layers, supported by Ethernet, that further enable end-to-end communications. Upper layers may include, for example, IP, MPLS and Ethernet (different networking opportunities using Ethernet in higher layers are described in Appendix IV). The higher layers will modify and may enhance the end-to-end performance compared to that provided at the Ethernet layer (for example, frame loss may result in retransmission and delayed delivery to a higher layer).



Note – The Ethernet layer is not terminated between the SRC and DST.

Figure 2 – Layered model of performance for Ethernet service – Example

7 Ethernet service performance model, reference events and outcomes

This clause defines a generic Ethernet service performance model. The model is primarily composed of two types of sections: the exchange link and the network section. These are defined in clause 7.2. They provide the building blocks with which any end-to-end Ethernet service may be represented. Each of the performance parameters defined in this Recommendation can be applied to the unidirectional transfer of Ethernet frames on a section or a concatenated set of sections.

Clause 7.3 defines the measurement points and measurable sections. Clause 7.4 specifies the set of Ethernet frame transfer reference events that provide the basis for performance parameter definition. These reference events are derived from and are consistent with relevant Ethernet service and protocol definitions. Clause 7.5 then uses those reference events to enumerate the possible outcomes when a frame is delivered into a section. Clause 7.6 defines the populations of interest.

7.1 Network components

The ETH topological components are defined in [ITU-T G.8010].

The following groupings of network components are defined.

7.2 Links and network sections

7.2.1 Exchange link (EL)

The link connecting:

- 1) a source or destination CE to its adjacent PE (e.g., bridge) possibly in another jurisdiction, sometimes referred to as an access link, ingress link or egress link; or
- 2) a bridge in one network section with a bridge in another network section.

Note that the responsibility for an exchange link, its capacity and its performance is typically shared between the connected parties.

7.2.2 Network section (NS)

A set of bridges together with all of their interconnecting links that together provide a part of the Ethernet service between an SRC and a DST, and are under a single (or collaborative) jurisdictional responsibility. Some network sections consist of a single bridge with no interconnecting links. Source NS and destination NS are particular cases of network sections. Pairs of network sections are connected by exchange links.

NOTE – "Network section" is roughly equivalent to the term "transport operator network" as defined in [b-ITU-T G.8011]. It is also possible that a transport operator network contains more than one network section.

Any set of bridges interconnected by links could be considered a network section. However, for the (future) purpose of Ethernet performance allocation, it will be relevant to focus on the set of bridges and links under a single (or collaborative) jurisdictional responsibility. Typically, these bridges belong to the same domain. The destination address, VLAN ID, and the configuration of the Ethernet network (e.g., forwarding rules) dictate the permissible egress port(s) out of this network section (to other NS via exchange links).

7.3 Measurement points and measurable sections

This clause defines the key elements of this Recommendation's performance measurement and specification framework. See Appendix VI for additional information on measurement points and measurable sections in the ITU-T G.8010 architecture.

7.3.1 Measurement point (MP)

A measurement point is the boundary between a bridge and an adjacent link at which performance reference events can be observed and measured.

A section or a combination of sections is measurable if it is bounded by a set of MPs. In this Recommendation, the following sections are measurable.

7.3.2 Basic section

A basic section is either an EL or a NS. Basic sections are delimited by MPs.

The performance of any EL or NS is measurable relative to any given Ethernet service. The *ingress MPs* are the set of MPs crossed by frames from that service as they go into that basic section. The *egress MPs* are the set of MPs crossed by frames from that service as they leave that basic section.

7.3.3 End-to-end Ethernet network

An end-to-end Ethernet network is the set of EL and NS that provide the transport of Ethernet frames transmitted from SRC to DST. The MPs that bind the end-to-end Ethernet network are the MPs at the SRC and the DST.

The end-to-end Ethernet network performance is measurable relative to any given Ethernet service. The *ingress MPs* are the MPs crossed by frames from that service as they go into the end-to-end network at the SRC. The *egress MPs* are the MPs crossed by frames from that service as they leave the end-to-end network at the DST.

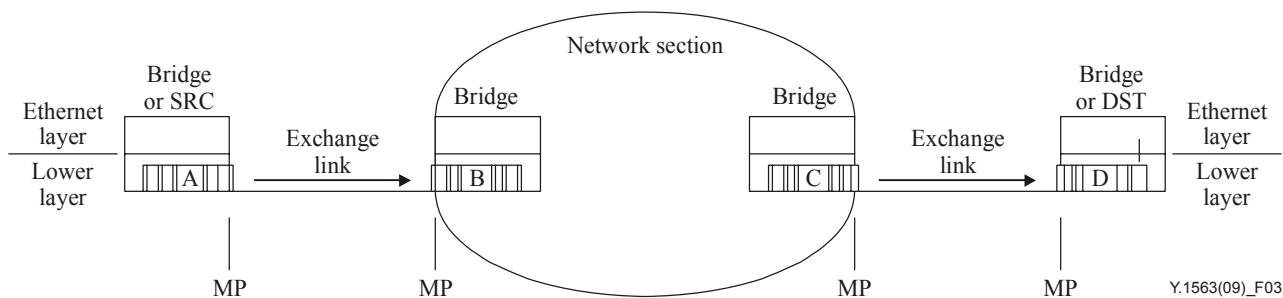
7.3.4 Network section ensemble (NSE)

An NSE refers to any connected subset of NSs together with all of the ELs that interconnect them. The term "NSE" can be used to refer to a single NS, two NSs or any number of NS and their connecting EL. Pairs of distinct NSEs are connected by exchange links. The term "NSE" can also be used to represent the entire end-to-end Ethernet network. NSEs are delimited by MPs.

The performance of any given NSE is measurable relative to any given unidirectional end-to-end Ethernet service. The *ingress MPs* are the set of MPs crossed by frames from that service as they go into that NSE. The *egress MPs* are the set of MPs crossed by frames from that service as they leave that NSE.

7.4 Ethernet frame transfer reference events (FREs)

In the context of this Recommendation, the following definitions apply on a specified point-to-point Ethernet connection or point-to-multipoint Ethernet connection. The defined terms are illustrated in Figure 3.



NOTE 1 – Ethernet exit events for frames A and C.
 NOTE 2 – Ethernet entry events for frames B and D.

Figure 3 – Example Ethernet frame transfer reference events

An Ethernet frame transfer event occurs when:

- an Ethernet frame crosses a measurement point (MP); and
- standard Ethernet procedures applied to the frame verify that the FCS is valid; and
- the source and destination address fields within the Ethernet frame header contain the expected MAC addresses.

Four types of Ethernet frame transfer events are defined below.

7.4.1 Ethernet frame entry event into a CE

An Ethernet frame transfer entry event into a bridge occurs when an Ethernet frame crosses an MP entering a bridge (PE or DST) from the attached EL.

7.4.2 Ethernet frame exit event from a CE

An Ethernet frame transfer exit event from a bridge occurs when an Ethernet frame crosses an MP exiting a bridge (PE or SRC) into the attached EL.

7.4.3 Ethernet frame ingress event into a basic section or NSE

An Ethernet frame transfer ingress into a basic section event occurs when an Ethernet frame crosses an ingress MP into a basic section.

7.4.4 Ethernet frame egress event from a basic section or NSE

An Ethernet frame transfer egress event from a basic section occurs when an Ethernet frame crosses an egress MP out of a basic section.

NOTE 1 – Ethernet frame entry and exit events always represent, respectively, entry into and exit from an end station. Ethernet frame ingress events and egress events always represent ingress into and egress from a section or an NSE. To illustrate this point, note that an ingress into an EL creates an exit event from the preceding bridge, while an ingress into an NS is an entry event because, by definition, NSs always have end stations at their edges.

NOTE 2 – For practical measurement purposes, Ethernet frame transfer reference events need not be observed within the MAC layer of the end station. Instead, the time of occurrence of these reference events can be approximated by observing the Ethernet frames crossing an associated physical interface. This physical interface should, however, be as near as possible to the desired MP. In cases where reference events are monitored at a physical interface, the time of occurrence of an exit event from an end station is approximated by the observation of the first bit of the Ethernet frame coming from the end station or test equipment. The time of occurrence of an entry event into an end station is approximated by the observation of the last bit of the Ethernet frame going to the end station or test equipment.