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SERIES Y: GLOBAL INFORMATION INFRASTRUCTURE, INTERNET PROTOCOL ASPECTS AND NEXT-GENERATION NETWORKS, INTERNET OF THINGS AND SMART CITIES

Internet protocol aspects – Quality of service and network performance

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Ethernet service activation test methodology

Recommendation ITU-T Y.1564

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Recommendation ITU-T Y.1564

Ethernet service activation test methodology

Summary

Recommendation ITU-T Y.1564 defines a test methodology that may be used in assessing the proper configuration and performance of an Ethernet network to deliver Ethernet-based services. This out-of-service test methodology was created so that service providers may have a standard way of measuring the performance of Ethernet-based services.

History

Edition	Recommendation	Approval	Study Group	Unique ID*
1.0	ITU-T Y.1564	2011-03-01	12	11.1002/1000/11080
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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.

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As of the date of approval of this Recommendation, ITU had not received notice of intellectual property, protected by patents, which may be required to implement this Recommendation. However, implementers are cautioned that this may not represent the latest information and are therefore strongly urged to consult the TSB patent database at http://www.itu.int/ITU-T/ipr/.

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Introduction

Ethernet services have evolved significantly with the deployment of Ethernet in service providers' networks. Not only is Ethernet found at the user network interface (UNI), it can be deployed anywhere in the network. With the capability to prioritize traffic, its built-in resiliency and high availability, service providers are now using this technology to deliver advanced services. Unfortunately, there are currently no standardized test methodologies that can deliver to the expectation of measuring performance parameters as specified in [ITU-T Y.1563].

Prior to this Recommendation, the only methodology widely used to assess performance of Ethernet-based network service was IETF's "Benchmarking Methodology for Network Interconnect Devices", also known as IETF RFC 2544. [b-IETF RFC 2544] was created to evaluate the performance characteristics of network devices in the lab. It was widely adapted to provide performance metrics of Ethernet-based network services as there was no other methodology available to measure the quantities defined in [b-IETF RFC 1242].

With its capability to measure throughput, latency, frame loss (FL), and burstability (back-to-back test), [b-IETF RFC 2544] could arguably be used to provide performance metrics. However, to do so [b-IETF RFC 2544] would have to be used beyond its intended scope.

This Recommendation fills the methodological gap for measurement of operational Ethernet network services. Also, Ethernet-based services have evolved to include more features and complexities than those covered by the [b-IETF RFC 2544] scope. The [b-IETF RFC 2544] benchmarking methodology is not applicable to Ethernet service activation because:

- [b-IETF RFC 2544] does not consider multiple time durations for tests, as are often performed in operational networks with time-varying impairments. Its procedures find the absolute performance limit of a network element in a laboratory environment rather than verify that a service is delivered to the agreed level.
- Latency is measured in a limited way, on only one frame every two minutes, and only at maximum transmitted load with no loss rate, which is very likely much higher than the agreed upon committed information rate (CIR).
- It does not provide for the verification of configuration and performance of CIR, committed burst size (CBS), excess information rate (EIR), excess burst size (EBS) and colour mode (CM), all important components of the bandwidth profile.
- Finally, important Ethernet service attributes, such as frame delay variation (FDV), are not part of the methodology.

Recommendation ITU-T Y.1564

Ethernet service activation test methodology

1 Scope

This Recommendation defines an out-of-service test methodology to assess the proper configuration and performance of an Ethernet service prior to customer notification and delivery. The test methodology applies to point-to-point and point-to-multipoint connectivity (using a pair-wise configuration) in the Ethernet layer, and to the network portions that provide or contribute to the provisioning of such services. This Recommendation does not define Ethernet network architectures or services, but defines a methodology to test Ethernet-based services at the service activation stage. In particular, it addresses testing outside of the scope of [b-IETF RFC 2544] methods, as listed in the introduction above.

This Recommendation assumes dedicated test equipment in the test methodology. It is understood that this test methodology may be implemented as a test function inside of a network element.

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.8010] Recommendation ITU-T G.8010/Y.1306 (2004), *Architecture of Ethernet layer networks.*

[ITU-T G.8011] Recommendation ITU-T G.8011/Y.1307 (2015), *Ethernet service characteristics*.

[ITU-T G.8011.1] Recommendation ITU-T G.8011.1/Y.1307.1 (2013), *Ethernet private line service*.

[ITU-T G.8011.2] Recommendation ITU-T G.8011.2/Y.1307.2 (2013), *Ethernet virtual private line service*.

[ITU-T G.8012] Recommendation ITU-T G.8012/Y.1308 (2004), *Ethernet UNI and Ethernet NNI.*

[ITU-T M.2110] Recommendation ITU-T M.2110 (2002), *Bringing into service international multi-operator paths, sections and transmission systems*.

[ITU-T Y.1543] Recommendation ITU-T Y.1543 (2007), *Measurements in IP networks for inter-domain performance assessment*.

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

[ITU-T Y.1730] Recommendation ITU-T Y.1730 (2004), *Requirements for OAM functions in Ethernet-based networks and Ethernet services*.

[ITU-T Y.1731] Recommendation ITU-T Y.1731 (2008), *OAM functions and mechanisms for Ethernet based networks.*

[IEEE 802.1Q] IEEE 802.1Q-2003, *IEEE Standards for Local and Metropolitan Area Networks – Virtual Bridged Local Area Networks.*

[MEF 10.2] Technical Specification MEF 10.2 (2009), *Ethernet Services Attributes, phase 2*.

3 Definitions

3.1 Terms defined elsewhere

None.

3.2 Terms defined in this Recommendation

This Recommendation defines the following terms:

3.2.1 Ethernet virtual connection (EVC) (derived from [MEF 10.2]: An association of two or more user network interfaces (UNIs) that limits the exchange of service frames between these interfaces.

3.2.2 information rate: The average bit rate of Ethernet service frames at the measurement point (MP) starting with the first medium access control (MAC) address bit and ending with the last frame check sequence (FCS) bit.

NOTE – Refer to [MEF 10.2] for a clear discussion of Ethernet service frames and specific examples of information rate –the committed information rate (CIR) and the excess information rate (EIR). So, for instance, a 100 Mbit/s Ethernet port can handle a total information rate of about 77 Mbit/s to 99 Mbit/s depending on the average frame size of the transmitted Ethernet frames.

3.2.3 service activation: The step of bringing a network feature into operation for eventual use by a customer, prior to customer notification that the feature is ready to use.

3.2.4 service activation test methodology: The procedures performed after service activation in order to verify that a newly operational network feature to be used by a customer is working properly prior to customer notification that the feature is ready to be used.

3.2.5 service acceptance criteria: A set of criteria used to ensure that a service meets its functionality and quality requirement and that the service is ready to operate when it has been deployed.

3.2.6 test flow: A protocol-compliant frame-size pattern used to simulate a stream of service frames and provide the basis for measurements and test results. Each unique test flow shall be categorized by its source and destination address and other header information, such as quality of service (QoS)/class of service (CoS) at the Ethernet layer (all eight [IEEE 802.1Q] priorities) and optionally the IP layer. Protocol layer configurations above IP layer may be used as part of the flow configuration because the network under test might require these layers to transmit data between source (SRC) and destination (DST).

3.2.7 utilized line rate: The average bit rate of the Ethernet line at the measurement point, including the bits a) allocable to the minimum-duration period of each interframe gap (but not the number of bits allocable to the part of each interframe gap longer than the minimum duration), b) in the preamble, c) in the start of frame delimiter and d) in the Ethernet service frame starting with the first MAC address bit and ending with the last FCS bit.

NOTE – This rate is calculated before the expansion effect of using code substitution at the physical layer. So for instance, a 1 Gbit/s Ethernet port has a 1 Gbit/s maximum Utilized Line Rate even though the 8/10 bit code substitution runs the actual physical interface at 1.25 Gbit/s.

4 Abbreviations and acronyms

This Recommendation uses the following abbreviations and acronyms:

ATM Asynchronous Transfer Mode

AVAIL Availability

CBS Committed Burst Size

CE Customer Edge

CF Coupling Flag

CIR Committed Information Rate

CM Colour Mode

CoS Class of Service

DST Destination CE

EBS Excess Burst Size

EIR Excess Information Rate

EL Exchange Link

EMIX Ethernet Mix

ETY Ethernet physical layer network

EVC Ethernet Virtual Connection

FCS Frame Check Sequence

FDV Frame Delay Variation

FL Frame Loss

FLR Frame Loss Ratio

FRE Frame Reference Event

FTD Frame Transfer Delay

GPS Global Positioning System

IMIX Internet Mix

IP Internet Protocol

IR Information Rate

LACP Link Aggregation Control Protocol

LAN Local Area Network

MAC Medium Access Control

MP Measurement Point

MPLS Multi-Protocol Label Switching

MTU Maximum Transmission Unit

NID Network Interface Device

NS Network Section

NSE Network Section Ensemble

OAM Operation, Administration and Maintenance

OTN	Optical Transport Network
PDH	Plesiochronous Digital Hierarchy
PE	Provider Edge
QoS	Quality of Service
SAC	Service Acceptance Criteria
SDH	Synchronous Digital Hierarchy
SLA	Service Level Agreement
SRC	Source CE
TCP	Transmission Control Protocol
ToD	Time of Day
UDP	User Datagram Protocol
ULR	Utilized Line Rate
UNI	User Network Interface
UNI-C	UNI – Customer
UNI-N	UNI – Network
VLAN	Virtual LAN

5 Conventions

This Recommendation uses the following terms to indicate requirement levels:

- MUST, SHALL, or REQUIRED means that the specification is a mandatory requirement for test functions that claim compliance with this Recommendation.
- SHOULD means that there may exist valid reasons to avoid this specification, but the reasons need to be fully understood otherwise this is a strong suggestion for test functions that claim compliance with this Recommendation.
- MAY means that the specification is truly optional and need not be implemented in test functions that claim compliance with this Recommendation.

6 Background on Ethernet network architecture and service attributes

This Recommendation does not define Ethernet network architectures or services, but defines a methodology to test Ethernet-based services at the service activation stage. To provide some background to the user, an overview of Ethernet network architecture and related service attributes will be covered in this clause.

As the methodology relates to the performance model defined in [ITU-T Y.1563], the network architecture it defines is used. From a service attributes perspective (i.e., CIR, EIR, etc.), there is no reference to any service attributes in [ITU-T Y.1563], therefore the ones presented in the ITU-T G.8011/Y.1307 family of Recommendations will be used.

6.1 Ethernet network architecture

As illustrated in Figure 1, based on Figure 2 of [ITU-T Y.1563], Ethernet services are delivered through a layered architecture. User information will be transported over a higher layer (usually IP), that will then be encapsulated in an Ethernet layer to be finally transmitted across a network to a destination. To provide an end-to-end transfer of user information, the higher layer at the source customer edge (CE) will use the Ethernet layer to access the network. The Ethernet layer has end-to-end significance only for a pair of source and destination MAC addresses.

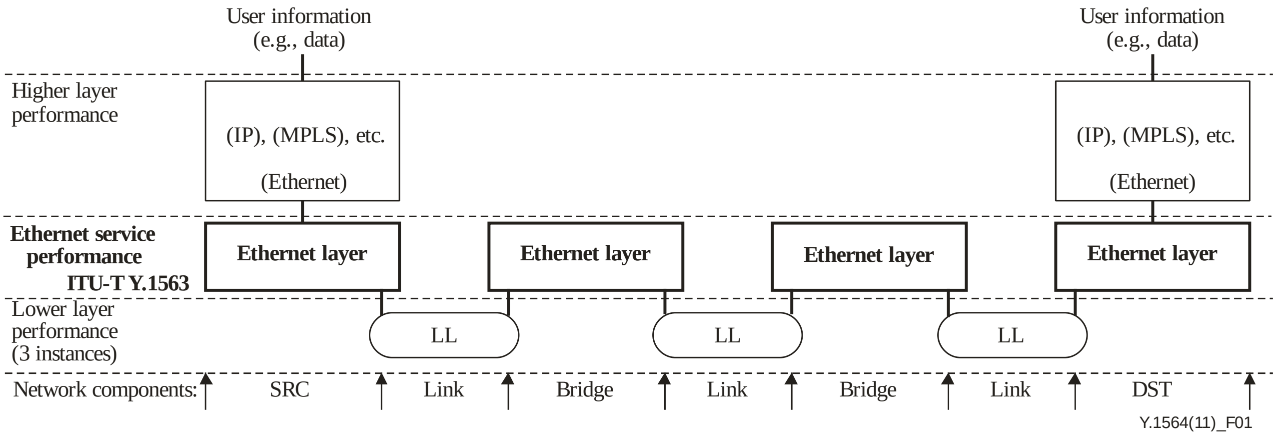


Figure 1 – Layered model of performance for Ethernet service – Example

This network is comprised of connection-oriented or connectionless links that are connected to bridges that will process the Ethernet layer inside the network. Each time an Ethernet frame goes through an Ethernet layer, it will be processed for integrity and sent to the next bridge through a lower layer connection. Lower layers are based on multiple technologies, for example, synchronous digital hierarchy (SDH), optical transport network (OTN), plesiochronous digital hierarchy (PDH), multi-protocol label switching (MPLS), asynchronous transfer mode (ATM) and Ethernet physical layer network (ETY). The performance of all Ethernet layers and lower layers will impact the end-to-end performance of the network used to deliver services.

Higher layers may be used to enable end-to-end communications. Higher layers may include protocols like internet protocol (IP) that allow a greater scalability for network deployment. Other protocols, like transmission control protocol TCP, provide the capability to retransmit frames should a frame loss occur. Unfortunately, two of the drawbacks of TCP are (1) added delay in the transmission of user information and (2) the possible limitation of throughput due to the interactions of maximum advertised window size, bandwidth-delay product, frame loss and frame transfer delay. As this Recommendation covers a test methodology to be used in the activation of Ethernet-based services, the performance and interoperation details with other protocols, such as link aggregation control protocol (LACP), IP, TCP and user datagram protocol (UDP) are out of scope for this Recommendation.

6.2 Ethernet service attributes

As mentioned in the introduction, Ethernet services attributes are not defined in [ITU-T Y.1563]. Therefore, this clause summarizes the important concepts found in the ITU-T G.8011/Y.1307 family of Recommendations.

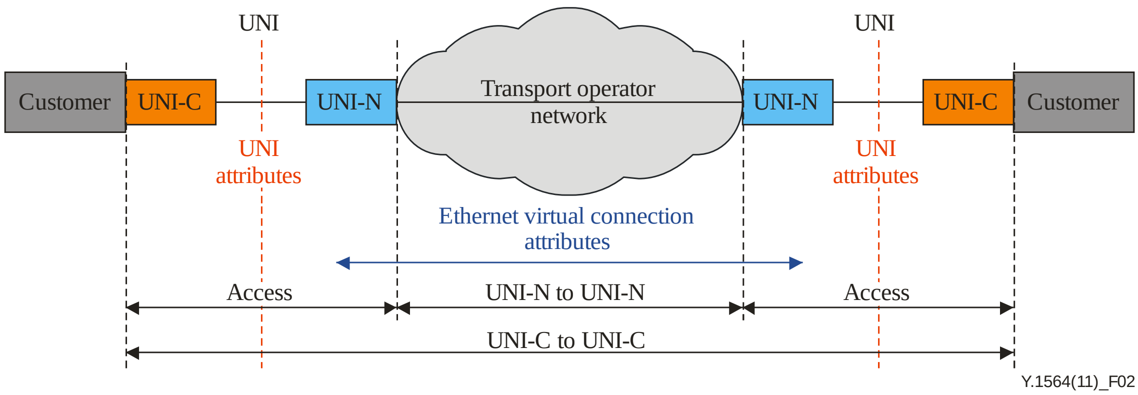


Figure 2 – Single provider view of Ethernet service areas

A simple example of Ethernet service areas is presented in Figure 2. This network, partly reproduced from [ITU-T G.8011], shows the different portions of a network that support an Ethernet service instance.

It is further shown that the user network interface (UNI) demarcation point occurs in the middle of the access link, or more precisely that the UNI is a reference point which splits the UNI-related functionalities into customer (UNI-C) and network (UNI-N) components. Additional UNI details are defined in [ITU-T G.8012]. From a service provider's perspective, they need to deliver services from UNI-C to UNI-C and it is from this perspective that the test methodology was created.

The customer's Ethernet network contains the last piece of equipment that connects to the operator's network. This last piece of equipment is called the customer edge). The port on the CE that connects to the operator's network across the UNI is called the UNI-C. Likewise, the operator's port that is presented to the customer at the UNI is called the UNI-N. The CE and the operator's network exchange service frames across the UNI, between the UNI-C and UNI-N. A service frame is an Ethernet frame transmitted across the UNI toward the service provider (called ingress service frame) or an Ethernet frame transmitted across the UNI towards the CE (called an egress service frame). Many services run on each UNI that are qualified by their attributes, which include, among others (e.g., see [MEF 10.2]):

- connection type;
- QoS (including virtual local area network (VLAN) information), traffic type (data vs management), etc.;
- bandwidth profile: CIR, CBS, EIR, EBS, CF and CM;
- performance criteria: FTD, FDV, FLR, AVAIL, etc.

6.2.1 Bandwidth profile

As per clause 7.10 of [ITU-T G.8011], bandwidth profile is applicable per service instance and is applicable at the ingress and egress UNI. It defines an upper bound on the volume of the expected service frames belonging to a particular service instance.

Bandwidth profile defines the following four traffic parameters: committed information rate (CIR), committed burst size (CBS, excess information rate (EIR) and excess burst size (EBS). CIR and CBS are related in such a way that CBS must be defined when CIR is set at a value that is greater than zero. EIR and EBS are related in the same way as CIR and CBS.

The CIR can be interpreted as the maximum sustained information rate (IR) the network is committed to transfer while meeting the performance level guaranteed in the service level agreement (SLA). Performance metrics in terms of FTD, FDV and FLR are applicable only to those frames that are transmitted at or below the CIR.

CBS is the number of allocated bytes available for bursts of ingress service frames transmitted at temporary rates above the CIR while meeting the SLA guarantees provided at the CIR.

EIR can be interpreted as the maximum sustained IR by which a user can exceed its CIR with some expectation that the excess traffic might be carried though the network.

EBS is the number of allocated bytes available for bursts of ingress service frames sent at temporary rates above the CIR+EIR while remaining EIR-conformant. Performance metrics in terms of FTD, FDV and FLR are not applicable to the frames that are transmitted at rates above the CIR but within the service EIR.

The bandwidth profile traffic parameters are enforced using a metering algorithm as part of the traffic conditioning. Two additional parameters relevant to the operation of the metering algorithms are introduced. Those parameters are the coupling flag (CF) and the colour mode (CM). CF and CM are referred to as bandwidth profile parameters. They allow for a choice between the different modes of operation for the metering algorithm. CF and CM take the values 0 or 1 only. More information can be found in section 7.11 of [MEF 10.2] on bandwidth profiles.

Ingress service frames are processed based on their conformance to CIR/CBS/EIR/EBS. Higher discard precedence is assigned to frames that are conformant to EIR (i.e., yellow coloured frames) than that assigned to frames that are conformant to CIR (i.e., green coloured frames). Yellow frames are expected to be dropped first when congestion is encountered at the service layer. Frames that are non-conformant to either CIR or EIR (i.e., red frames) are dropped at the interface. Traffic policing is a term which describes the process of dropping the red frames at the interface. Figure 3 illustrates the relation between CIR, EIR and colour coding of the traffic.

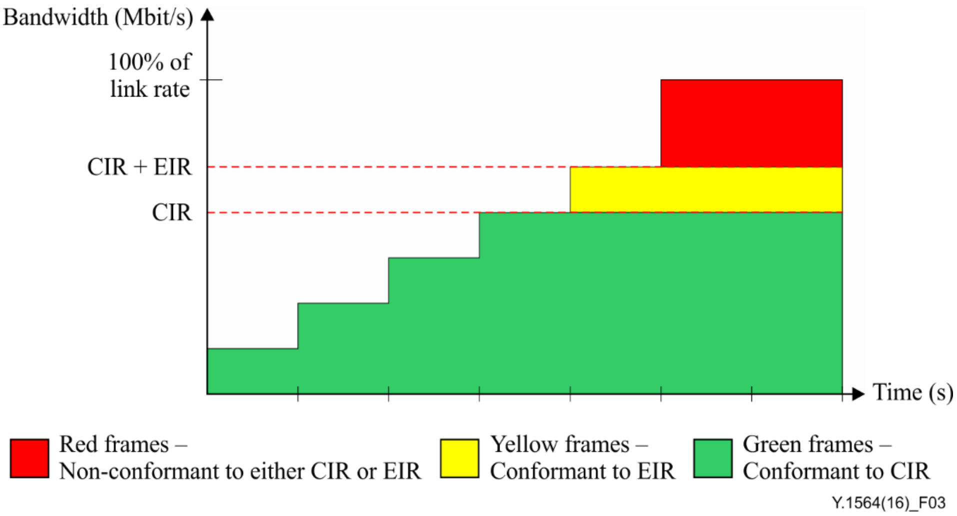
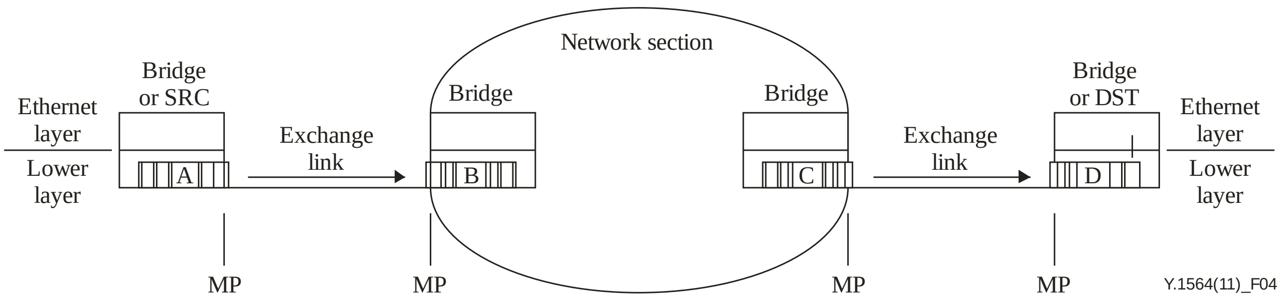


Figure 3 – Bandwidth profile

7 Test architecture and considerations

This clause summarizes the different network components and references used in the definition of the performance parameters given in clause 7 of [ITU-T Y.1563]. The reference model illustrated in Figure 4, based on Figure 3 of [ITU-T Y.1563], is composed of two types of sections: the exchange link (EL) and the network section (NS). They provide the building blocks with which any end-to-end Ethernet service may be represented. Each of the performance parameters defined in [ITU-T Y.1563] can be applied to the unidirectional transfer of Ethernet frames in a section or a concatenated set of sections.

From a test methodology perspective, the important points to cover in more detail are the measurement points and the measurable sections.



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

Figure 4 – Example Ethernet frame transfer reference events

7.1 Measurement points and measurable sections

This clause describes the key elements of this Recommendation's performance measurement and specification framework. See Appendix VI of [ITU-T Y.1563] for additional information on measurement points and measurable sections in the ITU-T G.8010/Y.1306 architecture, including a mapping between the different terms used in the Recommendations.

7.1.1 Measurement point (MP)

A measurement point is the boundary between a bridge and an adjacent exchange 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.

7.1.2 Basic section

A basic section is either an exchange link (EL) or a network section (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.

7.1.3 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 bound 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 towards the DST.

7.1.4 Network section ensemble (NSE)

A network section ensemble (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 NSs 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 MP.

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.

7.2 Ethernet frame transfer reference events (FRE)

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 4.

An Ethernet frame transfer reference 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 reference events are defined:

7.2.1 Ethernet frame entry event into an end station

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

7.2.2 Ethernet frame exit event from an end station

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

7.2.3 Ethernet frame ingress event into a basic section or NSE

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

7.2.4 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 (bridge, SRC or DST). 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 event into an EL follows from an exit event from the preceding bridge, while an ingress event into an NS is an entry event because, by definition, NSs always have end stations (bridge, SRC or DST) 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.

7.2.5 In-order and reordered Ethernet frame outcomes

The definition of these Ethernet frame outcomes requires some background discussion. In-order frame delivery is a property of successful frame transfer attempts, where the sending frame order is preserved on arrival at the destination (or measurement point). Arrival order is determined by the position relative to other frames of interest, though the extent to which a given frame has been reordered may be quantified in the units of position, time and payload byte distances.

A reordered frame performance parameter is relevant for most applications, especially when assessing network support for real-time media streams, owing to their finite ability to restore order or the performance implications of a lack of that capability. Frames usually contain some unique identifier applied at the SRC, sometimes assumed to be a sequence number, so this number or other information (such as time stamps from the MP0) is the reference for the original order at the source. The evaluation of arrival order also requires the ability to determine which specific frame is the "next expected" frame, and this is greatly simplified with sequence numbers that are consecutive increasing integers.

Assuming that sequence numbers are used for order verification, an in-order frame outcome occurs when a single Ethernet frame reference event at a permissible egress measurement point results in the following:

– The frame has a sequence number greater than or equal to the next expected frame value. After this sequence number comparison is complete, the next expected value is increased to the next number higher than the number in the just-received frame.

Assuming sequence numbers are used for order verification, a reordered or out-of-order frame outcome occurs when a single Ethernet frame reference event at a permissible egress measurement point results in the following:

– The frame has a sequence number lower than the next expected frame value, and therefore the frame is reordered. The next expected value does not change after this sequence number comparison.

Reordered and out-of-order frames outcome are an optional measurement in this Recommendation.

7.3 Test architecture considerations

This Recommendation explicitly uses the terms "test equipment" or "test instrument" in the test methodology. It is understood that this test methodology MAY be implemented as a test function inside a network element.

Compliant implementations of this methodology perform tests between two test instruments connected at different MPs in the network. When measuring an EVC as depicted in Figure 2, the test instruments will be connected to the service at the UNI, which represent the MPs. As per [ITU-T Y.1563], these performance measurements are performed in a one-way fashion, which means that performance parameters are measured separately in each direction.

There are unfortunately occasions when a dedicated testing resource is not available at one MP. For example, the remote location equipment (DST) might not have all the test functionality found in a test instrument. Some network elements found at the UNI will have the capability to loopback traffic to a test instrument. As these network elements only have a logical loopback function, they cannot be used in a one-way test.

When the ideal MPs described above cannot be accessed, or cannot be accessed without disrupting service, then alternative measurement connectivity MAY be permissible as long as the users understand and take steps to limit and quantify the measurement error.

One alternative measurement connection is to use a port loopback at one measurement point and make all measurements in a round-trip connection performed by a single test instrument. There are significant issues and limitations inherent to loopback connectivity, including:

• The network device performing the loopback may dominate the performance levels measured. Overload testing on shared devices can affect the performance of other services.

• Unless symmetrical link speeds, traffic profile, QoS configuration, and frame routing are present throughout the measured path, measurement errors can occur in any of the performance parameters.

- It is unreliable and likely inaccurate to perform tests of excess traffic or bursts and attempt to infer results for the return-from-loopback direction.

Where the precision of a one-way test is not needed, a logical loopback device can be used at one end in combination with test equipment at the other end to provide a round-trip measurement of service performance.

When the test instrument at the DST is replaced by a loopback function in a network device, then only round-trip service acceptance criteria may be measured. Loopback measurements are primarily intended for limited accuracy tests and for the convenience of maintenance forces, and cannot be used to strictly validate SLA performance metrics, especially one-way metrics.

When a round-trip measurement is made by two test instruments to assess the performance parameters and avoid clock synchronization requirements, some are not believed to be meaningful. Performance parameters such as round-trip FTD or FLR have some use when the round-trip path is symmetrical with regard to delay and the loss is zero. Also, round-trip acceptance thresholds are needed in addition to one-way thresholds. But items such as FDV and EIR are more problematic as the test flow traverses the network twice and could be disproportionately affected by the performance of the instrument providing the test loopback function or by network congestion in one direction. FDV and EIR results for round-trip measurement could be studied further, but their usefulness is questionable at this time.

Note that the network topology terminology of Figure 2 differs greatly from that of Figure 4. For the purposes of this Recommendation, the associated UNIs at each end of the circuit shown in Figure 2 are the two measurement points to be used to characterize end-to-end performance of the service as suggested in Figure 4 and this clause.

7.4 Required test equipment capabilities

As part of the methodology, test flows must be configured to simulate user data encapsulated into the different network layers so the traffic can be transported by the Ethernet network according to the provisioned service attributes. The service may be provisioned to be port based, in which case all flows from the UNI will be associated with a single bandwidth profile. Alternatively, the service bandwidth profile may be provisioned to be attached to an individual VLAN at the UNI, with the possibility of more than one VLAN having more than one bandwidth profile. Finally, bandwidth profiles may be attached to individual CoS flows within a given VLAN. Referring to Figure 2, a test instrument located at the UNI-N transmitting frames into the network section ensemble acts as the SRC, and another test instrument located at the UNI-N on the other side of the network section ensemble acts as the DST. Each service acceptance test requires testing to be configured in one or more simultaneous test flows, which will be measured as an appropriate aggregate of test flows for the service configuration test. Each test flow MUST have the capability to be configured for QoS/CoS at the Ethernet layer (all eight [IEEE 802.1Q] priorities) and MAY be configured at the IP layer. Protocol layer configurations above the IP layer MAY be used as part of the flow configuration because the network under test might require these layers to transmit data between SRC and DST.

Another capability required for one-way measurement is time of day (ToD) synchronization. One-way measurements SHOULD use synchronization to align their measurement clocks. Without a stable ToD reference (usually global positioning system (GPS)) based), a test instrument cannot accurately measure one-way FTD from SRC to DST with sub-millisecond accuracy. Therefore, round-trip FTD MAY be used as a service acceptance criteria. When the local clock has sufficiently stable frequency and long term-accuracy characteristics over the test interval, one-way FDV and FLR performance MAY be performed in accordance to the definition in [ITU-T Y.1543], where clock synchronization is discussed in clause 6.6.

Additional discussion of clock synchronization may be found in clause 8.2 of [ITU-T Y.1731]. With good stability, users may find the quality of one-way measurements acceptable, despite using temporarily non-synchronized clocks.

8 Ethernet service activation test methodology

The goal of this test methodology is to validate the Ethernet frame transfer performance parameters as defined in [ITU-T Y.1563]. The methodology has two main objectives, the first one is to validate that each Ethernet-based service is correctly configured and the second is to validate the quality of the services as delivered to the end user. Therefore the methodology presented in this Recommendation is a two-phased approach as demonstrated in Figure 5: a service configuration test and a service performance test.

The service configuration test verifies each defined Ethernet service to make sure that the configuration is correct. Each of the important parameters (IR, FTD, FDV and FLR) MUST be tested. This test is very short in length, at the judgment of the person performing the test, and is designed to prevent wasted time caused by failed service performance tests.

The service performance test is conducted to validate the quality of the Ethernet services over a medium to long time duration. The time duration is discussed in clause 8.2.1.

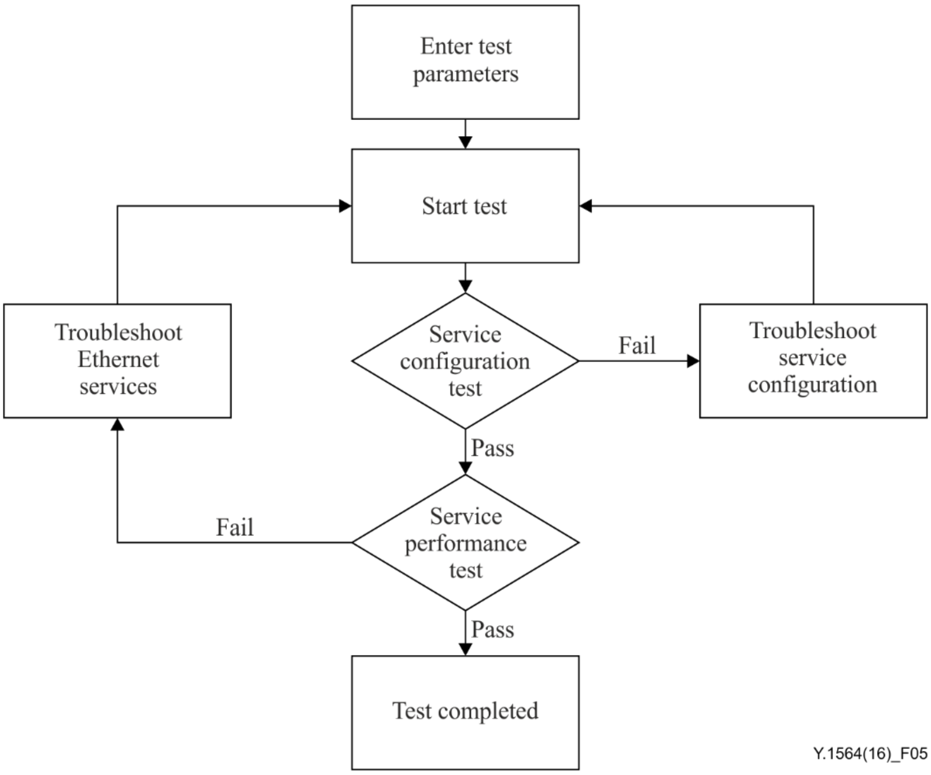


Figure 5 – High-level service activation test methodology

8.1 Service configuration test

The goal of the service configuration test is to validate that the services are configured as intended. Each service MUST be tested individually. For each service, a step load test MAY be used to gradually reach and exceed the CIR. An example of a step load is demonstrated in Figure 6. For each step up to the CIR, the IR, FTD, FDV and FLR MUST be measured simultaneously. As the performance limits are only used for service acceptance when Ethernet traffic is below or equal to the CIR (green traffic), the performance parameters will not be judged against the limits above the CIR.

The next step of the service configuration test is to validate the total information rate of the service. By varying the offered load and observing the FLR, it will be possible to determine the total information rate of the service.

After the EIR and traffic policing tests are performed, an optional burst size configuration test MAY be executed. An example of a CBS and EBS configuration test is illustrated in Appendix I. A normative methodology is for further study.

The burst configuration is verified first for the CBS, and then for the CBS and EBS together.

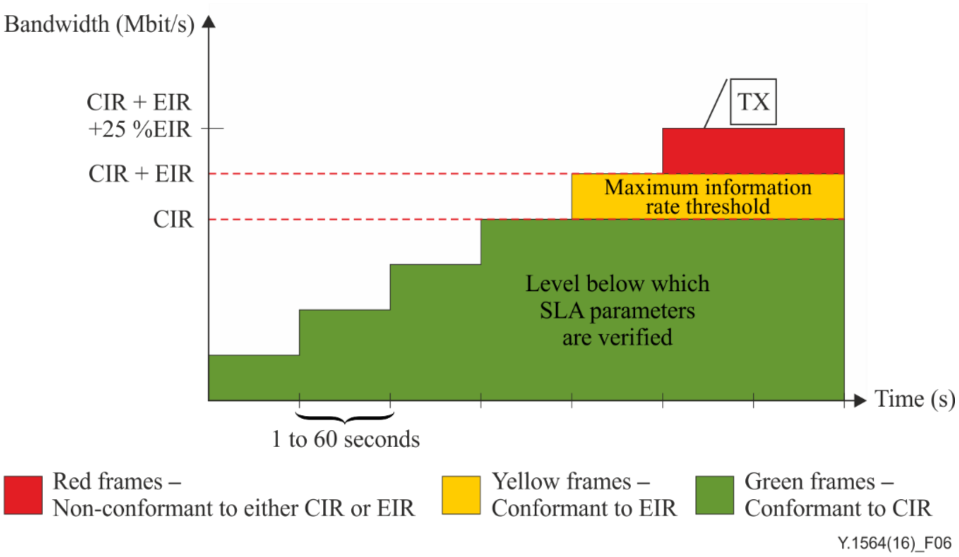


Figure 6 – Step-load test used in the service configuration test

NOTE 1 – The step load demonstrated in Figure 6 represents the transmission rate as would be seen at the output of the test instrument (denoted by the TX in the figure).

The test instruments SHOULD have the possibility of configuring the CIR, CBS, EIR, EBS, step size and step duration for each service (test flow). The duration for each step size SHOULD be configurable from at least 1 second up to 60 seconds. All equipment claiming compliance with this Recommendation MUST provide the default values as per clause 8.3.

NOTE 2 – Caution should be exercised when configuring the test time for the service configuration test to make sure the traffic police has enough time to be exercised. Low information rate combined with high burst sizes require more time for the traffic policing to take effect. Guidance on test time is for further study.

8.1.1 Service configuration test and service performance test frame size

The frame size used for the service configuration test and service performance test can be constant or a distribution of multiple frame sizes.

Each size (in octets) is shown with a size designator in Table 1.

Table 1 – Ethernet frame sizes and size designations

a	b	c	d	e	f	g	h	u
64	128	256	512	1024	1280	1518	MTU	User defined

The default frame size for the service configuration and service performance test is 512 octets. This size refers to the total size in octets including the header and trailer of the frame. C-tags and S-tags, if present, will augment the frame size of the Ethernet frame. When C-tags and S-tags are used, the value of g in Table 1 will need to grow to 1522 (for 1 tag) and 1526 (for 2 tags). User-defined Ethernet frame sizes MAY be used for testing.

Variable frame size patterns are permitted, using a set of frame sizes or a randomly chosen set of frame sizes, but the pattern must be a repeating sequence of sizes. These variable-size patterns are referred to as Ethernet mix (EMIX) (similar to the familiar name applied to the variable size patterns assigned in IP-layer testing by different vendors, Internet mix (IMIX); however, there is no standardized variable pattern referred to by the term IMIX.

EMIX patterns shall be specified by the size designator for each frame in the repeating pattern from Table 1. For example, a five-frame repeating pattern can be specified as follows:

EMIX – ggeaa = 1518, 1518, 1024, 64, 64

The default pattern SHOULD be the sequence of sizes:

EMIX – abceg

8.1.2 Service configuration test procedure

The following steps provide the test procedure for verifying proper network configuration before proceeding to the service performance test. Each of these tests MUST be run separately for each service to be activated between two or more UNIs and the corresponding measurement points.

Utilized line rate and information rate MAY be used to define and report bandwidth profiles test parameters, results or information in accordance with this Recommendation. To simplify this Recommendation, only information rate will be used in the procedure that follows.

Here is a high level summary of the paragraphs to follow in this clause. Only one procedure SHOULD be used from each of the five capitalized-letter subclauses below.

A. CIR configuration test, colour aware and non-colour aware:
   - A.1 Simple CIR validation (mandatory to implement, optional to perform).
   - A.2 Step load CIR test (mandatory to implement, optional to perform).

B. EIR configuration test:
   - B.1 Colour aware (mandatory to implement, optional to perform).
   - B.2 Non-colour aware (mandatory to implement, optional to perform).

C. Traffic policing test:
   - C.1 Colour aware (mandatory to implement, optional to perform).
   - C.2 Non-colour aware (mandatory to implement, optional to perform).

D. CBS configuration test, colour aware and non-colour aware (optional test to implement).

E. EBS configuration test (optional test to implement):
   - E.1 Colour aware and non-colour aware, CIR = 0.
   - E.2 Colour aware, CIR > 0.
   - E.3 Non-colour aware, CIR > 0.

A) CIR configuration test – Colour aware and non-colour aware

A.1) Simple CIR validation test

1. Configure test function CIR as target offered load rate, EIR, test duration, and frame size/pattern.
2. Transmit at the CIR. Frames SHOULD be transmitted at constant intervals, e.g., without burstiness or interval variation. If interval variation is present, it should be proportional to the size variation in the EMIX. Frames MAY be transmitted in units of IR bits per second, although transmission rate measured in utilized line rate (ULR) bits per second is also acceptable.
3. Measure the received IR, FLR, FTD and FDV. FLR_{SAC} is the frame loss ratio limit as specified in the SAC.

4. If the performance parameters are not within SAC limits, the user SHOULD troubleshoot the problem. Investigate the issues, determine the possible configuration error and correct the problem if necessary. Repeat the service configuration test from Step 2, or perform the step load CIR test (A.2).

If the FLR (including errored frames), FTD and FDV are all within the limits specified by the SAC, then the result is PASS. Proceed to the EIR configuration test.

A.2) Step load CIR test

1. Configure test function CIR as target offered load rate, EIR, load step size, load step duration time, and frame size/pattern.
2. Transmit at 25% of CIR (this is the default step size, other step sizes are allowed.) Frames SHOULD be transmitted at constant intervals, e.g., without burstiness or interval variation. If interval variation is present, it SHOULD be proportional to the size variation in the EMIX. Frames MAY be transmitted in units of IR bits per second, although transmission rate measured in utilized line rate (ULR) bits per second is also acceptable.
3. Measure the received IR, FLR, FTD and FDV. FLR_{SAC} is the frame loss ratio limit as specified in the SAC. If the FLR (including errored frames), FTD and FDV are all within the limits specified by the SAC, increase transmitted IR and repeat from Step 2 (at 50% of CIR, 75% of CIR and 100% of CIR) or other steps as configured by the user.
4. If the performance parameters are not within SAC limits, the user SHOULD troubleshoot the problem. Investigate the issues, determine the possible configuration error and correct the problem if necessary. Repeat the service configuration test from Step 2.
5. If 100% of the CIR has been reached successfully within the SAC limits, then the result is PASS. Proceed to the EIR configuration test.

B) EIR configuration test

B.1) EIR configuration test, colour aware

Continue from CIR test. If EIR = 0, proceed to the traffic policing test.

1. Transmit frames marked green and yellow into the measurement point at a rate equal to CIR for the green frames and EIR for the yellow frames. Frames SHOULD be transmitted at constant intervals, e.g., without burstiness or interval variation. If interval variation is present, it SHOULD be proportional to the size variation in the EMIX.
2. Measure the received rate, in bits per second as an IR. Measure IR-G, the information rate of green-coloured frames, IR-Y, the information rate of yellow-coloured frames, IR-T, the total combined information rate, FLR-G, the frame loss ratio for green frames, FTD-G, the frame transfer delay for green-coloured frames, FDV-G, the frame delay variation for green-coloured frames, FLR-Y, the frame loss ratio for yellow-coloured frames, FTD-Y, the frame transfer delay for yellow-coloured frames, and FDV-Y, the frame delay variation for yellow-coloured frames. Note that all the yellow-coloured parameters MAY be reported for reference purposes only, because the SAC does not apply to yellow-coloured frames.
3. If FLR-G, FTD-G, and FDV-G are all within the SAC limits, then the result is PASS; proceed to the traffic policing test.
4. If other results, find and correct the problem, then repeat the service configuration test from the CIR configuration test, Step 1.

B.2) EIR configuration test, non-colour-aware

Continue from the CIR configuration test. If EIR = 0, proceed to the traffic policing test.

1. Transmit frames at the source, at an IR equal to CIR + EIR. Frames SHOULD be transmitted at constant intervals, e.g., without burstiness or interval variation. If interval variation is present, it SHOULD be proportional to the size variation in the EMIX.
2. Measure the received IR, in bits per second, as an information rate. Also measure FLR, the frame loss ratio, FTD, the frame transfer delay and FDV, the frame delay variation for all frames. FLR_{SAC} is the frame loss ratio limit as specified in the SAC.
3. If $CIR*(1 – FLR_{SAC}) \leq IR_T \leq CIR+EIR$, then give a passing result; proceed to the traffic policing test.
4. If other results, find and correct the problem, then repeat the test from CIR configuration test Step 1.

C.1) Traffic policing test, colour-aware

1. Transmit green-marked frames at the source at an information rate equal to CIR, and transmit yellow-marked frames at an information rate of 125% EIR. Frames SHOULD be transmitted at constant intervals, e.g., without burstiness or interval variation. If interval variation is present, it SHOULD be proportional to the size variation in the EMIX. Note that if EIR < 20%*CIR, then the transmitted frames SHOULD be 100%*CIR green-marked frames plus 25%*CIR yellow marked frames plus 100%*EIR yellow-marked frames. This test is only valid if the CIR + EIR ULR is smaller than the interface ULR.
2. Measure the received IR. Measure IR-G, the information rate of green-coloured frames, IR-Y the information rate of yellow-coloured frames, IR-T the total combined information rate, FLR-G, the frame loss ratio for green frames, FTD-G, the frame transfer delay for green-coloured frames, FDV-G, the frame delay variation for green coloured frames, FLR-Y, the frame loss ratio for yellow frames, FTD-Y, the frame transfer delay for yellow-coloured frames, and FDV-Y, the frame delay variation for yellow-coloured frames. Note that all the yellow-coloured parameters MAY be reported for reference purposes only, because the SAC does not apply to yellow-coloured frames.
3. If FLR-G, FTD-G, FDV-G, are all within the SAC limits, and if $IR\text{-}T \leq CIR+EIR+M$ (see Note 1), then a passing result is obtained.
4. If other results, find and correct the problem, then repeat the test from CIR configuration test, Step 1.

Should there be active EVCs on an existing UNI, the traffic policing test (CIR + 125% EIR) should be deemed optional so that there will be no overloading of the UNI that will impact the active EVCs.

C.2) Traffic policing test, non-colour-aware

1. Transmit frames at the source, with an IR or ULR equal to CIR + 125% EIR. Frames SHOULD be transmitted at constant intervals, e.g., without burstiness or interval variation. If interval variation is present, it SHOULD be proportional to the size variation in the EMIX. Note that if EIR < 20%*CIR, then the transmitted IR or ULR SHOULD be 125%*CIR + EIR. This test is only valid if the CIR + EIR ULR is smaller than the interface ULR.
2. Measure the IR, in bits per second (this should be displayed as IR). Also measure FLR, the frame loss ratio, FTD, the frame transfer delay, and FDV, the frame delay variation.
3. IF $CIR*(1 – FLR_{SAC}) \leq IR \leq CIR+EIR+M$ (see Note 1), then a passing result is obtained and the test is completed.
4. If other results, find and correct the problem, then repeat the test from the CIR configuration test, Step 1.

NOTE 1 – The M factor is added to allow for the effect of the traffic policer's CBS and EBS settings, and test time. Experience will determine the values for M. Additional guidance on M is for further study.

Should there be active EVCs on an existing UNI, the traffic policing test MAY be deemed optional so that there will be no overloading of the UNI that will impact the active EVCs.

The following two tests which are still considered preliminary/experimental are included for informational purposes only in Appendix I:

D) CBS configuration test, colour aware and non-colour aware

E) EBS configuration test

8.1.3 Service configuration test reporting format

A record will be stored of the service configuration test configuration and measurement results. The configuration information SHOULD include the bandwidth profile and other data as required to make a complete record. The measurement results SHOULD be those from each step of the test. Note that it MAY be possible to run through the complete procedure without being able to correct all configuration problems, in which case a failed measurement result SHOULD be stored and taken back for additional analysis and future reference. It SHOULD also be possible to combine a service configuration test report with a service performance test report in which case redundant service configuration can be eliminated. An illustrative service configuration test report can be found in Appendix II.

8.2 Service performance test

From the service configuration test, the network is configured correctly to deliver Ethernet-based services. The service performance test validates the quality of the services over time. In this phase of the test methodology, all services MUST be generated at once to their configured CIR and all Ethernet performance parameters MUST be measured simultaneously. This means that the IR, FTD, FDV, FLR and AVAIL SHALL be monitored for each service simultaneously.

This phase of the test methodology SHOULD have a medium to long time duration. As the test duration has implications on the performance parameters measured, certain durations SHOULD be respected.

8.2.1 Test duration

As described in [ITU-T M.2110], when bringing transmission entities into service, several tests are necessary according to the concerned transmission entity. Test15m (15 minutes), Test2h (2 hours) or Test24h (24 hours) SHOULD be applied to each direction of transmission. Wherever possible, the per-direction measurement configuration SHOULD be used. For a bidirectional path or section, the test SHOULD be considered passed if both directions meet the pass/fail limits, or failed if either direction fails the pass/fail limits.

There are four test durations defined in [ITU-T M.2110]. The continuity test is out of scope as the end-to-end connectivity of the service under test has already been tested with the service configuration test. The applicable test duration SHOULD therefore be Test15m, Test2h or Test24h. For example, an operator MAY test services for 15 minutes if the services are provided over a network already carrying working traffic in a metro application. 2h test durations MAY be used for services running over a single operator long-haul network. Finally, a 24h test duration MAY be used for services which are being carried internationally over multiple operator networks.

The following test periods MUST be supported:

- T_{period} = 15 minutes
- T_{period} = 2 hours
- T_{period} = 24 hours

An unbounded test period MAY be supported to allow unbounded and monitored testing. Other test durations MAY be used for the service performance test. All test durations MUST be clearly identified in the test report.

8.2.2 Service performance test results

The display of the test results for this methodology is based on [ITU-T Y.1563]. Each of the following subclauses will provide some insight on what SHOULD be reported by a test instrument.

8.2.2.1 Information rate test results

IR results SHOULD be available for all test flows simultaneously. For each flow, the minimum, maximum, and average IR SHALL be displayed.

The display of results for an IR measurement can be challenging for the end-user if it is not clearly indicated at what layer the test instrument is displaying the result. As an example, utilized line rate of 100 Mbit/s at the physical layer does not translate into a 100 Mbit/s IR at the Ethernet or higher layers, especially for small frames or packets. The standard parameter is IR, measured in the same way as the CIR, the bit rate of service frames starting with the MAC address and ending with the FCS. Utilized line rate MAY also be provided in the event that the customer and/or operator prefers to work in this realm. Utilized line rate is the fully utilized bit rate available on the line, including the minimum size interframe gaps (but not the amount of the interframe gaps longer than the minimum), the preamble, the start of frame delimiter, and the service frame bits starting with the MAC address and ending with the FCS.

8.2.2.2 Ethernet frame transfer delay results

The FTD results SHOULD be displayed for all flows simultaneously. For each flow, the minimum, maximum, mean, and current FTD SHALL be displayed. The display of the results SHOULD also indicate whether the measurement was made one-way or round-trip. As the calculation for median FTD might be too intensive on test equipment, reporting the median MAY be optional.

8.2.2.3 Ethernet frame delay variation results

The FDV results SHOULD be displayed for all flows simultaneously. For each flow, the result and the current FDV value SHALL be displayed. The display of the results should also indicate if the measurement was made one-way or round-trip. As mentioned earlier in this Recommendation, the validity of round-trip FDV measurement could be studied further, but its usefulness is questionable at this time and this shall be noted with the reported result.

8.2.2.4 Ethernet frame loss ratio results

The FLR results SHOULD be displayed for all flows simultaneously. For each flow, the count and the ratio SHALL be displayed.

8.2.2.5 Service availability

The available seconds percentage and unavailable seconds count during the test SHALL be displayed for all flows simultaneously.

The Ethernet service availability function is based on a model which uses two states corresponding to the ability (availability) or inability (unavailability) of the network to sustain connectivity as assessed by measuring frame loss. Transitions between the states of the model are governed by the occurrence of patterns of severe errored seconds in the Ethernet layer (SES_{ETH}). This Recommendation views availability and unavailability from the network perspective, where availability performance is characterized independently of user behaviour. Refer to [ITU-T Y.1563] for more information on the Ethernet service availability function.

8.2.2.6 Pass/Fail criteria

The service must operate at or above the SAC performance levels for the service to be accepted for bringing into service. Some operators MAY set a higher level of performance at the time of service acceptance to allow for some level of degradation over time and still maintain minimum SAC performance levels. Higher performance can also offset some risk for taking the acceptance test over a shorter interval. For instance, the availability limit may be set at a much higher level than SAC or at exactly 100% during the acceptance measurement time. Also, if multiple operators are working together to deliver a service, each operator MAY need to get a budget for the performance for the particular link that the operator will provide, subject to negotiation among the cooperating providers, so that the overall SAC is met for the end-to-end service for the end user.

8.2.2.7 Service performance test report format

A record will be stored of the service performance test configuration and measurement results. The configuration information SHOULD include the bandwidth profile and other data as required to make a complete record. If this report is printed or downloaded with the service configuration test, then the configuration information SHOULD not be recorded twice, as long as it is the same for both tests. An illustrative service performance test report can be found in Appendix II.

8.3 Test configuration

The test equipment SHALL allow the user to configure the following functionality to perform the test (unless the word "optional" is fixed to the feature, in which case it is optional to provide the feature):

a) UNI attributes:

Port speed: 10 Mbit/s, 100 Mbit/s, 10/100 Mbit/s Auto negotiate, 1 Gbit/s, 10 Gbit/s

Port type: Optional combination of the following: 10/100BASE-T, 100BASE-FX, 1000BASE-T, 1000BASE-X, 10GBASE-W, 10GBASE-R

NOTE – Port type and port speed might be found on multiple test equipment to cover all possibilities.

b) Number of services being tested (test equipment MUST support at least one).

c) Service attribute configurations for each service:

Bandwidth profile (CIR/CBS/EIR/EBS/CM/optional CF).

Service acceptance criteria (FLR, FTD, FDV, AVAIL).

Maximum transmission unit size to test at (default 1518).

Traffic policing: On/Off.

d) Per flow test frame definitions – Destination MAC address, source MAC address, 0 or 1 VLAN ID/Priority tags, optional second VLAN ID for S-TAG, TAG protocol ID, PCP or IP DSCP.

e) Per test flow frame size:

Fixed (64, 128, 256, 512, 1024, 1280, 1518, or maximum transmission unit (MTU)).

Optional EMIX (64, 128, 256, 512, 1024, 1280, 1518, MTU).

Other pattern sequences are acceptable according to operational preference.

f) Test time/steps for the service configuration test (at least 1 to 60 seconds per step, at least 1 to 4 steps, optional to fall back to lower speeds to debug failure after starting at full CIR) and duration for the service performance test (choices provided at least for 15 minutes, 2 hours, and 24 hours).

8.4 Test connectivity considerations

This Recommendation explicitly uses test equipment to describe the test methodology. It is understood that this test methodology MAY be implemented as a test function inside of a network element.

As specified in clause 7.3, compliant implementations of this methodology SHOULD perform tests between two test instruments connected at different UNIs in the network when measuring an EVC as depicted in Figure 2. This is an intrusive test configuration that REQUIRES replacement of the customer equipment connection with a connection to the test equipment.

Other test connections MAY be used when unavoidable, with the understanding that results that differ from the compliant configuration are possible. Examples of such circumstances are discussed below.

On occasion, a new service will need to be tested that is running on an Ethernet line that is already carrying other in-service traffic. Care must be taken to avoid disrupting the in-service traffic while the new measurement is made. If there is a network interface device (NID) at the UNI, the NID MAY offer a test access port that can non-disruptively drop and insert traffic into the UNI while the other port is plugged in to the customer edge equipment carrying live traffic.

Alternatively, the test equipment MAY have a mode where it is able with dual ports to pass traffic through without disruption while dropping and inserting test flows toward the network or toward the customer premises. Care should be used with this method, however, because merely plugging the test equipment into the line will cause at least a momentary disruption to traffic, and if any configuration errors are made in setting up the equipment, then the disruption may become extended.

A final way to accomplish testing over an active service is to connect to the closest device to the UNI that offers non-disruptive test access, such as a switch. It should be noted that in this case, the user has an even larger burden to monitor the live traffic rates at the interface so that the test traffic that is introduced does not overload the physical ability of the UNI to carry all the transmitted frames.

Should there be active EVCs on an existing UNI, the traffic policing test MAY be deemed optional so that there is no overloading of the UNI that will impact the active EVCs.

8.5 Availability considerations for testing

[ITU-T Y.1563] and [MEF 10.2] exclude unavailable time for the purposes of performance parameter/attribute evaluation and comparison with objectives. This principle MUST be implemented in test equipment/function, to ensure that they consistently measure performance and the results compare favourably with other test equipment functions.

Availability was originally developed as an in-service monitoring performance parameter that would be accumulated and reported in monthly intervals. Unavailable time shall not be used for the purposes of SAC evaluation in service activation testing, beyond reporting the presence of unavailability in the reported results (as in clause 8.2.2.5). However, the operator MAY choose to include availability as a performance parameter with a limit that will drive a pass/fail result in the service performance test. The test equipment SHOULD support availability testing and its optional use as pass/fail criteria in the service performance test. The longer the test interval, the more statistically relevant the availability parameter becomes.

Test equipment SHOULD display periods of unavailability that occur during testing so that the operator can take action if desired.

8.6 Frame loss ratio and errored frame ratio

Errored frames are dropped by the network to prevent undesirable effects. Therefore, in most cases it SHOULD be sufficient to examine the frame loss ratio in order to see if the service has provided acceptable performance to the customer. However, in some cases such as microwave access links, the access portion of the network MAY provide by far the highest source of errors. In this case, frames egressing the network at the UNI MAY not be dropped if they are errored, particularly if a NID is not installed at the UNI. When performing service activation testing, service providers MAY also combine their frame error counts with their frame loss counts and require the sum of those parameters to meet the FLR acceptance limits.

Appendix I

CBS and EBS test methodology

(This appendix does not form an integral part of this Recommendation.)

I.1 Introduction

The two tests described below are still considered preliminary/experimental, and are therefore included for informational purposes only.

The bandwidth profile contains attributes of committed burst size and excess burst size that some service providers may wish to test at the time of service activation to verify proper attribute configuration. These procedures may be inserted after completion of the traffic policing test step of the service configuration test. As very little testing of CBS and EBS is documented in the certification tests heretofore available in the industry, there is a clear need for appropriate methods to be used at the time of service activation. One such method is provided below, and verifies the configuration of traffic policers that operate according to the bandwidth profile algorithm, as defined in Figure 13 of [MEF 10.2].

Some network element manufacturers may feel that alternative procedures may produce more appropriate results, and such manufacturers are welcome to provide their procedures to ITU-T for further review and study. Note that burst testing is most meaningful for high bandwidth Ethernet user network interfaces that have a small fraction of the line capacity provisioned to carry customer traffic. As the EIR or CIR grow to approach full line rate, the usefulness of burst testing declines, and it can take significantly longer to perform a burst test according to these procedures. These burst test procedures are designed to work best at committed and excess information rates up to 67% of maximum attainable information rate.

I.2 CBS test methodology

D) CBS configuration test – Colour aware and non-colour aware

1. If there is no CBS provisioned, proceed to the EBS test.
2. For procedural context, refer to [b-MEF 19], test case 36 and [MEF 10.2], Figure 13. The value for time interval *T* of test case 36 and a single period of this test is chosen so that a frame loss rate of 10% will occur if all frames that are sent through the associated back-to-back burst are dropped by the network. F (tolerance variance) of test case 36 is substituted by the FLR of the SAC or other lesser operator-chosen limit with exact acceptance criteria as described in Step 5 below.
3. At the beginning of the CBS test, the transmitter turns off for the smallest amount of time equal to or greater than 100%*CBS*8/CIR to initialize the measurement with the B_c CBS token bucket full (note that different transmitters will have differing degrees of precision as relates to their ability to transmit a frame at an exactly controlled time. The language is written to allow for these differences between different transmitters, each following this procedure).
4. Then the test instrument begins the CBS test bursting cycle of period *T*. The transmitter turns off for the smallest amount of time necessary to ensure that the B_c token bucket is full and has overflowed by an amount equal to or greater than 2%*CBS. Then the transmitter bursts the largest number of back-to-back (minimum interframe gap) frames that will draw down the number of remaining bytes in the B_c token bucket to more than or equal to the greatest of:
   a) 1% of the CBS;
   b) 1.5 times the size of the test frame (if only a single size frame is being transmitted);

c) 1.5 times the size of the largest frame in the current EMIX (if an EMIX of frames is being transmitted);

d) The lesser of (50%*CBS) and (0.001*CIR/8).

After the last frame of the burst, the transmitter turns off for the smallest amount of time necessary to refill the CBS token bucket to at least 50% full. Then the transmitter resumes transmission at the CIR. Frames should be transmitted at constant intervals, e.g., without burstiness or interval variation. If interval variation is present, it should be proportional to the size variation in the EMIX. The period *T* ends when the total number of frames transmitted during the period is 10 times the number of frames transmitted during the burst. The transmitter continues to cycle the frame bursting over successive periods of *T* in this sequence, starting from this Step 4, until the test is complete.

5. Measure the received frames upon egress at the other end of the network. IF FLR, FTD, FDV, are within the SAC limits specified by the SAC, then the measurement result is a PASS, record the measured IR, FLR, FTD, FDV and proceed to the EBS test.

6. If the performance parameters are not within the SAC limits, investigate the trouble or possible configuration error and correct the problem. Repeat from the CIR configuration test Step 1.

I.3 EBS configuration test methodology

E.1) EBS configuration test, colour aware and non-colour aware, CIR = 0

1. If there is no EBS on the service, proceed to the next service. Or, if all the services' configuration is verified, proceed to the service performance test.

2. For procedural context, refer to [b-MEF 19], test case 37, and [MEF 10.2], Figure 13. The value for time interval *T* of test case 37 and a single period of this test is chosen so that a frame loss rate of 10% will occur if all frames that are sent through the associated back-to-back burst are dropped by the network.

3. At the beginning of this EBS test, the transmitter turns off for the smallest amount of time equal to or greater than 100%*EBS*8/EIR to initialize the measurement with the B_e EBS token bucket full.

4. Then the test instrument begins the EBS test bursting cycle of period *T*. The transmitter turns off for the smallest amount of time necessary to ensure that the B_e token bucket is full and has overflowed by an amount equal to or greater than 2%*EBS. Then the transmitter bursts the largest number of back-to-back (minimum interframe gap) frames that will draw down the number of remaining bytes in the B_e token bucket to more than or equal to the greatest of:

   a) 1% of the EBS;

   b) 1.5 times the test frame;

   c) 1.5 times the largest frame in the current EMIX;

   d) the lesser of (50%*EBS) and (0.001*EIR/8).

   After the last frame of the burst, the transmitter turns off for the smallest time necessary to refill the EBS token bucket to at least 50% full. Then the transmitter resumes transmission at the CIR. Frames should be transmitted at constant intervals, e.g., without burstiness or interval variation. If interval variation is present, it should be proportional to the size variation in the EMIX. The transmitter continues to cycle the frame bursting over successive periods of *T* in this sequence, starting from this Step 4, until the test is complete.

5. Measure IR, FLR, FTD, and FDV. If FLR, FTD, FDV, are within the SAC limits specified by the SAC, then the result is a PASS (note, this test should always pass because yellow frames are not measured against the SAC); and

a) record the measured IR, FLR, FTD, FDV, and proceed back to the CBS test for the next service; or

b) if all services have passed the configuration test, move to the service performance test.

Otherwise,

6. If the performance parameters are not within the SAC limits, investigate the source of the trouble or possible configuration error and correct the problem. Repeat from CIR configuration test Step 1.

E.2) EBS configuration test, colour aware, CIR > 0

1. If there is no EBS on the service, proceed to the next service. Or, if all service configurations have been verified, proceed to the service performance test.

2. For procedural context, refer to [b-MEF 19], test case 37, and [MEF 10.2], Figure 13. The value for time interval *T* of test case 36 and a single green-frame or yellow-frame period of this test are chosen so that a frame loss rate of 10% will occur if all frames that are sent through the associated burst are dropped by the network.

3. In this test there will be two test flows, the first for the green/CBS test flow and the second for the yellow/EBS test flow.

4. In this EBS test there is a separate cycle for green frames and yellow frames. The green cycle has a period of nominal length T_G, and the yellow cycle has a period of nominal length T_Y. The green cycle and the yellow cycle run asynchronously with respect to each other.

   Note that the bursting may include periods of burst green frames only, burst yellow frames only, burst green and yellow frames combined, and burst frames from one cycle transmitted during EIR- or CIR-spaced frames from the other cycle. When a burst frame competes for a transmission time with a spaced frame, the burst frame shall take precedence if it is the first frame in the burst. If a later frame of the burst competes with an EIR- or CIR-spaced frame for transmission, then the timing of the spaced frame shall take precedence, and the burst frame shall wait in queue.

   Note that burst frames from one cycle may be transmitted freely at line rate in the spaced period of the frames from the other cycle transmitting at CIR or EIR. When burst frames of both cycles compete for the transmitter, the transmitter may be shared on a prorata basis between the bursts, or one burst may be served with preference, while the other stream waits its turn for bursting while continuing to be served at EIR or CIR. During non-burst periods, if a green frame transmitted at CIR competes for a transmit time with a yellow frame transmitted at EIR, then the green CIR frame shall be transmitted at the proper time while the yellow frame is queued. Green CIR frames may be transmitted during the idle time between yellow frames transmitted at EIR, and yellow EIR frames may be transmitted during the idle time between green frames transmitted at CIR.

   At the beginning of this EBS test, the transmitter stops sending all frames. It stops sending green frames for the smallest amount of time equal to or greater than 100%*(CBS*8/CIR). Likewise, the transmitter stops sending yellow frames for the smallest amount of time equal to or greater than 100%*(EBS*8/EIR). At the completion of each separate quiet period described in this Step 4, the separate green- and yellow-frame burst cycles will begin as described in next Step 5.

5. At the beginning of the green cycle, the green frame transmission stops for the smallest amount of time necessary to ensure that the B_c token bucket is full and has overflown by an amount equal to or greater than 2%*(CBS). At the beginning of the yellow cycle, the yellow frame transmission stops for the smallest amount of time necessary to ensure that the B_e token bucket is full and has overflown by an amount equal to or greater than 2%*(EBS). Then the transmitter bursts the largest number of green frames that will draw down the number of remaining bytes in the B_c token bucket, to more than or equal to the greatest of:

   a) either 1% of the CBS;

   b) 1.5 times the test frame;

   c) 1.5 times the size of the largest frame in the current EMIX;

   d) the lesser of (50%*CBS) and (0.001*CIR/8).

   Likewise, the transmitter bursts the largest number of yellow frames that will draw down the number of remaining bytes in the B_e token bucket to more than or equal to the greatest of:

   a) 1% of the EBS;

   b) 1.5 times the test frame;

   c) 1.5 times the largest frame in the current EMIX;

   d) the lesser of (50%*EBS) and (0.001*EIR/8).

   After the last frame of the green frame burst, the transmitter stops transmitting green frames for the smallest amount of time necessary to refill the CBS token bucket to at least 50% full. Likewise, after the last frame of the yellow frame burst, the transmitter stops transmitting yellow frames for the smallest amount of time necessary to refill the EBS token bucket to at least 50% full. Then the transmitter resumes non-bursty green and yellow frame transmission at the CIR and EIR for the rest of the periods T_G and T_Y, respectively. Each period ends when the total number of frames transmitted during that period is 10 times the number of frames transmitted during that period's burst. At the end of each period, the cycle is repeated from the beginning of this Step 5 until the test is complete. The test may be stopped at any time, with the green and/or yellow frame transmission stopped in mid-cycle.

6. Measure IR-G, the information rate of green-coloured frames, IR-Y the information rate of yellow-coloured frames, IR-T the total combined information rate, FLR-G, the frame loss ratio for green frames, FTD-G, the frame transfer delay for green-coloured frames, FDV-G, the frame delay variation for green coloured frames, FLR-Y, the frame loss ratio for yellow frames, FTD-Y, the frame transfer delay for yellow-coloured frames, FDV-Y, the frame delay variation for yellow-coloured frames. Note that all the yellow-coloured parameters are reported for reference purposes only, because the SAC does not apply to yellow-coloured frames.

7. If FLR-G, FTD-G, FDV-G, are within the SAC limits, then the result is a PASS, record the measured IR-G, FLR-G, FTD-G, FDV-G, IR-Y, FLR-Y, FTD-Y, FDV-Y, IR-T, FLR-T, FTD-T, FDV-T, and proceed back to the CIR test for the next service. Or, if all services have been tested, proceed to the service performance test.

8. If the performance parameters are not within the SAC limits, investigate the source of the trouble or possible configuration error and correct the problem. Repeat from CIR test Step 1.

E.3) EBS configuration test, non-colour aware, CIR > 0

1. If there is no EBS on the service, proceed to the next service. Or if all service configurations have been verified, proceed to the service performance test.

2. For procedural context, refer to [b-MEF 19], test case 37, and [MEF 10.2], Figure 13. The value for time interval T is chosen so that a frame loss rate of 10% will occur if all frames that are sent through the associated back-to-back burst are dropped by the network.

3. At the beginning of this EBS test, the transmitter turns off for the smallest amount of time equal to or greater than the greater of:

   a) 100% * (CBS*8/CIR);

   b) 100% * (EBS*8/EIR).

4. Then the test instrument begins the EBS test bursting cycle of length *T*. The transmitter turns off for the smallest amount of time necessary to ensure that the B_e token bucket is full and has overflowed by an amount equal to or greater than 2%*(EBS).

   Then the transmitter bursts the largest number of back-to-back (minimum interframe gap) frames that will draw down the B_e token bucket until the number of tokens is more than or equal to the greatest of:

   a) 1% of the EBS;

   b) 2.5 times the test frame;

   c) 2.5 times the largest frame in the current EMIX;

   d) the lesser of (50%*EBS) and (0.001*EIR/8).

   After the last frame of the burst, the transmitter transmits frames at the CIR for the smallest amount of time necessary to refill the EBS token bucket to at least 50% full. Then the transmitter transmits at the rate of CIR + EIR for the rest of the period *T*. The period *T* ends when the total number of frames transmitted during the period is 10 times the number of frames transmitted during the burst. The transmitter continues to cycle the frame bursting over successive periods of *T* in this sequence starting from this Step 4 until the test is complete. Frames transmitted at CIR or CIR + EIR should be transmitted at constant intervals, e.g., without burstiness or interval variation subject to the limitations for scheduling the two test flows. If interval variation is present, it should be proportional to the size variation in the EMIX.

5. Measure IR, the information rate, FLR, the frame loss ratio, FTD, the frame transfer delay, FDV, the frame delay variation. If $IR \geq CIR - FLR_{SAC}$, then the result is a PASS, record the measured IR, FLR, FTD, FDV, and proceed back to the CIR test for the next service. Or, if all services have been tested, proceed to the service performance test.

6. If the performance parameters are not within the service acceptance criteria (SAC) limits, investigate the source of the trouble or possible configuration error and correct the problem. Repeat from CIR configuration test, Step 1.

NOTE – In this appendix, phrases such as "transmitter resumes non-bursty frame transmission at the CIR" have been used. In this context, the phrase is to be interpreted to mean that an ideal token bucket which has been refilling during the interframe gap after the last frame was transmitted will be refilled to the exact same level it started at by the time the next frame is transmitted. In practice, if an EMIX is used, the gap after each frame should be tuned to the size of the previous frame transmitted. If a constant frame size is used, then the interframe gap is indeed uniform after each frame.

Appendix II

Example of service activation test reports

(This appendix does not form an integral part of this Recommendation.)

II.1 Introduction

A record will be stored of the service configuration test configuration and measurement results. The configuration information SHOULD include the bandwidth profile and other data as required to make a complete record. The measurement results SHOULD be those from each step of the test. Note that it SHOULD be possible to run through the complete procedure without being able to correct all configuration problems, in which case a failed measurement result SHOULD be stored and taken back for additional analysis and future reference. It SHOULD be possible to combine a service configuration test report with a service performance test report in which case redundant service configuration SHOULD be eliminated. This appendix illustrates a service configuration test report and a service performance test report.

II.2 Service configuration test reporting format

All items are recorded per individual service tested.

Service configuration test result format (illustrative)

a) UNI attributes:

Port speed: 1 Gbit/s;

Port type: 1000Base-T.

b) Number of services tested: 1

c) Service attributes:

Bandwidth profile: CIR: 15 Mbit/s CBS: 30KB EIR: 25 Mbit/s EBS: 10KB

Colour aware: On, colour method: PCP; Green: 03, 04, 05, 06, 07; Yellow: 00, 01, 02.

Service acceptance criteria: FLR: 3.0×10^{-3}; FTD: 22 ms; FDV: 11 ms; AVAIL: 99.9%.

MTU: 1522 bytes.

Traffic policing: On.

d) Per flow test frame definitions:

Destination MAC address: 5a b3 11 34 3c ff

Source MAC address: 5a b3 11 34 3c 16

VLAN ID: 2733

Test times:

Service configuration test step time: 3 seconds.

Service performance test time: 15 minutes.

Test patterns used: 512 byte fixed.

Date and time of test: 2010 Sept. 22 14:20 CDT.

Total elapsed time of test: 16 seconds.

	Pass/ Fail	IR (Mbit/s)			FL		FTD (ms)			FDV (ms)		
Overall	Pass	Min	Mean	Max	Count	FLR	Min	Mean	Max	Min	Mean	Max
CIR test	Pass	Duration: 12 seconds										
Step 1	Pass	3.73	3.75	3.76	41	4.9E-4	22	22	22	11	11	11
Step 2	Pass	7.50	7.50	7.50	0	0.0E-3	22	22	22	11	11	11
Step 3	Pass	11.22	11.25	11,26	0	0.0E-4	22	22	22	11	11	11
Step 4	Pass	15.0	15.0	15.0	83	2.4E-4	22	22	22	11	11	11
CIR/EIR test	Pass	Duration: 3 seconds										
Green	Pass	15.0	15.0	15.0	4	5.7E-4	22	22	22	11	11	11
Yellow	----	21.3	24.6	25.0	900	2.2E-2	22	22	22	11	11	11
Total	----	36.3	39.6	40.0	2000	1.0E-2	22	22	22	11	11	11
Traffic policing	Pass	Duration: 3 seconds			Transmitted rate: 46.25 Mbit/s							
Green	Pass	14.9	15.0	15.0	3	7.0E-4	22	22	22	11	11	11
Yellow	----	18.3	24.1	24.5	20000	2.0 E-1	22	22	22	11	11	11
Total	----	33.2	39.1	39.5	15400	1.3 E-1	22	22	22	11	11	11

CBS and EBS results in the table below are optional. Refer to Appendix I for the test methodology.

	Pass/ Fail	IR (kbit/s)			FL		FTD (ms)			FDV (ms)		
Overall	Pass	Min	Mean	Max	Count	FLR	Min	Mean	Max	Min	Mean	Max
CBS test	Pass	Duration: 3 seconds										
	Pass	22.2	22.2	22.2	2000	1.0E-2	22	22	22	11	11	11
EBS test	Pass	Duration: 3 seconds										
Green	Pass	22.2	22.2	22.2	2000	1.0E-2	22	22	22	11	11	11
Yellow	----	2.2	2.2	2.2	2000	1.0E-2	22	22	22	11	11	11
Total	----	24.4	24.4	24.4	2000	1.0E-2	22	22	22	11	11	11

II.3 Service performance test report format

Service performance test result format (illustrative)

a) UNI attributes:

Port speed: 1 Gbit/s;

Port type: 1000Base-T.

b) Number of services tested: 1.

c) Service attributes:

Bandwidth profile: CIR: 15 Mbit/s CBS: 30KB EIR: 25 Mbit/s EBS: 10KB

Colour aware: On, colour method: PCP; Green: 03, 04, 05, 06, 07; Yellow: 00, 01, 02.

Service acceptance criteria: FLR: 3.0×10^{-3}; FTD: 22 ms; FDV: 11 ms; AVAIL: 99.9%.

MTU: 1522 bytes.

Traffic policing: On.

d) Per flow test frame definitions

Destination MAC address: 5a b3 11 34 3c ff

Source MAC address: 5a b3 11 34 3c 16

VLAN ID: 2733

Test times:

Service configuration test step time: 3 seconds.

Service performance test time: 15 minutes.

Test patterns used: 512 bytes fixed.

Date and time of test: 2010 Sept. 22 14:20 CDT.

Total elapsed time of test: 16 seconds.

	Pass/ Fail	**IR** (Mbit/s)			**FL**		**FTD** (ms)			**FDV** (ms)			**AVAIL** (%)	**Una-vail**
Overall	Fail	Min	Mean	Max	Count	FLR	Min	Mean	Max	Min	Mean	Max		Count
Service performance	Fail	Duration: 15 minutes												
Service 1	Fail	22.2	22.2	22.2	41	4.9E-4	22	22	22	11	11	11	93.5	222

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