

**Optical Transport Networks & Technologies Standardization Work Plan
Issue 24, February 2018**

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General

This is a living document and may be updated even between meetings. The latest version can be found at the following URL.

<https://www.itu.int/en/ITU-T/studygroups/com15/Pages/otn.aspx> Proposed modifications and comments should be sent to: ITU-T TSB.

From the Issue 22, the document is split into two parts to separate the up-to-date snapshot-type information and comprehensive database-type information.

- Part 1 provides highlights of relevant SDOs' activity.
- Part 2 updated.

Editor of the document thanks continuous support of the SDOs and their information regularly provided, although no updates were received at this meeting.

Splitting the document and its information into the two parts is one of the attempts to make this kind of information useful and attractive to the potential readers. ITU-T SG15 is considering more effective way to provide the information and efficient way to maintain and update it. Regarding Part 1, setting up the common template for reporting is one idea. For Part 2, automated database representation is under consideration in ITU.

Any comments, not only the correction and update of the information but also the ways to provide the information are highly appreciated.

Part 1: Status reports as of January 2018

1 Highlight of ITU-T SG15

Highlights from the most recent SG15 Plenary meeting can be found here:

<https://www.itu.int/en/ITU-T/studygroups/2017-2020/15/Pages/exec-sum.aspx>

2 Reports from other organizations

The table below highlights the latest status reports received from the relevant organizations. ITU-T members can see the details of the reports by accessing ITU-T SG15 temporary documents for the January 2018 meeting as indicated in the reference: <https://www.itu.int/md/T17-SG15-180129-TD/en>


Table 1 – Summary of status reports from relevant organizations

ID	Organization	Summary	Reference
1	Broadband Forum	Liaison Report for Broadband Forum Related to WP3/15. The liaison report highlights some key initiatives and particular activities of interest to WP3. Initiatives: Broadband 20/20; 5G; Common YANG. Specific areas of interest: 5G Transport; TR-350 Ethernet Services using BGP MPLS-based Ethernet VPNs; FlexE in IP/MPLS Networks for 5G; YANG for Ethernet OAM/CFM and Alarm Models; Deterministic Transport; Network Slicing.	[137-WP3]
2	IEEE 802.1	IEEE 802.1 liaison report The 802.1 working group has five active task groups: Maintenance, Time Sensitive Networking (TSN), Security, Data Center Bridging (DCB) and OmniRAN. Note that last year, a new Industry Connections activity was started to explore IEEE 802 Network Enhancements For the Next Decade the Interworking. This activity will assess emerging requirements for IEEE 802-based communication infrastructures, identify commonalities, gaps, and trends not currently addressed by IEEE 802 standards and projects, and facilitate building industry consensus towards proposals to initiate new standards development efforts. The 802.1 working group has over 20 active projects ranging from revisions of existing work (like the MAC service definition), addition of new bridging features (like frame replication), support of YANG modelling and application to new verticals (like fronthaul). The liaison highlights the following projects to be noted in SG15: 1) all projects in TSN, 2) 802 Network Enhancements for the next decade (e.g., 5G), 3) P802.1CM – Profile for Fronthaul, 4) P802.1	[126-GEN]

3	IEEE 802.3	<p>AX-Rev – Link Aggregation revision, 5) P802.1Xck – YANG data model, 6) P802.1Qcp – YANG data model, 7) P802.1Qcx – CFM YANG data model, 8) P802.1ABcu – LLDP YANG data model, and 9) YANGsters – IEEE 802 YANG Editors’ coordination</p> <p>Relevant recent projects:</p> <ul style="list-style-type: none"> • IEEE P802.3cd • The IEEE P802.3cd 50 Gb/s, 100 Gb/s, and 200 Gb/s Ethernet Task Force was formed after the March 2016 plenary meeting to develop 50 Gb/s Ethernet. In addition next generation 100 Gb/s Ethernet PHYs and 200 Gb/s Ethernet PHYs based on 4 lanes of 50G over backplane, copper cable and multimode fibre are under development. The Draft 3.0 was produced in November 2017. IEEE P802.3ca <p>The 25 Gb/s, 50 Gb/s, and 100 Gb/s Ethernet Passive Optical Networks Task Force is working to adopt baselines.</p> <p>The IEEE 802.3 standards currently in force are:</p> <ol style="list-style-type: none"> 1) the base standard, IEEE Std 802.3-2015, approved by the Standards Board on 3 September 2015 and published on 4 March 2016; 2) eleven amendments and one corrigendum. 3) the base MIB standard, IEEE Std 802.3.1-2013 	[136-GEN]
4	MEF	<p>MEF liaison report</p> <p>With over 200 leading member companies, including 130 service providers, the MEF is the enabling force for the development and implementation of agile, assured and orchestrated Third Network services for the digital economy and the hyper-connected world. Third Network services are delivered over automated, virtualized, and interconnected networks globally powered by Carrier Ethernet 2.0 (CE 2.0), Lifecycle Service Orchestration (LSO), SDN, and NFV.</p> <p>CE 2.0 is MEF’s globally adopted services framework and the foundation for new services innovation. The current annual market for Carrier Ethernet products and services is approximately \$80B. The MEF is also facilitating industry neutral implementation environments for service orchestration (OpenLSO) and L2-L7 connectivity services (OpenCS) based on Open Source, SDN and NFV.</p> <p>MEF 3.0 is a transformational framework for defining, delivering, and certifying agile, assured, and orchestrated communication services across a global ecosystem of automated networks.</p> <p>MEF Active projects:</p> <ul style="list-style-type: none"> • Lifecycle Service Orchestration: 13 projects 	[125-GEN]

- Services: 10 projects and 2 ad-hocs
- Applications: 6 projects

5	OIF (PLL)	<p>Liaison report for OIF Physical and Link Layer (PLL) Working Group CEI (Common Electrical I-O) projects for 56G</p> <p>The following 56G CEI projects are complete and are included in CEI 4.0 published as OIF-CEI-04.0 (publicly available):</p> <ul style="list-style-type: none"> CEI-56G-USR-NRZ CEI-56G-XSR-NRZ CEI-56G-VSR-PAM4 CEI-56G-MR-PAM4 CEI-56G-LR-PAM4 CEI-56G-LR-ENRZ <p>At Nov-2016 Auckland meeting, it was agreed to start a new project as FlexE 2.0 that include:</p> <ul style="list-style-type: none"> • Support for FlexE groups composed of 200 Gb/s and 400 Gb/s Ethernet PHYs • More detail on use of FlexE management channels • Consider coarser calendar granularity to reduce gate count for high bandwidth devices • Management of skew for specific applications • Transport of frequency or time by the FlexE group <p>At the San Antonio meeting, the draft in oif2017.256.03 was sent to straw ballot.</p>	[135-GEN]
6	IETF	<p>Liaison report for IETF</p> <p>The meeting schedule for 2018 - 2020 was provided. One liaison on YANG Alarm Module from CCAMP was highlighted.</p>	[130-GEN]
7	JCA SDN	<p>Incoming liaison from JCA SDN JCA-SDN - LS 5 -E. JCA SDN has updated their SDN Standardisation Activity Roadmap which is available at http://www.itu.int/en/ITU-T/jca/sdn/. JCA SDN concluded at its November 2017 meeting.</p>	[119-GEN]
8	IEEE P1588	<p>Liaison report for IEEE 1588.</p> <p>IEEE 1588-v3 is expected to be completed in 2018. The most recent draft, which is in working group ballot, addresses:</p> <ul style="list-style-type: none"> - High Accuracy: improved time sync performance (assuming Layer 1 frequency synchronization and asymmetry calibrations). - Management: performance monitoring; future of the native IEEE1588 management protocol, PTP networks configurations; data information models; 1588 MIB. 	[127-GEN]

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- Upkeep-Architecture: various points requiring clarifications; solution for profile isolation; PTP redundancy (including definition of solutions for multi paths multi-masters); restructuring of the standard to separate the “media-dependent” functions from the “media- independent” functions.
 - Security: various options to provide security to the protocol.
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Part 2: Standard work plan

1 Introduction to Part 2

Today's global communications world has many different definitions for Optical and other Transport networks, which are supported by different technologies. This resulted in a number of different Study Groups within the ITU-T, e.g. SG 11, 12, 13, and 15 developing Recommendations related to Optical and other Transport Networks and Technologies. Moreover, other standards developing organizations (SDOs), forums and consortia are also active in this area.

Recognising that without a strong coordination effort there is the danger of duplication of work as well as the development of incompatible and non-interoperable standards, WTSA-08 (held in 2008) designated Study Group 15 as the Lead Study Group on Optical and other Transport Networks and Technologies, with the mandate to:

- study the appropriate core Questions (Question 6, 7, 9, 10, 11, 12, 13, 14),
- define and maintain overall (standards) framework, in collaboration with other SGs and SDOs,
- coordinate, assign and prioritise the studies done by the Study Groups (recognising their mandates) to ensure the development of consistent, complete and timely Recommendations.

Study Group 15 entrusted WP 3/15, under Question 3/15, with the task to manage and carry out the Lead Study Group activities on Optical and other Transport Networks and Technologies. To avoid misunderstanding that the mandate above is only applied to G.872-based Optical Transport Network (OTN), this Lead Study Group Activity is titled Optical and other Transport Networks & Technologies (OTNT) that encompass all the related networks, technologies and infrastructures for transport as defined in clause 3.

2 Scope

As the mandate of this Lead Study Group role implies, the standards area covered relates to Optical and other Transport networks and technologies. The Optical and other Transport functions include:

- client adaptation functions
- multiplexing functions
- cross connect and switching functions, including grooming and configuration
- management and control functions
- physical media functions
- network synchronization and distribution functions
- test and measurement functions.

Apart from taking the Lead Study Group role within the ITU-T, Study Group 15 will also endeavour to cooperate with other relevant organizations, including ATIS, ETSI, ISO/IEC, IETF, IEEE, MEF, OIF and TIA.

3 Abbreviations

ANSI	American National Standards Institute
ASON	Automatically Switched Optical Network
ASTN	Automatically Switched Transport Network
ATIS	Alliance for Telecommunications Industry Solutions
EoT	Ethernet frames over Transport
ETSI	European Telecommunications Standards Institute

IEC	International Electrotechnical Commission
IEEE	Institute of Electrical and Electronics Engineers
IETF	Internet Engineering Task Force
ISO	International Organization for Standardization
MON	Metropolitan Optical Network
MPLS	Multiprotocol Label Switching
MPLS-TP	MPLS Transport Profile
OIF	Optical Internetworking Forum
OTN	Optical Transport Network
OTNT	Optical and other Transport Networks & Technologies
SDH	Synchronous Digital Hierarchy
SONET	Synchronous Optical NETwork
TIA	Telecommunications Industry Association
TMF	TeleManagement Forum
WSON	Wavelength Switched Optical Network
WTSA	World Telecommunications Standardization Assembly

4 Definitions and descriptions

One of the most complicated factors in coordination work among multiple organizations in the area of OTNT is differing terminology. Often multiple different groups are utilising the same terms with different definitions. This clause includes definitions relevant to this document. See Annex A for more information on how common terms are used in different organizations.

4.1 Optical and other Transport Networks & Technologies (OTNT)

The transmission of information over optical media in a systematic manner is an optical transport network. The optical transport network consists of the networking capabilities/functionalities and the technologies required to support them. For the purposes of this standardization and work plan, all *new* optical transport networking functionalities and the related other transport technologies will be considered as part of the OTNT standardization work plan. The focus will be the transport and networking of digital client payloads over fibre optic cables. Though established optical transport mechanisms in transport plane (such as Synchronous Digital Hierarchy (SDH), Optical Transport Network (OTN), Ethernet frames over Transport (EoT), Multi-protocol label switching-transport profile (MPLS-TP)) fall within this broad definition, only standardization efforts relating to *new* networking functionalities of OTN, EoT and MPLS-TP will be actively considered as part of this Lead Study Group activity. Control plane and related equipment management aspects including ASON and SDN are also within the scope. Synchronization and time distribution aspects in the above transport network technologies are also included in the definition of OTNT.

4.2 Optical Transport Network (OTN) (largely revised in 09/2016 reflecting B100G)

ITU-T Recommendation G.709 (Interfaces for the optical transport network) with its amendment defines that an optical transport network (OTN) is composed of a set of optical network elements connected by optical fibres, that provide functionality to encapsulate, transport, multiplex, route, manage, supervise and provide survivability of client signals.

The 5th edition of Recommendation ITU-T G.709/Y.1331 “Interfaces for the Optical Transport Network”, published in June 2016, enables optical transport at rates higher than 100 Gbit/s (the code name is beyond 100 Gbit/s or B100G).

The revised ITU-T G.709/Y.1331 extends OTN with a new, flexible $n \times 100\text{G}$ frame format (OTUCn) designed for use at beyond 100G line-side and client-side interfaces, where the “C” corresponds to the Roman numeral for 100.

The OTUCn format can be used for line-side interfaces up to 25.6 Tbit/s, giving system vendors the ability to develop higher-rate OTUCn line-side interfaces at their own pace over the coming 15 to 20 years, in line with market demand and technology availability and independently of progress in standardization.

OTUCn client-side interfaces will use the new, flexible $n \times 100\text{G}$ FlexO frame format and forward error correction (FEC) combined with the available client optical modules. The initial $n \times 100\text{G}$ FlexO standard, ITU-T G.709.1, was published in the beginning of 2017. Future $n \times 200\text{G}$ and $n \times 400\text{G}$ FlexO standards will be available when next-generation 200G or 400G client optical modules become available.

The revised ITU-T G.709/Y.1331 provides the necessary support for 200G and 400G Ethernet under development within IEEE. The revision also extends OTN to support the FlexE-unaware, FlexE-aware subrate and FlexE Client services developed by OIF; in addition introducing the capability to transport frequency and time synchronization information, complementing the similar capability in packet transport networks.

The majority of the initial OTUCn applications to be enabled by ITU-T G.709/Y.1331 will relate to line-side interfaces. Examples of initial OTUCn applications are likely to include:

- Interconnecting 10+ Tbit/s OTN cross connects via 200G, 300G, 400G, 500G, etc. OTUCn line ports
- Interconnecting 200G and 400G transponders, which support the emerging 200GE and 400GE services under development in the IEEE 802.3bs project, as well as the emerging subrated $n \times 100\text{G}$ FlexE_Aware services developed by OIF’s FlexE Implementation Agreement project
- Interconnecting $n \times 100\text{G}$ muxponders with 200G, 300G, 400G, 500G, etc. tunnels

In sync with the introduction to the B100G support, a number of ITU-T Recommendations are updating information on the implementation of the OTN for example:

- [ITU-T G.709] provides the rates and formats used in the OTN
- [ITU-T G.709.1] specifies Flexible OTN short-reach interface
- [ITU-T G.798] defines the equipment functional blocks
- [ITU-T G.872] defines OTN architecture
- [ITU-T G.873.1] and [ITU-T G.873.2] describes linear and ring protection
- [ITU-T G.874] and [ITU-T G.874.1] define the management interface
- [ITU-T G.698.1], [ITU-T G.698.2] and [ITU-T G.959.1] define the physical interfaces.

According to the revised G.872, the OTN is decomposed into the following layer structure.

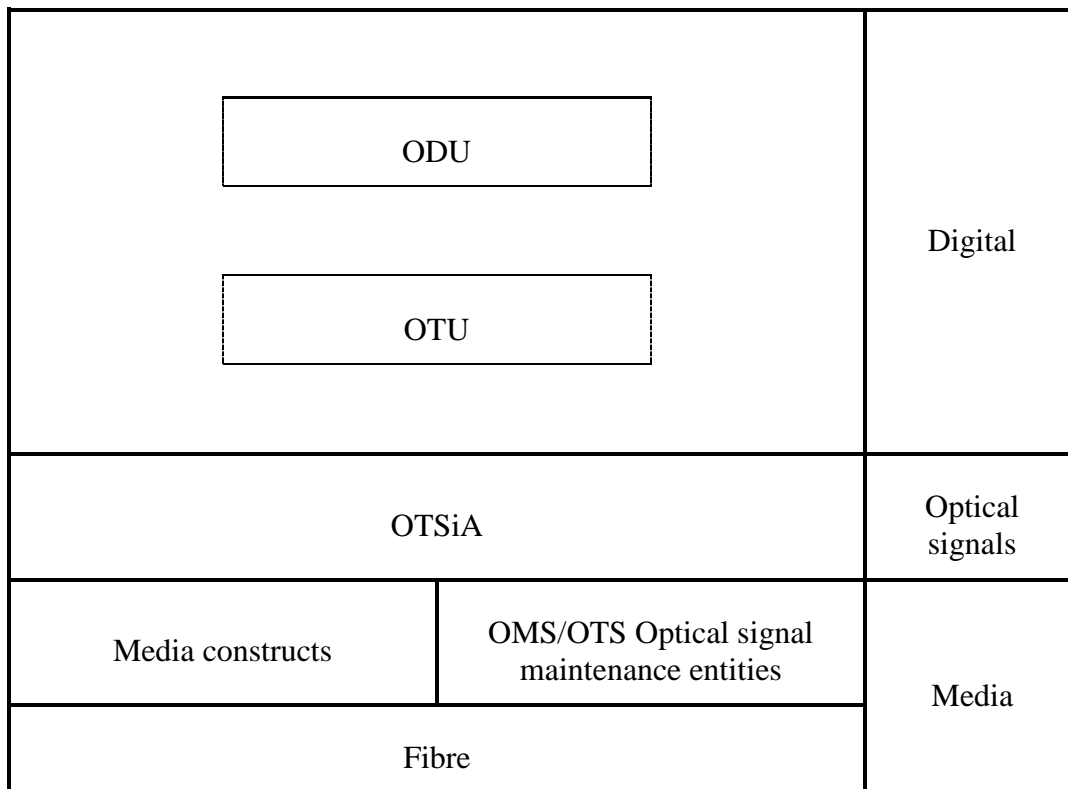


Figure 6-1/G.872 – Overview of the OTN covering beyond 100 Gbit/s

The digital layers of the OTN (optical data unit (ODU), optical transport unit (OTU)) provide for the multiplexing and maintenance of digital clients. There is one-to-one mapping between an OTU and an optical tributary signal assembly (OTSiA). The OTSiA represents the optical tributary signal group (OTSiG) and the non associated overhead (OTSiG O), which is used for management for OTSiG. The OTSiG, represents one or more optical tributary signals (OTSi) that are each characterized by their central frequency and an application identifier. This approach allows the OTU (in particular for bit rates higher than 100Gb/s) to be distributed across multiple optical tributary signals (OTSi).

Below the OTSi are the media constructs (optical devices) that provide the ability to configure the media channels. A media channel is characterized by its frequency slot (i.e. nominal central frequency and width as defined in [ITU T G.694.1]). Each OTSi is guided to its destination by an independent network media channel.

4.2.1 FlexE in OIF (updated in June-2017)

OIF specified a Flex Ethernet implementation agreement in June 2016.

This implementation agreement provides a bonding mechanism to create higher-rate interfaces out of multiple Ethernet PHYs, a mechanism to support smaller clients (Ethernet flows with lower effective MAC rates) over Ethernet PHYs, and a mechanism to multiplex multiple lower rate flows across a group of Ethernet PHYs. The first version of this implementation agreement is based on the bonding of 100GBASE-R Ethernet PHYs into a FlexE group.

FlexE 2.0

At Nov-2016 Auckland meeting, it was agreed to start a new project as FlexE 2.0 that include:

- Support for FlexE groups composed of 200 Gb/s and 400 Gb/s Ethernet PHYs
- More detail on use of FlexE management channels
- Consider coarser calendar granularity to reduce gate count for high bandwidth devices
- Management of skew for specific applications

- Transport of frequency or time by the FlexE group

400ZR Interop

At Nov-2016 Auckland meeting, it was agreed to start a new project to specify optical interfaces with the following characteristics:

- Passive single channel ZR and amplified short reach DWDM with distances up to 120 km
- Single-carrier 400G
- Coherent detection and advanced DSP/FEC
- Target loss budget 24 dB

4.3 Support for mobile networks (reference to ITU-R M2375 added in 09/2016)

MEF 22.1 Mobile Backhaul Implementation Agreement (MBH IA) identifies the requirements for MEF Ethernet Services (EVC) and MEF External Interfaces (EIs such as UNIs) for use in mobile backhaul networks based on MEF specifications (referenced in ITU-T Rec. G.8011). MEF MBH IA, Phase 3 goals include small cells, multi-operator networks and time synchronization. As part of Phase 3, MEF has introduced some terms in MEF 22.1.1. These terms (backhaul, fronthaul and midhaul) may assist in describing how transport network technologies in SG15 may be applied in the international mobile telecommunications architecture.

Phase 3 of the Mobile Backhaul Implementation Agreement incorporates the Small Cell amendment in the base IA, aligns with revised MEF Service definitions and attributes in MEF 6.2 and MEF 10.3, as well as adding support for multi-operator networks.

SG 15 is responsible for developing Recommendations for transport networks, access networks, and home networking, including standard architectures of optical transport networks as well as physical and operational characteristics of their constituent technologies. These technologies may be used to support the backhaul, midhaul and fronthaul for mobile networks depending on the performance requirements of each.

4.4 Ethernet frames over transport

Ethernet is today the dominant LAN technology in private and enterprise sectors. It is defined by a set of IEEE 802 standards. Emerging multi-protocol/multi-service Ethernet services are also offered over public transport networks. Public Ethernet services and Ethernet frames over transport standards and implementation agreements continue being developed in the ITU-T and other organizations. Specifically, the ITU-T SG15 focuses on developing Recommendations related to the support and definition of Ethernet services over traditional telecommunications transport, such as PDH, SDH, and OTN. Ethernet can be described in the context of three major components: *services aspects*, *network layer*, and *physical layer*. The following description is meant to provide a brief overview of Public Ethernet considering each of the above aspects.

The Public Ethernet *services aspects* (for service providers) include different service markets, topology options, and ownership models. Public Ethernet services are defined to a large extent by the type(s) of topologies used and ownership models employed. The topology options can be categorized by the three types of services they support: Line services, LAN services, and Access services. Line services are point-to-point in nature and include services like Ethernet private and virtual lines. LAN services are multi-point-to-multi-point (such as virtual LAN services). Access services are of hub-and-spoke nature and enable single ISP/ASP to serve multiple, distinct, customers. (Due to the similar aspects from a public network perspective, Line and Access services may be essentially the same.)

The services can be provided with different service qualities. A circuit switched technology like SDH always provides a guaranteed bit rate service while a packet switched technology like MPLS can

provide various service qualities from best effort traffic to a guaranteed bit rate service. Ethernet services can be provided for the Ethernet MAC layer or Ethernet physical layer.

The Ethernet *network layer* is the Ethernet MAC layer that provides end-to-end transmission of Ethernet MAC frames between Ethernet end-points of individual services, identified by their MAC addresses. Ethernet MAC layer services can be provided as Line, LAN and Access services over circuit switched technologies like SDH VCs and OTN ODUs or over packet switched technologies like MPLS and RPR. For the Ethernet LAN service Ethernet MAC bridging might be performed within the public transport network in order to forward the MAC frames to the correct destination. Ethernet MAC services can be provided at any bit rate. They are not bound to the physical data rates (i.e. 10 Mbit/s, 100 Mbit/s, 1 Gbit/s, 10 Gbit/s, 40 Gbit/s and 100 Gbit/s) defined by IEEE. It should be noted that there are current IEEE 802.3 efforts aimed at introducing interfaces with new rates of operation at 2.5 Gb/s, 5 Gb/s, 25 Gb/s, 50 Gb/s, 200 Gb/s, and 400 Gb/s.

IEEE has defined a distinct set of *physical layer* data rates for Ethernet with a set of interface options (electrical or optical). An Ethernet physical layer service transports such signals transparently over a public transport network. Examples are the transport of a 10 Gbit/s Ethernet WAN signal over an OTN or the transport of a 1 Gbit/s Ethernet signal over SDH using transparent GFP mapping. Ethernet physical layer services are point-to-point only and are always at the standardized data rates. They are less flexible compared to Ethernet MAC layer services, but offer lower latencies.

4.5 Overview of the standardization of carrier class Ethernet

4.5.1 Evolution of "carrier-class" Ethernet

Ethernet became to be used widely in network operator's backbone or metro area networks. Although Ethernet was originally designed for LAN environment, it has been enhanced in several aspects so that it can be used in network operators' environment. In addition, Ethernet can easily realize multipoint-to-multipoint connectivity, which would require $n*(n-1)/2$ connections if an existing point to point transport technology is used. The following subclauses explain enhancements which have been adopted in Ethernet networks thus far.

4.5.1.1 High bit rate and long reach interfaces

Up to 100Gbit/s for example 40GBASE-KR4/CR4/SR4/LR4/FR and 100GBASE-CR10/SR10/LR4/ER4 have been standardized by IEEE 802.3 WG.

The IEEE Std 802.3-2015 includes 100GBASE-CR4, 100GBASE-KR4, and 100GBASE-KP4, 100GBASE-SR4 and 40GBASE-ER4.

4.5.1.2 Ethernet-based access networks

One of the Ethernet capabilities as access networks regarding 10G-EPON was enhanced by IEEE 802.3 WG into IEEE Std 802.3-2015. Up to 10Gbit/s interfaces, 2BASE-TL, 10PASS-TS, 100BASE-LX10/BX10, 1000BASE-LX10/BX10, 1000BASE-PX10/PX20/PX30/PX40 (1G-EPON), and 10GBASE-PR10/PR20/PR30/PR40/PRX10/PRX20/PRX30/PRX40 (10G-EPON), are specified in IEEE 802.3-2015 as well.

4.5.1.3 Enhancement of scalability

VLAN technology is widely used to provide customers with logically independent networks while sharing network resource physically. However, since 12bit VLAN ID must be a unique value throughout the network, the customer accommodation is limited to 4094 (2 values, 0 and 4095, are reserved for other purposes).

To relax this limitation, a method which uses two VLAN IDs in a frame was standardized by IEEE 802.1ad (Provider Bridges) in October 2005. This method allows the network to provide up to 4094 Service VLANs, each of which can accommodate up to 4094 Customer VLANs.

4.5.1.4 Scalable Ethernet-based backbone

In order to realize further scalable networks, IEEE 802.1ah (Backbone Provider Bridges) specifies a method which uses B-Tag, I-Tag and C-Tag. B-Tag and C-Tag include 12 bit VLAN ID. I-Tag includes 20bit Service ID (note: the size of the Service ID under study). One VLAN ID identifies a Customer VLAN. Service ID identifies a service in a provider network. Another VLAN ID identifies a Backbone VLAN. This allows the network to use 12bit VLAN ID space and 20 bit service ID space as well as its own MAC address space. IEEE 802.1ah was approved in June 2008.

4.5.1.5 The number of MAC addresses to be learned by bridges

Bridges in a network automatically learn the source MAC addresses of incoming frames. When the number of stations is large, this learning process consumes a lot of resources of each bridge. To alleviate this burden, IEEE 802.1ah (Backbone Provider Bridges) standardized a method which encapsulates MAC addresses of user stations by backbone MAC addresses so that bridges inside the backbone network do not learn MAC addresses of user stations.

4.5.1.6 Network level OAM

To enable network operators to detect, localize and verify defects easily and efficiently, network-level Ethernet OAM functions were standardized in ITU-T SG13 (Q5/13) and IEEE 802.1ag under a close collaboration.

ITU-T Recommendation Y.1731 was approved in May 2006 and revised in February 2008. IEEE 802.1ag was approved in September 2007. IEEE 802.1ag covers fault management functions only while Y.1731 covers both fault management and performance management.

Ethernet services performance parameters were standardized by ITU-T SG12 (Q.17/12) in Recommendation Y.1563, approved in January 2009. Service OAM Framework (MEF17), Service OAM Fault Management Implementation Agreement (MEF 30) and Service OAM Performance Monitoring Implementation Agreement (MEF 35) are specified in MEF.

In October 2008, WTSA-08 transferred Q5/13 (OAM) to SG15 and now Ethernet OAM work is conducted in SG15.

4.5.1.7 Fast survivability technologies

To realize fast and simple protection switching in addition to Link Aggregation and Rapid Spanning Tree Protocol, Recommendation on Ethernet linear protection switching mechanism (G.8031) was approved in June 2006. Recommendation on Ethernet ring protection (G.8032) was approved in June 2008. In March 2010, the revised G.8032v2 covered interconnected and multiple rings, operator commands and non-revertive mode. In September 2016, a supplement on Ethernet linear protection switching with dual node interconnection (G.sup60) was approved. This is based on G.8031.

In March 2012, IEEE 802.1 WG developed a standard on Shortest Path Bridging (IEEE 802.1aq) to optimize restoration capabilities. In June 2009, they completed a standard on Provider Backbone Bridge Traffic Engineering (IEEE 802.1Qay), which includes linear protection switching.

In 2014, IEEE 802.1 WG completed a revision of the 802.1AX Link Aggregation standard, introducing the Distributed Resilient Network Interface. This standard incorporates technology sometimes known as multi-chassis link aggregation, and allows the construction of multi-vendor protected network-to-network interfaces. The aims included preventing changes in one attached network from affecting the other attached network, where possible. This standard was again revised starting in 2017 in the light of implementation experience to ensure interoperability and proper operation.

IEEE 802.1CB “Frame Replication and Elimination for Reliability” is a standard with applications in the area of protection. It specifies procedures, managed objects and protocols for bridges and end stations that provide:

- Identification and replication of frames, for redundant transmission;
- Identification of duplicate frames;
- Elimination of duplicate frames;
- Stream identification.

4.5.1.8 QoS/traffic control/traffic conditioning

QoS, traffic control, and traffic conditioning issues are being studied in ITU-T (SG12 and SG13), IEEE 802.3, and MEF. IEEE 802.1 completed work in June 2009 on Provider Backbone Bridge Traffic Engineering (IEEE 802.1Qay). MEF developed MEF 10.3: "Ethernet Services Attributes", in October 2013, together with further amendments on "Composite Performance Metric" (MEF 10.3.1, February 2015) and "UNI Resiliency" (MEF 10.3.2, October 2015).

4.5.1.9 Service Activation Testing (SAT)

Recommendation Y.1564, "Ethernet service activation test methodology" was approved in SG12 in March, 2011. MEF completed MEF 48: "Service Activation Testing" in October 2014.

4.5.1.10 Time-Sensitive Networking and Deterministic Networking

Following on from the development of Audio-Video Bridging in IEEE 802.1, itself based upon advances in time synchronisation in IEEE 1588, IEEE 802.1 formed the Time-Sensitive Networking task force. This group completed the Stream Reservation Protocol (802.1Qat) and the Credit-based Shaper (802.1Qav) to provide lossless guaranteed bandwidth over Ethernet. This was followed by the Frame Pre-emption (802.1Qbu) and Interspersing Express Traffic (802.3br) projects, which create an express lane for high-priority traffic. Together with the strict priority scheduling capabilities of 802.1Q, these technologies underpin the P802.1CM Profile for Fronthaul. For more demanding time-sensitive streams, a combination of Enhancements for Scheduled Traffic (802.1Qbv), Per-Stream Filtering and Policing (802.1Qci) and Cyclic Queuing and Forwarding (802.1Qch) provide bounded latency, guaranteed bandwidth and zero congestion loss, on a network which can support best-effort traffic at the same time.

4.5.1.11 Status of IEEE 802.1 (Updated in 06/2017)

The 802.1 working group has five active task groups: Maintenance, Time-Sensitive Networking (TSN), Security, Data Center Bridging (DCB) and OmniRAN. Note that last year, a new Industry Connections activity was started to explore IEEE 802 Network Enhancements For the Next Decade the Interworking. This activity will assess emerging requirements for IEEE 802-based communication infrastructures, identify commonalities, gaps, and trends not currently addressed by IEEE 802 standards and projects, and facilitate building industry consensus towards proposals to initiate new standards development efforts. The 802.1 working group has over 20 active projects ranging from revisions of existing work (like the MAC service definition), addition of new bridging features (like frame replication), support of YANG modelling and application to new verticals (like fronthaul).

Within each TG there are a number of active projects as shown below:

Security

- [802.1AR-rev](#) - Secure Device Identity - Revision
- [802.1Xck](#) - Port-Based Network Access Control Amendment: YANG Data Model
- [802E](#) - Recommended Practice for Privacy Considerations for IEEE 802 Technologies
- [802.1AE-rev](#) - MAC Security (MACsec) - Revision

[Time Sensitive Networking](#)

- [802.1ABcu](#) – LLDP YANG Data Model
- [802.1AS-Rev](#) - Timing and Synchronisation: Timing and Synchronisation for Time-Sensitive Applications – Revision
- [802.1Qcc](#) - Stream Reservation Protocol (SRP) Enhancements and Performance Improvements
- [802.1Qcj](#) - Automatic Attachment to Provider Backbone Bridging (PBB) services
- [802.1CM](#)- Time-Sensitive Networking for Fronthaul
- [802.1Qcp](#) - YANG Data Model
- [802.1Qcr](#) - Asynchronous Traffic Shaping
- [802.1CS](#) – Link-local Registration Protocol
- [802.1Qcw](#) – YANG Data Models for Scheduled Traffic, Frame Preemption, and Per-Stream Filtering and Policing
- [802.1Qcx](#) – YANG Data Model for Connectivity Fault Management

Data Center Bridging

- [802.1Qcy](#) - Virtual Station Interface (VSI) Discovery and Configuration Protocol (VDP) Extension to Support Network Virtualization Overlays Over Layer 3 (NVO3)
- 802.1CQ - Multicast and Local Addresses Assignment

OmniRAN

- [802.1CF](#) - Network Reference Model and Functional Description of IEEE 802 Access Network

Maintenance

- [802.1AX-Rev](#) - Link Aggregation Revision
- [802.1Q-Rev](#) - Bridges and Bridged Networks Revision
- 802.1ACct – MAC Service Definition - Support for 802.15.3
- [802.1AC-2016-Cor1](#) – MAC Service – LLC Encapsulation EtherType Corrigendum

The following are the current new projects under development:

[P802.1CBcy](#) - Frame Replication and Elimination for Reliability Amendment: Information Model, YANG Data Model and MIB Module

This amendment specifies a Unified Modeling Language (UML) based information model for the capabilities currently specified in clauses 9 and 10 of 802.1CB. A YANG data model and a MIB module both based on that UML model support configuration and status reporting.

P802.1Qcz - Congestion Isolation

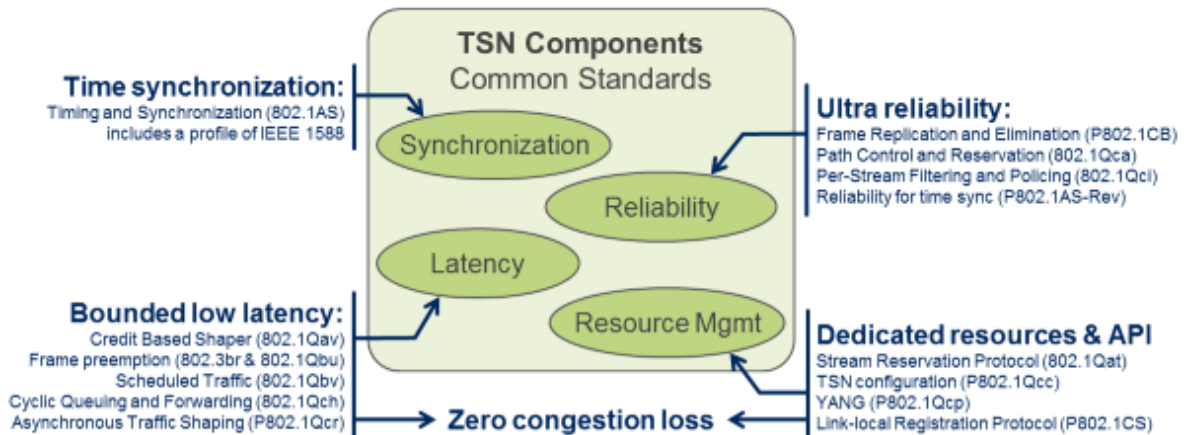
This amendment specifies improvements to 802.1Q Congestion Management to support current layer 3 environments in data centres. Congestion Isolation provides mitigation of Head-of-Line blocking caused by priority flow control and improvement of flow completion times.

Ongoing projects related to OTNT

Time Sensitive Networking

This task group is home to a group of standards projects and can be summarized in the following diagram:

IEEE 802.1 Time-Sensitive Networking (TSN)



Guaranteed data transport with bounded low latency, low delay variation, and extremely low loss

<http://www.ieee802.org/1/pages/tsn.html>

API: Application Programming Interface; YANG: a data modeling language

IEEE STANDARDS ASSOCIATION



[802 Network Enhancements for the next decade](#) (e.g., 5G)

As a result of the IEEE 802 5G standing committee, the 802.1 OmniRAN TG agreed to create an Industry Connections activity to develop requirements for 802 network enhancements (including those related to 5G). This would effectively be an architectural description of all 802 technologies (wired and wireless) and would comprise an access network with appropriate interfaces that could be applicable for some 5G use cases. Several verticals including automotive, industrial and the cable industry have been noted as potential beneficiaries of enhancements for 802 networks. This activity will identify requirements that could result in new standards projects.

Currently two areas are developing reports: Flexible Factory IOT and Lossless Network for Data Centers.

[P802.1CM](#) – Profile for Fronthaul

This standard defines profiles that select features, options, configurations, defaults, protocols and procedures of bridges, stations and LANs that are necessary to build networks that are capable of transporting fronthaul streams, which are time sensitive.

This project is being developed with the participation of the CPRI cooperation. There is a draft in task group ballot. This draft includes the requirements of CPRI 7.0 as Class 1 and contains a placeholder for eCPRI as Class 2 that is expected to be added after the next plenary. Class 1 is then described, including the limits of synchronization/syntonization accuracy, and subdivided into two profiles based on either strict priority queues or pre-emption.

The draft is in working group ballot, and a recent [tutorial](#) was provided to MEF Forum.

[P802.1AX-rev](#) – Link Aggregation

Link Aggregation (LAG) allows the establishment of full-duplex point-to-point links that have a higher aggregate bandwidth than the individual links that form the aggregation, and the use of multiple systems at each end of the aggregation. This allows improved utilization of available links in bridged local area network (LAN) environments, along with improved resilience in the face of failure of individual links or systems.

This revision will correct and clarify Link Aggregation specifications in the light of implementation experience to ensure interoperability and ensure proper operation. In addition, a LAG YANG module is in scope of the revision.

[P802.1Xck](#) – YANG data model

This standard specifies a YANG data model that allows configuration and status reporting for port-based network access control for IEEE Std. 802.1X and IEEE Std 802.1AE, using the information model already specified.

802.1Xck YANG model derived from IEEE Std 802.1Xbx, Figure 12-3 (PAE management information UML model)

The draft is in working group ballot, and 802.1X YANG modules are also deposited in GitHub in IEEE branch (<https://github.com/YangModels/yang>)

P802.1Qcp – YANG data model

This standard specifies a UML-based information model and a YANG data model that allows configuration and status reporting for bridges and bridge components including TPMRs, MAC Bridges, Customer VLAN Bridges, and Provider Bridges. It further defines the relationship between the information and data model and models for the other management capabilities specified in this standard and for IEEE Std 802.1AX and IEEE Std 802.1X

802.1Qcp YANG model is derived from UML models that are based from IEEE Std 802.1Q, Clause 12 (Bridge management)

The draft is in working group ballot, and 802.1Q YANG modules are also deposited in GitHub in the IEEE branch (<https://github.com/YangModels/yang>)

P802.1Qcx - CFM YANG data model

This amendment specifies a Unified Modeling Language (UML)-based information model and a YANG data model that allows configuration and status reporting for bridges and bridge components for Connectivity Fault Management (CFM) as specified in 802.1Q. It further defines the relationship between the information and data model and models for the other management capabilities.

This project will require coordination with ITU-T SG15 as well as MEF.

P802.1ABcu - LLDP YANG data model

This amendment specifies a Unified Modeling Language (UML)-based information model and a YANG data model that allows configuration and status reporting for bridges and bridge components with regards to topology discovery with the capabilities currently specified in clauses 10 (LLDP management) and 11 (LLDP MIB definitions) of 802.1AB.

YANGsters - IEEE 802 YANG editors' coordination

This group is responsible for discussing common practice for YANG models supporting IEEE 802 protocols. This common practice includes, but is not limited to, URN root, style, structure, tooling and process. While the primary attendees are expected to be editors of existing IEEE 802 YANG projects, other experts interested in YANG are welcome.

Published IEEE 802 standards are available free of charge six months after publication from the following website: <http://standards.ieee.org/getieee802/>

For the first six months, they are available for sale from the following website (note that corrigenda are free of charge):

<http://www.techstreet.com/ieee/subgroups/38361>

4.5.1.12 Status of IEEE 802.3 (Updated in 02/2018)

The following are the IEEE 802.3 standards currently in force:

- The base standard, IEEE Std 802.3-2015, was approved by the Standards Board on 3 September 2015 and was published on 4 March 2016.

- Nine amendments and a corrigendum are currently in force:
 - IEEE Std 802.3bz-2016 - *Media Access Control Parameters, Physical Layers, and Management Parameters for 2.5 Gb/s and 5 Gb/s Operation, Types 2.5GBASE-T and 5GBASE-T*, was approved on 22nd September 2016 and published on 18th October 2016.
 - IEEE Std 802.3bn-2016 - *Physical Layer Specifications and Management Parameters for Ethernet Passive Optical Networks Protocol over Coax*, was approved on 22nd September 2016 and published on 7th December 2016.
 - IEEE Std 802.3bu-2016 – *Physical Layer and Management Parameters for Power over Data Lines (PoDL) of Single Balanced Twisted-Pair Ethernet*, was approved on 7th December 2016 and published on 7th February 2017.
 - IEEE Std 802.3bv-2017 - *Physical Layer Specifications and Management Parameters for 1000 Mb/s Operation Over Plastic Optical Fiber*, was approved on 14th February 2017 and published on 14th March 2017.
 - IEEE Std 802.3-2015 Cor 1-2017 - *Multi-lane Timestamping*, was approved on 23rd March 2017 and published on 21st April 2017.
 - IEEE Std 802.3bw-2015 - *Physical Layer Specifications and Management Parameters for 100 Mb/s Operation over a Single Balanced Twisted Pair Cable (100BASE-T1)* which was approved by the Standard Board on 26 October 2015 and published on 8 March 2016.
 - IEEE Std 802.3by-2016 - *Media Access Control Parameters, Physical Layers, and Management Parameters for 25 Gb/s Operation*, which was approved on 30 June 2016 and published on 29 July 2016.
 - IEEE Std 802.3bq-2016 - *Physical Layer and Management Parameters for 25 Gb/s and 40 Gb/s Operation, Types 25GBASE-T and 40GBASE-T* – which was approved on 30 June 2016 and published on 8 September 2016.
 - IEEE Std 802.3bp-2016 - *Physical Layer Specifications and Management Parameters for 1 Gb/s Operation over a Single Twisted Pair Copper Cable* – which was approved on 30 June 2016 and published on 9 September 2016.
 - IEEE Std 802.3br-2016 - *Specification and Management Parameters for Interspersing Express Traffic* – which was approved on 30 June 2016 and published on 14 October 2016.
 - IEEE Std 802.3bs-2017 - *Media Access Control Parameters, Physical Layers, and Management Parameters for 200 Gb/s and 400 Gb/s Operation* – which was approved on 6th December 2017 and published on 12th December 2017
 - IEEE Std 802.3cc-2017 - *Physical Layer and Management Parameters for Serial 25 Gb/s Ethernet Operation Over Single-Mode Fiber* – which was approved on 6th December 2017 and published on 15th January 2018.

- The current version of the Ethernet MIBs standard is published as IEEE Std 802.3.1-2013. The following Task Forces, Study Groups, and ad hoc groups are currently active within the IEEE 802.3 working group:

- The IEEE P802.3bt DTE Power via MDI over 4-Pair Task Force is currently in the Sponsor Ballot phase.
- The IEEE P802.3ca 25 Gb/s, 50 Gb/s, and 100 Gb/s Passive Optical Networks Task Force is working to select baselines.
- The IEEE P802.3cb 2.5 Gb/s and 5 Gb/s Backplane Task Force is in the Sponsor ballot phase.
- The IEEE P802.3cd 50 Gb/s, 100 Gb/s, and 200 Gb/s Ethernet Task Force is in the Sponsor

ballot phase.

- The IEEE P802.3cf YANG data models Task Force has selected objectives and the draft is in the Working Group ballot phase.
- The IEEE P802.3cg 10 Mb/s Single Twisted Pair Ethernet Task Force has selected objectives.
- The IEEE P802.3ch Multi-Gig Automotive PHY Task Force is in the proposal selection phase.

In addition to the projects described above, the next revision project, which is expected to become IEEE Std 802.3-2018 once completed, is in Sponsor ballot. This is expected to update IEEE Std 802.3-2015 by including the eleven approved amendments and corrigendum, and all ready-for-ballot maintenance requests.

4.5.2 Standardization activities on Ethernet

Standardization work on "carrier-class" Ethernet is conducted within ITU-T SG12, ITU-T SG15, IEEE 802.1 WG, IEEE 802.3 WG, IETF, and MEF. The table below summarizes the current standardization responsibilities on "carrier-class" Ethernet. Table 8 lists the current status of individual Ethernet-related ITU-T Recommendations.

Table 2 – Standardization on "carrier-class" Ethernet

#	Standard bodies	Q/SG or WG	Study items
1	ITU-T SG12	Q17/12	Ethernet services performance
2	ITU-T SG15	Q3/15	Coordination on OTN including optical Ethernet
		Q9/15	Ethernet protection/restoration
		Q10/15	Ethernet OAM mechanisms and equipment functional architecture
		Q11/15	Ethernet Service description and frame mapping (GFP)
		Q12/15	Ethernet architecture
		Q13/15	Synchronous Ethernet
		Q14/15	Management aspects of Ethernet
3	IEEE 802	802.1	Higher layers above the MAC (including Network level Ethernet OAM mechanisms, Provider bridges, Provider backbone bridges, and quality of service)
		802.3	Standard for Ethernet
4	IETF (Refer to Annex B on organization restructuring)	CCAMP WG	common control plane and measurement plane solutions and GMPLS mechanisms/protocol extensions to support source-controlled and explicitly-routed Ethernet data paths for Ethernet data planes
		MPLS WG	many elements of the support of Ethernet "carrier-class" pseudowires over MPLS and MPLS-TP networks
		L2VPN WG	Layer 2 Virtual Private Networks
		PWE3 WG	encapsulation, transport, control, management, interworking and security of Ethernet services emulated over MPLS enabled IP packet switched networks
5	MEF	Technical Committee	Service attributes including traffic and performance parameters, service definitions, Aggregation and E-NNI interfaces, management interfaces, performance monitoring, and test specifications.

4.5.3 Further details

Further details about standardization on Ethernet can be found on the following websites:

ITU-T SG12 : <http://www.itu.int/ITU-T/studygroups/com12/index.asp>

ITU-T SG13: <http://www.itu.int/ITU-T/studygroups/com13/index.asp>

ITU-T SG15: <http://www.itu.int/ITU-T/studygroups/com15/index.asp>

IEEE 802.1 WG: <http://www.ieee802.org/1/>

IEEE 802.3 WG: <http://www.ieee802.org/3/>

IETF: <http://www.ietf.org/>

MEF: <https://www.mef.net/>

5 OTNT correspondence and Liaison tracking

5.1 OTNT related contacts

The International Telecommunication Union - Telecommunications Sector (ITU-T) maintains a strong focus on global OTNT standardization. It is supported by other organizations that contribute to specific areas of the work at both the regional and global levels. Below is a list of the most notable organizations recognised by the ITU-T and their URL for further information.

- ATIS - Alliance for Telecommunications Industry Solutions: <http://www.atis.org>
- TIA - Telecommunications Industry Association: <http://www.tiaonline.org>
- IEC - International Electrotechnical Commission: <http://www.iec.ch/>
- IETF - Internet Engineering Task Force: <http://www.ietf.org>
- IEEE 802 LAN/MAN Standards Committee: <http://www.ieee802.org/>
- Optical Internetworking Forum (OIF) Technical Committee:
<http://www.oiforum.com/public/techcommittee.html>
- Broadband (ex. IP/MPLS) Forum: <http://www.broadband-forum.org/>
- MEF Technical Committee: <https://www.mef.net/>
- TMF- TeleManagement Forum: <http://www.tmforum.org/browse.aspx>

6 Overview of existing standards and activity

With the rapid progress on standards and implementation agreements on OTNT, it is often difficult to find a complete list of the relevant new and revised documents. It is also sometimes difficult to find a concise representation of related documents across the different organizations that produce them. This clause attempts to satisfy both of those objectives by providing concise tables of the relevant documents.

6.1 New or revised OTNT standards or implementation agreements

Many documents, at different stages of completion, address the different aspect of the OTNT space. The table below lists the known drafts and completed documents under revision that fit into this area. The table does not list all established documents which might be under review for slight changes or addition of features.

Three major families of documents (and more) are represented by fields in the following table, SDH/SONET, OTN Transport Plane, and ASON Control Plane. All of the recommendations and standards of the three families are included in tables in the later clauses of this document.

Table 3 – OTNT Related Standards and Industry Agreements (ITU-T Recommendations)

Organization (Subgroup responsible)	Number	Title
ITU-T (SG2)	M.2401 (12/2003)	Error performance limits and procedures for bringing-into-service and maintenance of multi-operator international paths and sections within an optical transport network
ITU-T (Q17/12)	Y.1563 (01/2009)	Ethernet frame transfer and availability performance
ITU-T (Q2/15)	G.983.1 (01/2005)	Broadband optical access systems based on Passive Optical Networks (PON)
ITU-T (Q2/15)	G.983.2 (07/2005)	ONT management and control interface specification for B-PON
ITU-T (Q2/15)	G.983.3 (03/2001)	A broadband optical access system with increased service capability by wavelength allocation
ITU-T (Q2/15)	G.983.4 (11/2001)	A broadband optical access system with increased service capability using dynamic bandwidth assignment
ITU-T (Q2/15)	G.983.5 (01/2002)	A broadband optical access system with enhanced survivability
ITU-T (Q2/15)	G.984.1 (03/2008)	Gigabit-capable passive optical networks (GPON): General characteristics
ITU-T (Q2/15)	G.984.2 (03/2003)	Gigabit-capable Passive Optical Networks (G-PON): Physical Media Dependent (PMD) layer specification
ITU-T (Q2/15)	G.984.3 (01/2014)	Gigabit-capable passive optical networks (G-PON): Transmission convergence layer specification
ITU-T (Q2/15)	G.984.4 (02/2008)	Gigabit-capable passive optical networks (G-PON): ONT management and control interface specification
ITU-T (Q2/15)	G.984.5 (05/2014)	Gigabit-capable passive optical networks (G-PON): Enhancement band
ITU-T (Q2/15)	G.984.6 (03/2008)	Gigabit-capable passive optical networks (GPON): Reach extension
ITU-T (Q2/15)	G.984.7 (07/2010)	Gigabit-capable passive optical networks (GPON): Long reach
ITU-T (Q2/15)	G.985 (03/2003)	100 Mbit/s point-to-point Ethernet based optical access system
ITU-T (Q2/15)	G.986 (01/2010)	1 Gbit/s point-to-point Ethernet-based optical access system
ITU-T (Q2/15)	G.987 (06/2012)	10-Gigabit-capable passive optical network (XG-PON) systems: Definitions, abbreviations and acronyms
ITU-T (Q2/15)	G.987.1 (03/2016)	10-Gigabit-capable passive optical networks (XG-PON): General requirements
ITU-T (Q2/15)	G.987.2 (10/2010)	10-Gigabit-capable passive optical networks (XG-PON): Physical media dependent (PMD) layer specification
ITU-T (Q2/15)	G.987.3 (01/2014)	10-Gigabit-capable passive optical networks (XG-PON): Transmission convergence (TC) layer specification
ITU-T (Q2/15)	G.987.4 (06/2012)	10-Gigabit-capable passive optical networks (XG-PON): Reach extension
ITU-T (Q2/15)	G.988 (10/2012)	ONU management and control interface (OMCI) specification
ITU-T (Q2/15)	G.989.1 (03/2013)	40-Gigabit-capable passive optical networks (NG-PON2): General requirements
ITU-T (Q2/15)	G.989.2 (12/2014)	40-Gigabit-capable passive optical networks 2 (NG-PON2): Physical media dependent (PMD) layer specification
ITU-T (Q3/15)	G.780/Y.1351 (07/2010)	Terms and definitions for synchronous digital hierarchy (SDH) networks
ITU-T (Q3/15)	G.870/Y.1352 (11/2016)	Terms and definitions for optical transport networks
ITU-T (Q3/15)	G.8001/Y.1354 (04/2016)	Terms and definitions for Ethernet frames over transport
ITU-T (Q3/15)	G.8081/Y.1353 (02/2012)	Terms and definitions for automatically switched optical networks
ITU-T (Q3/15)	G.8101/Y.1355 (11/2016)	Terms and definitions for MPLS transport profile
ITU-T (Q5/15)	G.650.1 (07/2010)	Definitions and test methods for linear, deterministic attributes of single-mode fibre and cable
ITU-T (Q5/15)	G.650.2 (07/2007)	Definitions and test methods for statistical and non-linear related attributes of single-mode fibre and cable
ITU-T (Q5/15)	G.650.3 (03/2008)	Test methods for installed single-mode optical fibre cable links

Organization (Subgroup responsible)	Number	Title
ITU-T (Q5/15)	G.651.1 (07/2007)	Characteristics of a 50/125 µm multimode graded index optical fibre cable for the optical access network
ITU-T (Q5/15)	G.652 (11/2016)	Characteristics of a single-mode optical fibre and cable
ITU-T (Q5/15)	G.653 (07/2010)	Characteristics of a dispersion-shifted, single-mode optical fibre and cable
ITU-T (Q5/15)	G.654 (11/2016)	Characteristics of a cut-off shifted single-mode optical fibre and cable
ITU-T (Q5/15)	G.655 (11/2009)	Characteristics of a non-zero dispersion-shifted single-mode optical fibre and cable
ITU-T (Q5/15)	G.656 (07/2010)	Characteristics of a fibre and cable with non-zero dispersion for wideband optical transport
ITU-T (Q5/15)	G.657 (11/2016)	Characteristics of a bending-loss insensitive single-mode optical fibre and cable for the access network
ITU-T (Q6/15)	G.664 (10/2012)	Optical safety procedures and requirements for optical transmission systems
ITU-T (Q6/15)	G.680 (07/2007)	Physical transfer functions of optical network elements
ITU-T (Q6/15)	G.691 (03/2006)	Optical interfaces for single channel STM-64 and other SDH systems with optical amplifiers
ITU-T (Q6/15)	G.692 (10/1998)	Optical interfaces for multichannel systems with optical amplifiers
ITU-T (Q6/15)	G.693 (11/2009)	Optical interfaces for intra-office systems
ITU-T (Q6/15)	G.694.1 (02/2012)	Spectral grids for WDM applications: DWDM frequency grid
ITU-T (Q6/15)	G.694.2 (12/2003)	Spectral grids for WDM applications: CWDM wavelength grid
ITU-T (Q6/15)	G.695 (01/2015)	Optical interfaces for coarse wavelength division multiplexing applications
ITU-T (Q6/15)	G.696.1 (07/2010)	Longitudinally compatible intra-domain DWDM applications
ITU-T (Q6/15)	G.697 (11/2016)	Optical monitoring for dense wavelength division multiplexing systems
ITU-T (Q6/15)	G.698.1 (11/2009)	Multichannel DWDM applications with single-channel optical interfaces
ITU-T (Q6/15)	G.698.2 (11/2009)	Amplified multichannel dense wavelength division multiplexing applications with single channel optical interfaces
ITU-T (Q6/15)	G.698.3 (02/2012)	Multichannel seeded DWDM applications with single-channel optical interfaces
ITU-T (Q6/15)	G.698.4 (xx/2018)	Multichannel bi-directional DWDM applications with port agnostic single-channel optical interfaces
ITU-T (Q6/15)	G.911 (04/1997)	Parameters and calculation methodologies for reliability and availability of fibre optic systems
ITU-T (Q6/15)	G.957 (03/2006)	Optical interfaces for equipment and systems relating to the synchronous digital hierarchy
ITU-T (Q6/15)	G.959.1 (04/2016)	Optical transport network physical layer interfaces
ITU-T (Q7/15)	G.671 (02/2012)	Transmission characteristics of optical components and subsystems
ITU-T (Q7/15)	G.672 (10/2012)	Characteristics of multi-degree reconfigurable optical add/drop multiplexers
ITU-T (Q11/15)	G.781 (09/2008)	Synchronization layer functions
ITU-T (Q11/15)	G.783 (03/2006)	Characteristics of synchronous digital hierarchy (SDH) equipment functional blocks
ITU-T (Q11/15)	G.798 (12/2012)	Characteristics of optical transport network hierarchy equipment functional blocks
ITU-T (Q11/15)	G.806 (02/2012)	Characteristics of transport equipment – Description methodology and generic functionality
ITU-T (Q11/15)	G.871/Y.1301 (10/2000)	Framework of Optical Transport Network Recommendations
ITU-T (Q9/15)	G.808 (11/2016)	Terminology for protection and restoration
ITU-T (Q9/15)	G.808.1 (05/2014)	Generic protection switching – Linear trail and subnetwork protection
ITU-T (Q9/15)	G.808.2 (11/2013)	Generic protection switching – Ring protection
ITU-T (Q9/15)	G.808.3 (10/2012)	Generic protection switching – Shared mesh protection
ITU-T (Q9/15)	G.841 (10/1998)	Types and characteristics of SDH network protection architectures
ITU-T (Q9/15)	G.842 (04/1997)	Interworking of SDH network protection architectures
ITU-T (Q9/15)	G.873.1 (10/2017)	Optical transport network (OTN): Linear protection

Organization (Subgroup responsible)	Number	Title
ITU-T (Q9/15)	G.873.2 (07/2015)	ODUk shared ring protection
ITU-T (Q9/15)	G.873.3 (09/2017)	OTN Shared Mesh Protection
ITU-T (Q10/15)	G.8021/Y.1341 (11/2016)	Characteristics of Ethernet transport network equipment functional blocks
ITU-T (Q10/15)	G.8021.1/Y.1341.1 (10/2012)	Types and characteristics of Ethernet transport network equipment
ITU-T (Q9/15)	G.8031/Y.1342 (01/2015)	Ethernet linear protection switching
ITU-T (Q9/15)	G.8032/Y.1344 (02/2012)	Ethernet ring protection switching
ITU-T (Q9/15)	G.8131/Y.1382 (07/2014)	Linear protection switching for MPLS transport profile
ITU-T (Q9/15)	G.8132/Y.1383 (08/2017)	MPLS-TP shared ring protection
ITU-T (Q9/15)	Y.1720 (12/2006)	Protection switching for MPLS networks
ITU-T (Q10/15)	G.8011/Y.1307 (11/2016)	Ethernet service characteristics
ITU-T (Q10/15)	G.8012/Y.1308 (08/2004)	Ethernet UNI and Ethernet NNI
ITU-T (Q10/15)	G.8012.1/Y.1308.1 (12/2012)	Interfaces for the Ethernet transport network
ITU-T (Q10/15)	G.8013/Y.1731 (11/2013)	OAM functions and mechanisms for Ethernet based networks
ITU-T (Q10/15)	G.8112/Y.1371 (10/2012)	Interfaces for the MPLS Transport Profile layer network
ITU-T (Q10/15)	G.8113.1/Y.1372.1 (04/2016)	Operations, administration and maintenance mechanism for MPLS-TP in packet transport networks
ITU-T (Q10/15)	G.8113.2/Y.1372.2 (11/2012)	Operations, administration and maintenance mechanisms for MPLS-TP networks using the tools defined for MPLS
ITU-T (Q10/15)	G.8121/Y.1381 (04/2016)	Characteristics of MPLS-TP equipment functional blocks
ITU-T (Q10/15)	G.8121.1/Y.1381.1 (04/2016)	Characteristics of MPLS-TP equipment functional blocks supporting ITU-T G.8113.1/Y.1372.1 OAM mechanisms
ITU-T (Q10/15)	G.8121.2/Y.1381.2 (04/2016)	Characteristics of MPLS-TP equipment functional blocks supporting ITU-T G.8113.2/Y.1372.2 OAM mechanisms
ITU-T (Q10/15)	Y.1710 (11/2002)	Requirements for Operation & Maintenance functionality in MPLS networks
ITU-T (Q10/15)	Y.1711 (02/2004)	Operation & Maintenance mechanism for MPLS networks
ITU-T (Q10/15)	Y.1712 (01/2004)	OAM functionality for ATM-MPLS interworking
ITU-T (Q10/15)	Y.1713 (03/2004)	Misbranching detection for MPLS networks
ITU-T (Q10/15)	Y.1714 (01/2009)	MPLS management and OAM framework
ITU-T (Q10/15)	Y.1730 (01/2004)	Requirements for OAM functions in Ethernet-based networks and Ethernet services
ITU-T (Q11/15)	G.707/Y.1322 (01/2007)	Network node interface for the synchronous digital hierarchy (SDH)
ITU-T (Q11/15)	G.709/Y.1331 (06/2016)	Interfaces for the optical transport network (OTN)
ITU-T (Q11/15)	G.709.1/Y.1331.1 (01/2017)	Flexible OTN short-reach interface
ITU-T (Q11/15)	G.798.1 (01/2013)	Types and characteristics of optical transport network equipment

Organization (Subgroup responsible)	Number	Title
ITU-T (Q11/15)	G.7041/Y.1303 (08/2016)	Generic framing procedure
ITU-T (Q11/15)	G.7042/Y.1305 (03/2006)	Link capacity adjustment scheme (LCAS) for virtual concatenated signals
ITU-T (Q11/15)	G.7043/Y.1343 (07/2004)	Virtual concatenation of plesiochronous digital hierarchy (PDH) signals
ITU-T (Q11/15)	G.7044/Y.1347 (10/2011)	Hitless adjustment of ODUflex(GFP)
ITU-T (Q11/15)	G.8201 (04/2011)	Error performance parameters and objectives for multi-operator international paths within optical transport networks
ITU-T (Q12/15)	G.800 (04/2016)	Unified functional architecture of transport networks
ITU-T (Q12/15)	G.805 (03/2000)	Generic functional architecture of transport networks
ITU-T (Q12/15)	G.872 (01/2017)	Architecture of optical transport networks
ITU-T (Q12/15)	G.7701 (11/2016)	Common Control Aspects
ITU-T (Q12/15)	G.8010/Y.1306 (02/2004)	Architecture of Ethernet layer networks
ITU-T (Q12/15)	G.8080/Y.1304 (02/2012)	Architecture for the automatically switched optical network
ITU-T (Q12/15)	G.8110/Y.1370 (01/2005)	MPLS layer network architecture
ITU-T (Q12/15)	G.8110.1/Y.1370.1 (12/2011)	Architecture of the Multi-Protocol Label Switching transport profile layer network
ITU-T (Q13/15)	G.813 (03/2003)	Timing characteristics of SDH equipment slave clocks (SEC)
ITU-T (Q13/15)	G.8251 (09/2010)	The control of jitter and wander within the optical transport network (OTN)
ITU-T (Q13/15)	G.8260 (02/2012)	Definitions and terminology for synchronization in packet networks
ITU-T (Q13/15)	G.8261/Y.1361 (08/2013)	Timing and synchronization aspects in packet networks
ITU-T (Q13/15)	G.8261.1/Y.1361.1 (02/2012)	Packet delay variation network limits applicable to packet-based methods (Frequency synchronization)
ITU-T (Q13/15)	G.8262/Y.1362 (01/2015)	Timing characteristics of a synchronous Ethernet equipment slave clock
ITU-T (Q13/15)	G.8264/Y.1364 (05/2014)	Distribution of timing information through packet networks
ITU-T (Q13/15)	G.8265/Y.1365 (10/2010)	Architecture and requirements for packet-based frequency delivery
ITU-T (Q13/15)	G.8265.1/Y.1365.1 (07/2014)	Precision time protocol telecom profile for frequency synchronization
ITU-T (Q13/15)	G.8266/Y.1376 (11/2016)	Timing characteristics of telecom grandmaster clocks for frequency synchronization
ITU-T (Q13/15)	G.8271/Y.1366 (07/2016)	Time and phase synchronization aspects of packet networks
ITU-T (Q13/15)	G.8271.1/Y.1366.1 (08/2013)	Network limits for time synchronization in packet networks
ITU-T (Q13/15)	G.8272/Y.1367 (01/2015)	Timing characteristics of primary reference time clocks
ITU-T (Q13/15)	G.8272.1/Y.1367.1 (11/2016)	Timing characteristics of enhanced primary reference time clocks
ITU-T (Q13/15)	G.8273/Y.1368 (08/2013)	Framework of phase and time clocks

Organization (Subgroup responsible)	Number	Title
ITU-T (Q13/15)	G.8273.2/Y.1368.2 (01/2017)	Timing characteristics of telecom boundary clocks and telecom time slave clocks
ITU-T (Q13/15)	G.8275/Y.1369 (11/2013)	Architecture and requirements for packet-based time and phase distribution
ITU-T (Q13/15)	G.8275.1/Y.1369.1 (06/2014)	Precision time protocol telecom profile for phase/time synchronization with full timing support from the network
ITU-T (Q13/15)	G.8275.2/Y.1369.2 (06/2016)	Precision time Protocol Telecom Profile for time/phase synchronization with partial timing support from the network
ITU-T (Q14/15)	G.784 (03/2008)	Management aspects of synchronous digital hierarchy (SDH) transport network elements
ITU-T (Q14/15)	G.874 (08/2017)	Management aspects of optical transport network elements
ITU-T (Q14/15)	G.874.1 (11/2016)	Optical transport network: Protocol-neutral management information model for the network element view
ITU-T (Q14/15)	G.7710/Y.1701 (02/2012)	Common equipment management function requirements
ITU-T (Q14/15)	G.7711/Y.1702 (12/2016)	Generic protocol-neutral information model for transport resources
ITU-T (Q14/15)	G.7712/Y.1703 (09/2010)	Architecture and specification of data communication network
ITU-T (Q14/15)	G.7713/Y.1704 (11/2009)	Distributed call and connection management (DCM)
ITU-T (Q14/15)	G.7713.1/Y.1704.1 (03/2003)	Distributed Call and Connection Management (DCM) based on PNNI
ITU-T (Q14/15)	G.7713.2/Y.1704.2 (03/2003)	Distributed Call and Connection Management: Signalling mechanism using GMPLS RSVP-TE
ITU-T (Q14/15)	G.7713.3/Y.1704.3 (03/2003)	Distributed Call and Connection Management: Signalling mechanism using GMPLS CR-LDP
ITU-T (Q14/15)	G.7714/Y.1705 (08/2005)	Generalized automatic discovery for transport entities
ITU-T (Q14/15)	G.7714.1/Y.1705.1 (08/2017)	Protocol for automatic discovery in SDH and OTN networks
ITU-T (Q14/15)	G.7715/Y.1706 (06/2002)	Architecture and requirements for routing in the automatically switched optical networks
ITU-T (Q14/15)	G.7715.1/Y.1706.1 (02/2004)	ASON routing architecture and requirements for link state protocols
ITU-T (Q14/15)	G.7715.2/Y.1706.2 (02/2007)	ASON routing architecture and requirements for remote route query
ITU-T (Q14/15)	G.7716/Y.1707 (01/2010)	Architecture of control plane operations
ITU-T (Q14/15)	G.7718/Y.1709 (07/2010)	Framework for ASON management
ITU-T (Q14/15)	G.7718.1/Y.1709.1 (12/2006)	Protocol-neutral management information model for the control plane view
ITU-T (Q14/15)	G.8051/Y.1345 (08/2015)	Management aspects of the Ethernet Transport (ET) capable network element
ITU-T (Q14/15)	G.8052/Y.1346 (11/2016)	Protocol-neutral management information model for the Ethernet Transport capable network element
ITU-T (Q14/15)	G.8151/Y.1374 (08/2017)	Management aspects of the MPLS-TP network element
ITU-T (Q14/15)	G.8152/Y.1375 (12/2016)	Protocol-neutral management information model for the MPLS-TP network element
ITU-T (Q15/15)	O.172 (04/2005)	Jitter and wander measuring equipment for digital systems which are based on the synchronous digital hierarchy (SDH)
ITU-T (Q15/15)	O.173 (02/2012)	Jitter measuring equipment for digital systems which are based on the optical transport network

Organization (Subgroup responsible)	Number	Title
ITU-T (Q15/15)	O.174 (11/2009)	Jitter and wander measuring equipment for digital systems which are based on synchronous Ethernet technology
ITU-T (Q15/15)	O.175 (10/2012)	Jitter measuring equipment for digital systems based on XG-PON
ITU-T (Q15/15)	O.182 (07/2007)	Equipment to assess error performance on Optical Transport Network interfaces
ITU-T (Q15/15)	O.201 (07/2003)	Q-factor test equipment to estimate the transmission performance of optical channels

Table 4 – OTNT Related Standards and Industry Agreements (IEEE 802 standards)

Organisation (Subgroup responsible)	Number	Title	Publication Date
IEEE 802.1	IEEE Std. 802-2014	IEEE Standard for Local and Metropolitan Area Networks: Overview and Architecture	2014
IEEE 802.1	IEEE Std. 802.1AS-2011	IEEE Standard for Local and Metropolitan Area Networks - Timing and Synchronization for Time-Sensitive Applications in Bridged Local Area Networks	2011
IEEE 802.1	IEEE Std. 802.1AS-2011/Cor 1-2013	IEEE Standard for Local and metropolitan area networks— Timing and Synchronization for Time-Sensitive Applications in Bridged Local Area Networks— Corrigendum 1: Technical and Editorial Corrections	2013
IEEE 802.1	IEEE Std. 802.1AS-2011/Cor 2-2015	IEEE Standard for Local and metropolitan area networks— Timing and Synchronization for Time-Sensitive Applications in Bridged Local Area Networks— Corrigendum 2: Technical and Editorial Corrections	2015
IEEE 802.1	IEEE Std. 802.1AX-2014	Link Aggregation	2008
IEEE 802.1	IEEE 802.1AX-2014/Cor 1-2017	Link Aggregation – Corrigendum 1	2017
IEEE 802.1	IEEE Std. 802.1D-2004	Media access control (MAC) Bridges (Incorporates IEEE 802.1t-2001 and IEEE 802.1w)	2004
IEEE 802.1	IEEE Std. 802.1Q-2014	Virtual Bridged Local Area Networks—Revision	2011
IEEE 802.1	IEEE Std. 802.1Qcd-2015	Application Virtual Local Area Network (VLAN) Type, Length, Value (TLV)	2015
IEEE 802.1	IEEE Std 802.1Qca-2015	Path Control and Reservation	2015
	IEEE Std 802.1Q-2014 Cor 1-2015	Technical and editorial corrections	2015
	IEEE Std 802.1Qbv-2015	Enhancements for scheduled traffic	2015
	IEEE Std 802.1Qbu-2016	Frame preemption	2016
	IEEE Std 802.1Qbz-2016	Enhancements to Bridging of IEEE 802.11 Media	2016
	IEEE Std 802.1Qci-2017	Per-Stream Filtering and Policing	2017
IEEE 802.3	IEEE Std 802.3-2015	IEEE Standard for Ethernet	03/2016

IEEE 802.3	IEEE Std 802.3bw-2015	Amendment 1: Physical Layer Specifications and Management Parameters for 100 Mb/s Operation over a Single Balanced Twisted Pair Cable (100BASE-T1))	03/2016
IEEE 802.3	IEEE Std 802.3bz-2016	Media Access Control Parameters, Physical Layers, and Management Parameters for 2.5 Gb/s and 5 Gb/s Operation, Types 2.5GBASE-T and 5GBASE-T,	10/2016.
IEEE 802.3	IEEE Std 802.3bn-2016	Physical Layer Specifications and Management Parameters for Ethernet Passive Optical Networks Protocol over Coax,	12/2016
IEEE 802.3	IEEE Std 802.3bu-2016	Physical Layer and Management Parameters for Power over Data Lines (PoDL) of Single Balanced Twisted-Pair Ethernet	02/2017
IEEE 802.3	IEEE Std 802.3bv-2017	Physical Layer Specifications and Management Parameters for 1000 Mb/s Operation Over Plastic Optical Fiber,	03/2017.
IEEE 802.3	IEEE Std 802.3-2015 Cor 1-2017	Multi-lane Timestamping,	04/2017.
IEEE 802.3	IEEE Std 802.3by-2016	Media Access Control Parameters, Physical Layers, and Management Parameters for 25 Gb/s Operation,	07/2016
IEEE 802.3	IEEE Std 802.3bq-2016	Physical Layer and Management Parameters for 25 Gb/s and 40 Gb/s Operation, Types 25GBASE-T and 40GBASE-T	09/2016
IEEE 802.3	IEEE Std 802.3bp-2016	Physical Layer Specifications and Management Parameters for 1 Gb/s Operation over a Single Twisted Pair Copper Cable	09/2016
IEEE 802.3	IEEE Std 802.3br-2016	Specification and Management Parameters for Interspersing Express Traffic	10/2016
IEEE 802.3	IEEE Std 802.3bz-2016	Media Access Control Parameters, Physical Layers, and Management Parameters for 2.5 Gb/s and 5 Gb/s Operation, Types 2.5GBASE-T and 5GBASE-T,	10/2016.
IEEE 802.3	IEEE Std 802.3.1-2013	IEEE Standard for Management Information Base (MIB) Definitions for Ethernet	08/2013

Table 5 – OTNT Related Standards and Industry Agreements (MEF documents)

Organisation (Subgroup responsible)	Number	Title	Publication Date
Carrier Ethernet Service Definitions	6.2	Metro Ethernet Services Definitions Phase 3	
Carrier Ethernet Service Definitions	8	Implementation Agreement for the Emulation of PDH Circuits over Metro Ethernet Networks	
Carrier Ethernet Service Definitions	22.2.1	Mobile Backhaul Phase 3 Implementation Agreement	
Carrier Ethernet Service Definitions	28	External Network Network Interface (ENNI) Support for UNI Tunnel Access and Virtual UNI	
Carrier Ethernet Service Definitions	33	Ethernet Access Services Definition	
Carrier Ethernet Service Definitions	43	Virtual NID (vNID) Functionality for E-Access Services	
Carrier Ethernet Service Definitions	47	Carrier Ethernet Services for Cloud implementation Agreement	
Carrier Ethernet Service Definitions	51	OVC Services Definitions	
Carrier Ethernet Service Attributes	10.3	Ethernet Services Attributes Phase 3	
Carrier Ethernet Service Attributes	10.3.1	Composite Performance Metric (CPM) Amendment to MEF 10.3	
Carrier Ethernet Service Attributes	10.3.2	UNI Resiliency Enhancement Amendment to MEF 10.3	
Carrier Ethernet Service Attributes	23.2	Class of Service Phase 3 Implementation Agreement	
Carrier Ethernet Service Attributes	23.2.1	Models for Bandwidth Profiles with Token Sharing	
Carrier Ethernet Service Attributes	26.2	External Network Network Interface (ENNI) and Operator Service Attributes	
Carrier Ethernet Service Attributes	41	Generic Token Bucket Algorithm	
Carrier Ethernet Service Definitions	45	Multi-CEN L2CP	
Carrier Ethernet Service Definitions	45.0.1	OVC Services Requirement for L2CP	
Architecture	2	Requirements and Framework for Ethernet Service Protection	
Architecture	3	Circuit Emulation Service Definitions, Framework and Requirements in Metro Ethernet Networks	
Architecture	4	Metro Ethernet Network Architecture Framework Part 1: Generic Framework	
Architecture	11	User Network Interface (UNI) Requirements and Framework	
Architecture	12.2	Carrier Ethernet Network Architecture Framework Part 2: Ethernet Services Layer	
Architecture	13	User Network Interface (UNI) Type 1 Implementation Agreement	
Architecture	20	UNI Type 2 Implementation Agreement	
Architecture	29	Ethernet Services Constructs	
Architecture	32	Requirements for Service Protection Across External Interfaces	
Information and Data Models	7.3	Carrier Ethernet Management Information Model	
Information and Data Models	31	Service OAM Fault Management Definition of Managed Objects (SNMP)	
Information and Data Models	31.0.1	Amendment to Service OAM SNMP MIB for Fault Management	

Organisation (Subgroup responsible)	Number	Title	Publication Date
Information and Data Models	36.1	Service OAM SNMP MIB for Performance Monitoring	
Information and Data Models	38	Service OAM Fault Management YANG Modules	
Information and Data Models	39	Service OAM Performance Monitoring YANG Module	
Information and Data Models	40	UNI and EVC Definition of Managed Objects (SNMP)	
Information and Data Models	42	ENNI and OVC Definition of Managed Objects (SNMP)	
Information and Data Models	44	Virtual NID (vNID) Definition of Managed Objects (SNMP)	
Service Activation and Test	46	Latching Loopback Protocol and Functionality	
Service Activation and Test	48	Service Activation Testing	
Service Activation and Test	49	Service Activation Testing Control Protocol and PDU Formats	
SOAM Fault and Performance Management	17	Service OAM Framework and Requirements	
SOAM Fault and Performance Management	30.1	Service OAM Fault Management Implementation Agreement Phase 2	
SOAM Fault and Performance Management	30.1.1	Amendment to MEF 30.1 - Correction to Requirement	
SOAM Fault and Performance Management	35.1	SOAM PM Implementation Agreement Amendment	
Management	15	Requirements for Management of Metro Ethernet Phase 1 Network Elements	
Management	16	Ethernet Local Management Interface	
MEF Service Lifecycle	50	Service Operations Guidelines A process model for the generic Carrier Ethernet service lifecycle, including Service Operations Lifecycle management and Product Lifecycle management. It establishes a foundation for specifications developed by the MEF Service Operations Committee.	
Abstract Test Suites	9	Abstract Test Suite for Ethernet Services at the UNI	
Abstract Test Suites	14	Abstract Test Suite for Traffic Management Phase 1	
Abstract Test Suites	18	Abstract Test Suite for Circuit Emulation Services	
Abstract Test Suites	19	Abstract Test Suite for UNI Type 1	
Abstract Test Suites	21	Abstract Test Suite for UNI Type 2 Part 1 Link OAM	
Abstract Test Suites	24	Abstract Test Suite for UNI Type 2 Part 2 E-LMI	
Abstract Test Suites	25	Abstract Test Suite for UNI Type 2 Part 3 Service OAM	
Abstract Test Suites	27	Abstract Test Suite For UNI Type 2 Part 5: Enhanced UNI Attributes & Part 6: L2CP Handling	
Abstract Test Suites	34	ATS for Ethernet Access Services	
Abstract Test Suites	37	Abstract Test Suite for ENNI	

6.2 SDH & SONET Related Recommendations and Standards

Refer to Issue 21 of this standard work plan document.

6.3 ITU-T Recommendations on the OTN Transport Plane

The following table lists all of the known ITU-T Recommendations specifically related to the OTN Transport Plane. Many also apply to other types of optical networks.

Table 6 – ITU-T Recommendations on the OTN Transport Plane

	ITU-T Published Recommendations
Definitions	G.870 Definitions and Terminology for Optical Transport Networks (OTN)
Architectural Aspects	G.872 Architecture of Optical Transport Networks
Control Plane	ASTN/ASON recommendations are moved to specific ASTN/ASON standards page.
Structures & Mapping	G.709/Y.1331 Interfaces for the Optical Transport Network (OTN)
	G.709.1/Y.1331.1 Flexible OTN short-reach interface
	G.975 Forward Error Correction
	G.798 Characteristics of optical transport network (OTN) equipment functional blocks
	G.806 Characteristics of transport equipment - Description Methodology and Generic Functionality
	G.7041 Generic Framing Procedure
	G.7042 Link capacity adjustment scheme (LCAS) for virtual concatenated signals
	G.Sup43 Transport of IEEE 10GBASE-R in optical transport networks (OTN)
	G.873.1 Optical Transport network (OTN) - Linear Protection
Protection Switching	G.873.2 ODUk shared ring protection
	G.873.3 OTN shared mesh protection
	G.874 Management aspects of the optical transport network element
Management Aspects	G.Imp874 Implementer's Guide
	G.874.1 Optical Transport Network (OTN) Protocol-Neutral Management Information Model For The Network Element View
	G.Imp874.1 Implementer's Guide
	G.7710/Y.1701 Common Equipment Management Requirements
	G.7711/Y.1702 Generic protocol-neutral information model for transport resources
	G.7714/Y.1705 Generalized automatic discovery for transport entities
	G.7714.1/Y.1705.1 Protocol for automatic discovery in SDH and OTN networks
Data Communication Network (DCN)	G.7712/Y.1703 Architecture and specification of data communication network
Error Performance	G.8201 Error performance parameters and objectives for multi-operator international paths within the Optical Transport Network (OTN)
	M.2401 Error Performance Limits and Procedures for Bringing-Into-Service and Maintenance of multi-operator international paths and sections within Optical Transport Networks
Jitter & Wander Performance	G.8251 The control of jitter and wander within the optical transport network (OTN)
Physical-Layer Aspects	G.664 General Automatic Power Shut-Down Procedures for Optical Transport Systems
	G.691 Optical Interfaces for single-channel STM-64 and other SDH systems with Optical Amplifiers,
	G.692 Optical Interfaces for Multichannel Systems with Optical Amplifiers
	G.693 Optical interfaces for intra-office systems
	G.694.1 Spectral grids for WDM applications: DWDM frequency grid
	G.694.2 Spectral grids for WDM applications: CWDM wavelength grid
	G.695 Optical interfaces for Coarse Wavelength Division Multiplexing applications
	G.696.1 Intra-Domain DWDM applications
	G.697 Optical monitoring for DWDM system
	G.698.1 Multichannel DWDM applications with single-channel optical interfaces
	G.698.2 Amplified multichannel DWDM applications with single channel optical interfaces
	G.959.1 Optical Transport Networking Physical Layer Interfaces
G.Sup.39 Optical System Design and Engineering Considerations	
Fibres	G.651.1 Characteristics of a 50/125 µm multimode graded index optical fibre cable for the optical access network
	G.652 Characteristics of a single-mode optical fibre and cable
	G.653 Characteristics of a dispersion-shifted single mode optical fibre and cable

	ITU-T Published Recommendations
	G.654 Characteristics of a cut-off shifted single-mode fibre and cable
	G.655 Characteristics of a non-zero dispersion shifted single-mode optical fibre and cable
	G.656 Characteristics of a fibre and cable with non-zero dispersion for wideband optical transport
	G.657 Characteristics of a bending loss insensitive single mode optical fibre and cable for the access network
	G.Sup40 Optical fibre and cable Recommendations and standards guideline
Components & Sub-systems	G.661 Definition and test methods for the relevant generic parameters of optical amplifier devices and subsystems
	G.662 Generic characteristics of optical amplifier devices and subsystems
	G.663 Application related aspects of optical amplifier devices and subsystems
	G.665 Generic characteristics of Raman amplifiers and Raman amplified subsystems
	G.666 Characteristics of PMD compensators and PMD compensating receivers
	G.667 Characteristics of Adaptive Chromatic Dispersion Compensators
	G.671 Transmission characteristics of optical components and subsystems
G.672 Characteristics of multi-degree reconfigurable optical add/drop multiplexers	

6.4 Standards on the ASTN/ASON Control Plane

The following table lists ITU-T Recommendations specifically related to the ASTN/ASON Control Plane.

Table 7 – Standards on the ASTN/ASON Control Plane

Topic	Title
Definitions	G.8081/Y.1353 Definitions and Terminology for Automatically Switched Optical Networks (ASON)
Architecture	G.8080/Y.1304 Architecture for the Automatic Switched Optical Network (ASON)
	G.Imp8080 Implementer's Guide
Protocol Neutral Specifications for key signalling elements	G.7713/Y.1704 Distributed Call and Connection Management (DCM)
	G.Imp7713/Y.1704 Implementer's Guide
	G.7713.1/Y.1704 Distributed Call and Connection Management based on PNNI
	G.Imp7713.1/Y.1704 Implementer's Guide
	G.7713.2/Y.1704 Distributed Call and Connection Management: Signalling mechanism using GMPLS RSVP-TE
	G.Imp7713.2/Y.1704 Implementer's Guide
	G.7713.3/Y.1704 Distributed Call and Connection Management : Signalling mechanism using GMPLS CR-LDP
	G.Imp7713.3/Y.1704 Implementer's Guide
	G.7714/Y.1705 Generalised automatic discovery for transport entities
	G.7714.1/Y.1705.1 Protocol for automatic discovery in SDH and OTN networks
	G.Imp7714.1 Implementer's Guide
	G.7715/Y.1706 Architecture and requirements for routing in automatically switched optical networks
	G.Imp7715 Implementer's Guide
	G.7715.1/Y.1706.1 ASON routing architecture and requirements for link state protocols
	G.Imp7715.1 Implementer's Guide
	G.7715.2/Y.1706.2 ASON routing architecture and requirements for remote route query
	G.7716/Y.1707 Architecture of control plane operations
	G.7718/Y.1709 Framework for ASON Management
	G.7718.1/Y.1709.1 Protocol-neutral management information model for the control plane view

Topic	Title
Data Communication Network (DCN)	G. 7712/Y.1703 Architecture and specification of data communication network

6.5 Standards on the Ethernet Frames, MPLS, and MPLS-TP

The following tables list ITU-T Recommendations specifically related to Ethernet, MPLS and MPLS-TP.

Table 8 – Ethernet related Recommendations

Organisation (Subgroup responsible)	Number	Title
SG12 (Q.17/12)	G.1563	Ethernet frame transfer and availability performance
SG13(Q7/13)	Y.1415	Ethernet-MPLS network interworking - User plane interworking
SG15(Q.10/15)	Y.1730	Requirements for OAM functions in Ethernet-based networks and Ethernet services
SG15(Q.10/15)	Y.1731	OAM functions and mechanisms for Ethernet based networks
SG15(Q.3/15)	G.8001	Terms and definitions for Ethernet frames over transport
SG15(Q.12/15)	G.8010/Y.1306	Architecture of Ethernet Layer Networks
SG15(Q.10/15)	G.8011/Y.1307	Ethernet service characteristics
SG15(Q.10/15)	G.8012/Y.1308	Ethernet UNI and Ethernet NNI
SG15(Q.10/15)	G.8012.1/Y.1308.1	Interfaces for the Ethernet transport network
SG15(Q.10/15)	G.8013/Y.1731	OAM functions and mechanisms for Ethernet based networks
SG15(Q.9/15)	G.8021/Y.1341	Characteristics of Ethernet transport network equipment functional blocks
SG15(Q.9/15)	G.8021.1/Y.1341.1	Types and characteristics of Ethernet transport network equipment
SG15(Q.9/15)	G.8031/Y.1342	Ethernet linear protection switching
SG15(Q.9/15)	G.8032/Y.1344	Ethernet ring protection switching
SG15(Q.9/15)	G.8131/Y.1382	Linear protection switching for MPLS transport profile
SG15(Q.9/15)	G.8132/Y.1383	MPLS-TP shared ring protection
SG15(Q14/15)	G.8051/Y.1345	Management aspects of the Ethernet-over-Transport (EoT) capable network element
SG15(Q14/15)	G.8052/Y.1346	Protocol-neutral management information model for the Ethernet Transport capable network element
SG15(Q.13/15)	G.8262/Y.1362	Timing characteristics of synchronous Ethernet equipment slave clock (EEC)

Table 9 – MPLS related Recommendations

Organisation (Subgroup responsible)	Number	Title
SG13(Q.3/13)	Y.1311.1	Network-based IP VPN over MPLS architecture
SG12 (Q.17/12)	Y.1561	Performance and availability parameters for MPLS networks
SG13(Q4/13)	Y.2174	Distributed RACF architecture for MPLS networks
SG13(Q4/13)	Y.2175	Centralized RACF architecture for MPLS core networks
SG13(Q.12/13)	Y.1411	ATM-MPLS network interworking - Cell mode user plane interworking
SG13(Q.12/13)	Y.1412	ATM-MPLS network interworking - Frame mode user plane interworking
SG13(Q.12/13)	Y.1413	TDM-MPLS network interworking - User plane interworking
SG13(Q.12/13)	Y.1414	Voice services - MPLS network interworking
SG13(Q.12/13)	Y.1415	Ethernet-MPLS network interworking - User plane interworking

Organisation (Subgroup responsible)	Number	Title
SG13(Q.12/13)	Y.1416	Use of virtual trunks for ATM/MPLS client/server control plane interworking
SG13(Q.12/13)	Y.1417	ATM and frame relay/MPLS control plane interworking: Client-server
SG15(Q.10/15)	Y.1710	Requirements for OAM functionality for MPLS networks
SG15(Q.10/15)	Y.1711	Operation & Maintenance mechanism for MPLS networks
SG15(Q.10/15)	Y.1712	OAM functionality for ATM-MPLS interworking
SG15(Q.10/15)	Y.1713	Misbranching detection for MPLS networks
SG15(Q.10/15)	Y.1714	MPLS management and OAM framework
SG15(Q.9/15)	Y.1720	Protection switching for MPLS networks
SG15(Q.12/15)	G.8110/Y.1370	MPLS Layer Network Architecture

Table 10 – MPLS-TP-related Recommendations

Organisation (Subgroup responsible)	Number	Title
SG15(Q3/15)	G.8101/Y.1355	Terms and definitions for MPLS transport profile
SG15(Q12/15)	G.8110.1/Y.1370.1	Architecture of the Multi-Protocol Label Switching transport profile layer network
SG15(Q10/15)	G.8112/Y.1371	Interfaces for the MPLS Transport Profile layer network
SG15(Q10/15)	G.8113.1/Y.1372.1	Operations, administration and maintenance mechanism for MPLS-TP in packet transport networks
SG15(Q10/15)	G.8113.2/Y.1372.2	Operations, administration and maintenance mechanisms for MPLS-TP networks using the tools defined for MPLS
SG15(Q10/15)	G.8121/Y.1381	Characteristics of MPLS-TP equipment functional blocks
SG15(Q10/15)	G.8121.1/Y.1381.1	Characteristics of MPLS-TP equipment functional blocks supporting ITU-T G.8113.1/Y.1372.1 OAM mechanisms
SG15(Q10/15)	G.8121.2/Y.1381.2	Characteristics of MPLS-TP equipment functional blocks supporting ITU-T G.8113.2/Y.1372.2 OAM mechanisms
SG15(Q9/15)	G.8131/Y.1382	Linear protection switching for MPLS transport profile
SG15(Q9/15)	G.8132/Y.1383	MPLS-TP shared ring protection
SG15(Q14/15)	G.8151/Y.1374	Management aspects of the MPLS-TP network element
SG15(Q14/15)	G.8152/Y.1375	Protocol-neutral management information model for the MPLS-TP network element

6.6 Standards on Synchronization [Newly introduced in 09/2016]

The series of G.8200-G.8299 ITU-T Recommendations are dedicated for Synchronization, quality and availability targets.

Common aspects:

G.8201: Error performance parameters and objectives for multi-operator international paths within optical transport networks

G.8251: The control of jitter and wander within the optical transport network (OTN)

G.8260: Definitions and terminology for synchronization in packet networks

Table 11 – Synchronizaion-related Recommendations

	Frequency	Time and phase
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Network	G.8261/Y.1361: Timing and synchronization aspects in packet networks G.8261.1/Y.1361.1: Packet delay variation network limits applicable to packet-based methods (Frequency synchronization)	G.8271/Y.1366: Time and phase synchronization aspects of packet networks G.8271.1/Y.1366.1: Network limits for time synchronization in packet networks
Clock	G.8262/Y.1362: Timing characteristics of a synchronous Ethernet equipment slave clock G.8263/Y.1363: Timing characteristics of packet-based equipment clocks	G.8272/Y.1367: Timing characteristics of primary reference time clocks G.8273/Y.1368: Framework of phase and time clocks G.8273.2/Y.1368.2: Timing characteristics of telecom boundary clocks and telecom time slave clocks
Distribution	G.8264/Y.1364: Distribution of timing information through packet networks G.8265: Architecture and requirements for packet-based frequency delivery G.8265.1: Precision time protocol telecom profile for frequency synchronization	G.8275/Y.1369: Architecture and requirements for packet-based time and phase distribution G.8275.1/Y.1369.1: Precision time protocol telecom profile for phase/time synchronization with full timing support from the network G.8275.2/Y.1369.2: Precision time protocol telecom profile for time/phase synchronization with partial timing support from the network

Annex A - Terminology Mapping

The terminology used by different organizations working on similar or overlapping technical areas of standardization has complicated attempts to co-ordinate work between different groups. The same terms are often used, with different meanings by multiple organizations. Question 3 of ITU-T Study Group 15 is responsible for maintaining “Terms and definitions” Recommendations on a number of established major categories of optical networks and technologies, as listed in Table 7-1-1. Readers are warned to verify the definitions before assuming a common understanding of the terms. Specific appendices have been included in ITU-T Recommendations G.7713.x to assist the reader in mapping signalling protocol terminology used in those document to the similar terms used in other well know references. Documents for terminology mapping in IETF such as RFC4397 and draft-ietf-mpis-tp-rosetta-stone can also be referred.

