Optical Transport Networks & Technologies Standardization Work Plan
Issue 27, February 2020

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.

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 February 2020

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 February 2019 meeting as indicated in the reference: https://www.itu.int/md/T17-SG15-200127-TD/en. Some TDs may be from earlier SG15 plenaries.

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: Open Broadband; 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.	[219-GEN]
2	IEEE 802.1	IEEE 802.1 liaison report The 802.1 working group has three active task groups: Maintenance, Time Sensitive Networking (TSN), and Security. In addition, an Industry Connections activity exists 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 25 active projects ranging from revisions of existing work (like time synchronization), addition of new bridging features (like asynchronous traffic shaping), support of YANG modelling and application to new verticals (like fronthaul). The liaison highlights the following projects to be noted in SG15: 1) 802 Network Enhancements for the next decade, 2) all projects in TSN, 3) P802.1 AX-Rev – Link Aggregation revision, 4) P802.1Qcx – CFM YANG data model, 5) P802.1ABcu – LLDP	[549-WP3]

		YANG data model P802.1Xck – YANG data model, 6) YANGsters – IEEE 802 YANG Editors' coordination P802.1Qcp – YANG data model, 7) P802.1CBcv – Frame Replication and Elimination for Reliability Amendment: Information Model, YANG Data Model and MIB Module, and 8) P802.1DC – Quality of Service Provision by Network Systems	
3	IEEE 802.3	See section 4.7.1.12	
4	MEF	MEF liaison report 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. 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. 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. MEF Active projects: • Lifecycle Service Orchestration: 13 projects • Services: 10 projects and 2 ad-hocs • Applications: 6 projects	[473-WP3]
5	OIF (PLL)	Liaison report for OIF Physical and Link Layer (PLL) Working Group The following 56G CEI (Common Electrical I-O) projects are active: CEI-56G-VSR. FlexE 2.1 IA is now published as http://www.oiforum.com/wp-content/uploads/OIF-FLEXE02.1.pdf (publicly available). FlexE Neighbor Discovery is now published as http://www.oiforum.com/wp-content/uploads/OIF-FLEXE-ND-01.0-.pdf (publicly available). CFP2 Digital Coherent Optics (CFP2-DCO) is now published as http://www.oiforum.com/wp-	[488-WP3]

		content/uploads/OIF-CFP2-DCO-01.0.pdf (publicly available). High Baud Rate Coherent Driver Modulator (HB-CDM) is now published as http://www.oiforum.com/wp-content/uploads/OIF-HB-CDM-01.0.pdf (publicly available). Coherent Modem Management	
6	IETF	Liaison report for IETF The meeting schedule for 2018 - 2020 was provided. One liaison on YANG Alarm Module from CCAMP was highlighted.	[218-GEN] [360-WP3]
7	JCA IMT2020	Incoming liaison from JCA IMT2020 is in TD227/G JCA IMT2020 has updated their Standardisation Activity Roadmap which is available at https://www.itu.int/net4/ITU-T/roadmap. JCA IMT2020 held its 6th meting 2019-07-02.	[227-GEN]
8	IEEE P1588	Liaison report for IEEE 1588. IEEE 1588-v3 is expected to be completed in 2019. The most recent draft, which is in working group ballot, addresses: - 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. - 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. Additional information on the WG can be found on its website: https://ieee-sa.centraldesktop.com/1588public/	[289-GEN]

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, 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 12/15, 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
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 amendement 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 x 100G 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 × 100G FlexO frame format and forward error correction (FEC) combined with the available client optical modules. The initial n × 100G FlexO standard, ITU-T G.709.1, was published in the beginning of 2017. Future n × 200G and n × 400G 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 200GE and 400GE services in the IEEE Std 802.3-2018, as well as the emerging subrated n×100G FlexE_Aware services developed by OIF’s FlexE Implementation Agreement project
- Interconnecting n × 100GE 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.709.2] specifies OTU4 long-reach interface
- [ITU-T G.709.3] specifies Flexible OTN long-reach interfaces
- [ITU-T G.798] defines the equipment functional blocks
- [ITU-T G.872] defines OTN architecture
- [ITU-T G.807] defines optical media 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.875] 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.

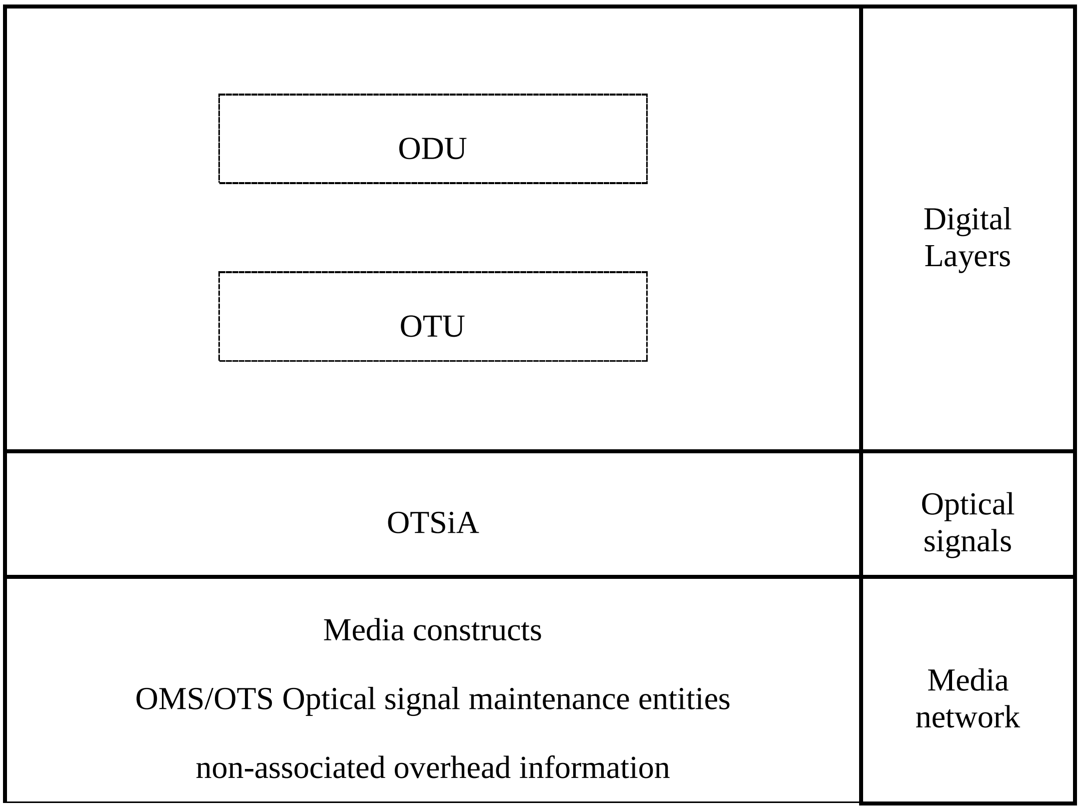


Figure 6-1/G.872 – Overview of the OTN covering beyond 100 Gbit/s

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). An interface may be created by bonding standard-rate interfaces (e.g., m * 100G), over which the OTUCn ($n \geq 1$) signal is adapted. This is known as a FlexO group and is used in G.709.1 and G.709.3. FlexO enables ODUflex services >100Gbit/s to be supported across multiple interfaces.

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. This is now described in G.807 and is not OTN specific.

4.2.1 FlexE in OIF

OIF specified a Flex Ethernet 1.0 implementation agreement in June 2016, additional features in FlexE 2.0 in 2018, and FlexE 2.1 in 2019.

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 adds:

- 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

FlexE 2.1 adds support for FlexE groups composed of 50GBASE-R PHYs.

FlexE Neighbor Discovery Implementation Agreement was published 2018-Sept-12 and specifies OIF extensions to the 802.1AB Link Layer Discovery Protocol (LLDP) for FlexE neighbor discovery.

400ZR Interop

Discussion continues on this project (start in oif2016.400.04) to specify optical interfaces with the following characteristics:

- Short-reach DWDM (amplified) as a priority over single channel ZR (passive). Both applications have a minimum distance of 80km
- DP-16QAM modulation format
- System-side interface support for IEEE Std 802.3bs (now integrated into IEEE Std 802.3-2018)

At the Nuremberg meeting, this project updated the baseline in oif2017.245.08 with optical parameters. At the Vancouver meeting a third application code (unamplified link up to 10 km) was firstly added and then removed again and the draft in oif2017.245.09 was sent to straw ballot..
The most recent (2019) liaisons concerning this project are in TD308/G and TD330/G.

4.3 Subscriber and Operator Layer 1 Services

In late 2016 the MEF launched a new project to define both Subscriber (UNI-to-UNI) and Operator (wholesale) L1 Services. The first specification defines the attributes of a Subscriber L1 service for Ethernet and Fibre Channel client protocols, used in LAN and SAN extension for data centre interconnect, as well as SONET and SDH client protocols for legacy WAN services. It was published as MEF 63 in August 2018. In parallel, work is concluding on a partner specification defining Operator L1 services between a UNI and OTN ENNI (access) and between OTN ENNIs (transit). This will provide the basis for streamlining the interconnection of multi-domain L1 services. It is expected to be published in early 2020.

4.4 Subscriber and Operator IP Services

In early 2016 the MEF launched a new project to define the service attributes to describe Subscriber (retail) and Operator (wholesale) IP services. The first of these, IP Service Attributes for Subscriber IP Services Technical Specification (MEF 61), was published in early 2018. It specifies a standard set of service attributes for describing IP VPNs and Internet access services offered to end-users. In May 2019 the revision MEF 61.1 was published adding the definition of service attributes for Operator IP services. Two related projects were started in early 2018: Service OAM for IP Services and Service Activation Testing for IP Services. The first phase of both of these projects is expected to complete in 2020. In late 2018, work began on the definition of Subscriber IP Services, based on the Service Attributes in MEF 61. The first phase, defining Internet access services, resulted in published MEF 69, and the definition of IP VPN Services is now underway.

4.5 Support for mobile networks

MEF 22.3 Implementation Agreement (IA) Transport Services for Mobile Networks identifies the requirements for MEF Ethernet Services (EVC) and MEF External Interfaces (EIs such as UNIs) for use in mobile networks. It includes an amendment for small cells, support for multi-operator networks and time synchronization. It also aligns with revised MEF service definitions and attributes in MEF 6.2 and MEF 10.3. A new MEF project was launched in 2017 on Transport Services for Mobile Networks to include 5G requirements for fronthaul and the description of network slicing applicability. That amendment to MEF 22.3 is planned for completion in 2020.

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.

4.6 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 four types of services they support: Line services, LAN services, Tree 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). Tree services are rooted multi-point. 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, Tree and Access services over circuit switched technologies like SDH VCs and OTN ODUs or over packet switched technologies like MPLS. 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, 2.5 Gb/s, 5 Gb/s, 10 Gbit/s, 25 Gb/s, 40 Gbit/s, 50 Gb/s, 100 Gbit/s, 200 Gb/s, and 400 Gb/s) defined by IEEE.

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.

4.7 Overview of the standardization of carrier class Ethernet

4.7.1 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.

4.7.1.1 High bit rate and long reach interfaces

The IEEE Std 802.3-2018 includes 200GBASE-DR4/FR4/LR4 and 400GBASE-SR16/DR4/FR8/LR8.

IEEE Std 802.3cd-2018 specifies 200GBASE- SR4, and IEEE Std 802.3cn-2019 specifies 200GBASE-ER4 and 400GBASE-ER8.

Additional high bit rate interfaces are under development by the currently active IEEE P802.3cp, IEEE P802.3ct, IEEE P802.3cu, and (pending IEEE-SA Standards Board approval expected in early February 2020) IEEE P802.3cw projects.

4.7.1.2 Ethernet-based access networks

Various PON interfaces exist in IEEE Std 802.3-2018 that may be used as Ethernet access networks. Additional optical PON PHY types are under development by the currently active IEEE P802.3ca and IEEE P802.3cs projects.

4.7.1.3 Enhancement of scalability

VLAN technology is widely used to provide customers with logically independent networks while sharing network resource physically. However, since the 12-bit 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 Std 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.

4.7.1.4 Scalable Ethernet-based backbone

In order to realize further scalable networks, IEEE Std 802.1ah (Backbone Provider Bridges) specified a method which uses B-Tag, I-Tag and C-Tag. B-Tag and C-Tag include a 12-bit VLAN ID. I-Tag includes a 20-bit Service ID. One VLAN ID identifies a Customer VLAN. The Service ID identifies a service in a provider network. Another VLAN ID identifies a Backbone VLAN. This allows the network to use 12-bit VLAN ID and 20-bit service ID spaces as well as its own MAC address space. IEEE Std 802.1ah was approved in June 2008 and has since been incorporated in IEEE Std 802.1Q-2018.

4.7.1.5 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 in each bridge. To alleviate this burden, IEEE Std 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 need not learn the MAC addresses of user stations.

4.7.1.6 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 Std 802.1ag under a close collaboration.

ITU-T Recommendation G.8013/Y.1731 was approved in May 2006. It was last revised in August 2015 and has been amended since. IEEE Std 802.1ag was approved in September 2007. IEEE Std 802.1ag covers fault management functions only while G.8013/Y.1731 covers both fault management and performance monitoring. Guidance for Ethernet OAM performance monitoring was provided in G.Suppl. 53 in December 2014.

Ethernet services performance parameters were standardized by ITU-T SG12 (Q17/12) in Recommendation Y.1563, approved in January 2009. Service OAM Framework (MEF17), Service OAM Fault Management Implementation Agreement (MEF 30.1) and Service OAM Performance Monitoring Implementation Agreement (MEF 35.1) are specified in MEF.

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

4.7.1.7 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. G.8032 was later revised to effect refinements not impacting the protocol behavior or its state machines. 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, the IEEE 802.1 Working Group (WG) developed a standard on Shortest Path Bridging (IEEE Std 802.1aq) to optimize restoration capabilities. In June 2009, they completed a standard on Provider Backbone Bridge Traffic Engineering (IEEE Std 802.1Qay), which includes linear protection switching.

In 2014, the IEEE 802.1 WG completed a revision of the IEEE 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 construnction 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 reopened starting in 2017 to progress a revision expected to be published in 2020 in the light of implementation experience and to ensure interoperability and proper operation.

IEEE Std 802.1CB "Frame Replication and Elimination for Reliability" was approved in 2017 as 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.

4.7.1.8 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 Std 802.1Qay).

4.7.1.9 Subscriber and Operator Ethernet Services

MEF developed MEF 10.4 Subscriber Ethernet Service Attributes, published in December 2018. MEF 6.2 EVC Ethernet Services Definitions Phase 3, published in August 2014, defines six Ethernet Services and was updated to in particular align with MEF 10.4. This resulted in revised MEF 6.3, published in November 2019. MEF 26.2 External Network Network Interfaces (ENNI) and Operator Service Attributes was published in August 2016 and specifies Service Attributes which can be used to realize Operator Services. MEF 51.1 Operator Ethernet Service Definitions, published in December 2018, specifies Operator Virtual Connection (OVC) Services based on the Service Attributes defined in MEF 26.2.

4.7.1.10 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. An updated version MEF 48.1 is planned for early 2020.

4.7.1.11 Time-Sensitive Networking and Deterministic Networking

Following on from the development of Audio-Video Bridging (AVB) in IEEE 802.1, itself based upon advances in time synchronisation in IEEE 1588, IEEE 802.1 renamed the AVB Task Group to Time-Sensitive Networking Task Group. This Task Group completed the Stream Reservation Protocol (IEEE Std 802.1Qat) and the Credit-based Shaper (IEEE Std 802.1Qav) to provide lossless guaranteed bandwidth over Ethernet. This was followed by the Frame Preemption (IEEE Std 802.1Qbu) project and clause 99 of IEEE 802.3-2018 (was the "Interspersing Express Traffic" project), which create an express lane for high-priority traffic. Together with the strict priority scheduling capabilities of IEEE Std 802.1Q, these technologies underpin the IEEE Std 802.1CM TSN Profile for Fronthaul. For other applications of time-sensitive streams, a combination of Enhancements for Scheduled Traffic (IEEE Std 802.1Qbv), Per-Stream Filtering and Policing (IEEE Std 802.1Qci) and Cyclic Queuing and Forwarding (IEEE Std 802.1Qch) provide bounded latency, guaranteed bandwidth and zero congestion loss, on a network which can support best-effort traffic at the same time.

4.7.1.12 Status of IEEE 802.1

The 802.1 working group currently has three active Task Groups: Maintenance, Time-Sensitive Networking (TSN), and Security. In addition, an Industry Connections activity exists 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 IEEE 802.1 Working Group has over 25 active projects ranging from revisions of existing work (like time synchronization), addition of new bridging features (like asynchronous traffic shaping), 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

- P802E: Recommended Practice for Privacy Considerations for IEEE Technologies

- P802.1X-Rev: Port-Based Network Access Control *(Revision)*
- P802.1AE-2018-Cor1: Tag Control Information Figure

Time Sensitive Networking

- Standalone (specifying new base standards):
  - IEC/IEEE 60802 TSN Profile for Industrial Automation
  - P802.1CS – Link-local Registration Protocol
  - P802.1DC – Quality of Service Provision by Network Systems
  - P802.1CQ – Multicast and Local Address Assignment
  - P802.1DF – TSN Profile for Service Provider Networks
  - P802.1DG – TSN Profile for Automotive In-Vehicle Ethernet Communications
- Revisions (of a base standard):
  - P802.1AS-Rev – Timing and Synchronization for Time-Sensitive Applications
  - P802.1AX-Rev – Link Aggregation Revision

- 802.1Q amendments (amending IEEE Std 802.1Q-2018):
  - P802.1Qcj – Automatic Attachment to Provider Backbone Bridging (PBB) services
  - P802.1Qcr – Bridges and Bridged Networks Amendment: Asynchronous Traffic Shaping
  - P802.1Qcw – YANG Data Models for Scheduled Traffic, Frame Preemption, and Per-Stream Filtering and Policing
  - P802.1Qcx – YANG Data Model for Connectivity Fault Management
  - P802.1Qcz – Congestion Isolation
  - P802.1Qdd – Resource Allocation Protocol
  - P802.1Qdj – Configuration Enhancements for Time-Sensitive Networking

- 802.1AB amendments (amending IEEE Std 802.1AB-2016):
  - P802.1ABcu – LLDP YANG Data Model
  - P802.1ABdh – Support for Multiframe Protocol Data Units
- 802.1CB amendments (amending IEEE Std 802.1CB-2017):
  - P802.1CBcv – FRER YANG Data Model and Management Information Base Module
  - P802.1CBdb – FRER Extended Stream Identification Functions
- 802.1CM amendments (amending IEEE Std 802.1CM-2018):
  - P802.1CMde – Enhancements to Fronthaul Profiles to Support New Fronthaul Interface, Synchronization, and Syntonization Standards

Maintenance

- 802.1ACct – Support for IEEE Std 802.15.3

Ongoing projects related to OTNT

[802 Network Enhancements for the next decade]

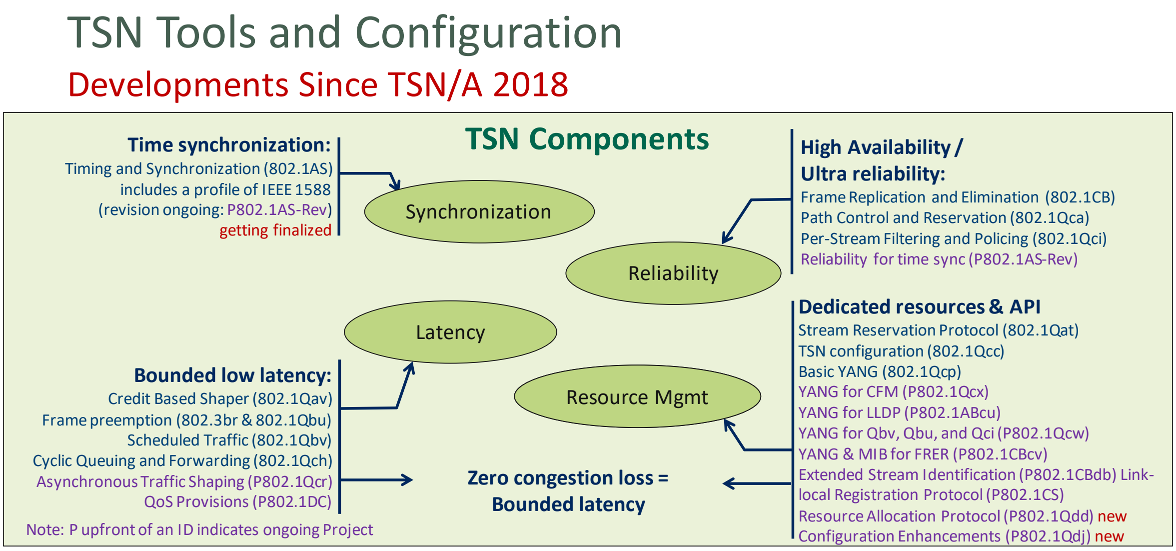
The goal of this activity is to assess, outside of the IMT activity, emerging requirements for IEEE 802 wireless and higher-layer communication infrastructures, identify commonalities, gaps, and trends not currently addressed by IEEE 802 standards and projects, and facilitate building industry consensus towards proposals to initiate new standards development efforts. Encouraged topics include enhancements of IEEE 802 communication networks and vertical networks as well as enhanced cooperative functionality among existing IEEE standards in support of network integration. Findings related to existing IEEE 802 standards and projects are forwarded to the responsible working groups for further considerations. Stakeholders identified to date include but are not limited to: users and producers of systems and components for networking systems, data center networks, high performance computing, cloud computing, telecommunications carriers, automotive, intelligent transport systems, eHealth, smart cities, smart buildings, Internet of Things (IoT), factory automation, and industrial applications. External standardization bodies and industry organizations, such as the Internet Engineering Task Force (IETF), North American Network Operators Group (NANOG), and Telecommunications Industry Association (TIA), International Telecommunication Union (ITU), have been engaged with Nendica activities and will be encouraged to participate in enhanced cooperation.

[Time-Sensitive Networking (TSN)]

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

[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.

P802.1Qcx – 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.

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

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.

P802.1CBcv – 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.

P802.1DC – Quality of Service Provision by Network Systems

This new standard will specify procedures and managed objects for Quality of Service (QoS) features specified in IEEE Std 802.1Q, such as per-stream filtering and policing, queuing, transmission selection, flow control and preemption, in a network system which is not a bridge.
IEEE Std 802.1Q specifies Quality of Service (QoS) features for bridges. These features are perfectly applicable to other devices, e.g. end stations, routers, or firewall appliances. In IEEE Std 802.1Q, the specifications of these features are scattered, and coupled tightly to the operation of a bridge. There is a need for simple reference points to these QoS specifications that are usable for non-bridge systems, and for managed objects for these features that are not specific to bridges.

P802.1CMde – Time-Sensitive Networking for Fronthaul Amendment: Enhancements for Fronthaul Interface, Synchronization, and Syntonization Standards

This amendment defines enhancements to the base standard's features, options, configurations, defaults, protocols and procedures of bridges, stations, and LANs in order to address new developments in fronthaul interface standards, and related synchronization and syntonization standards. This amendment also addresses errors and omissions in existing content.
The purpose of this standard is to specify defaults and profiles that enable the transport of time-sensitive fronthaul streams in Ethernet bridged networks.
The fronthaul interfaces supported by the base standard have been further developed. The synchronization and syntonization standards that the base standard relies on are being enhanced. These developments need to be addressed by enhancing the fronthaul profiles.
Some background on the 802.1CM activity can be seen in a recent press release and summary presentation.

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

4.7.1.13 Status of IEEE 802.3 (Updated in 02/2020)

The following are the IEEE 802.3 standards currently in force:

- The base standard, IEEE Std 802.3-2018, was approved by the Standards Board on 14 June 2018 and published on 31 August 2018. It incorporates and supersedes the following amendments:
  - IEEE Std 802.3bw-2015
  - IEEE Std 802.3by-2016
  - IEEE Std 802.3bq-2016
  - IEEE Std 802.3bp-2016
  - IEEE Std 802.3br-2016
  - IEEE Std 802.3bn-2016
  - IEEE Std 802.3bz-2016
  - IEEE Std 802.3bu-2016
  - IEEE Std 802.3bv-2017
  - IEEE Std 802.3-2015/Cor 1-2017
  - IEEE Std 802.3bs-2017
  - IEEE Std 802.3cc-2017

There are now three approved and published Amendments in-force to IEEE Std 802.3-2018:

- Amendment 1: IEEE Std 802.3cb-2018, 2.5 Gb/s and 5 Gb/s Operation over Backplane, was approved by the Standards Board on 27 September 2018 and published on 4 January 2019.
- Amendment 2: IEEE Std 802.3bt-2018, Power over Ethernet over 4 Pairs, was approved by the Standards Board on 27 September 2018 and published on 31 January 2019.
- Amendment 3: IEEE Std 802.3cd-2018, Media Access Control Parameters for 50 Gb/s and Physical Layers and Management Parameters for 50 Gb/s, 100 Gb/s, and 200 Gb/s Operation, was approved by the Standards Board on 6 December 2018 and published on

15 February 2019.

- Amendment 4: IEEE Std 802.3cn-2019, Physical Layers and Management Parameters for 50 Gb/s, 200 Gb/s, and 400 Gb/s Ethernet over Single-Mode Fiber, was approved by the Standards Board on 7th November 2019 and was published on 20th December 2019.
- Amendment 5: IEEE Std 802.3cg-2019, Physical Layer Specifications and Management Parameters for 10 Mb/s Operation and Associated Power Delivery over a Single Balanced Pair of Conductors, was approved by the Standards Board on 7th November 2019 and is awaiting publication

The current version of the Ethernet MIBs standard is published as IEEE Std 802.3.1-2013. There has been no proposal to update this SNMP MIB document to cover the new features present in IEEE Std 802.3-2018.

The current version of IEEE Std 802.3.2-2019, Ethernet YANG models, which was approved by the Standards Board on 26th March 2019 and was published on 21st June 2019.

The following Task Forces, Study Groups, and ad hoc groups are currently active within the IEEE 802.3 Working Group:

- The IEEE P802.3ca 25 Gb/s and 50 Gb/s Passive Optical Networks Task Force is currently in the Standards Association ballot phase.
- The IEEE P802.3ch Multi-Gig Automotive PHY Task Force is currently in the Standards Association ballot phase.
- The IEEE P802.3ck 100 Gb/s, 200 Gb/s, and 400 Gb/s Electrical Interfaces Task Force is currently in Task Force Review.
- The IEEE P802.3cm 400 Gb/s over Multimode Fiber Task Force has completed the Standards Association ballot phase and is currently awaiting IEEE-SA Standards Board approval.
- The IEEE P802.3cq Power over Ethernet over 2 pairs (Maintenance #13) Task Force has completed the Standards Association ballot phase and is currently awaiting IEEE-SA Standards Board approval.
- The IEEE P802.3cr Isolation (Maintenance #14) Task Force is in the Working Group ballot phase.
- The IEEE P802.3cs Increased-reach Ethernet optical subscriber access (Super- PON) Task Force is in the proposal selection/Task Force Review phase.
- The IEEE P802.3ct 100 Gb/s and 400 Gb/s over DWDM systems Task Force is in the Task Force Review phase. The IEEE 802.3 Working Group has agreed to a split of this project, with 100 Gb/s operation remaining in the IEEE P802.3ct project, and 400 Gb/s operation moving to a new IEEE P802.3cw project, to allow 100 Gb/s to proceed on an earlier timeline. The new IEEE P802.3cw project is currently awaiting IEEE-SA Standards Board approval.
- The IEEE P802.3cu 100 Gb/s and 400 Gb/s over SMF at 100 Gb/s per Wavelength Task Force is expected to initiate Working Group ballot soon.
- The IEEE P802.3cv Power over Ethernet (Maintenance #15, focusing on 4-pairs) Task Force is in the Task Force review phase

There are several active Study Group, which are study activityies that has not yet reached the stage of an approved Project Authorization Request (PAR), Criteria for Standardization Development (CSD), or project objectives:

- The Greater than 10 Gb/s Automotive Ethernet Electrical PHYs Study Group
- Multi Gigabit Automotive Optical PHYs Study Group
- Improving PTP Timestamping Accuracy Study Group. Note that this group submitted a PAR, CSD, and Objective which were approved by the IEEE 802.3 Working Group and IEEE 802 Executive Committee at the November 2019 plenary, but the project is currently awaiting IEEE-SA Standards Board approval (expected in February) before creating what is anticipated to be the IEEE P802.3cx Task Force.
- 10Mb/s Single Pair Ethernet Multidrop Enhancements Study Group
- 100 Gb/s Wavelength Short Reach PHYs Study Group

4.7.2 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 7 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
	ITU-T SG15	Q10/15	Ethernet OAM mechanisms and equipment functional architecture, Ethernet protection/restoration
		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	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	Services Committee	Service attributes including traffic and performance parameters, Subscriber and Operator services definitions, aggregation and ENNI interfaces, management interfaces, performance monitoring, fault management and test specifications.

4.7.3 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 Forum: 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 Forum: http:// 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/SDN Control. All of the Recommendations and standards of the three families are included in tables in the later clauses of this document that provide context for the topic they relate to ITU-T Recommendations may be obtained at https://www.itu.int/rec/T-REC/e.

Table 3 – 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-2018	Virtual Bridged Local Area Networks—Revision	2018
IEEE 802.1	IEEE Std 802.1Qcp-2018	YANG Data Model	2018
IEEE 802.1	IEEE Std 802.1Qcc-2018	Stream Reservation Protocol (SRP) Enhancements and Performance Improvements	2018
IEEE 802.1	IEEE Std 802.1Qcy-2018	Virtual Station Interface (VSI) Discovery and Configuration Protocol (VDP) Extension to Support Network Virtualization Overlays Over Layer 3 (NVO3)	2019
IEEE 802.1	IEEE Std 802.1CM-2018	Time-Sensitive Networking for Fronthaul	2018
IEEE 802.3	IEEE Std 802.3-2018	IEEE Standard for Ethernet	08/2018
	IEEE Std 802.3cb-2018 IEEE Std 802.3bt-2018 IEEE Std 802.3cd-2018 IEEE Std 802.3cn-2019 IEEE Std 802.3cg-2019	Amendments 1, 2, 3, 4, 5	2019
IEEE 802.3	IEEE Std 802.3.1-2013	IEEE Standard for Management Information Base (MIB) Definitions for Ethernet	08/2013

Table 4 – OTNT Related Standards and Industry Agreements (MEF documents)

Category	Number	Title
Service Definitions	6.2	EVC Ethernet Services Definitions Phase 3
Service Definitions	8	Implementation Agreement for the Emulation of PDH Circuits over Metro Ethernet Networks
Service Definitions	22.3	Implementation Agreement – Transport Services for Mobile Networks
Service Definitions	43	Virtual NID (vNID) Functionality for E-Access Services
Service Definitions	47	Carrier Ethernet Services for Cloud Implementation Agreement
Service Definitions	51.1	Operator Ethernet Service Definitions
Service Definitions	62	Managed Access E-Line Service Implementation Agreement
Service Attributes	10.4	Subscriber Ethernet Service Attributes
Service Attributes	23.2	Class of Service Phase 3 Implementation Agreement
Service Attributes	23.2.1	Models for Bandwidth Profiles with Token Sharing
Service Attributes	26.2	External Network Network Interface (ENNI) and Operator Service Attributes
Service Attributes	41	Generic Token Bucket Algorithm
Service Attributes	45.1	Layer 2 Control Protocols in Ethernet Services
Service Attributes	61.1	IP Service Attributes
Service Attributes	63	Subscriber Layer 1 Service Attributes
Service Attributes	70	SD-WAN Service Attributes and Services
Service Attributes	74	Commercial Affecting Attributes
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 Service 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
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)
Information and Data Models	56	Interface Profile Specification – Service Configuration and Activation
Information and Data Models	58	Legato - EVC Services YANG - Service Configuration and Activation
Information and Data Models	59	Network Resource Management - Information Model: Connectivity
Information and Data Models	60	Network Resource Provisioning - Interface Profile Specification
Information and Data Models	78	MEF Core Model (MCM)
Information and Data Models	72	Network Resource Model – Subscriber Layer 1
Information and Data Models	83	Network Resource Model – OAM
Information and Data Models	86	Presto Service OAM Interface Profile Specification
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

Category	Number	Title
Service Activation and Test	49.0.1	Amendment to 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	Service OAM Performance Monitoring Implementation Agreement
Element Management	15	Requirements for Management of Metro Ethernet Phase 1 Network Elements
Element Management	16	Ethernet Local Management Interface
MEF Service Lifecycle	50.1	MEF Services Lifecycle Process Flows
MEF Service Lifecycle	52	Carrier Ethernet Performance Reporting Framework
MEF Service Lifecycle	53	Ethernet Services Qualification Questionnaire
MEF Service Lifecycle	54	Ethernet Interconnection Point (EIP): An ENNI Implementation Agreement
MEF Service Lifecycle	55	Lifecycle Service Orchestration (LSO): Reference Architecture and Framework
MEF Service Lifecycle	55.0.1	Amendment to MEF 55 - Operational Threads
MEF Service Lifecycle	55.0.2	Amendment to MEF 55 - TOSCA Service Templates
MEF Service Lifecycle	57.1	Ethernet Ordering Technical Standard - Business Requirements and Use Cases
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

The current set of MEF technical specifications is at: https://www.mef.net/resources/technical-specifications

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 5 – 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.800** Unified functional architecture of transport networks **G.805** Generic functional architecture of transport networks **G.807** Generic functional architecture of the optical media **G.872** Architecture of Optical Transport Networks
Control Plane	ASON recommendations are moved to specific ASON/SDN 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.709.2/Y.1331.2 OTU4 long-reach interface
	G.709.3/Y.1331.3 Flexible OTN long-reach interfaces

	ITU-T Published Recommendations
	G.975 Forward Error Correction
	G.798 Characteristics of optical transport network (OTN) equipment functional blocks
	G.798.1 Types and characteristics of optical transport network equipment
	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.Sup58 Optical transport network module framer interfaces
	G.Sup.5gotn Application of OTN to 5G Transport
Protection Switching	**G.873.1** Optical Transport network (OTN) - Linear Protection
	G.873.2 ODUk shared ring protection
	G.873.3 OTN shared mesh protection
Management Aspects	**G.874** Management aspects of the optical transport network element
	G.Imp874 Implementer's Guide
	G.875 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
	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

	ITU-T Published Recommendations
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 ASON and SDN Architectural approaches to Control

The following table lists ITU-T Recommendations specifically related to ASON and SDN Control.

Table 6 – Standards on the ASON/SDN 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.7701 Common Control Aspects
	G.7702 Architecture for SDN control of transport networks
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.7719 (ex. G.7718.1/Y.1709.1) Protocol-neutral management information model for the control plane view
Data Communication Network (DCN)	**G. 7712/Y.1703** Architecture and specification of data communication network

The following table lists ITU-T Recommendations specifically related to ASON and SDN Control.

Table 11 – IETF work related to Control Plane

RFC	Title	Working Group
RFC8282	Extensions to the Path Computation Element Communication Protocol (PCEP) for Inter-Layer MPLS and GMPLS Traffic Engineeringhttps://datatracker.ietf.org/doc/rfc8282/	
RFC8283	An Architecture for Use of PCE and the PCE Communication Protocol (PCEP) in a Network with Central Control	
RFC8363	GMPLS OSPF-TE Extensions in Support of Flexi-Grid Dense Wavelength Division Multiplexing (DWDM) Networks https://datatracker.ietf.org/doc/rfc8363/	
RFC8413	Framework for Scheduled Use of Resources https://datatracker.ietf.org/doc/rfc8413/	
RFC 8453	Framework for Abstraction and Control of TE Networks (ACTN) https://datatracker.ietf.org/doc/rfc8453/	
RFC 8469	Recommendation to Use the Ethernet Control Word https://datatracker.ietf.org/doc/rfc8469/	
	A framework for Management and Control of DWDM optical interface Parameters https://datatracker.ietf.org/doc/draft-ietf-ccamp-dwdm-if-mng-ctrl-fwk/	CCAMP
	YANG data model for Flexi-Grid media-channels https://datatracker.ietf.org/doc/draft-ietf-ccamp-flexigrid-media-channel-yang/	CCAMP
	YANG data model for Flexi-Grid Optical Networks https://datatracker.ietf.org/doc/draft-ietf-ccamp-flexigrid-yang/	CCAMP
	Applicability of GMPLS for B100G Optical Transport Network https://datatracker.ietf.org/doc/draft-ietf-ccamp-gmpls-otn-b100g-applicability/	CCAMP
	A YANG Data Model for L1 Connectivity Service Model (L1CSM) https://datatracker.ietf.org/doc/draft-ietf-ccamp-l1csm-yang/	CCAMP
	A YANG Data Model for Optical Transport Network Topology https://datatracker.ietf.org/doc/draft-ietf-ccamp-otn-topo-yang/	CCAMP
	OTN Tunnel YANG Model https://datatracker.ietf.org/doc/draft-ietf-ccamp-otn-tunnel-model/	CCAMP
	Information Encoding for WSON with Impairments Validation https://datatracker.ietf.org/doc/draft-ietf-ccamp-wson-iv-encode/	CCAMP
	Information Model for Wavelength Switched Optical Networks (WSONs) with Impairments Validation https://datatracker.ietf.org/doc/draft-ietf-ccamp-wson-iv-info/	CCAMP
	A Yang Data Model for WSON Tunnel https://datatracker.ietf.org/doc/draft-ietf-ccamp-wson-tunnel-model/	CCAMP
	A YANG Data Model for WSON (Wavelength Switched Optical Networks) https://datatracker.ietf.org/doc/draft-ietf-ccamp-wson-yang/	CCAMP
	PCEP Extension for WSON Routing and Wavelength Assignment https://datatracker.ietf.org/doc/draft-ietf-pce-wson-rwa-ext/	PCE
	PCEP extensions for GMPLS https://datatracker.ietf.org/doc/draft-ietf-pce-gmpls-pcep-extensions/	PCE
	PCEP Extension for Flexible Grid Networks	PCE

	https://datatracker.ietf.org/doc/draft-ietf-pce-flexible-grid/	
	Path Computation Element (PCE) Protocol Extensions for Stateful PCE Usage in GMPLS-controlled Networks https://datatracker.ietf.org/doc/draft-ietf-pce-pcep-stateful-pce-gmpls/	PCE
	Path Computation Element Communication Protocol (PCEP) Extensions for remote-initiated GMPLS LSP Setup https://datatracker.ietf.org/doc/draft-ietf-pce-remote-initiated-gmpls-lsp/	PCE

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 7 – Ethernet related Recommendations

Organisation (Subgroup responsible)	**Number**	**Title**
SG12 (Q17/12)	G.1563	Ethernet frame transfer and availability performance
SG13(Q7/13)	Y.1415	Ethernet-MPLS network interworking - User plane interworking
SG15(Q10/15)	Y.1730	Requirements for OAM functions in Ethernet-based networks and Ethernet services
SG15(Q10/15)	Y.1731	OAM functions and mechanisms for Ethernet based networks
SG15(Q10/15)	G.8001	Terms and definitions for Ethernet frames over transport
SG15(Q12/15)	G.8010/Y.1306	Architecture of Ethernet Layer Networks
SG15(Q10/15)	G.8011/Y.1307	Ethernet service characteristics
SG15(Q10/15)	G.8012/Y.1308	Ethernet UNI and Ethernet NNI
SG15(Q10/15)	G.8012.1/Y.1308.1	Interfaces for the Ethernet transport network
SG15(Q10/15)	G.8013/Y.1731	OAM functions and mechanisms for Ethernet based networks
SG15(Q10/15)	G.8021/Y.1341	Characteristics of Ethernet transport network equipment functional blocks
SG15(Q10/15)	G.8021.1/Y.1341.1	Types and characteristics of Ethernet transport network equipment
SG15(Q10/15)	G.8031/Y.1342	Ethernet linear protection switching
SG15(Q10/15)	G.8032/Y.1344	Ethernet ring protection switching
SG15(Q10/15)	G.8131/Y.1382	Linear protection switching for MPLS transport profile
SG15(Q10/15)	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(Q13/15)	G.8262/Y.1362	Timing characteristics of synchronous Ethernet equipment slave clock (EEC)

Table 8 – MPLS related Recommendations

Organisation (Subgroup responsible)	**Number**	**Title**
SG13(Q3/13)	Y.1311.1	Network-based IP VPN over MPLS architecture
SG12 (Q17/12)	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

Organisation (Subgroup responsible)	Number	Title
SG13(Q12/13)	Y.1411	ATM-MPLS network interworking - Cell mode user plane interworking
SG13(Q12/13)	Y.1412	ATM-MPLS network interworking - Frame mode user plane interworking
SG13(Q12/13)	Y.1413	TDM-MPLS network interworking - User plane interworking
SG13(Q12/13)	Y.1414	Voice services - MPLS network interworking
SG13(Q12/13)	Y.1415	Ethernet-MPLS network interworking - User plane interworking
SG13(Q12/13)	Y.1416	Use of virtual trunks for ATM/MPLS client/server control plane interworking
SG13(Q12/13)	Y.1417	ATM and frame relay/MPLS control plane interworking: Client-server
SG15(Q10/15)	Y.1710	Requirements for OAM functionality for MPLS networks
SG15(Q10/15)	Y.1711	Operation & Maintenance mechanism for MPLS networks
SG15(Q10/15)	Y.1712	OAM functionality for ATM-MPLS interworking
SG15(Q10/15)	Y.1713	Misbranching detection for MPLS networks
SG15(Q10/15)	Y.1714	MPLS management and OAM framework
SG15(Q10/15)	Y.1720	Protection switching for MPLS networks
SG15(Q12/15)	G.8110/Y.1370	MPLS Layer Network Architecture

Table 9 – MPLS-TP-related Recommendations

Organisation (Subgroup responsible)	Number	Title
SG15(Q10/15)	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/Y1372.1	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(Q10/15)	G.8131/Y.1382	Linear protection switching for MPLS transport profile
SG15(Q10/15)	G.8132/Y.1383	MPLS-TP shared ring protection
SG15(Q10/15)	G.8133	Dual Homing Protection for MPLS-TP Pseudowires
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

The series of G.8200-G.8299 ITU-T Recommendations are dedicated for Synchronization, quality and availability targets.Other synchronization related Recommendations can be found into the series G.810-G.819 (Design objectives for digital networks) and into the G.780-G.789 series (Principal characteristics of multiplexing equipment for the synchronous digital hierarchy).

Common aspects:

G.8201: Error performance parameters and objectives for multi-operator international paths within optical transport networks
G.810: Defiitions and terminology for synchronization networks
G.8260: Definitions and terminology for synchronization in packet networks
G.781: Synchronization Layer Functions
G.781.1: Synchronization Layer Functions for packet-based networks (work in progress as of Feb. 2020)

Supplements and Technical Reports:
GNSS-TR: Considerations on the Use of GNSS as a Primary Time Reference in Telecommunications
G.Suppl.65: Simulations of transport of time over packet networks
G.Suppl.SyncOAM: Synchronization OAM requirements

Table 10 – Synchronization-related Recommendations

	Frequency	**Time and phase**
Network Requirements	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 telecommunication networks G.8271.1/Y.1366.1: Network limits for time synchronization in packet networks with full timing support from the network G.8271.2/Y.1366.2: Network limits for time synchronization in packet networks with partial timing support from the network
Clock	G.811: Timing characteristics of primary reference clocks G.811.1: Timing characteristics of enhanced primary reference clocks G.812: Timing requirements of slave clocks suitable for use as node clocks in synchronization networks G.813: Timing characteristics of SDH equipment slave clocks (SEC) G.8262/Y.1362: Timing characteristics of synchronous equipment slave clock G.8262.1/Y.1362.1: Timing characteristics of enhanced synchronous equipment slave clock G.8263/Y.1363: Timing characteristics of packet-based equipment clocks G.8251: The control of jitter and wander within the optical transport network (OTN)	G.8273/Y.1368: Framework of phase and time clocks G.8273.1/Y.1368.1: Timing characteristics of telecom grandmaster clocks for time synchronization (in progress) G.8273.2/Y.1368.2: Timing characteristics of telecom boundary clocks and telecom time slave clocks for use with full timing support from the network G.8273.3/Y.1368.3: Timing characteristics of telecom transparent clocks for use with full timing support from the network G.8273.4/Y.1368.4: Timing characteristics of partial timing support telecom boundary clocks and telecom time slave clocks (in progress)

	G.8266/Y.1376: Timing characteristics of telecom grandmaster clocks for frequency synchronization	
	G.8272/Y.1367: Timing characteristics of primary reference time clocks G.8272.1/Y.1367.1: Timing characteristics of enhanced primary reference time 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

6.7 ITU-T Recommondation Relationships

For a given layer technology studied in WP3 of SG15, there are a set of Recommendations that cover interface, architecture, and management/control aspects. Table 12 shows how the relationships between sets of Recommendations. Parallels between Recommendations in the same category but for different layers become evident when arranged as in the table. Should a new layer technology be studied, it would be natural to expect Recommendations to cover interface(s), architecture, equipment, protection, management requirements, and information model. For example, new work items on the Metro Transport Network (MTN) layer are shown as draft Recommendations. MTN work items were initiated in October 2018 and July 2019 and introduce two new layers that reuse OIF FlexE technology and selected IEEE 802.3 interfaces to provide connection-oriented capability.

Table 12 Recommendation Relationships

	Control/Management Continuum (for controlling/managing transport resources)			Transport technology					
Common Arch	G.7701			G.800, G.805, G.807					Synchronization G.8265.1 (freq) G.8275.1 (time/phase) G.8275.2 (time/phase)
Arch	G.7702 G.7703 (ex G.8080)			OTN: G.872	ETH: G.8010	MT: G.8110.1	MTN: G.mtn-arch	Media G.807	
Interface				G.709 G.709.x	IEEE802.3 G.8013	G.8113.1 G.8113.2	G.mtn	G.698.1-.4	
Protection				G.873.x	G.8031 G.8032	G.813x	G.mtn-prot		
Requirement	G.7713.x	G.7714.x	G.7715.x	G.798.x	G.8021 G.8023	G.8121 G.8121.x	G.mtn-eqpt		
DCN	G.7712								
Common Mgmt Requirement	G.7718			G.7710					
Mgmt Requirement				G.874	G.8051	G.8151	G.mtn-mgmt	G.876	G.7721
Mgmt protocol-neutral IM	G.7719			G.875	G.8052	G.8152			
Purpose-specific information model (in UML) & data models (e.g., in Yang)	G.7719.x			G.875.x (.1)	G.8052.1 G.8052.2	G.8152.1 G.8152.2			G.7721.1
Common Mgmt IM	G.7711 (for managing/controlling resources, including control components and media)								

See Tables 6, 7, 10, & 11 for titles of the Recommendations referenced in Table 12.