Optical Transport Networks & Technologies Standardization Work Plan

Issue 22, September 2016

General

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

http://www.itu.int/ITU-T/studygroups/com15/otn/

Proposed modifications and comments should be sent to:

Naotaka Morita, e-mail: naotaka.morita [at] ntt-at.co.jp, Tel.: +81 422 36 7502

In this issue (Issue 22), the document is split into two parts to separate up-to-date snapshot-type information and comprehensive database-type information.

- Part 1 (newly introduced) 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 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 and latest topics [Newly introduced in 09/2106]

1 Highlight of ITU-T SG15

The 5th edition of Recommendation ITU-T G.709/Y.1331 "Interfaces for the Optical Transport Network" was published in June 2016, which 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.

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, is expected to be approved by the close of 2016. 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 the Institute of Electrical and Electronics Engineers (IEEE). The revision also extends OTN to support the FlexE-unaware, FlexE-aware subrate and FlexE Client services developed by the Optical Internetworking Forum (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×100G FlexE_Aware services developed by OIF's FlexE Implementation Agreement project
- Interconnecting n × 100GE muxponders with 200G, 300G, 400G, 500G, etc. tunnels

More information on ITU-T Study Group 15 can be found on the group's homepage.

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 September 2016 meeting as indicated in the reference.

http://www.itu.int/md/T13-SG15-160919-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 Three initiatives: 2.1 Broadband 20/20 In October of 2015, the Broadband Forum launched an initiative called Broadband 20/20 which continues to be successful. The initiative focuses on the "innovative use of NFV, SDN, Ultra-Fast access and IoT (Internet of Things) and, when formally defined, 5G, to enable the delivery of exciting ultra-fast broadband services, with distributed compute and storage to anywhere and any device in the home and business locations." Details of the initiative can be found on the Broadband 20/20 web pages and in the Broadband 20/20 white paper. 2.2 5G The Broadband Forum is continuing to assess impact of 5G mobile on the broadband network including 5G transport, mobile backhaul and fixed/mobile convergence. Work has already begun on defining requirements for broadband support of 5G and in particular 5G transport. First published works are anticipated by 1H2017. 2.3 Common YANG The Broadband Forum is producing YANG data models related to its work. BBF has been producing data models for Residential Gateway Management in the form of TR-061 for years. This effort has been expanded to other areas such as Fiber to the Distribution Point (FttDP) and includes common YANG models (e.g., for QoS) defined in cooperation with the IETF. Technical aspects WT-319 - Achieving Packet Network Optimization using DWDM Interfaces: Base, Part A and B are published with the interactions with Q12/15. The current focuse is on WT-319 Part C – Physically Separated/Logically Integrated Model. TR-221 Amd 2 - Technical Specifications for MPLS in Mobile Backhaul Networks: This is subsequent work that augments the BBFs previous work on MPLS in Mobile Backhaul networks. This series of documents	[325-GEN]

		comprises architecture and equipment requirements to provide network services (e.g., TDM, ATM, Ethernet, IP) for interconnection of mobile RAN equipment for 2G through LTE. The architectures deal with backhaul (between RAN and mobile core), midhaul (between small cells and macro cells for radio coordination) and fronthaul (between radio heads and digital base station units). Q13/15 interacts with BBF on time and phase synchronization. TR-350 Ethernet Services using BGP MPLS Based Ethernet VPNs (EVPN): This is to implement the carrier ethernet services using BGP MPLS-based EVPNs in order to overcome the limitations of VPLS and address the additional requirements. The Phase 2 work is nearing completion and is anticipated to begin the Broadband Forum approval process after their 4Q2016 meeting.	
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, the Interworking (i.e., Ethernet Bridging) task group was merged with the TSN task group and the Local Address study group was merged with the DCB task group. 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).	[316-GEN]
3	IEEE 802.3	LS/i on Liaison letter to ITU-T Study Group 15 [from IEEE 802.3 Working Group] Developing new projects: IEEE P802.3bs 200 Gb/s and 400 Gbs Ethernet Task Force and the IEEE P802.3cd 50 Gb/s, 100 Gb/s, and 200 Gb/s Ethernet Task Force. 1) IEEE P802.3bs IEEE 802.3 agreed to PAR modifications and additional objectives for IEEE P802.3bs to add 200 Gb/s operation to the scope of the project in the March 2016 plenary meeting in Macau. Baselines have subsequently been adopted for 200 Gb/s operation and added to their draft. It was agreed at San Diego meeting in July 2016 to begin the Working Group ballot phase on IEEE P802.3bs Draft 2.0. 2) IEEE P802.3cd	[311-GEN] [328-GEN]

		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 will be developed. This project will develop backplane, copper cable, MMF and SMF (except for 200 Gb/s operation) PMDs. IEEE P802.3cd is in the process of evaluating and adopting baselines and has not yet advanced to the stage of developing a draft specification.	
4	MEF	MEF liaison report MEF Technical & Operations Committee Project Dashboard produced in August 2016 shows their ongoing activities in services, orchestration and operations areas. MEF 22.2.1 IA Mobile Backhaul Phase 3 Amendment 1 was approved in August 2016. MEF has organized its Third Network Service Projects, environment platforms and collaboration under the MEF CTO Office. The Open Initiative - which includes OpenLSO (Lifecycle Service Orchestration) projects, OpenCS (connectivity services) projects, MEFnet and LSO Hackathon is focused on enabling service providers to create Third Network services. Examples of Third Network services are scoped out, developed, tested and documented. A joint steering committee between MEF and ITU-T was set up in October 2015. The report is given below.	[315-GEN]
5	MEF	ITU/MEF MoU SC (Steering Committee) report Key messages: Topics discussed in two conference calls in March and September 2016. Planning “SDO event” in MEF16 and MEF President participation in GSS. MEF Lifecycle Service Orchestration (LSO) Reference Architecture and ITU-T G.8011 work. The ITU conformity database and MEF members’ interests Potential collaboration around the MEF Carrier Ethernet Certified Professional (CECP) program MEF UNITE Partner Summit to be held 10 November 2016	[324-GEN]
6	OIF (PLL)	Liaison report for OIF Physical and Link Layer (PLL) Working Group	[321-GEN]

	Key messages: Overall status reports about 12 topics discussed in two OIF (Optical Internetworking Forum) meetings since the SG15 meeting 15 to 26 February 2016.

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 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). Details of G.709 are given in Part 1 of this document.

In syc 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.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.

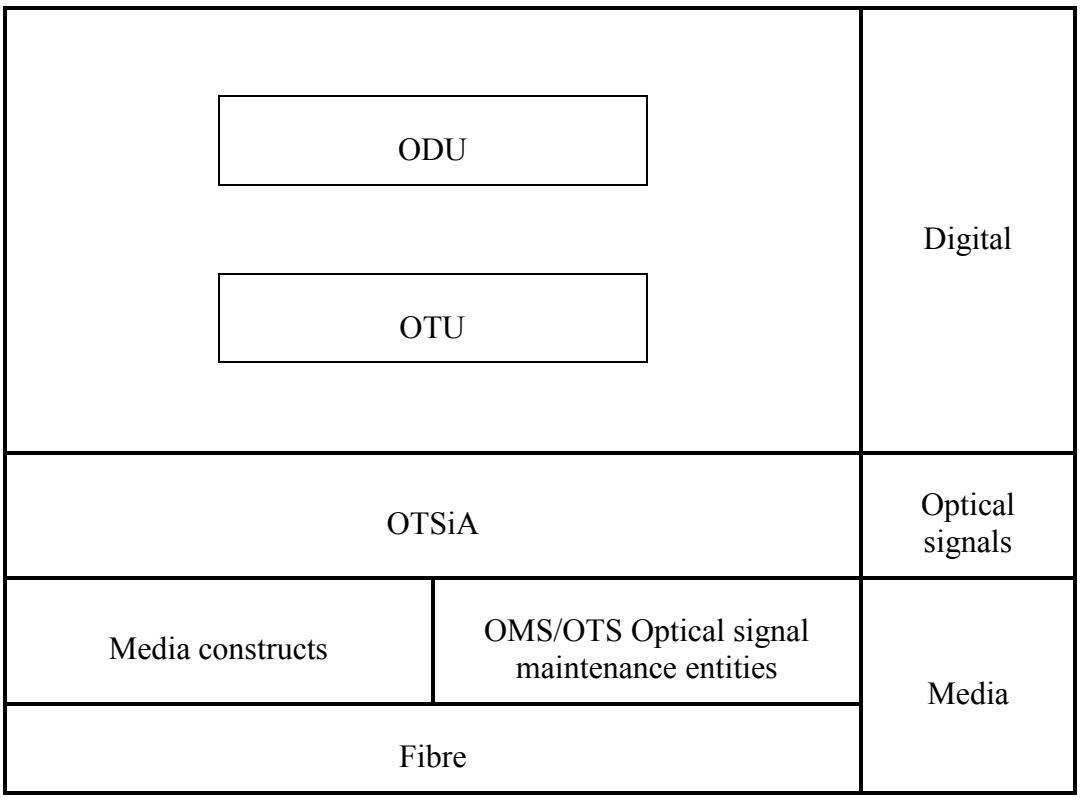

Figure 6-1/G.872 – Overview of the OTN covering beyond 100 Gbit/s

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

OIF started work to develop a Flex Ethernet implementation agreement. Agreement to start this project was reached at our 1Q2015 meeting, and at its 3Q2015 meeting in Ottawa the draft has reached the stage to issue for straw ballot.
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. A future version is expected to support bonding of higher rate Ethernet PHYs such as 400G.

4.3 Support for mobile networks [Adding ITU-R M2375 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 draft 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.
The work on this deliverable MEF MBH Phase 3 is projected to complete in late-2015. The deliverable, MEF 22.2, will supersede MEF 22.1 and MEF 22.1.1 after it is approved by the MEF Board at that time.

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.

ITU-R report on architecture and topology of IMT networks, M.2375 (06/2015)

As traffic demand for mobile broadband communications represented by International Mobile Telecommunications (IMT), including both IMT-2000 and IMT-Advanced as defined in Resolution ITU-R 56 are increasing, the transport network in the mobile infrastructure is becoming an important application that requires special consideration.

The transport network supports the connections between one and the other of separated radio transceiver functions within one base station, between different base stations of the mobile broadband network, as well as the connections of one base station to other network elements of the mobile infrastructure.

The Report ITU-R M.2375, published in June 2015, offers an overview of the architecture and topology of IMT networks and a perspective on the dimensioning of the respective transport requirements in these topologies, in order to assist relevant studies on the transport network in the mobile infrastructure. The Report covers different architectural aspects in a general level of detail.

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) is standardizing 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 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.

IEEE 802.17 WG is developing standards on Resilient Packet Ring (RPR). The latest 802.17 project has been IEEE P802.17c: "Protected Inter-Ring Connection". This project extends the property of fast restoration time (50 ms), associated with an individual RPR ring, to dual-interconnected rings.

IEEE 802.1CB “Frame Replication and Elimination for Reliability” is a draft 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.

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 10.2: "Amendment to Ethernet Services Attributes Phase 2", in September 2009.

4.5.1.9 Service Activation Testing (SAT)

Recommendation Y.1564, "Ethernet service activation test methodology" was approved in SG12 in March, 2011.

4.5.1.10 Status of IEEE 802.1 [Updated in 09/2016]

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

The IEEE 802.1 Working Group (WG) develops standards in the following areas: 802 LAN/MAN architecture, internetworking among 802 LANs, MANs and other wide area networks, 802 Security, 802 overall network management, and protocol layers above the MAC & LLC layers. Additional information on the WG can be found on its website: http://www.ieee802.org/1/

The 802.1 working group has five active task groups: Maintenance, Time Sensitive Networking (TSN), Security, Data Center Bridging (DCB) and OmniRAN. Note that the Interworking (i.e., Ethernet Bridging) task group has been merged with TSN. In addition the Local Address study group has merged with the DCB task group.

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

- 802.1Xbx - MAC Security Key Agreement protocol (MKA) extensions
- 802.1ARce - Secure Device Identity - Amendment 1: SHA-384 and P-384 Elliptic Curve
- 802.1AEcg - MAC Security - Ethernet Data Encryption Devices
- 802.1Xck - Port-Based Network Access Control Amendment: YANG Data Model
- 802E - Recommended Practice for Privacy Considerations for IEEE 802 Technologies

Time Sensitive Networking

- 802.1AS-Rev - Timing and Synchronisation: Timing and Synchronisation for Time-Sensitive Applications - Revision
- 802.1CB - Frame Replication and Elimination for Reliability
- 802.1Qcc - Stream Reservation Protocol (SRP) Enhancements and Performance Improvements
- 802.1Qch - Cyclic Queuing and Forwarding
- 802.1Qci - Per-Stream Filtering and Policing
- 802.1AC-Rev- MAC Service Definition Revision
- 802.1CM- Time-Sensitive Networking for Fronthaul
- 802.1Qcj - 802.1Qcj - Automatic Attachment to Provider Backbone Bridging (PBB) services
- 802.1Qcr - 802.1Qcr - Asynchronous Traffic Shaping
- 802.1Qcp - Bridges and Bridged Networks Amendment: YANG Data Model
- 802d – URN Namespace

Data Center Bridging

- 802.1Qcd - 802.1Qcd - Application VLAN TLV
- 802.1Qcn - Virtual Station Interface (VSI) Discovery and Configuration Protocol (VDP) Extension to Support Network Virtualization Overlays Over Layer 3 (NVO3)
- 802c - Local Medium Access Control (MAC) Address Usage
- 802.1CQ – Local address protocol

OmniRAN

- 802.1CF - Network Reference Model and Functional Description of IEEE 802 Access Network

Maintenance

- 802.1AX/Cor1 - Link Aggregation – Corrigendum
- 802.1AX/Rev - Link Aggregation - Revision

As of September 2016,

the following projects are currently in Task Group (TG) ballot:

P802.1CF

802.1CM

802.1Xck

802.1Qcp

The following are currently in Working Group (WG) ballot:

P802.1CB

P802c

P802.1Qch

The following are currently in Sponsor ballot:

P802.1AX/Cor1

P802d

P802.1AEcg

P802.1Qci

The following are currently submitted to the Review Committee for final approval:

P802.1AC-rev

The following are the current new projects under development:

5G Access Network

As a result of the IEEE 802 5G standing committee, the 802.1 OmniRAN TG is brainstorming on the development of a 5G Access Network. 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. An Industry Connections program has been suggested to solicit additional industry input on the requirements and use cases.

P802.1Qcs – Link-local Registration Protocol

This standard specifies protocols, procedures and managed objects to provide link-local registration of attributes. The standard will serve as a basis for applications in other projects to distribute attributes through a network based on link-local registration. The standard will consider the constraints of resource limited systems. Current MRP "802.1Q Multiple Registration Protocol" is suited only for applications with limited information rate. There is a need to overcome this limitation in an efficient manner.

P802.1Q – Bridges and Bridged Networks

Bridges, as specified by this standard, allow the compatible interconnection of information technology equipment attached to separate individual LANs.

This revision project will roll-up all of the recent amendments into the base standard.

Ongoing projects related to OTN

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 a new functional split as Class 2. 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.

P802.1Qci – Per stream policing

This standard specifies procedures and managed objects for a bridge to perform frame counting, filtering, policing, and service class selection for a frame based on the particular data stream to which the frame belongs, and a synchronized cyclic time schedule. Policing and filtering functions include the detection and mitigation of misbehavior by other systems in a network, improving the robustness of that network.

This project is about to start sponsor ballot.

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)

There is a draft in 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 derived from UML models that are based from IEEE Std 802.1Q, Clause 12 (Bridge management)

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

P802c – Local Address space

The standard will provide an optional local address space structure to allow multiple administrations to coexist. Three are currently specified: a range of addresses for protocols using a Company ID assigned by the IEEE Registration Authority; a range of local addresses designated for assignment by an IEEE 802 Standard; and a range of local addresses designated for assignment by local administrators.

This project is currently in working group ballot.

P802.1AX – 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, it is expected that a LAG YANG module will be added as part of the revision.

4.5.1.11 Status of IEEE 802.3 [Updated in 09/2016]

IEEE P802.3bn EPON Protocol over a Coax (EPoC) PHY Task Force

This draft amendment has completed Sponsor ballot and is awaiting final approval from the IEEE SASB.

IEEE P802.3bp 1000BASE-T1 PHY Task Force

IEEE Std 802.3bp-2016 was approved on 30 June 2016 and was published on 9 September 2016.

IEEE P802.3bq 25G/40GBASE-T Task Force

IEEE Std 802.3bq-2016 was approved on 30 June 2016 and was published on 8 September 2016.

IEEE P802.3br Interspersing Express Traffic Task Force.

IEEE Std 802.3br-2016 was approved on 30 June 2016 and is awaiting publication.

IEEE P802.bs 200 Gb/s and 400 Gb/s Ethernet Task Force

The P802.3bs draft is currently in the Working Group ballot stage and covers:
200GBASE-DR4 – 500 m over 4 SMF fibres per dir. using 4 x 50 Gb/s PAM4 (25 GBd)*
200GBASE-FR4 – 2 km WDM over SMF using 4 x 50 Gb/s PAM4 (25 GBd)*
200GBASE-LR4 – 10 km WDM over SMF using 4 x 50 Gb/s PAM4 (25 GBd)*
400GBASE-SR16 – 100 m over 16 MMF fibres per dir. using 16 x 25 Gb/s NRZ (25 GBd)
400GBASE-DR4 – 500 m over 4 SMF fibres per dir. using 4 x 100 Gb/s PAM4 (50 GBd)
400GBASE-FR8 – 2 km WDM over SMF using 8 x 50 Gb/s PAM4 (25 GBd)
400GBASE-LR8 – 10 km WDM over SMF using 8 x 50 Gb/s PAM4 (25 GBd)

The newly added PHYs and objectives for 200 Gb/s Ethernet over 500 m, 2 km and 10 km of SMF are shown with *.

IEEE P802.bt DTE Power via MDI over 4-Pair Task Force.

This Task Force is currently in Working Group ballot phase.

IEEE P802.bu 1-Pair Power over Data Lines (PoDL) Task Force.

This Task Force is currently in Sponsor ballot phase.

IEEE P802.3bv Gigabit Ethernet Over Plastic Optical Fiber Task Force

This Task Force is currently in Sponsor ballot phase.

IEEE P802.3bw 100BASE-T1 PHY Task Force

The P802.3bw amendment was published on 8 March 2016.

IEEE P802.3bx Revision to IEEE Std 802.3-2012 Maintenance #11 Task Force

The 802.3bx revision of 802.3 that incorporates the IEEE Std 802.3bk-2013, IEEE Std 802.3bj-2014, and IEEE Std 802.3bm-2015 amendments was published as IEEE Std 802.3-2015 on 4 March 2016.

IEEE P802.3by 25 Gb/s Ethernet Task Force

IEEE Std 802.3by-2016 was approved on 30 June 2016 and was published on 29 July 2016.

The amendment covers the following PHYs which all use single lane NRZ signaling:
25GBASE-KR – over a backplane using RS-FEC
25GBASE-KR-S – over a backplane using BASE-R FEC
25GBASE-CR – 5m over twinax cable using RS-FEC
25GBASE-CR-S – 3m over twinax cable using BASE-R FEC
25GBASE-SR – 100 m over one MMF using RS-FEC

IEEE P802.3bz 2.5G/5GBASE-T Task Force

This draft amendment has completed Sponsor ballot and is awaiting final approval from the IEEE SASB.

IEEE P802.3ca 25 Gb/s, 50 Gb/s, and 100 Gb/s Ethernet Passive Optical Networks Task Force.

This Task Force is working to adopt baselines.

The project objectives are:

- Support subscriber access networks using point to multipoint topologies on optical fiber
- Provide specifications for physical layers operating over a single SMF strand and supporting symmetric and/or asymmetric MAC data rates of:
  - 25 Gb/s in downstream and less than or equal to 25 Gb/s in upstream
  - 50 Gb/s in downstream and less than or equal to 50 Gb/s in upstream
  - 100 Gb/s in downstream and less than or equal to 100 Gb/s in upstream
- PHY(s) to have a BER better than or equal to 10^{-12} at the MAC/PLS service interface (or the frame loss ratio equivalent)
- Support coexistence with 10G-EPON
  - Optical power budgets to accommodate channel insertion losses equivalent to those supported by the 10G-EPON standard
  - Wavelength allocation allowing concurrent operation with 10G-EPON PHYs

IEEE P802.3cb 2.5 Gb/s and 5 Gb/s Backplane and Copper Cables Task Force.

This Task Force is in Working Group ballot phase.

The non boilerplate project objectives (with recent changes in blue) are:

Support MAC data rates of 2.5 Gb/s and 5 Gb/s
Support Auto-Negotiation (Clause 73)
Support a BER better than or equal to 10^{-12} at the MAC/PLS service interface (or the frame loss ratio equivalent)
Define a PHY for 2.5 Gb/s operation over a printed circuit board backplane with total channel insertion loss of <= 11 dB at 1.5625 GHz
Define a PHY for 5 Gb/s operation over a printed circuit board backplane with total channel insertion loss of <= 16 dB at 2.578125 GHz

P802.3cc 25 Gigabit/s Ethernet over single-mode fiber Task Force

This Task Force is in the Task Force review phase on their draft which covers:
25GBASE-LR – 10 km over SMF using 1 x 25 Gb/s NRZ
25GBASE-ER – 40 km over SMF using 1 x 25 Gb/s NRZ

P802.3cd 50, 100, and 200Gb/s Ethernet Task Force

This new Task Force covers:

50 Gb/s Ethernet
New 100Gb/s Ethernet variants
200 Gb/s Ethernet based on 4 lanes of 50G over backplane, copper cable and multimode fibre.

The expected PMDs are (SMF based PMDs in blue and red):
50GBASE-LR – 10 km over SMF using 1 x 50 Gb/s PAM4 (25 GBd)
50GBASE-FR – 2 km over SMF using 1 x 50 Gb/s PAM4 (25 GBd)
50GBASE-SR – 100 m over MMF using 1 x 50 Gb/s PAM4 (25 GBd)
50GBASE-CR – 3 m over copper twinax using 1 x 50 Gb/s PAM4 (25 GBd)
50GBASE-KR – ~1 m over backplane using 1 x 50 Gb/s PAM4 (25 GBd)
100GBASE-DR – 500 m over SMF using 1 x 100 Gb/s PAM4 (50 GBd)
100GBASE-SR2 – 100 m over parallel MMF using 2 x 50 Gb/s PAM4 (25 GBd)
100GBASE-CR2 – 3 m over copper twinax using 2 x 50 Gb/s PAM4 (25 GBd)
100GBASE-KR2 – ~1 m over backplane using 2 x 50 Gb/s PAM4 (25 GBd)
200GBASE-SR4 – 100 m over parallel MMF using 4 x 50 Gb/s PAM4 (25 GBd)
200GBASE-CR4 – 3 m over copper twinax using 4 x 50 Gb/s PAM4 (25 GBd)
200GBASE-KR4 – ~1 m over backplane using 4 x 50 Gb/s PAM4 (25 GBd)

Ethernet YANG models Study Group

This new Study Group has created proposed project documentation for a Task Force on YANG data model(s) for IEEE 802.3 management. This needs to be approved by the IEEE Standards Board in their September meeting.

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 12 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

4.6 Standardization on MPLS and MPLS-TP

In order to make MPLS technology fully applicable to operators' networks, standardization for enhancing MPLS was started in ITU-T SG13 and SG15. In addition to “normal” MPLS, Transport MPLS was studied actively. In 2007-2008 timeframe, several meetings were held to discuss the

working method on Transport MPLS between ITU-T (in particular, SG13 and SG15) and IETF. In February 2008, SG15 set up a Joint Work Team (JWT) to discuss this matter intensively. In December 2008, SG 15 agreed to use the term MPLS-TP to refer to the extensions to MPLS technology, which was being developed by the IETF to meet the requirements of the transport network. The meeting also agreed the plan to migrate the existing Trasnport MPLS Recommendations to MPLS-TP. In October 2009, MPLS-TP steering committee was established to provide MPLS-TP project management coordination between IETF and ITU-T. Figure 4-4 shows the structural relationship between IETF and ITU-T.

IETF and ITU-T relationship on MPLS-TP

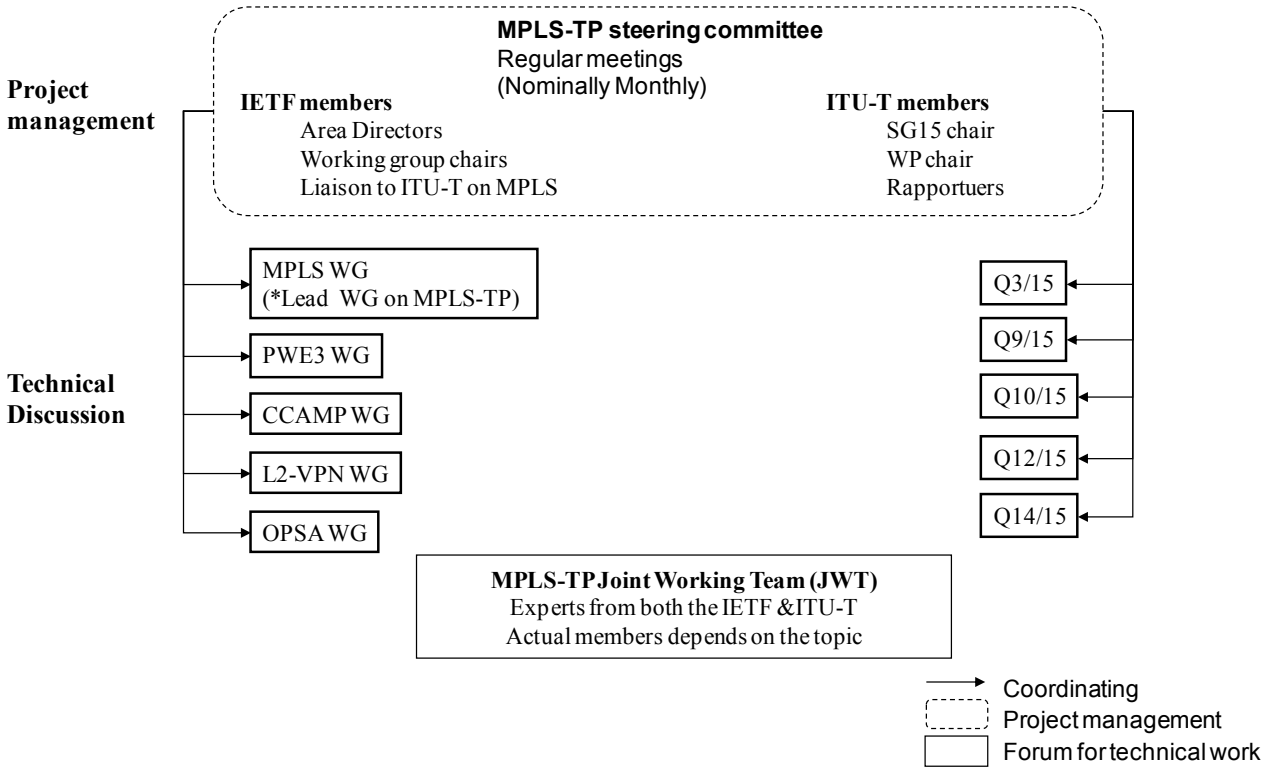

Figure 4-4 Structure of the Joint Working Team (JWT) and related Sub-Groups

The JWT recommended that:

- Jointly agree to work together and bring transport requirements into the IETF and extend IETF MPLS forwarding, OAM, survivability, network management and control plane protocols to meet those requirements through the IETF Standards Process
- The JWT believes this would fulfill the mutual goal of improving the functionality of the transport networks and the internet and guaranteeing complete interoperability and architectural soundness
- Refer to the technology as the Transport Profile for MPLS (MPLS-TP)
- Therefore, we recommend that future work should focus on:
  - In the IETF: Definition of the MPLS-TP
  - In the ITU-T:

- Integration of the MPLS-TP into the transport network
- Alignment of the current T-MPLS Recommendations with MPLS-TP and,
- Terminate the work on current T-MPLS.

Further details can be found at:

http://ties.itu.int/ftp/public/itu-t/ahtmpls/readandwrite/doc_exchange/overview/MPLS-TP_overview-22.ppt

Table 3 below summarizes the current standardization responsibilities on MPLS-TP.

Table 3 – Standardization on MPLS-TP

#	Standard body	Q/SG (WG)	Study items
1	ITU-T SG15	Q3/15	Terms and definitions for MPLS-TP
		Q9/15	MPLS-TP protection/survivability
		Q10/15	MPLS-TP interfaces, OAM architecture and mechanisms and equipment functional architecture
		Q12/15	MPLS-TP network architecture
		Q14/15	MPLS-TP network management and control
2	IETF (Refer to Annex B on organization restructuring and Annex C on transport network management)	BFD WG	Bidirectional Forwarding Detection (bfd) extensions for MPLS-TP
		CCAMP WG	Common control plane and measurement plane solutions and GMPLS mechanisms/protocol extensions for MPLS transport profile (MPLS-TP), Automatically Switched Optical Networks (ASON) and Wavelength Switched Optical Networks (WSON)
		L2VPN WG	Extensions to L2VPN protocols and RFC's necessary to create an MPLS Transport Profile (MPLS-TP)
		MPLS WG	Requirements, mechanisms, protocols and framework for MPLS-TP
		OPSAWG	Definition of the OAM acronym
		PCE WG	Specification of Path Computation Element (PCE) based architecture for the computation of paths for MPLS and GMPLS LSPs
		PWE3 WG	Extensions to the PWE3 protocols and RFCs necessary to create an MPLS Transport Profile (MPLS-TP)

4.6.1 OAM for MPLS and MPLS-TP

In ITU-T, SG13 (Q5/13) originally specified MPLS OAM, such as Recommendations on OAM requirements (Y.1710), mechanisms (Y.1711), OAM under ATM-MPLS interworking (Y.1712) and misbranch detection (Y.1713). IETF also specified MPLS OAM, such as the usage of the "OAM Alert label" in RFC3429, MPLS OAM requirements in RFC4377, MPLS OAM framework in RFC4378, methods for defect detection (LSP ping and traceroute) in RFC4379.

In October 2008, WTSA-08 transferred Q5/13 (OAM) with the work of MPLS/MPLS-TP OAM to

SG15 (i.e., Q.10/15). Since then, SG15 determined a new Recommendation G.8113.1 (ex. G.tpoam) under TAP in February 2011 and sent it without modification to WTSA-12 for approval in December 2011. Another MPLS-TP OAM Recommendation G.8113.2 was also sent to WTSA-12 in September 2012.

In November 2012, the WTSA-12 approved both Recommendations on the first day. On the next day of the approval, IETF and IANA published RFC6671, which allocates pseudowire associated channel type 0x8902, and G.8113.1 became operational.

4.6.2 MPLS/MPLS-TP protection switching

MPLS protection switching is standardized in ITU-T SG15 (Q.9/15). Recommendation on MPLS protection switching (Y.1720) was revised in December 2006. T-MPLS linear protection switching (G.8131) was approved in December 2006. IETF is also standardizing MPLS survivability techniques. RFC3469 describes MPLS recovery framework. RFC4090 specifies Fast ReRoute (FRR).

Regarding MPLS-TP, MPLS-TP linear protection switching (revised G.8131) and MPLS-TP ring protection switching (new G.8132) were developed under the cooperation with IETF based on the agreement of JWT. Both Recommendations were planned to be consent in December 2011, but were deferred. In 2014, the revised G.8131 was published.

4.6.3 MPLS interworking

Interworking with MPLS networks was studied in ITU-T SG13 (Q7/13). Recommendations on ATM-MPLS interworking (cell mode: Y.1411, frame mode: Y.1412), TDM-MPLS interworking (Y.1413), voice services – MPLS interworking (Y.1414) and Ethernet-MPLS network interworking (Y.1415) are available.

4.6.4 MPLS-TP network architecture

MPLS layer network architecture (G.8110) was approved by ITU-T SG15 in January 2005. Transport MPLS network architecture (G.8110.1) was approved by ITU-T SG15 (Q.12/15) in November 2006. Regarding MPLS-TP, architecture of MPLS-TP Layer Network was approved in December 2011.

4.6.5 MPLS-TP equipment functional architecture

Transpot MPLS equipment functional architecture (G.8121) was approved within ITU-T SG15 (Q.9/15) in March 2006 and amended October 2007. Its revision, MPLS-TP equipment functional architecture, was consented under AAP in December 2011 and was approved in September 2012. Further revision became available in November 2013.

4.6.6 MPLS-TP equipment network management

Transport MPLS equipment network management (G.8151) was approved in ITU-T SG15 (Q14/15) in October 2007. MPLS-TP network management (revised G.8151) was consented in December 2011 and approved in July 2012.

4.6.7 MPLS-TP interface

G.8112 (Interfaces for the Transpot MPLS hierarchy) was approved by ITU-T SG15 (Q.11/15) in October 2006. In December 2008, the packet transport work of Q.11/15 was transferred to a new Question 10/15 in order to balance the load among questions of Working Party 3/15. Since then, Q10/15 developed MPLS-TP interface (revised G.8112), which was consent in September 2012.

4.6.8 Further details

Table 13 lists the current status of MPLS-related ITU-T Recommendations. Table 14 lists the current status of MPLS-TP-related IETF RFCs, internet drafts, and ITU-T Recommendations.

Further details about standardization of MPLS/MPLS-TP can be found in the following:

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

Further details about standardization of MPLS-TP can be found in the following:

http://www.itu.int/ITU-T/studygroups/com15/ahmpls-tp/

The dependency between the draft revised MPLS-TP Recommendations and the MPLS-TP drafts and RFCs can be found at

http://www.itu.int/oth/T0906000002/en

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://grouper.ieee.org/groups/802/index.shtml
- 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: 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 Control Plane. All of the recommendations and standards of the three families are included in tables in the later clauses of this document.

Table 4 – OTNT Related Standards and Industry Agreements (ITU-T Recomendations)

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

Organization (Subgroup responsible)	Number	Title
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 (10/2012)	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 (01/2015)	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
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 (11/2009)	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 (10/2012)	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 (10/2012)	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 (02/2012)	Optical monitoring for dense wavelength division multiplexing systems

Organization (Subgroup responsible)	**Number**	**Title**
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.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 (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.808.1 (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 (05/2014)	Optical transport network (OTN): Linear protection
ITU-T (Q9/15)	G.873.2 (04/2012)	ODUk shared ring protection
ITU-T (Q10/15)	G.8021/Y.1341 (01/2015)	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)	Y.1720 (12/2006)	Protection switching for MPLS networks
ITU-T (Q10/15)	G.8011/Y.1307 (01/2015)	Ethernet service characteristics

Organization (Subgroup responsible)	**Number**	**Title**
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.798.1 (01/2013)	Types and characteristics of optical transport network equipment
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)

Organization (Subgroup responsible)	**Number**	**Title**
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 (10/2012)	Architecture of optical transport networks
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.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.8273/Y.1368 (08/2013)	Framework of phase and time clocks
ITU-T (Q13/15)	G.8273.2/Y.1368.2 (05/2014)	Timing characteristics of telecom boundary clocks and telecom time slave clocks

Organization (Subgroup responsible)	Number	Title
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 (08/2013)	Management aspects of optical transport network elements
ITU-T (Q14/15)	G.874.1 (10/2012)	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.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 (01/2015)	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 (08/2013)	Management aspects of the Ethernet Transport (ET) capable network element
ITU-T (Q14/15)	G.8052/Y.1346 (08/2013)	Protocol-neutral management information model for the Ethernet Transport capable network element

Organization (Subgroup responsible)	Number	Title
ITU-T (Q14/15)	G.8151/Y.1374 (01/2015)	Management aspects of 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
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 5 lists IETF RFCs and Internet Drafts. It should be noted that all Internet-Drafts should be identified as "work in progress". This request is made, as standard, by the IETF in the following text at the head of every Internet-Draft:

Internet-Drafts are draft documents valid for a maximum of six months and may be updated, replaced, or obsoleted by other documents at any time. It is inappropriate to use Internet-Drafts as reference material or to cite them other than as "work in progress."

Table 5 – OTNT Related Standards and Industry Agreements (IETF RFCs and Internet Drafts)

Organisation (Subgroup responsible)	Number	Title	Publication Date
IETF (mpls)	RFC5317	JWT Report on MPLS Architectural Considerations for a Transport Profile	02/2009
IETF (mpls)	RFC5586	MPLS Generic Associated Channel	06/2009
IETF (mpls)	RFC5654	MPLS-TP Requirements	08/2009
IETF (mpls)	RFC5718	An Inband Data Communication Network For the MPLS Transport Profile	08/2009
IETF (mpls)	RFC5860	Requirements for OAM in MPLS Transport Networks	03/2010
IETF (mpls)	RFC5921	A Framework for MPLS in Transport Networks	07/2010
IETF (mpls)	RFC5950	MPLS-TP Network Management Framework	09/2010
IETF (mpls)	RFC5951	MPLS TP Network Management Requirements	9/2010
IETF (mpls)	RFC5960	MPLS Transport Profile Data Plane Architecture	08/2010
IETF(mpls)	RFC6215	MPLS Transport Profile User-to-Network and Network-to-Network Interfaces	04/2011

Organisation (Subgroup responsible)	Number	Title	Publication Date
IETF (mpls)	RFC6291	Guidelines for the use of the OAM acronym in the IETF	06/2011
IETF (mpls)	RFC6370	MPLS-TP Identifiers	9/2011
IETF (mpls)	RFC6371	MPLS-TP OAM Framework	09/2011
IETF (mpls)	RFC6372	Multiprotocol Label Switching Transport Profile Survivability Framework	09/2011
IETF(ccamp)	RFC6373	MPLS Transport Profile (MPLS-TP) Control Plane Framework	09/2011
IETF(mpls)	RFC6374	Packet Loss and Delay Measurement for MPLS Networks	09/2011
IETF(mpls)	RFC6375	A Packet Loss and Delay Measurement Profile for MPLS-Based Transport Networks	09/2011
IETF(mpls)	RFC6427	MPLS Fault Management Operations, Administration, and Maintenance (OAM)	11/2011
IETF	RFC6428	Proactive Connectivity Verification, Continuity Check, and Remote Defect Indication for the MPLS Transport Profile	11/2011
IETF	RFC6435	MPLS Transport Profile Lock Instruct and Loopback Functions	11/2011
IETF (mpls)	RFC7054	Addressing Requirements and Design Considerations for Per-Interface Maintenance Entity Group Intermediate Points (MIPs)	2013
IETF (mpls)	RFC7087	A Thesaurus for the Interpretation of Terminology Used in MPLS Transport Profile (MPLS-TP) Internet-Drafts and RFCs in the Context of the ITU-T's Transport Network Recommendations	2013
IETF(mpls)	RFC6669	An Overview of the Operations, Administration, and Maintenance (OAM) Toolset for MPLS-Based Transport Networks	07/2012
IETF	RFC6671	Allocation of a Generic Associated Channel Type for ITU-T MPLS Transport Profile Operation, Maintenance, and Administration (MPLS-TP OAM)	11/2012
IETF	RFC6923	MPLS Transport Profile (MPLS-TP) Identifiers Following ITU-T Conventions	05/2013
IETF	RFC6941	MPLS Transport Profile (MPLS-TP) Security Framework	04/2013
IETF (mpls)	RFC 7271	MPLS Transport Profile (MPLS-TP) Linear Protection to Match the Operational Expectations of Synchronous Digital Hierarchy, Optical Transport Network, and Ethernet Transport Network Operators	2014
IETF (ccamp)	RFC 3468	The Multiprotocol Label Switching (MPLS) Working Group decision on MPLS signaling protocols	02/2003
IETF (ccamp)	RFC 3609	Tracing Requirements for Generic Tunnels	09/2003

Organisation (Subgroup responsible)	Number	Title	Publication Date
IETF (ccamp)	RFC 3945	Generalized Multi-Protocol Label Switching Architecture	10/2004
IETF (ccamp)	RFC 4003	GMPLS Signaling Procedure For Egress Control – updates RFC 3473	02/2005
IETF (ccamp)	RFC 4139	Requirements for Generalized MPLS (GMPLS) Signaling Usage and Extensions for Automatically Switched Optical Network (ASON)	07/2005
IETF (ccamp)	RFC 4201	Link Bundling in MPLS Traffic Engineering (TE)	10/2005
IETF (ccamp)	RFC 4202	Routing Extensions in Support of Generalized Multi-Protocol Label Switching (GMPLS)	10/2005
IETF (ccamp)	RFC 4203	OSPF Extensions in Support of Generalized Multi-Protocol Label Switching – updates RFC 3630	10/2005
IETF (ccamp)	RFC 4204	Link Management Protocol (LMP)	10/2005
IETF (ccamp)	RFC 4207	Synchronous Optical Network (SONET)/Synchronous Digital Hierarchy (SDH) Encoding for Link Management Protocol (LMP) Test Messages	10/2005
IETF (ccamp)	RFC4208	Generalize Multiprotocol Label Switching(GMPLS) User-Network Interface (UNI): Resource ReserVation Protocol-Traffic Engineering (RSVP-TE) Support for the Overlay Model	10/2005
IETF (ccamp)	RFC4209	Link Management Protocol (LMP) for Dense Wavelength Division Multiplexing (DWDM) Optical Line Systems	10/2005
IETF (ccamp)	RFC4258	Requirements for Generalized Multi-Protocol Label Switching (GMPLS) Routing for the Automatically Switched Optical Network (ASON)	11/2005
IETF (ccamp)	RFC4257	Framework for Generalized Multi-Protocol Label Switching (GMPLS)-based Control of Synchronous Digital Hierarchy/Synchronous Optical Networking (SDH/SONET) Networks	12/2005
IETF (ccamp)	RFC4328	Generalized Multi-Protocol Label Switching (GMPLS) Signaling Extensions for G.709 Optical Transport Networks Control – updates RFC 3471	01/2006
IETF (ccamp)	RFC4394	A Transport Network View of the Link Management Protocol	02/2006
IETF (ccamp)	RFC4397	A Lexicography for the Interpretation of Generalized Multiprotocol Label Switching (GMPLS) Terminology within The Context of the ITU-T's Automatically Switched Optical Network (ASON) Architecture	02/2006
IETF (ccamp)	RFC4426	Generalized Multi-Protocol Label Switching (GMPLS) Recovery Functional Specification	03/2006
IETF (ccamp)	RFC4427	Recovery (Protection and Restoration) Terminology for Generalized Multi-Protocol Label Switching (GMPLS)	03/2006

Organisation (Subgroup responsible)	Number	Title	Publication Date
IETF (ccamp)	RFC4428	Analysis of Generalized Multi-Protocol Label Switching (GMPLS)-based Recovery Mechanisms (including Protection and Restoration)	03/2006
IETF (ccamp)	RFC4558	Node ID based RSVP Hello: A Clarification Statement	06/2006
IETF (ccamp)	RFC4606	Generalized Multi-Protocol Label Switching (GMPLS) Extensions for Synchronous Optical Network (SONET) and Synchronous Digital Hierarchy (SDH) Control	08/2006
IETF (ccamp)	RFC4631	Link Management Protocol (LMP) Management Information Base (MIB) – updates RFC4327	09/2006
IETF (ccamp)	RFC4652	Evaluation of existing Routing Protocols against ASON routing requirements	10/2006
IETF (ccamp)	RFC4726	A Framework for Inter-Domain MPLS Traffic Engineering	11/2006
IETF (ccamp)	RFC4736	Reoptimization of Multiprotocol Label Switching (MPLS) Traffic Engineering (TE) loosely routed Label Switch Path (LSP)	11/2006
IETF (ccamp)	RFC4783	GMPLS – Communication of Alarm Information	12/2006
IETF (ccamp)	RFC4801	Definitions of Textual Conventions for Generalized Multiprotocol Label Switching (GMPLS) Management	02/2007
IETF (ccamp)	RFC4802	Generalized Multiprotocol Label Switching (GMPLS) Traffic Engineering Management Information Base	02/2007
IETF (ccamp)	RFC4803	Generalized Multiprotocol Label Switching (GMPLS) Label Switching Router (LSR) Management Information Base	02/2007
IETF (ccamp)	RFC4872	RSVP-TE Extensions in support of End-to-End Generalized Multi-Protocol Label Switching (GMPLS)-based Recovery	05/2007
IETF (ccamp)	RFC4873	GMPLS Based Segment Recovery	05/2007
IETF (ccamp)	RFC4874	Exclude Routes – Extension to RSVP-TE	04/2007
IETF (ccamp)	RFC4920	Crankback Signaling Extensions for MPLS and GMPLS RSVP-TE	07/2007
IETF (ccamp)	RFC4972	Routing extensions for discovery of Multiprotocol (MPLS) Label Switch Router (LSR) Traffic Engineering (TE) mesh membership	07/2007
IETF (ccamp)	RFC4974	Generalized MPLS (GMPLS) RSVP-TE Signaling Extensions in support of Calls	08/2007
IETF (ccamp)	RFC4990	Use of Addresses in Generalized Multi-Protocol Label Switching (GMPLS) Networks	09/2007
IETF (ccamp)	RFC5063	Extensions to GMPLS RSVP Graceful Restart	10/2007
IETF (ccamp)	RFC5073	IGP Routing Protocol Extensions for Discovery of Traffic Engineering Node Capabilities	12/2007

Organisation (Subgroup responsible)	Number	Title	Publication Date
IETF (ccamp)	RFC5145	Framework for MPLS-TE to GMPLS Migration	03/2008
IETF (ccamp)	RFC5146	Interworking Requirements to Support Operation of MPLS-TE over GMPLS Networks	03/2008
IETF (ccamp)	RFC5150	Label Switched Path Stitching with Generalized Multiprotocol Label Switching Traffic Engineering (GMPLS TE)	02/2008
IETF (ccamp)	RFC5151	Inter-Domain MPLS and GMPLS Traffic Engineering -- Resource Reservation Protocol-Traffic Engineering (RSVP-TE) Extensions	02/2008
IETF (ccamp)	RFC5152	A Per-Domain Path Computation Method for Establishing Inter-Domain Traffic Engineering (TE) Label Switched Paths (LSPs)	02/2008
IETF (ccamp)	RFC5212	Requirements for GMPLS-Based Multi-Region and Multi-Layer Networks (MRN/MLN)	07/2008
IETF (ccamp)	RFC5298	Analysis of Inter-Domain Label Switched Path (LSP) Recovery	08/2008
IETF (ccamp)	RFC5316	ISIS Extensions in Support of Inter-Autonomous System (AS) MPLS and GMPLS Traffic Engineering	12/2008
IETF (ccamp)	RFC5339	Evaluation of Existing GMPLS Protocols against Multi-Layer and Multi-Region Networks (MLN/MRN)	09/2008
IETF (ccamp)	RFC5392	OSPF Extensions in Support of Inter-Autonomous System (AS) MPLS and GMPLS Traffic Engineering	01/2009
IETF (ccamp)	RFC5420 (replaces RFC4420)	Encoding of Attributes for MPLS LSP Establishment Using Resource Reservation Protocol Traffic Engineering (RSVP-TE)	02/2009
IETF (ccamp)	RFC5467	GMPLS Asymmetric Bandwidth Bidirectional Label Switched Paths (LSPs)	03/2009
IETF (ccamp)	RFC5493	Requirements for the Conversion between Permanent Connections and Switched Connections in a Generalized Multiprotocol Label Switching (GMPLS) Network	04/2009
IETF (ccamp)	RFC5495	Description of the Resource Reservation Protocol - Traffic-Engineered (RSVP-TE) Graceful Restart Procedures	03/2009
IETF (ccamp)	RFC5553	Resource Reservation Protocol (RSVP) Extensions for Path Key Support	05/2009
IETF (ccamp)	RFC5787	OSPFv2 Routing Protocols Extensions for ASON Routing	03/2010
IETF (ccamp)	RFC 7260	GMPLS RSVP-TE extensions for OAM Configuration	2014
IETF (ccamp)	RFC 7369	GMPLS RSVP-TE Extensions for Ethernet OAM Configuration	2014
IETF (ccamp)	draft-ietf-ccamp-gmpls-g-694-lambda-labels-04.txt	Generalized Labels for G.694 Lambda-Switching Capable Label Switching Routers	03/2009

Organisation (Subgroup responsible)	Number	Title	Publication Date
IETF (ccamp)	draft-ietf-ccamp-ethernet-traffic-parameters-08.txt	Ethernet Traffic Parameters	04/2009
IETF (ccamp)	draft-ietf-ccamp-wson-impairments-00.txt	A Framework for the Control of Wavelength Switched Optical Networks (WSON) with Impairments	06/2009
IETF (ccamp)	draft-ietf-ccamp-ethernet-gmpls-provider-reqs-02.txt	Service Provider Requirements for Ethernet control with GMPLS	06/2009
IETF (ccamp)	draft-ietf-ccamp-rwa-wson-encode-02.txt	Routing and Wavelength Assignment Information Encoding for Wavelength Switched Optical Networks	07/2009
IETF (ccamp)	draft-ietf-ccamp-pc-spc-rsvpte-ext-03.txt	RSVP-TE Signaling Extension For Management Plane To Control Plane LSP Handover In A GMPLS Enabled Transport Network	07/2009
IETF (ccamp)	draft-ietf-ccamp-gmpls-mln-extensions-07.txt	Generalized Multi-Protocol Label Switching (GMPLS) Protocol Extensions for Multi-Layer and Multi-Region Networks (MLN/MRN)	08/2009
IETF (ccamp)	draft-ietf-ccamp-confirm-data-channel-status-07.txt	Data Channel Status Confirmation Extensions for the Link Management Protocol	09/2009
IETF (ccamp)	draft-ietf-ccamp-rwa-wson-framework-03.txt	Framework for GMPLS and PCE Control of Wavelength Switched Optical Networks (WSON)	09/2009
IETF (ccamp)	draft-ietf-ccamp-lsp-dppm-08.txt	Label Switched Path (LSP) Dynamic Provisioning Performance Metrics in Generalized MPLS Networks	09/2009
IETF (ccamp)	draft-ietf-ccamp-rwa-info-04.txt	Routing and Wavelength Assignment Information Model for Wavelength Switched Optical Networks	09/2009
IETF (ccamp)	draft-ietf-ccamp-gmpls-ethernet-arch-05.txt	Generalized Multi-Protocol Label Switching (GMPLS) Ethernet Label Switching Architecture and Framework	09/2009
IETF (ccamp)	draft-ietf-ccamp-mpls-graceful-shutdown-10.txt	Graceful Shutdown in MPLS and Generalized MPLS Traffic Engineering Networks	09/2009
IETF (ccamp)	draft-ietf-ccamp-gmpls-vcat-lcas-08.txt	Operating Virtual Concatenation (VCAT) and the Link Capacity Adjustment Scheme (LCAS) with Generalized Multi-Protocol Label Switching (GMPLS)	07/2009
IETF (ccamp)	draft-ietf-ccamp-gmpls-ted-mib-05.txt	Traffic Engineering Database Management Information Base in support of GMPLS	01/2009
IETF (ccamp)	draft-ietf-ccamp-rwa-info-04.txt	Routing and Wavelength Assignment Information Model for Wavelength Switched Optical Networks	09/2009
IETF (ccamp)	draft-ietf-ccamp-oam-configuration-fwk-03	OAM Configuration Framework and Requirements for GMPLS RSVP-TE	01/2010

Organisation (Subgroup responsible)	Number	Title	Publication Date
IETF (pce)	RFC 4655	A Path Computation Element (PCE) Based Architecture	08/2006
IETF (pce)	RFC 4657	Path Computation Element (PCE) Communication Protocol Generic Requirements	09/2006
IETF (pce)	RFC 4674	Requirements for Path Computation Element (PCE) Discovery	10/2006
IETF (pce)	RFC4927	PCE Communication Protocol (PCECP) Specific Requirements for Inter-Area Multi Protocol Label Switching (MPLS) and Generalized MPLS (GMPLS) Traffic Engineering	07/2007
IETF (pce)	RFC 5088	OSPF Protocol Extensions for Path Computation Element (PCE) Discovery	01/2008
IETF (pce)	RFC 5089	IS-IS Protocol Extensions for Path Computation Element (PCE) Discovery	01/2008
IETF (pce)	RFC 5376	Inter-AS Requirements for the Path Computation Element Communication Protocol (PCECP)	11/2008
IETF (pce)	RFC 5394	Policy-Enabled Path Computation Framework	12/2008
IETF (pce)	RFC 5440	Path Computation Element (PCE) Communication Protocol (PCEP)	03/2009
IETF (pce)	RFC 5441	A Backward-Recursive PCE-Based Computation (BRPC) Procedure to Compute Shortest Constrained Inter-Domain Traffic Engineering Label Switched Paths	04/2009
IETF (pce)	RFC 5455	Diffserv-Aware Class-Type Object for the Path Computation Element Communication Protocol	03/2009
IETF (pce)	draft-ietf-pce-vpn-req-00.txt	PCC-PCE Communication Requirements for VPNs	03/2009
IETF (pce)	RFC 5520	Preserving Topology Confidentiality in Inter-Domain Path Computation Using a Path-Key-Based Mechanism	04/2009
IETF (pce)	RFC 5521	Extensions to the Path Computation Element Communication Protocol (PCEP) for Route Exclusions	04/2009
IETF (pce)	RFC 5541	Encoding of Objective Functions in the Path Computation Element Communication Protocol (PCEP)	06/2009
IETF (pce)	draft-ietf-pce-monitoring-05.txt	A set of monitoring tools for Path Computation Element based Architecture	06/2009
IETF (pce)	RFC 5557	Path Computation Element Communication Protocol (PCEP) Requirements and Protocol Extensions in Support of Global Concurrent Optimization	07/2009
IETF (pce)	draft-ietf-pce-gmpls-aps-req-01.txt	Requirements for GMPLS applications of PCE	07/2009

Organisation (Subgroup responsible)	Number	Title	Publication Date
IETF (pce)	draft-ietf-pce-manageability-requirements-07.txt	Inclusion of Manageability Sections in PCE Working Group Drafts	07/2009
IETF (pce)	draft-ietf-pce-vendor-constraints-00.txt	Conveying Vendor-Specific Constraints in the Path Computation Element Protocol	07/2009
IETF (pce)	draft-ietf-pce-pcep-svec-list-02.txt	The use of SVEC (Synchronization VECtor) list for Synchronized dependent path computations	08/2009
IETF (pce)	draft-ietf-pce-inter-layer-req-10.txt	PCC-PCE Communication Requirements for Inter-Layer Traffic Engineering	08/2009
IETF (pce)	draft-ietf-pce-inter-layer-frwk-10.txt	Framework for PCE-Based Inter-Layer MPLS and GMPLS Traffic Engineering	03/2009 (awaiting RFC #)
IETF(opsawg)	draft-ietf-opsawg-mpls-tp-oam-def-05.txt	"The OAM Acronym Soup"	05/2010

Table 6 – 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	2011
IEEE 802.1	IEEE Std. 802.1AX-2014	Link Aggregation	2008
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. 802.16k-2007	Media Access Control (MAC) Bridges - Amendment 2: Bridging of IEEE 802.16	2007
IEEE 802.1	IEEE Std. 802.1Q-2014	Virtual Bridged Local Area Networks—Revision	2011
IEEE 802.3	IEEE Std 802.3-2015	IEEE Standard for Ethernet	09/2015
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))	2015

IEEE 802.3	IEEE Std 802.3.1-2013	IEEE Standard for Management Information Base (MIB) Definitions for Ethernet	08/2013
IEEE 802.17	IEEE Std. 802.17-2011	Resilient packet ring (RPR) access method and physical layer specifications	09/2011
IEEE 802.17	IEEE Std. 802.17a-2004	Media Access Control (MAC) Bridges - Amendment 1: Bridging of IEEE Std 802.17	102004
IEEE 802.17	IEEE Std. 802.17b-2007	Resilient packet ring (RPR) access method and physical layer specifications - Amendment 2: Spatially aware sublayer	07/2007
IEEE 802.17	IEEE Std. 802.17c-2010	Resilient Packet Ring (RPR) Access Method and Physical Layer Specifications - Amendment 3 - Protected Inter-Ring Connection	05/2010

Table 7 – OTNT Related Standards and Industry Agreements (OIF documents)

Organisation (Subgroup responsible)	**Number**	**Title**	**Publication Date**
OIF	OIF-TL-01.1	Implementation Agreement for Common Software Protocol, Control Syntax, and Physical (Electrical and Mechanical) Interfaces for Tunable Laser Modules.	11/2002
OIF	OIF-TLMSA-01.0	Multi-Source Agreement for CW Tunable Lasers.	05/2003
OIF	OIF-ITLA-MSA-01.0	Integratable Tunable Laser Assembly Multi-Source Agreement.	06/2004
OIF	OIF-ITLA-MSA-01.1	Integrable Tunable Laser Assembly Multi Source Agreement	11/2005
OIF	OIF-ITLA-MSA-01.2	Integrable Tunable Laser Assembly Multi Source Agreement	06/2008
OIF	OIF-ITTA-MSA-01.0	Integrable Tunable Transmitter Assembly Multi Source Agreement	11/2008
OIF	OIF-UNI-01.0	User Network Interface (UNI) 1.0 Signaling Specification	10/2001
OIF	OIF-UNI-01.0-R2-Common	User Network Interface (UNI) 1.0 Signaling Specification, Release 2: Common Part	02/2004
OIF	OIF-UNI-01.0-R2-RSVP	RSVP Extensions for User Network Interface (UNI) 1.0 Signaling, Release 2	02/2004
OIF	OIF-UNI-02.0-Common	User Network Interface (UNI) 2.0 Signaling Specification: Common Part	02/2008
OIF	OIF-UNI-02.0-RSVP	User Network Interface (UNI) 2.0 Signaling Specification: RSVP Extensions for User Network Interface (UNI) 2.0	02/2008
OIF	OIF-CDR-01.0	Call Detail Records for OIF UNI 1.0 Billing	04/2002
OIF	OIF-SEP-01.0	Security Extension for UNI and NNI	05/2003
OIF	OIF-SEP-02.1	Addendum to the Security Extension for UNI and NNI	03/2006
OIF	OIF-SLG-01.0	OIF Control Plane Logging and Auditing with Syslog	11/2007
OIF	OIF-E-NNI-Sig-01.0	Intra-Carrier E-NNI Signaling Specification	02/2004

Organisation (Subgroup responsible)	Number	Title	Publication Date
OIF	OIF-E-NNI-Sig-02.0	E-NNI Signaling Specification	04/2009
OIF	OIF-ENNI-OSPF-01.0	External Network-Network Interface (E-NNI) OSPF-based Routing - 1.0 (Intra-Carrier) Implementation Agreement	01/2007
OIF	OIF-G-Sig-IW-01.0	OIF Guideline Document: Signaling Protocol Interworking of ASON/GMPLS Network Domains	06/2008
OIF	OIF-SMI-01.0	Security Management Interfaces to Network Elements	09/2003
OIF	OIF-SMI-02.1	Addendum to the Security for Management Interfaces to Network Elements	03/2006
OIF	OIF-VSR4-01.0	Very Short Reach (VSR) OC-192 Interface for Parallel Optics	12/2000
OIF	OIF-VSR4-03.0	Very Short Reach (VSR) OC-192 Four Fiber Interface Based on Parallel Optics	07/2003
OIF	OIF-VSR4-04.0	Serial Shortwave Very Short Reach (VSR) OC-192 Interface for Multimode Fiber	01/2001
OIF	OIF-VSR4-05.0	Very Short Reach (VSR) OC-192 Interface Using 1310 Wavelength and 4 and 11 dB Link Budgets	10/2002
OIF	OIF-VSR5-01.0	Very Short Reach Interface Level 5 (VSR-5): SONET/SDH OC-768 Interface for Very Short Reach (VSR) Applications	09/2002
OIF	OIF-LRI-02.0	Interoperability for Long Reach and Extended Reach 10 Gb/s Transponders and Transceivers	07/2006
OIF	OIF-FD-100G-DWDM-01.0	100G Ultra Long Haul DWDM Framework Document	06/2009

Table 8 – 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	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 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	23.1	Class of Service Phase 2 Implementation Agreement	
Carrier Ethernet Service Attributes	26.1	External Network Network Interface (ENNI) Phase 2	
Carrier Ethernet Service Attributes	41	Generic Token Bucket Algorithm	
Carrier Ethernet Service Definitions	45	Multi-CEN 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	7.2	Carrier Ethernet Management Information Model	

Organisation (Subgroup responsible)	Number	Title	Publication Date
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	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	

Organisation (Subgroup responsible)	Number	Title	Publication Date
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 9 – 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.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)
Protection Switching	**G.808.1** Generic protection switching - Linear trail and subnetwork protection
	G.873.1 Optical Transport network (OTN) - Linear Protection
	G.Imp873.1 Implementer's Guide
	G.873.2 ODUk shared ring protection
Management Aspects	**G.874** Management aspects of the optical transport network element
	G.Imp874 Implementer's Guide
	G.874.1 Optical Transport Network (OTN) Protocol-Neutral Management Information Model For The Network Element View

	ITU-T Published Recommendations
	G.Imp874.1 Implementer's Guide
	G.7710/Y.1701 Common Equipment Management Requirements
	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
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

	ITU-T Published Recommendations
	G.665 Generic characteristics of Raman amplifiers and Raman amplified subsystems
	G.671 Transmission characteristics of optical components and subsystems

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 10 – 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.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.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

Table 11 shows the mapping of existing protocol-specific documents between ITU-T Recommendations and ones that were received from other organizations.

Table 11 – Estimated mapping of protocol-specific documents in ITU-T ASON Recommendations

	Requirements Protocol neutral		Requirement Protocol dependent	Protocol specific related documents in OIF & IETF					
				UNI		I-NNI		E-NNI	
G.8080 (ASON)	G.7713 (Signalling)		G.7713.1 (PNNI)	PNNI					
			G.7713.2 (RSVP-TE)	OIF	UNI 1.0	IETF	RFC3471	OIF	E-NNI 1.0
					UNI 2.0		RFC3473		E-NNI 2.0
				IETF	RFC4208		RFC4974		G-Sig-Iw
					RFC4974		RFC4328	IETF	RFC5151
					RFC4606		RFC4139		RFC4974
									RFC5150
			G.7713.3 (CR-LDP)			IETF	RFC3471		
							RFC3472		
							RFC3468		
	G.7714 (Discovery)		G.7714.1 (SDH&OTN)	IETF	RFC4204				
					RFC5073				
					RFC5088				
					RFC5089				
	G.7715 (Routing)		G.7715.1 (Link State)			IETF	RFC4258	OIF	E-NNI 1.0
							RFC4202	IETF	gmpls-ason-routing-ospf
							RFC4652		
							RFC4393		
			G.7715.2 (RRQ)	IETF	RFC5440				
	G.7716 (C-plane operation)								
	G.7718 (Management)	G.7718.1 (Information Model)		OIF	SEP.01	IETF	RFC4801	OIF	SEP.01
					SEP.02		RFC4631		SEP.02
							RFC4802		
							RFC4783		
							RFC4803		

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

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

Table 12 – 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

Organisation (Subgroup responsible)	Number	Title
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(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 13 – 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
SG13(Q.12/13)	Y.1416	Use of virtual trunks for ATM/MPLS client/server control plane interworking

Organisation (Subgroup responsible)	Number	Title
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 14 – 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/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(Q9/15)	G.8131/Y.1382	Linear protection switching for MPLS transport profile
SG15(Q14/15)	G.8151/Y.1374	Management aspects of 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 15 – Synchorozaion-related Recommendations

	Frequency	Time and phase
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

7 Overview of existing holes, overlaps, and conflicts

Considering the number and diversity of different organizations working on standardising aspects of OTNT, it is inevitable that some areas will be missed. For the same reasons, some aspects will be addressed in multiple groups, resulting in possible conflicts based on different applications, priorities, or technical expertise. These items need to be identified and addressed as appropriate. The following table lists those that have been identified, the recommended action, and the status of that action.

Table 16 – Known OTNT standardization holes, overlaps, conflicts (as of 07/2015)

No	Issue	Action	Status

No	Issue	Action	Status
1.	WSON (wavelength switched optical network) is now under discussion between IETF ccamp and ITU-T SG15. While ITU-T SG15 is specifying architecture and transport plane aspects, IETF ccamp is specifying control plane standard	Liaisons to and from the IETF ccamp, continuing work by Q6 & 12/15	Resolved
2	**Interconnection of core & access transport of time & SSM issues** Timing distribution method over access technologies such as GPON/xPON and XDSL for directly passing time and phase information from the ONU to the base stations are requested and investigated. Both frequency synchronization aspect and time synchronization aspect are discussed.	Possible proposals should be considered in Q2/15, Q4/15 and Q13/15	On-going
3	Ethernet over OTN (E-OTN) issues The use of Ethernet technology in PTN requires an extension of the tagging option defined in 802.1Q to support VC, VP, VS stacking in single and multi-domain scenarios. The necessity of the new transport tag option, PTN Layer Hierarchy (the 3 packet layer) and the role of each layer are still under discussion. PB and PBB models are also need to be considered.	Liaisons to and from the IEEE 802.1, continuing work by Q.9/15 and Q12/15	Resolved
4	**Transport of CPRI interface over OTN** Transport of CPRI over OTN is proposed. A definition of the applicable OTN hypothetical reference model (HRM) is required. Further clarifications of the requirements are undergoing discussion.	Contribution is invited in Q11 and Q13 G.SupCPRI was produced in July 2015.	On-going
5	**OTN beyond 100G** Possible additions to G.709 for standardization of interfaces at rates beyond 100G are being developed. Proposals are being considered and working assumptions are being collected in preparation for standardization. Final specification of an interoperable inter-domain interface is awaiting stability in the definition of 400GbE by the IEEE. Other SG15 Questions are being consulted, but the current work is focused in Q11.	Contribution is invited in Q11	On-going
6	**Software Defined Networking in transport networks** SG15 has responsibility for transport aspects of SDN. Two Recommendations have started in jointly in Q12 and Q14, and there is ongoing coordination with JCA-SDN and ONF.	Contributions are invited in Q12 and Q14 Representatives from SG15 participate in JCA-SDN.	On-going
7	**Terminology update on OTN and refinement of modelling** OTN terminology is being updated to be more precise and consistent across multiple Recommendations under the scopes of Q6, Q11, Q12, and Q14/15. The SG15 Questions are collaborating to select new terms that are consistent with the scopes of the Questions defining them and the Recommendations where they are used. The new terms and revisions to incorporate them should make OTN Recommendations easier to read while possibly reducing overlap across the document scopes.	Contributions are invited in Q11, Q12, and Q14/15.	Identified in Nov. 2014. On-going

No	Issue	Action	Status
8	**Management of synchronization network** • Configuration of the synchronization network • Performance monitoring and related OAM tools • Information modelling • SDN control of synchronization network.	Q10, 13, 14	Identified in Nov. 2014. On-going.

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-mpls-tp-rosetta-stone can also be referred.

Annex B – Routing Area Reorganization in IETF (as of Nov. 2014)

The IETF's Routing Area Directors have proposed and received agreement to reorganize the Routing area. This directly impacts a number of the working groups that have liaised with ITU-T in the past.

A summary of the restructuring is as follows:

L2VPN, L3VPN and PWE3 are closed, with active work shuffled based on topic into two new working groups:

BESS: BGP Enabled Services
PALS: Pseudo-wire and LDP-enabled Services

NVO3's charter will be adjusted with some of the work moving to BESS and PALS.

Traffic Engineering aspects in CCAMP, MPLS and PCE are moved into a new working group:

TEAS: Traffic Engineering Architecture and Signaling

Charters for the BESS and PALS working groups have been completed and are found on the IETF list of working groups found here: http://datatracker.ietf.org/wg/

A charter for TEAS as well as revised charters for CCAMP, MPLS and PCE are under development.

No changes are made to the remaining Routing Area working Groups (BFD, FORCES, I2RS, IDR, ISIS, MANET, OSPF, PIM, ROLL, RTWG, SFC, SIDR, SPRING).

The restructuring is scheduled to take effect after the IETF91 (Nov. 2014).

Annex C – IETF transport network management (as of July 2015)

This Annex reports on the status of the transport management related activities in IETF.

Layer Independent OAM Management in the Multi-Layer Environment (lime)

The LIME working group will concentrate on the operational challenges in consistent handling of end-to-end OAM and coordination of OAM within underlying network layers. This work will enable consistent configuration, reporting, and presentation for the OAM mechanisms used to manage the network, regardless of the layers and technologies, including management mechanisms to facilitate better mapping between information reported from OAM mechanisms that operate in different network layers. It will also produce architectural guidelines for the development of new OAM tools and protocols in both management plane and data plane so that they may be coherent with these mechanisms and more easily integrated from operational points of view. The charter of the Working Group can be found at http://datatracker.ietf.org/wg/lime/charter/.

Network Configuration Protocol (netconf)

The NETCONF protocol (RFC 6241) provides mechanisms to install, manipulate, and delete the configuration of network devices. NETCONF is based on the secure transport (SSH is mandatory to implement while TLS is an optional transport) and uses an XML-based data representation. The NETCONF protocol is data modeling language independent, but YANG (RFC 6020) is the recommended NETCONF modeling language, which introduces advanced language features for configuration management.

In the current phase of the incremental development of NETCONF the WG will focus on following items:

Develop the call home mechanism for the mandatory SSH binding (Reverse SSH) providing a server-initiated session establishment.

Develop a zero touch configuration document (a technique to establish a secure network management relationship between a newly delivered network device configured with just its factory default settings, and the Network Management System), specific to the NETCONF use case.

Advance NETCONF over TLS to be in-line with NETCONF 1.1 (i.e., update RFC 5539) and add the call home mechanism to provide a server-initiated session establishment.

Combine the server configuration data models from Reverse SSH and RFC5539bis drafts in a separate call home YANG module.

Develop RESTCONF, a protocol based on NETCONF in terms of capabilities, but over HTTP and with some REST characteristics, for accessing YANG data using the datastores defined in NETCONF. An "ordered edit list" approach is needed (the YANG patch) to provide client developers with a simpler edit request format that can be more efficient and also allow more precise client control of the transaction procedure than existing mechanisms. The YANG patch operation, based on the HTTP PATCH method, will be prepared in a separate draft. RESTCONF should not deviate from the NETCONF capabilities unless proper justification is provided and documented. The RESTCONF work will consider requirements suggested by the other working groups (for example I2RS).

RFC published since December 2014:

RFC7589 (Proposed Standard 2015.06) Using the NETCONF Protocol over Transport Layer Security (TLS) with Mutual X.509 Authentication (former title: NETCONF Over Transport Layer Security (TLS)). This document describes how to use the Transport Layer Security (TLS) protocol to secure the exchange of NETCONF messages. This document obsoletes RFC 5539.

Full details of the work of the Network Configuration (netconf) WG, including the published RFCs and Internet-Drafts, can be found at http://www.ietf.org/dyn/wg/charter/netconf-charter.html and http://datatracker.ietf.org/wg/netconf/.

Network Configuration Data Modeling Language (netmod)

The Network Configuration Data Modeling Language (netmod) WG is chartered to define a modeling language or accompanying rules that can be used to model the management information that is to be configured using NETCONF, including defining the semantics of operational data, configuration data, notifications, and operations. This language will be used to serve as the normative description of NETCONF data models.

The most recently published RFC is:

RFC-7407 A YANG Data Model for SNMP Configuration: This document defines a collection of YANG definitions for configuring SNMP engines. (2014.12).

Full details of the work of the NETCONF Data Modeling Language (netmod) WG, including the published RFCs and Internet-Drafts, can be found at http://www.ietf.org/dyn/wg/charter/netmod-charter.html and http://datatracker.ietf.org/wg/netmod/.

Traffic Engineering Architecture and Signaling-related work (TEAS)

The Traffic Engineering Architecture and Signaling (TEAS) Working Group, recently transitioning in charter work from the MPLS and CCAMP WGs, is responsible for defining MPLS and GMPLS traffic engineering architecture, standardizing the RSVP-TE signaling protocol, and identifying required related control-protocol functions, i.e., routing and path computation element functions. Traffic Engineering (TE) is the term used to refer to techniques that enable operators to control how specific traffic flows are treated within their networks. TE is applied to packet networks via MPLS TE tunnels and LSPs. The MPLS-TE control plane was generalized to additionally support non-packet technologies via GMPLS. RSVP-TE is the signaling protocol used for both MPLS-TE and GMPLS.

The TEAS WG has recently published the following RFC:

RFC 7551 (Proposed Standard) RSVP-TE Extensions for Associated Bidirectional Label Switched Paths (LSPs): This document describes Resource Reservation Protocol (RSVP) extensions to bind two point-to-point unidirectional Label Switched Paths (LSPs) into an associated bidirectional LSP. The association is achieved by defining new Association Types for use in ASSOCIATION and in Extended ASSOCIATION Objects. One of these types enables independent provisioning of the associated bidirectional LSPs on both sides, while the other enables single-sided provisioning. The REVERSE_LSP Object is also defined to enable a single endpoint to trigger creation of the reverse LSP and to specify parameters of the reverse LSP in the single-sided provisioning case. (2015.05)

Full details of the work of the Traffic Engineering Architecture and Signaling (TEAS) WG, including the published RFCs and individual Internet-Drafts, can be found at http://datatracker.ietf.org/wg/teas/charter/.

GMPLS management-related work (CCAMP)

The CCAMP working group is responsible for standardizing a common control plane and a separate common measurement plane for non-packet technologies found in the Internet and in the networks of telecom service providers (ISPs and SPs). Examples of the devices in such networks include photonic cross-connects, OEO switches, ROADMs, TDM switches, microwave links, and Ethernet switches.

The CCAMP WG has recently published the following management-related RFC:

RFC 7446 (Proposed Standard) Routing and Wavelength Assignment Information Model for Wavelength Switched Optical Networks: This document provides a model of information needed by the Routing and Wavelength Assignment (RWA) process in Wavelength Switched Optical Networks (WSONs). The purpose of the information described in this model is to facilitate constrained optical path computation in WSONs. This model takes into account compatibility constraints between WSON signal attributes and network elements but does not include constraints due to optical impairments. Aspects of this information that may be of use to other technologies utilizing a GMPLS control plane are discussed.(2015.02)

RFC 7487 (Proposed Standard) Configuration of pro-active MPLS-TP Operations, Administration, and Maintenance (OAM) Functions for MPLS-based Transport Network Using RSVP-TE: This specification describes the configuration of pro-active MPLS-TP OAM Functions for a given LSP using a common set of TLVs that can be carried on RSVP-TE protocol. (2015.03)

Full details of the work of the Common Control and Measurement Plane (ccamp) WG, including the published RFCs and individual Internet-Drafts, can be found at http://www.ietf.org/dyn/wg/charter/ccamp-charter.html and http://datatracker.ietf.org/wg/ccamp/

MPLS management-related work (MPLS)

The MPLS working group is responsible for standardizing technology for label switching and for the implementation of label-switched paths over packet based link-level technologies.

The MPLS WG has recently published the following management-related RFC:

RFC 7506 (Proposed Standard) IPv6 Router Alert Option for MPLS Operations, Administration, and Maintenance (OAM). (2015.04).

RFC-7453 (Proposed Standard) MPLS Transport Profile (MPLS-TP) Traffic Engineering (TE) Management Information Base (MIB): This memo defines a portion of the Management Information Base (MIB) for use with network management protocols in the Internet community. In particular, it describes additional managed objects and textual conventions for tunnels, identifiers, and Label Switching Routers to support multiprotocol Label Switching (MPLS) MIB modules for transport networks.(2015.02)

RFC-7412 (Proposed Standard) Requirements for MPLS Transport Profile (MPLS-TP) Shared Mesh Protection: This document presents the basic network objectives for the behavior of Shared Mesh Protection (SMP) that are not based on control-plane support. This document provides an expansion of the basic requirements presented in RFC 5654 ("Requirements of an MPLS Transport Profile") and RFC 6372 ("MPLS Transport Profile (MPLS-TP) Survivability Framework"). This document provides requirements for any mechanism that would be used to implement SMP for MPLS-TP data paths, in networks that delegate protection switch coordination to the data plane. (2014.12)

Full details of the work of the MPLS (mpls) WG, including the published RFCs and Internet-Drafts, can be found at http://www.ietf.org/dyn/wg/charter/mpls-charter.html and http://datatracker.ietf.org/wg/mpls/.
