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SERIES G: TRANSMISSION SYSTEMS AND MEDIA, DIGITAL SYSTEMS AND NETWORKS

Access networks – Optical line systems for local and access networks

Ethernet passive optical networks using OMCI

Recommendation ITU-T G.9801

ITU-T G-SERIES RECOMMENDATIONS

TRANSMISSION SYSTEMS AND MEDIA, DIGITAL SYSTEMS AND NETWORKS

INTERNATIONAL TELEPHONE CONNECTIONS AND CIRCUITS	G.100–G.199
GENERAL CHARACTERISTICS COMMON TO ALL ANALOGUE CARRIER-TRANSMISSION SYSTEMS	G.200–G.299
INDIVIDUAL CHARACTERISTICS OF INTERNATIONAL CARRIER TELEPHONE SYSTEMS ON METALLIC LINES	G.300–G.399
GENERAL CHARACTERISTICS OF INTERNATIONAL CARRIER TELEPHONE SYSTEMS ON RADIO-RELAY OR SATELLITE LINKS AND INTERCONNECTION WITH METALLIC LINES	G.400–G.449
COORDINATION OF RADIOTELEPHONY AND LINE TELEPHONY	G.450–G.499
TRANSMISSION MEDIA AND OPTICAL SYSTEMS CHARACTERISTICS	G.600–G.699
DIGITAL TERMINAL EQUIPMENTS	G.700–G.799
DIGITAL NETWORKS	G.800–G.899
DIGITAL SECTIONS AND DIGITAL LINE SYSTEM	G.900–G.999
MULTIMEDIA QUALITY OF SERVICE AND PERFORMANCE – GENERIC AND USER-RELATED ASPECTS	G.1000–G.1999
TRANSMISSION MEDIA CHARACTERISTICS	G.6000–G.6999
DATA OVER TRANSPORT – GENERIC ASPECTS	G.7000–G.7999
PACKET OVER TRANSPORT ASPECTS	G.8000–G.8999
ACCESS NETWORKS	G.9000–G.9999
Metallic access networks	G.9700–G.9799
Optical line systems for local and access networks	**G.9800–G.9899**
In premises networks	G.9900–G.9999

For further details, please refer to the list of ITU-T Recommendations.

Recommendation ITU-T G.9801

Ethernet passive optical networks using OMCI

Summary

Recommendation ITU-T G.9801 describes requirements and specifications of Ethernet passive optical network (EPON) systems using the ONU management and control interface (OMCI), which is called OMCI-EPON.

OMCI-EPON is based on IEEE 802.3 and IEEE 1904.1 for user data transport, and applies Annex C of Recommendation ITU-T G.988 for its management. OMCI-EPON supports 1G-EPON, 10/1G-EPON and 10/10G-EPON architectures defined in IEEE 802.3, and provides a mechanism that enables coexistence with the existing PON systems using time division multiple access (TDMA) technologies and/or wavelength blocking filter (WBF).

History

Edition	Recommendation	Approval	Study Group	Unique ID*
1.0	ITU-T G.9801	2013-08-29	15	11.1002/1000/12009-en

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FOREWORD

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Table of Contents

Recommendation ITU-T G.9801

Ethernet passive optical networks using OMCI

1 Scope

The Ethernet passive optical network (EPON) system is a general name for PON systems that are based on the IEEE 802.3 standard and the IEEE 1904.1 standard. This Recommendation focuses on EPON systems that apply the ONU management and control interface (OMCI) defined by [ITU-T G.988] to create an effective PON operation system. This Recommendation calls these EPON systems OMCI-EPON.

OMCI-EPON includes 1G-EPON, 10/1G-EPON and 10/10G-EPON architectures defined in [IEEE 802.3].

The requirements and specifications of OMCI-EPON conform to [IEEE 802.3] and the IEEE 1904.1 Package B standard and to the operational requirements and specifications defined by Annex C of [ITU-T G.988]. The requirements and specifications of OMCI-EPON enable the use of OMCI to manage IEEE 802.3/IEEE 1904.1 Package B compliant systems, thus providing 1G-EPON and 10G-EPON solutions to network operators who prefer OMCI management.

As much as possible, this Recommendation maintains backward compatibility with existing optical distribution networks (ODN) that comply with the existing PON systems defined by [IEEE 802.3] and ITU-T Recommendations such as [b-ITU-T G.983.x], [b-ITU-T G.984.x] and [b-ITU-T G.987.x]. Furthermore, this Recommendation provides a mechanism that enables coexistence with the existing PON systems using TDMA technologies and/or wavelength blocking filter (WBF).

2 References

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

[ITU-T G.902]   Recommendation ITU-T G.902 (1995), *Framework Recommendation on functional access networks (AN) – Architecture and functions, access types, management and service node aspects*.

[ITU-T G.984.1]   Recommendation ITU-T G.984.1 (2008), *Gigabit-capable passive optical networks (GPON): General characteristics*.

[ITU-T G.988]   Recommendation ITU-T G.988 (2012), *Optical network unit management and control interface specification*.

[IEEE 1904.1]   IEEE 1904.1-2013, *IEEE Standard for Service Interoperability in Ethernet Passive Optical Networks (SIEPON)*.

[IEEE 802.3]   IEEE 802.3-2012, *IEEE Standard for Ethernet*.

3 Definitions

3.1 Terms defined elsewhere

This Recommendation uses the following terms defined elsewhere:

3.1.1 access network (AN) [ITU-T G.902]: An implementation comprising those entities (such as cable plant, transmission facilities, etc.) which provide the required transport bearer capabilities for the provision of telecommunications services between a service node interface (SNI) and each of the associated user-network interfaces (UNI).

3.1.2 Ethernet LAN service (E-LAN) [b-MEF 6.1]: An Ethernet service type that is based on a multipoint-to-multipoint Ethernet virtual connection.

3.1.3 Ethernet line service (E-Line) [b-MEF 6.1]: An Ethernet service type that is based on a point-to-point Ethernet virtual connection.

3.1.4 Ethernet tree service (E-Tree) [b-MEF 6.1]: An Ethernet service type that is based on a rooted-multipoint Ethernet virtual connection.

3.1.5 Ethernet virtual connection (EVC) [b-MEF 6.1]: An association of UNIs to which the exchange of service frames is limited.

3.1.6 service node (SN) [ITU-T G.902]: A network element that provides access to various switched and/or permanent telecommunication services.

3.1.7 service node interface (SNI) [ITU-T G.902]: An interface which provides customer access to a service node.

3.1.8 user-network interface (UNI) [b-ITU-T I.112]: The interface between the terminal equipment and a network termination at which interface the access protocols apply.

3.2 Terms defined in this Recommendation

This Recommendation defines the following terms:

Terms related to optical access architecture

3.2.1 Ethernet passive optical network (EPON): A general name for PON systems that are based on the [IEEE 802.3] standard and the [IEEE 1904.1] standard.

3.2.2 OMCI-EPON: An EPON system that applies the ONU Management and Control Interface (OMCI) defined by [ITU-T G.988].

3.2.3 optical access network (OAN): A part of an access network whose network elements are interconnected by optical communication channels.

NOTE – An OAN may or may not extend all the way to the UNI, so that the user-side interface of the OAN does not necessarily coincide with the UNIs of the AN.

3.2.4 optical distribution network (ODN): A point-to-multipoint optical fibre infrastructure. A *simple* ODN is entirely passive and is represented by a single-rooted point-to-multipoint tree of optical fibres with splitters, combiners, filters, and possibly other passive optical components. A *composite* ODN consists of two or more passive *segments* interconnected by active devices, each of the segments being either an optical trunk line segment or an optical distribution segment. A passive optical distribution segment is a simple ODN itself. Two ODNs with distinct roots can share a common subtree.

3.2.5 optical line termination (OLT): A network element in an ODN-based optical access network that terminates the root of at least one ODN and provides an OAN SNI.

3.2.6 optical network terminal (ONT): An ONU supporting a single subscriber.

3.2.7   optical network unit (ONU): A network element in an ODN-based optical access network that terminates a leaf of the ODN and provides an OAN UNI.

3.2.8   passive optical network (PON) system: A combination of network elements in an ODN-based optical access network that includes an OLT and multiple ONUs and implements a particular coordinated suite of physical medium dependent layer, transmission convergence layer, and management protocols.

Terms related to optical parameters, power and loss budget

3.2.9   attenuation: The total relative optical power loss of an optical signal propagating through the ODN. Attenuation is caused by absorption and scattering of light in the fibre (caused by fibre impurities and imperfections, fluctuations of the refractive index, material dispersion), as well as connectors, splices, splitters, wavelength couplers, attenuators, and other passive optical components.

3.2.10   differential fibre distance: The absolute difference between the fibre distances of two particular ONUs connected to the same OLT PON interface.

3.2.11   dispersion: A physical phenomenon comprising the dependence of the phase or group velocity of a light wave in the medium on its propagation characteristics such as optical frequency (wavelength) or polarization mode.

3.2.12   dynamic range: An optical receiver characteristic that represents the difference between the worst-case sensitivity (i.e., maximum over the operating conditions) and the worst-case overload (i.e., minimum over the operating conditions), and is usually expressed as a ratio of the former to the latter.

3.2.13   extinction ratio: With respect to a digital signal generated by an optical source (laser diode), the ratio of the two optical power levels corresponding to the high and low intensities of light emission.

3.2.14   fibre distance: The overall length of fibre (and, if applicable, equivalent fibre runs representing delay-inducing components) between the R/S and S/R reference points.

3.2.15   mean optical launch power: An optical transmitter characteristic expressing the average optical power of an optical signal transmitted into the fibre and carrying a given digital sequence. When specified as a range, the minimum mean launch power provides the power level that the transmitter should guarantee at all times, and the maximum mean launch power provides the power level that the transmitter should never exceed. When applied to burst mode transmission, the term pertains to the time interval during which the transmitter is fully active, and excludes possible starting and ending transient behaviour.

3.2.16   nominal line rate: The total number of bits that can be physically transferred per unit of time over a communication link. Nominal line rate accounts for useful data as well as for all possible protocol overheads and necessarily exceeds the effective data rate on any given protocol level.

3.2.17   optical path penalty (OPP): The apparent reduction of receiver sensitivity due to distortion of the signal waveform during its transmission over the optical path. The optical path penalty accounts for total degradations including the effects of reflections, intersymbol interference, mode partition noise, and laser chirp.

3.2.18   optical return loss (ORL): The total reflection at the source reference point of the optical signal propagation path associated with both discrete reflections at the refractive index discontinuities and distributed backscattering, such as Rayleigh scattering, along the path. Optical return loss is measured as a ratio of the transmitted power to the reflected power.

3.2.19   overload: A receiver parameter that characterizes the maximum value of the average received optical power to achieve the BER at or below the specified reference level.

3.2.20 reflectance: The reflection from any single discrete reflection point in the optical signal propagation path, which is defined to be the ratio of the reflected optical power present at a point, to the optical power incident to that point.

3.2.21 sensitivity: A receiver parameter that characterizes the minimum value of the average received optical power to achieve the BER at or below the specified reference level.

3.2.22 tolerance to reflected power (receiver): A receiver parameter that characterizes the minimum admissible ratio of the average optical input power incident at the receiver to the average reflected power regarded as a noise.

3.2.23 tolerance to reflected power (transmitter): A transmitter parameter that characterizes the maximum admissible ratio of the average reflected optical transmit power incident at the transmitter to the average optical transmit power.

Other terms

3.2.24 activation: A set of distributed procedures executed by the OLT and the ONUs that allows an inactive ONU to join or resume operations on the PON. The activation process includes three phases: parameter learning, serial number acquisition, and ranging.

3.2.25 activation cycle: A time interval between ONU's consecutive entries into the Initial state (O1).

3.2.26 bandwidth allocation: An upstream transmission opportunity granted by the OLT for a specified time interval to a specified traffic-bearing entity within an ONU.

3.2.27 dynamic bandwidth assignment (DBA): A process by which the OLT distributes upstream PON capacity between the traffic-bearing entities within ONUs, based on dynamic indication of their traffic activity and their configured traffic contracts.

3.2.28 effective key length: The number of randomly generated bits of a cryptographic key. The effective key length may be less than the nominal key length of a particular cryptosystem, if a part of the key is replaced by a well-known bit pattern.

3.2.29 equalization delay (EqD): The requisite delay assigned by the OLT to an individual ONU in order to ensure that the ONU's transmissions are precisely aligned on a common OLT-based upstream frame reference. The ONU's equalization delay is assigned as a result of ranging and is subject to in-service updates in the course of burst arrival phase monitoring.

3.2.30 Logical Link Identifier (LLID): A numeric identifier assigned to a Point-to-Multi Point association between an OLT and ONU established through the Point-to-Point Emulation sublayer. Each Point-to-Multi Point association is assigned a unique LLID. The Point-to-Multi Point association is bound to a logical ONU, where a MAC would observe a private association.

3.2.31 ONU management and control interface (OMCI): An operation and management channel between the OLT and an ONU that is message-based and employs an extendable management information base.

3.2.32 physical layer OAM (PLOAM): An operation and management channel between the OLT and the ONUs that is close to real time and is based on a fixed set of messages.

3.2.33 quiet window: A time interval during which the OLT suppresses all bandwidth allocations to in-service ONUs in order to avoid collisions between their upstream transmissions and the transmissions from ONUs whose burst arrival time is uncertain. The OLT opens a quiet window to allow new ONUs to join the PON and to perform ranging of specific ONUs.

3.2.34 ranging: A procedure of measuring the logical distance between the OLT and any of its subtending ONUs with the objective to determine and assign the appropriate equalization delay, which is necessary to align the ONU's upstream transmissions on a common OLT-based upstream frame reference. Ranging is performed during ONU activation and may be performed while the ONU is in service.

3.2.35 requisite delay: A general term denoting the total extra delay the OLT may require an ONU to apply to the upstream transmission beyond the ONU's regular response time. The purpose of requisite delay is to compensate for variation of propagation and processing delays of individual ONUs, and to avoid or reduce the probability of collisions between upstream transmissions.

4 Abbreviations and acronyms

This Recommendation uses the following abbreviations and acronyms:

AN   Access Network

BER   Bit-Error Ratio

BW   Bandwidth

CAPEX   Capital Expenditure

CBU   Cell-site Backhauling Unit

CIR   Committed Information Rate

CO   Central Office

DBA   Dynamic Bandwidth Assignment

DSL   Digital Subscriber Line

E-LAN   Ethernet LAN service

E-Line   Ethernet Line service

EPON   Ethernet Passive Optical Network

E-Tree   Ethernet Tree Service

EVC   Ethernet Virtual Connection

FEC   Forward Error Correction

FTTCell   Fibre to the Cell site base stations

FTTx   Fibre to the x (B – building, business; H – home; C – cabinet, curb, P – premises)

G-PON   Gigabit-capable Passive Optical Network

ID   Identifier

IP   Internet Protocol

IPTV   Internet Protocol TV

LAN   Local Area Network

LLID   Logical Link Identifier

MAC   Media Access Control

MDU   Multi-Dwelling Unit

ME   Managed Entity

MIB   Management Information Base

MPCPDU	Multipoint Control Protocol Data Unit
MTU	Multi-Tenant Unit
OAM	Operation, Administration and Management
OAN	Optical Access Network
ODN	Optical Distribution Network
OLT	Optical Line Terminal
OMCI	Optical network unit Management and Control Interface
ONT	Optical Network Terminal
ONU	Optical Network Unit
OPEX	Operational Expenditure
PIR	Peak Information Rate
PLOAM	Physical Layer Operations, Administration and Maintenance
PM	Performance Monitoring
PMD	Physical Medium Dependent (protocol layer)
PON	Passive Optical Network
QoS	Quality of Service
RE	Reach Extender
R/S	Reference point at the interface of the ONU to the ODN
R'/S'	Reference point at the interface of the Reach extender to the OTL
RF	Radio Frequency
Rx	Receiver
S'/R'	Reference point at the interface of Reach extender to ODN
S/R	Reference point at the interface of the OLT to the ODN
SNI	Service Node Interface
TDMA	Time Division Multiple Access
Tx	Transmitter
UNI	User Network Interface
VLAN	Virtual Local Area Network
VoIP	Voice over IP
VPN	Virtual Private Network
V-Rx	Video Receiver
V-Tx	Video Transmitter
WBF	Wavelength Blocking Filter
WDM	Wavelength Division Multiplexing
X/S	Crosstalk-to-Signal ratio

5   Conventions

OMCI-EPON has sublayers in both the physical layer and the data link layer for the user data channel and has some clients and functions for the management channel, as shown in Figure 5-1. The sublayers are detailed in [IEEE 802.3], while the clients and functions are detailed in [IEEE 1904.1]. OMCI-EPON replaces the OAM client functions which IEEE 1904.1 Package B defines with OMCI client functions defined by Annex C of [ITU-T G.988].

The physical layer consists of the physical medium dependent (PMD) sublayer, physical medium attachment (PMA) sublayer, physical coding (PCS) sublayer and reconciliation sublayer. The medium dependent interface (MDI) connects the optical fibre to PMD. The gigabit medium-independent interface (GMII) and 10 gigabit medium-independent interface (XGMII) are defined between PCS and reconciliation. The PMD sublayer and MDI make reference to clauses 60 and 75 of [IEEE 802.3], and the other sublayers and interfaces refer to clauses 65 and 76 of [IEEE 802.3].

The data link layer consists of a media access control (MAC) sublayer, multipoint MAC control (MPMC) sublayer, operations, administration and maintenance (OAM) sublayer and MAC client sublayer. The specifications of the MAC sublayer are the same as gigabit Ethernet except for the preamble, and make reference to clause 56 of [IEEE 802.3]. The MPMC sublayer makes reference to clause 64 of [IEEE 802.3]. The OAM sublayer makes reference to clause 57 of [IEEE 802.3]. MAC client sublayer makes reference to clause 6 of [IEEE 1904.1].

The management channel consists of the MAC control client, OAM client and their functions. The MAC control client is a pointer between the MPMC sublayer and its functions, and OAM client is a pointer between the OAM sublayers and OMCI, which corresponds to OAM client functions. These clients and their functions make reference to clause 5 of [IEEE 1904.1].

When OMCI is used for EPON ONU management, the same functionality as G-PON PLOAM can be adopted by EPON. The MAC control extension which is defined in Annex 31C of [IEEE 802.3] is a suitable control channel for some requirements such as power management (clause 10.5.4 of [IEEE 1904.1]) and protection (clause 9.3.7 of [IEEE 1904.1]) because of its broadcasting capability and lack of frame rate limitation. The use of the MAC control extension frame payload in OMCI-EPON is described in clause 9.2.4.

ITU-T Recommendations such as [b-ITU-T G.984.x] and [b-ITU-T G.987.x] separate PON specifications into three documents: PMD layer Recommendation, TC layer Recommendation and OMCI Recommendation. The PMD layer Recommendation corresponds to the specifications of the PMD sublayer and MDI of EPON. The OMCI Recommendation corresponds to the OAM client functions of EPON as described above. The TC layer Recommendation corresponds to the specifications of the other sublayers, clients and functions of EPON.
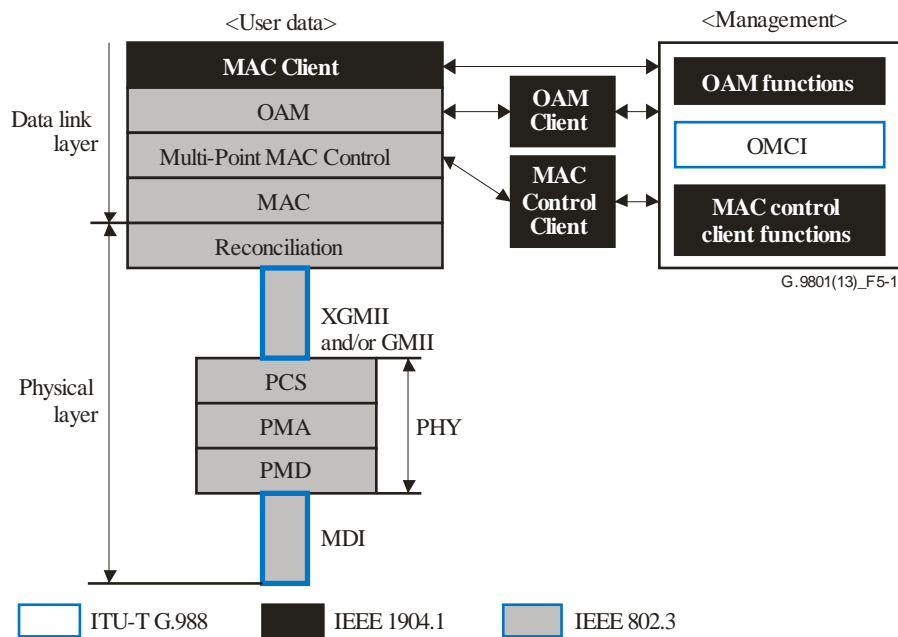
Figure 5-1 – Layer structure of OMCI-EPON

6 Architecture of the optical access network

6.1 Network architecture

The optical section of a local access network system can be either active or passive and its architecture can be either point-to-point or point-to-multipoint. Figure 6-1 shows the architectures considered, such as fibre to the home (FTTH), fibre to the cell sites (FTTCell), fibre to the building/curb (FTTB/C) and fibre to the cabinet (FTTCab). The optical distribution network (ODN) is common to all architectures as shown in Figure 6-1; hence the commonality of this system has the potential to generate large worldwide volumes.
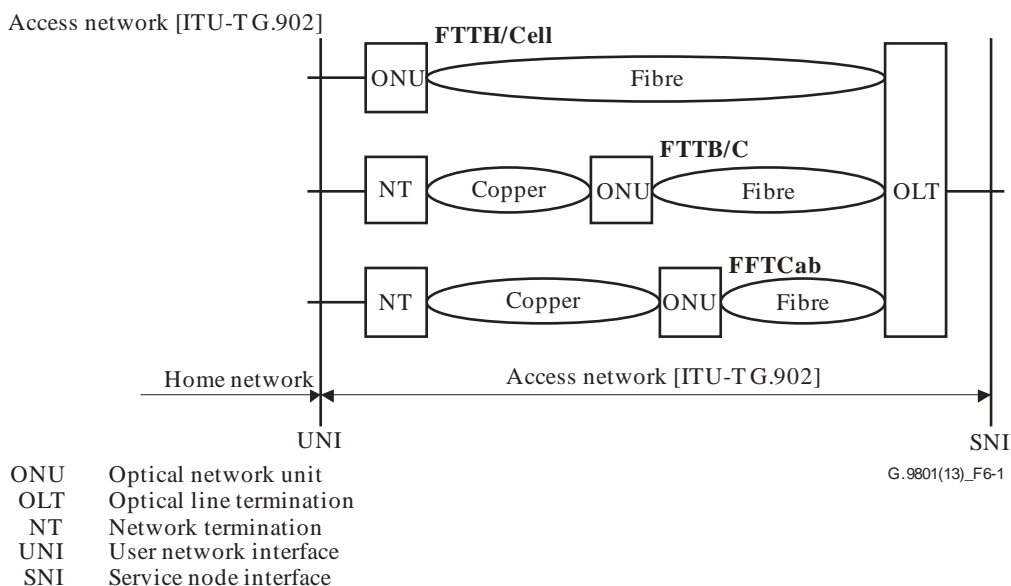

Figure 6-1 – Network architecture

The differences among these FTTx options are mainly due to the different services supported and the different locations of the ONUs rather than the ODN itself, so they can be treated as one in this

Recommendation. It must be noted that a single OLT optical interface might accommodate a combination of several of the scenarios described in clause 7.

6.2 Reference architecture

A high level and simple reference architecture of OMCI-EPON is depicted in Figure 6-2 which shows a high level reference architecture very similar to those of [b-ITU-T G.983.x], [b-ITU-T G.984.x] and [b-ITU-T G.987.x].

As depicted in Figure 6-2, the ONU provides the UNI towards end users, while the OLT provides the SNI towards core networks. The interface types of UNI/SNI depend on the services offered by the service provider. Typical interfaces are Ethernet interfaces such as 10/100/1000 Base-T. The interface at reference points S/R and R/S at OLT and ONU optical port is a PON-specific interface based on Ethernet frames.
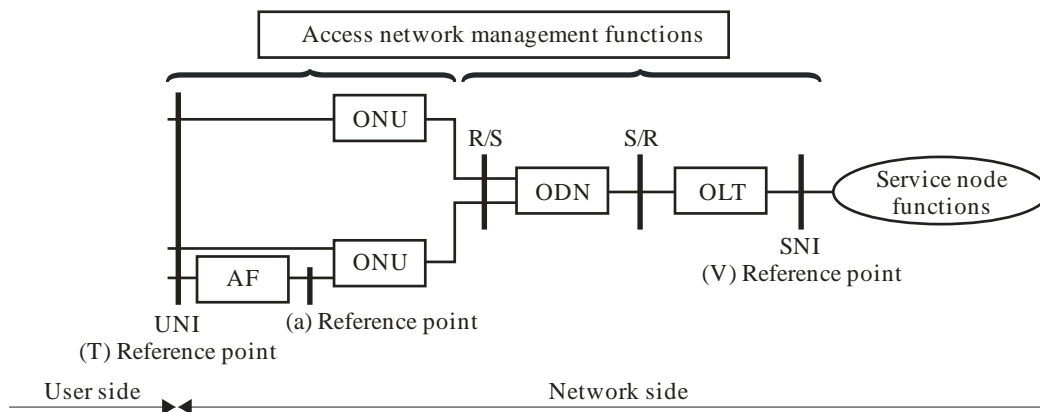

Figure 6-2 – High level reference architecture of OMCI-EPON

6.3 ODN architectures

OMCI-EPON can use the same ODN architecture as existing PON systems such as B-PON ([b-ITU-T G.983.x]), G-PON ([b-ITU-T G.984.x]) and XG-PON ([b-ITU-T G.987.x]) defined in ITU-T Recommendations, and 1G-EPON and 10G-EPON defined in [IEEE 802.3].

The PON systems can be categorized into 1G class PON and 10G class PON by their downstream line rates. 1G class PON includes 1G-EPON described in [IEEE 802.3] and G-PON defined by [b-ITU-T G.984.x]. 10G class PON includes 10G-EPON described in [IEEE 802.3] and XG-PON defined by ITU-T [b-ITU-T G.987.x]. 1G class PON, 10G class PON and video distribution services can co-exist on the same ODN because their downstream signals use different wavelengths. However, TDMA technology is necessary for multiplexing upstream signals of 1G class PON and 10G class PON because some of their wavelengths are the same.

Figure 6-3 is a reference diagram of the ODN architecture that supports the coexistence of 1G class PON and 10G class PON by OMCI-EPON. Typical line rate of OMCI-EPON is 10G class, but it permits dual rate mode of 10G-EPON and 1G-EPON because clause 75.6 of [IEEE 802.3] defines the dual rate mode. The figure assumes that wavelength blocking filters (WBFs) are used when 10G class EPON, 1G class EPON and video signal are shared within the same ODN.

Note that this diagram simply provides a reference architecture of the ODN and WBF, and is not intended to limit future designs and implementations. For example, when only 10G-EPON is used, WBF is not necessary. In addition, the coexistence of the 10G-EPON and the 1G-EPON can be achieved by TDMA, but the method of TDMA implementation lies outside the scope of this clause since this would not affect WDM configuration.
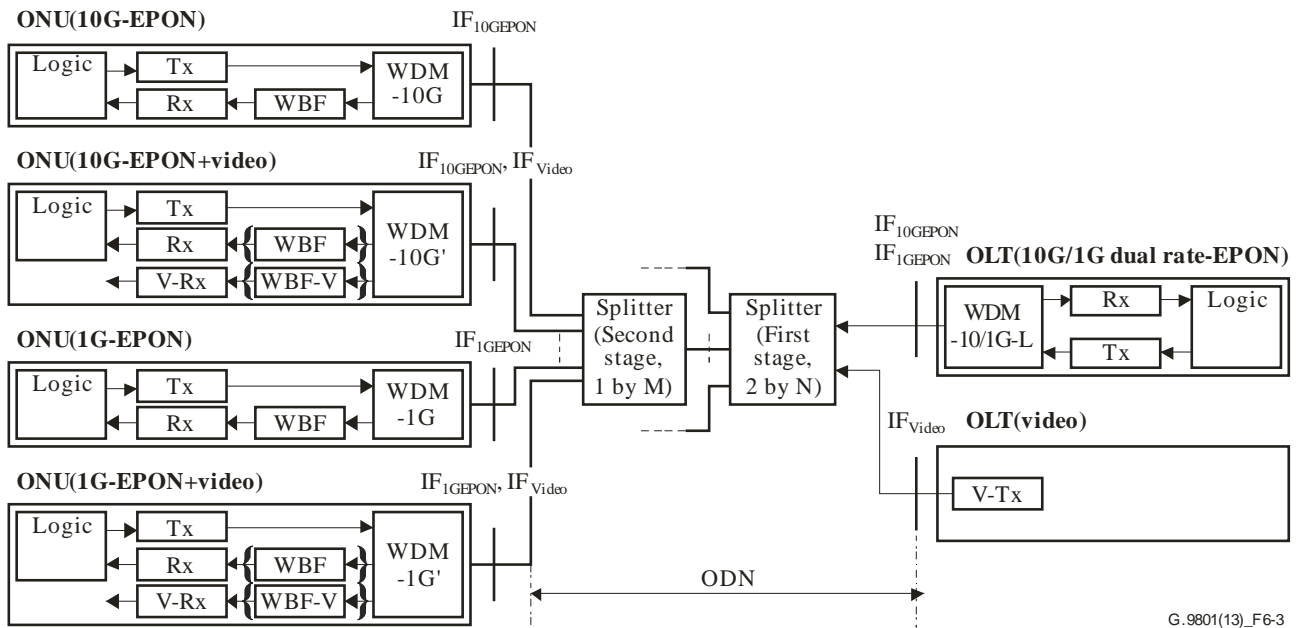
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Figure 6-3 – Reference optical architecture for EPON coexistence through splitter

Functions of WBFs and WDMs that enable the 10G-EPON and the 1G-EPON coexistence, shown in Figure 6-3, are listed as follows:

Tx   Optical transmitter

Rx   Optical receiver

V-Tx   Video transmitter

V-Rx   Video receiver

WBF   Wavelength blocking filter for blocking interference signals to Rx.

WBF-V   Wavelength blocking filter for blocking interference signals to V-Rx.

WDM-10G   WDM filter in the 10G-EPON ONU to combine/isolate the wavelengths of the 10G-EPON upstream and downstream.

WDM-10G'   WDM filter in the 10G-EPON ONU to combine/isolate the wavelengths of the 10G-EPON upstream and downstream and isolate the video signal(s).

WDM-1G   WDM filter in the 1G-EPON ONU to combine/isolate the wavelengths of the 1G-EPON upstream and downstream.

WDM-G'   WDM filter in 1G-EPON ONU to combine/isolate the wavelengths of the 1G-EPON upstream and downstream and isolate the video signal(s).

WDM-10G-L   WDM filter in the 10G-EPON OLT to combine/isolate the wavelengths of the 10G-EPON upstream and downstream.

WDM-10/1G-L   WDM filter in the 10G/1G dual rate-EPON OLT to combine/isolate the wavelengths of the 10G-EPON and 1G-EPON upstream and downstream.

7 Scenarios and services

7.1 Scenarios

7.1.1 FTTH scenario

Within this scenario, the following service categories are considered:

– Asymmetric broadband services (e.g., IPTV, digital broadcast services, VOD, file download, etc.);

– Symmetric broadband services (e.g., content broadcast, e-mail, file exchange, distance learning, telemedicine, online-game, etc.);

– Voice services – the access network must be able to provide, in a flexible way, narrow-band telephone services.

7.1.2 FTTO scenario

Fibre to the office (FTTO) has the same architecture as FTTH, but it addresses business ONUs dedicated to small business customers. Within this scenario, the following service categories are considered:

– Symmetric broadband services (e.g., group software, content broadcast, e-mail, file exchange, etc.);

– Voice services – the access network must be able to provide, in a flexible way, narrow-band telephone services;

– Private line – the access network must be able to provide, in a flexible way, private line services at several rates.

7.1.3 FTTB scenario

The FTTB scenario is divided into two scenarios, one for multi-dwelling units (MDUs) and the other for businesses or mixed environments (MTUs). Each scenario has the following service categories:

7.1.4 FTTB for MDU served residential users

Within this scenario, the same service categories as FTTH are considered.

7.1.5 FTTB for MTU-served business users

Within this scenario, the same service categories as FTTO are considered.

7.1.6 FTTC and FTTCab scenario

Within this scenario, the following service categories have been added to the FTTH scenario:

– xDSL backhaul.

7.1.7 FTTCell wireless scenario

Within this scenario, the ONU is called CBU and will have to offer connectivity to wireless base stations:

– Symmetric TDM services (e.g., 2G cell site backhaul);

– Symmetric/Asymmetric packet-based broadband services (e.g., 3G/4G cell site backhaul);

– Hot spots.

7.1.8 Environment conditions in outdoor scenarios

To support the wide range of scenarios and applications, optical parameters for the OLT and the ONU should be determined to allow outdoor operation.

7.2 Services

Telecommunication networks are evolving from traditional circuit-based networks to packet-based (i.e., IP/Ethernet-oriented) next-generation networks (NGN), which can effectively provide various services with a common platform [b-ITU-T Y.2201], [b-ITU-T Y.2001].

Table 7-1 summarizes examples of PON services for NGN.

Table 7-1 – Examples of PON services for NGN

	Service		Remark
1	Telephony	VoIP	
2	TV (real time)	IPTV	To be transported using IP multicast/unicast
		Digital TV broadcasting	Transported using RF-video overlay (see [b-ITU-T G.984.5], [b-ITU-T J.185] and [b-ITU-T J.186])
3	High speed Internet access		UNI is typically Gigabit Ethernet
4	Mobile backhaul		Accurate frequency/phase/time synchronization should be supported
5	L2 VPN services		Such as Ethernet services, etc.
6	IP services		Such as L3 VPN, VoIP, etc.
NOTE – See [b-ITU-T G.810], [b-ITU-T G.8261], [b-ITU-T G.8262].			

For the business applications, OMCI-EPON should provide access to Ethernet services such as point-to-point, multipoint-to-multipoint and rooted-multipoint Ethernet virtual connection (EVC) services. OMCI-EPON shall also support accurate frequency/phase/time synchronization for the mobile backhaul application.

As a general requirement, OMCI-EPON needs to support IPv6.

7.3 Maximum/Mean signal transfer delay tolerance

OMCI-EPON may accommodate services that require a maximum mean signal transfer delay of 1.5 ms for 20 km PONs. Specifically, OMCI-EPON systems may have a maximum mean signal transfer delay time of less than 1.5 ms between T-V (or (a)-V, depending on operator's preference). See clause 12 of [b-ITU-T G.982]. Delays introduced by the adaptation functions such as circuit emulation are not included in this value.

Although a section of the delay measurement is T-V for FTTH system or (a)-V for the other application in [b-ITU-T G.982], in OMCI-EPON systems the reference points are not restricted by the system configuration.

7.4 Frame length

OMCI-EPON technology shall support Ethernet frames having a maximum length of 2000 bytes.

7.5 Synchronization features and quality

Network operators are motivated to leverage the OMCI-EPON infrastructure and systems to deliver high bandwidth to mobile cell sites optionally. This requires accurate synchronization and timing delivery to the cell sites. Typically, T1 or E1 interfaces have been used for backhaul and these provide the necessary synchronization and timing references. However, driven by the popularity of 3G/4G wireless, it is increasingly important to provide accurate synchronization and timing over packet interfaces (e.g., Ethernet), especially to the cell sites where no T1/E1 interface is available.

OMCI-EPON OLTs for this application may be able to receive a high-quality timing clock as well as to serve as a master timing source for the ONUs. The ONUs may be able to distribute accurate timing/synchronization to the cell sites to meet the cell site frequency/phase/time synchronization requirements.

For this purpose, OMCI-EPON may be required to transfer accurate phase/time information between OLT and ONUs taking into account the propagation delay and the processing delay between them. Additional inaccuracy incurred in the PON section should be much less than the reference accuracy to leave a margin for other network sections in order to apply the optional function. [b-ITU-T G.8261] and [b-ITU-T G.8262] contain synchronization requirements for different wireless technologies.

The mechanisms, for instance as specified in [b-ITU-T G.8261] and [b-ITU-T G.8262], for distributing accurate timing to the 3G/4G cell sites are for further study depending on the performance and economics. In view of the extra complexity in delivering timing to applications such as mobile backhaul, the additional functionality might be limited to specific "CBU" ONUs.

7.6   QoS and traffic management

OMCI-EPON may be capable of supporting multiple existing and emerging services across multiple market segments, such as consumer, business and mobile backhaul. OMCI-EPON may provide simultaneous access to packet-based services, such as high speed Internet access, IPTV and VoIP. In addition, OMCI-EPON may provide access to carrier-grade Metro Ethernet services, such as point-to-point, multipoint-to-multipoint and rooted-multipoint EVC services for business customers. These varieties of services present a broad range of QoS characteristics, which demand systems that provide appropriate traffic management mechanisms.

To provide access to various packet-based services, such as IPTV, VoIP, L2/L3 VPNs and high speed Internet access, OMCI-EPON may provide at least 4 classes of services to map UNI flows. It is desirable for OMCI-EPON to provide at least 6 classes of services to map UNI flows. OMCI-EPON may also support drop precedence within at least 2 traffic classes.

In addition to the priority-based class of services, OMCI-EPON ONU may support rate-controlled services (e.g., CIR/PIR) with policing and shaping function in addition to the priority-based traffic management, for instance for business applications and mobile backhaul. Business customer ONUs may also support industry specifications at UNI ports.

OMCI-EPON may support any mix of residential, business and mobile backhaul traffic within the same PON as shown in clause 7.1. It may also support a mix of consumer and business users within a multiple subscriber ONU. OMCI-EPON may support a mix of rate-based (including CIR/PIR provisioning, policing, shaping, etc.) and priority-based traffic management within the same PON and same ONU.

OMCI-EPON OLT must support Transparent VLAN mode, Tagging VLAN mode and Translation VLAN mode. Furthermore OMCI-EPON ONU must support Transparent VLAN mode, Tagging VLAN mode and ToS/CoS Conversion VLAN mode.

8   Requirements

8.1   Physical layer and MAC layer requirements

Physical layer specifications and MAC layer specifications of OMCI-EPON are the IEEE 802.3 standard.

8.2   System level requirements

System level requirements and specifications are based on the IEEE 1904.1 standard, with some additional requirements as below.

8.2.1   Power saving and energy efficiency

See clause 10.5.4 of [IEEE 1904.1].

8.2.2   Authentication/Identification/Encryption

See clause 11.3.4 of [IEEE 1904.1].

8.2.3   Dynamic bandwidth assignment (DBA)

OMCI-EPON OLT may support DBA for the efficient sharing of upstream bandwidth among the connected ONUs and the traffic-bearing entities within the individual ONUs based on the dynamic indication of their activity.

The OLT may support any of the dynamic activity indication methods or a combination thereof. It is outside the scope of the requirement specification to define how the OLT utilizes the obtained dynamic activity indication information, or how the OLT upstream scheduler is implemented.

8.2.4   Eye safety

Given the high launched optical powers that can be injected into the fibre in OMCI-EPONs, both at the OLT level and the RE level, all necessary mechanisms must be provided to ensure that end users unaware of the risks suffer no eye damage, especially if fibre is terminated inside the home. OMCI-EPON elements need to conform to the following specific classes defined in the IEEE 802.3 standard, respectively:

•   Class 1 for OLT

•   Class 1 for ONU

8.3   Operational requirements

Operational requirements and specifications are defined in [IEEE 1904.1] Package B. Additional requirements are described as below.

8.3.1   ONU management

8.3.1.1   OMCI managed ONU

It is necessary from the network operation perspective to manage OMCI-EPON, i.e., an OLT together with its ONUs, as a single entity, with ONUs being managed via OLTs, wherever possible. Therefore, OMCI-EPON shall support full PON real time management through OMCI for EPON defined by Annex C of [ITU-T G.988].

8.3.1.2   Dual managed ONU

OMCI-EPON should support collaborative ONU management partition between EPON OMCI and remote configuration mechanisms.

8.3.2   PON supervision

While it is most important to minimize CAPEX in the initial stage of FTTH deployment, it is getting more important to reduce OPEX as well as to optimize the balance between CAPEX and OPEX according to the full deployment of FTTH. The goal of PON supervision is to reduce the OPEX of PON systems, without significantly increasing the CAPEX by including as much test and diagnostic capability as possible without compromising the available bandwidth for services. Test and diagnostics must not impact the service.

The ability to reliably differentiate between optical and electrical faults and establish if the faults are in the ODN or in the electronics is a key operator requirement. Inference can usually be made from the presence (i.e., power or equipment failure) or absence (i.e., fibre failure) of the ONU Dying Gasp Alarm. Several key points for the supervision of OMCI-EPON can be summarized as follows:

–   Transceiver status monitoring:

    See clause 9.1.5 of [IEEE 1904.1].

–   ODN monitoring/checking:

    Monitoring and on-demand checking the condition of ODN independently from a PON system is important to differentiate ODN failures from device failures. It is desirable that such monitoring and checking are available regardless of whether the ONU is in service or even not connected. An Optical Time Domain Reflectometer (OTDR) is a powerful tool for diagnosing such faults in the ODN, and a power meter and light source can be used to aid the process. Several demarcation devices are under research for further improving the ODN monitoring and checking.

    OMCI-EPON systems would benefit from the ability to automatically and autonomously detect and locate ODN faults. This is especially critical for the feeder section between the serving CO and the first-stage splitter, the length of which can be up to 60 km if RE is used.

–   End-to-end performance monitoring up to the Ethernet layer:

    End-to-end performance monitoring enables operators to diagnose and identify where customer traffic may have been dropped or throttled. Higher layer tools, such as Ethernet performance monitoring, need to support the capability of monitoring and verification of ingress and egress traffic flows in PON network elements.

–   Proactive versus reactive repair:

    PON systems with their monitoring and control systems will allow operators to make decisions regarding the utilization of proactive or reactive fault repairs in most fault cases. It is of course up to the operators to decide on how to use PON status reports.

8.4   Resilience and protection on ODN

See clause 9.3.7 of [IEEE 1904.1].

9   Optical network requirements

9.1   Physical medium dependent (PMD) sublayer

This clause addresses physical media dependent layer requirements for OMCI-EPON. OMCI-EPON shall support the parameters specified in the following clause of [IEEE 802.3].

For 1G link, see clause 60 of [IEEE 802.3].

For 10G link, see clause 75 of [IEEE 802.3].

9.2   Media access control (MAC), extensions of the reconciliation sublayer (RS) and physical coding sublayer (PCS)/physical media attachment (PMA)

This clause addresses data link layer requirements and physical layer requirements except on the PMD layer for OMCI-EPON.

9.2.1 Extensions of the reconciliation sublayer (RS) and physical coding sublayer (PCS)/physical media attachment (PMA)

This clause addresses the functions that modify the bit stream modulating the optical transmitter with the goal of improving the detection, reception and delineation properties of the signal transmitted over the optical medium. Forward error correction and line coding functionalities are included in this clause. OMCI-EPON shall comply with the specifications described in the following clauses of [IEEE 802.3].

For 1G link, see clause 65 of [IEEE 802.3].

For 10G link, see clause 76 of [IEEE 802.3].

9.2.2 Media access control (MAC) frame and packet specifications

This clause addresses the frame format of data link layer for OMCI-EPON. OMCI-EPON shall comply with the specifications described in the following clause of [IEEE 802.3].

See clause 3 of [IEEE 802.3].

9.2.3 Multipoint MAC control

This clause addresses the mechanism and control protocols required in order to reconcile the point to multi-point topology into the Ethernet framework. OMCI-EPON shall comply with the specifications described in the following clause of [IEEE 802.3].

For 1G link, see clause 64 of [IEEE 802.3].

For 10G link, see clause 77 of [IEEE 802.3].

9.2.4 MAC control extension

As OMCI is adopted for EPON ONU management, the same functionality of PLOAM can be adopted by the EPON system for supporting functionalities such as protection switching and ONU power saving. For such functionalities, MAC control extension, which is defined in Annex 31C of [IEEE 802.3], is the suitable control channel because of its broadcast capability and lack of frame rate limitation. Definition of the MAC control extension frame payload is reserved for ITU-T. This Recommendation provides a detailed definition of the MAC control extension frame.

Specifications for the MAC control-frame structure and the various messages for the optical link protection function are found in clause 9.3.5 of [IEEE 1904.1].

Specifications for the MAC control-frame structure and the various messages for the ONU power management function are found in clause 10.5.4 of [IEEE 1904.1].

9.2.5 Resource allocation and Quality of Service

This clause addresses the REPORT MPCPDU format and Quality of Service mechanisms. OMCI-EPON shall support the requirements described in the following clause of [IEEE 1904.1].

See clause 8.4.3 of [IEEE 1904.1].

In EPON, REPORT MPCPDU format is configurable. The OLT configures the REPORT MPCPDU with related attributes in ANI-E ME in [ITU-T G.988].

9.2.6 Performance monitoring, supervision and defects

This clause addresses the mechanisms to detect link failure and monitor the health and performance of links.

9.2.6.1 Performance monitoring

OMCI-EPON shall support the event monitoring functions described in the following clause of [IEEE 1904.1].

See clause 9.2.7 of [IEEE 1904.1].

9.2.6.2 Defects

See clauses 9.2.6 and 9.2.8 of [IEEE 1904.1].

9.2.7 Security

This clause addresses the encryption mechanism and the authentication mechanism for OMCI-EPON. OMCI-EPON shall support the requirements described in the following clauses in [IEEE 1904.1].

For encryption mechanism, see clause 11.2.3 of [IEEE 1904.1].

For authentication mechanism, see clause 11.3.4 of [IEEE 1904.1].

In [IEEE 1904.1] Package B, encryption capability is mandatory for 10G-EPON. The OLT enables or disables encryption function with the encryption capability and configuration attribute in ANI-E ME in [ITU-T G.988].

9.2.8 ONU power management

This clause addresses the ONU power management mechanism for OMCI-EPON. OMCI-EPON shall optionally support the requirements described in the following clauses in [IEEE 1904.1].

For signalling protocol, see clause 10.5.4 of [IEEE 1904.1].

The OLT configures parameters for ONU power management with ONU dynamic power management control ME in [ITU-T G.988].

9.2.9 Optical link protection

This clause addresses the optical link protection mechanism for OMCI-EPON. That protection scheme is the same configuration as type-B protection in [ITU-T G.984.1]. OMCI-EPON shall optionally support the requirements described in the following clauses in [IEEE 1904.1].

For signalling protocol, see clause 9.3.7 of [IEEE 1904.1].

In EPON, a timer for the type-B protection is defined as HoldOver timer. It is similar to timer TO2 in G-PON/XG-PON, and its value is configurable. Triggers for state transition of the ONU to the HoldOver state are defined as LoS_Optical and LoS_MAC. Durations for these parameters are configurable. The OLT configures the parameters for the optical link protection with related attributes of ANI-E ME in [ITU-T G.988].

9.2.10 Connectivity configurations

This clause addresses the VLAN configurations and multicast configurations for OMCI-EPON. OMCI-EPON shall support the requirements in the following clause in [IEEE 1904.1].

For VLAN configurations, see clauses 7.2.2.1.1, 7.2.2.1.3 and 7.2.2.1.5 of [IEEE 1904.1].

For multicast configurations, see clause 7.4.2 of [IEEE 1904.1].

The OLT configures parameters for multicast configurations with L2 multicast GEM interworking termination point ME in [ITU-T G.988].

9.3 OMCI-EPON management

See Annex C of [ITU-T G.988].

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