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| **itu-old** | INTERNATIONAL TELECOMMUNICATION UNION | | | | **COM 15 – C 1751 Rev. 1 – E** |
| **TELECOMMUNICATION STANDARDIZATION SECTOR**  STUDY PERIOD 2009-2012 | | | **November 2011** | |
| **English only**  **Original: English** | |
| **Question(s):** | | 2/15 | Geneva, 5-16 December 2011 | | |
| **STUDY GROUP 15 – CONTRIBUTION 1751 Rev. 1** | | | | | |
| **Source:** | | Nippon Telegraph and Telephone Corporation (NTT); Mitsubishi Electric Corporation; OKI Electric Industry Company Ltd. (OKI) | | | |
| **Title:** | | Draft document of G.epon | | | |

Abstract

ONU management and control interface (OMCI) defined in ITU-T has been already extended to Ethernet P2P systems and Ethernet PON (EPON) management. Currently, higher layer functionalities such as Quality of service, ONU power management, and protection switching are being added to EPON. Such higher layer functionalities are related to both EPON MAC layer extension and OMCI management. Therefore, a new recommendation needs to be developed to clarify whole system specification and OMCI management. Moreover, it should cover 10Gbit/s bidirectional transmission capability. This contribution proposes G.epon as this new recommendation.

Proposal

**Title**

Ethernet Passive Optical Networks using OMCI

# 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 P1904.1 standard. This Recommendation focuses on EPON systems that apply the ONU Management and Control Interface (OMCI) defined by ITU-T Recommendation G.988 to create an effective PON operation system. This Recommendation calls these EPON systems OMCI-EPON.

Line rates of OMCI-EPON are 10.3125 Gbit/s with 64B66B coding for upstream (ONU to OLT) signals and downstream (OLT to ONU) signals, which are based on IEEE 802.3 standard.

The requirements and specifications of OMCI-EPON include physical layer and MAC layer requirements and specifications which are based on IEEE 802.3 standard, system level requirements and specifications which are based on the IEEE P1904.1 standard and operational requirements and specifications defined by ITU-T Recommendation G.988 Annex C. The requirements and specifications of OMCI-EPON can be adopted and extended from the IEEE standards in order to apply OMCI and to meet the need to support the various business and residential applications requested by network operators.

As much as possible, this Recommendation maintains backward compatibility with existing Optical Distribution Networks (ODN) that comply with the existing PON systems defined by the IEEE 802.3 standard and ITU-T Recommendations such as G.983, G.984 and G.987 series. Furthermore, this Recommendation provides a mechanism that enables co-existence with the existing PON systems using TDMA and Wavelength Blocking Filter (WBF).

# References

# Definitions

# Abbreviations

# Conventions

OMCI-EPON has some sub-layers in both the physical layer and the data link layer for the data channel and has some clients and functions for the management channel shown in Figure 5-1. The sub-layers are detailed in the IEEE 802.3 standard including 802.3av, while the clients and functions are detailed in the IEEE P1904.1 standard. OMCI-EPON exchanges OAM client functions which IEEE P1904.1 defines into OMCI which ITU-T G.988 Annex C defines.

The physical layer consists of physical medium dependent (PMD) sub-layer, physical medium attachment (PMA) sub-layer, physical coding (PCS) sub-layer, and reconciliation sub-layer. The medium dependent interface (MDI) connects optical fiber to PMD. Gigabit medium-independent interface (GMII) and 10 gigabit medium-independent interface (XGMII) are defined between PCS and reconciliation. PMD sub-layer and MDI make reference to clause 60 and 75 of 802.3, and the other sub-layers and interfaces refer to clause 65 and 76 of 802.3.

The data link layer consists of media access control (MAC) sub-layer, multipoint MAC control (MPMC) sub-layer, operations, administration and maintenance (OAM) sub-layer and MAC client sub-layer. The specifications of MAC sub-layer are the same as Giga-bit Ethernet except for the preamble, and make reference to clause 56 of 802.3. MPMC sub-layer makes reference to clause 64 of 802.3. OAM sub-layer makes reference to clause 57 of 802.3. MAC client sub-layer makes reference to clause 6 of P1904.1.

The management consists of MAC control client, OAM client and their functions. MAC control client is a pointer between MPMC sub-layer and its functions, and OAM client is a pointer between OAM sub-layers and OMCI, which corresponds to OAM client functions. These clients and their functions make reference to clause 5 of P1904.1.

When OMCI is used for EPON ONU management, the same functionality as G-PON PLOAM can be adopted by EPON. MAC control extension which is defined in Annex31C of 802.3 is a suitable control channel because of its broadcasting capability and lack of frame rate limitation. Definition of the MAC control extension frame payload is reserved for ITU-T.

ITU-T Recommendations such as G.984 series and G.987 series separate PON specifications into three documents, PMD layer Recommendation, TC layer Recommendation, and OMCI Recommendation. PMD layer Recommendation corresponds to the specifications of PMD sub-layer and MDI of EPON. OMCI Recommendation corresponds to OAM client functions of EPON as described above. TC layer Recommendation corresponds to the specifications of the other sub-layers, clients and functions of EPON.



**Figure 5-1 Layer structure of OMCI-EPON**

# Architecture of the optical access network

## 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 6-1shows the considered architectures, 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 Fig.6-1; hence the commonality of this system has the potential to generate large worldwide volumes.

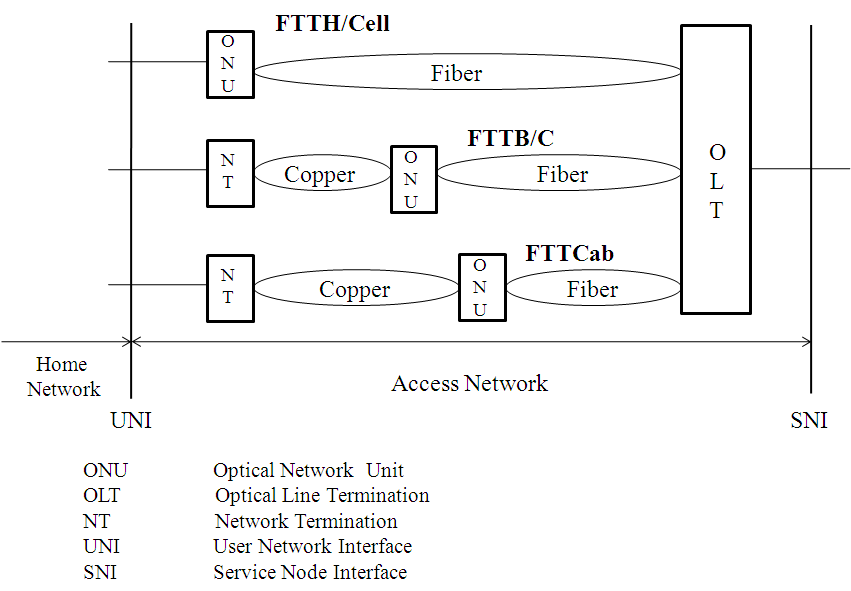


Figure 6-1 - Network Architecture

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 Section 7.

## Reference architecture

A high level and simple reference architecture of OMCI-EPON is depicted in Fig.6-2 which shows a high level reference architecture very similar to those of G.983, G.984 and G.987 series.

As depicted in Fig.6-2, the ONU provides 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.



Figure6-2 - High Level Reference Architecture of OMCI-EPON

## ODN architectures

OMCI-EPON can use the same ODN architecture as existing PON systems such as B-PON, G-PON and XG-PON defined in ITU-T Recommendations, GE-PON 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 GE-PON described in IEEE 802.3 and G-PON defined by ITU-T G.984 series. 10G class PON includes 10G-EPON described in IEEE 802.3 and XG-PON defined by ITU-T G.987 series. 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 co-existence 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 Section 75.6 of IEEE 802.3 standard defines the dual rate mode. The figure assumes that wavelength blocking filters (WBF) 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.



Figure 6-3 Reference optical architecture for EPON co-existence through splitter

Functions of WBFs and WDMs that enable the 10G-EPON and the 1G-EPON co-existence, shown in Fig. 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.

## Reach extender

A reference architecture that uses a reach extender is illustrated in Fig. 6-4. A reach extender device is inserted between the ODN and an optical trunk line (OTL), which is connected to the OLT. This architecture extends the reach of the PON by the length of the OTL, and may also increase the splitting ratio of the PON. However, the reach extender does require electrical power.

Details of the reach extender are described in G.984.6.

ONU

ONU

ODN

OLT

UNI

UNI

SNI

R/S

R/S

S/R

Reach

Extender

OTL

S'/R'

R'/S'

Figure 6-4 Reference architecture that uses reach extender

# Scenarios and services

## Scenarios

### 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.

### FTTO scenario

Fiber 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.

### FTTB scenario

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

#### FTTB for MDU served residential users

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

#### FTTB for MTU served business users

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

### FTTC and FTTCab scenario

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

– xDSL backhaul.

### 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

### 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.

## 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 [ITU-T Y.2201] [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 [ITU-T G.984.5], [ITU-T J.185] and [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, and VoIP, etc. |
| NOTE – See [ITU-T G.810], [ITU-T G.8261], [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 (also called E-Line, E-LAN and E-Tree, respectively). 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.

## Maximum / mean signal transfer delay tolerance

OMCI-EPON must accommodate services that require a maximum mean signal transfer delay of 1.5 ms. Specifically, OMCI-EPON systems must 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 in [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 [ITU-T G.982], in OMCI-EPON systems the reference points are not restricted by the system configuration.

## Frame length

OMCI-EPON technology shall support Ethernet frames having a maximum length of 1526 bytes.

## Synchronization features and quality

Network operators are motivated to leverage the OMCI-EPON infrastructure and systems to deliver high bandwidth to mobile cell sites. 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 must be able to receive a high quality timing clock as well as to serve as a master timing source for the ONUs. The ONUs must 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 shall provide a function 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 shall be much less than the reference accuracy to leave a margin for other network sections. ITU-T G.8261 contains a summary of the synchronization requirements for different wireless technologies。

The mechanisms, for instance as specified in [ITU-T G.8261] and [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.

## QoS and traffic management

OMCI-EPON must be capable of supporting multiple existing and emerging services across multiple market segments, such as consumer, business, and mobile backhaul. OMCI-EPON must provide simultaneous access to packet-based services, such as high speed internet access, IPTV, and VoIP. In addition, OMCI-EPON must provide access to carrier-grade Metro Ethernet services, such as point-to-point, multipoint-to-multipoint, and rooted-multipoint EVC services, also known as E-Line, E-LAN and E-Tree, respectively, defined by MEF for business customers. These varieties of services present a broad range of QoS characteristics, which demands systems that provide appropriate traffic management mechanisms.

To provide access to a various packet-based services, such as IPTV, VoIP, L2/L3 VPNs, and high speed internet access, OMCI-EPON must 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 must also support drop precedence within at least 2 traffic classes.

In addition to the priority-based class of services, as indicated above and also specified in [BBF TR-200], OMCI-EPON ONU must 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 must also support industry specifications at UNI ports, such as [MEF 10.1]. However, it is not required for OMCI-EPON to provide full MAC address learning for the whole Metro-Ethernet Network. OMCI-EPON will utilize the Metro Ethernet Network capability to provide full Ethernet services.

OMCI-EPON must support any mix of residential, business, and mobile backhaul traffic within the same PON as shown in Section 7.1. It must also support a mix of consumer and business users within a multiple subscriber ONU. OMCI-EPON must 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 must support N:1 VLAN, 1:1 VLAN, and access to VLAN for Business Ethernet Service (VBES) service on the same PON.

# Requirements

## Physical layer and MAC layer requirements

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

## System level requirements

System level requirements and specifications are based on the IEEE P1904.1 standard, with some additional requirements as below.

### Power saving & Energy efficiency

Power saving in telecommunication network systems has become an increasingly important concern in the interest of reducing operators’ OPEX and　reducing the network contribution to greenhouse emission gases. The primary objective of the power saving function in access networks is to keep providing the lifeline service(s) such as voice as long as possible through the use of a backup battery when the electricity service goes out. For example, some operators require a lifeline interface to operate for 4 to 8 hours after a mains outage. Therefore, OMCI-EPON shall support energy efficiency based the mechanisms derived from [ITU-T G. Sup45]. The secondary goal is to reduce the power consumption at all times. It is also an important requirement that we should not sacrifice service quality and user experience.

Full service mode, dozing mode, and sleep mode are the options that can offer various levels of power saving during the normal mode of operation. In addition, when a mains outage happens, power shedding should be activated for power saving. Realizing the detailed values may vary for EPON, but [ITU-T G. Sup45] offers a comparison of the efficiency of each power saving technique as well as the service impact.

### Authentication/identification/Encryption

PON is a shared medium based system in which all the ONUs on the same ODN receive the full data. Accordingly, countermeasures must be taken to avoid impersonation/spoofing and snooping.

To protect against impersonation/spoofing, authentication and identification mechanisms must be standardized OMCI-EPON. Use of these mechanisms is optional and will be determined by the operators. They shall include, but will not be limited to:

* Identification of ONU serial number and/or a registration ID used for ONU registration process.
* Authentication of CPE, based on IEEE 802.1X.
* A strong authentication mechanism.

A simple but secure identification method is also necessary for recovery from the "sleep" mode when the power saving function is used.

To protect against snooping at the ONUs, all unicast data in downstream shall be encrypted with a strong and well characterized algorithm, e.g., AES. Therefore, OMCI-EPON shall also provide a reliable key exchange mechanism to start an encrypted communication session. In the upstream direction, the encryption function shall be optional, and implemented upon each operator's requirement.

### Dynamic Bandwidth Assignment (DBA)

OMCI-EPON OLT shall 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 dynamic activity indication can be based on the following two methods:

* Status reporting (SR) DBA employs the explicit buffer occupancy reports that are solicited by the OLT and submitted by the ONUs in response;
* Traffic monitoring (TM) DBA employs OLT’s observation of the actual traffic amount in comparison with the allocated upstream transmission opportunities.

The DBA definition comprises the reference model that specifies the ideal bandwidth assignment among the contending upstream traffic-bearing entities under the given traffic load conditions. To allow for effective numerical comparison of the DBA implementations, the standard contains suggested discrepancy metrics between the DBA implementation and the reference model. To guarantee multi-vendor interoperability, the standard specifies the formats of the SR DBA status enquiries and buffer occupancy reports and the associated protocol.

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 which specific methods have to be supported, how the OLT utilizes the obtained dynamic activity indication information, or how the OLT upstream scheduler is implemented.

DBA covering several upstream wavelengths, for the case of overlaying multiple PONs or redundancy through dual homing, lies out of the scope of this specification.

### Eye safety

Given the high launched optical powers that can be injected into the fiber in OMCI-EPONs, both at the OLT level and the RE level, all necessary mechanisms must be provided to insure that the end users unaware of the risks suffer no eye damage, especially if fiber is terminated inside the home. OMCI-EPON elements need to conform to the following specific classes defined in IEC 60825-2 standard, respectively:

* Class 1M for OLT
* Class 1 for ONU
* Class 1M for RE

## Operational requirements

Operational requirements and specifications are defined in Annex C of ITU-T Recommendation G.988. Additional requirements are described as below.

### ONU management

#### 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 G.988 Annex C.

#### Dual managed ONU

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

### 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., fiber failure), of the ONU Dying Gasp Alarm. Several key points for the supervision of OMCI-EPON can be summarized as follows:

* 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 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.

## Resilience and protection on ODN

OMCI-EPON is required to support a diverse range of high value services (e.g., IPTV) for residential and also some business applications with increasing levels of system integration at the head-ends. Failures in the shared portions of the PON will impact multiple customers and services. Consequently, the capability to offer improved service availability figures in OMCI-EPON systems will become increasingly important.

Individual operators need to determine the best resilience architecture for their specific market and geography. Accordingly, OMCI-EPON should include a range of cost-effective resilience options with both duplex and dual parenting duplex system configurations as defined in Section 14 of [ITU-T G.984.1] as well as extensions described in Appendix I and II of this Recommendation. These resilience schemes should be options available in OMCI-EPON scenarios whether they use mid-span reach extenders or not. Different types of service and specific offerings will require different recovery speeds. These may range from a few tens of milliseconds, for critical and important services such as e.g., protected leased lines, up to the order of minutes for residential applications. Note that support of resilience options should not increase the cost of such systems if deployed without resilience options.

The protection architecture of OMCI-EPON should be considered as one of the means to enhance the reliability of the access networks. However, protection shall be considered as an optional mechanism because its implementation depends on the realization of economical systems. It is also likely to use other methods, such as using alternative access technologies, e.g., LTE, for backup for better economics. Further information on protection switching can be found in [ITU-T G.808.1].

# Optical network requirements

## 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 Std 802.3] and [IEEE P802.3av].

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

For 10G link, see Clause 75 of [IEEE P802.3av].

## 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 PMD layer for OMCI-EPON.

### 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 Std 802.3] and [IEEE P802.3av].

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

For 10G link, see Clause 76 of [IEEE P802.3av].

### Media Access Control (MAC) frame and packet specifications

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

See Clause 3 of [IEEE Std 802.3].

### Multipoint MAC Control

This clause addresses the mechanism and control protocols required in order to reconcile the P2MP topology into the Ethernet framework. OMCI-EPON shall comply with the specifications described in the following clause of [IEEE Std 802.3].

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

For 10G link, see Clause 77 of [IEEE P802.3av].

### MAC control extension

As OMCI is adopted for EPON ONU management, the same functionality of PLOAM can be adopted by EPON system for supporting functionalities such as protection switching and ONU power saving. For such functionalities, MAC control extension which is defined in Annex31C of [IEEE P802.3av] 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 MAC control extension frame.

#### MAC control extension frame structure

Figure 9‑1 shows the MAC control extension frame for OMCI-EPON.

図1

Figure 9‑1 MAC control extension frame structure

The extension MAC control frame format and fields are defined in Table 9‑1.

Table 9‑1 MAC control extension frame format and fields

|  |  |  |  |
| --- | --- | --- | --- |
| **Field** | **Length** | **Definition** | **Value** |
| Preamble and LLID/SFD | 8 bytes | Defined in clause 4.2 and clause 76 of [IEEE 802.3] | LLID is assigned during ONU discovery process |
| Destination MAC address | 6 bytes | Destination MAC address | MAC address of far-end equipment, which is obtained during ONU discovery process. |
| Source MAC address | 6 bytes | Source MAC address | MAC address of source equipment |
| Length/Type | 2 bytes | Length/Type | 0x8808 |
| Opcode | 2 bytes | Opcode | 0xFFFE |
| OUI | 3 bytes | ITU-T OUI | 0x0019A7 |
| Organization specific data | 41 byte | Message content | The message content is defined in the clause that describes each Message type ID. |
| Frame check sequence | 4 bytes | FCS defined in [IEEE 802.3] |  |

#### Downstream message summary

Table 9‑2 summarizes the downstream messages.

Table 9‑2 Downstream message summary

| Message Type ID | Message name | Function | Trigger | Effect of receipt |
| --- | --- | --- | --- | --- |
| 0x06 | Disable\_Serial \_Number | Broadcast message To disable/enable ONU with this serial number. | At the OLT’s discretion. | Disable option: Moves the specified ONU, or all ONUs, to the Emergency Stop state. The disabled ONU is prohibited from transmitting.  Enable option: Moves the specified ONU or all ONUs in the Emergency Stop state, to the Initial state.  No Acknowledgement. |
| 0x0C | Holdover | The OLT forces all the ONUs which are in Holdover state to Registered state or Registered state to Holdover state. | At the OLT’s discretion | End option: Moves the all ONUs, to the registered state.  Start option: Moves the all ONUs, to the Holdover state. |
| 0x0D | Key\_Control (TBD) |  |  |  |
| 0x12 | Sleep\_Allow | To enable or disable sleep modes in real time. | At the OLT’s discretion | At its own discretion, the ONU may enter one of the sleep modes.  If the ONU does not support at least one of the authorized sleep modes, it silently discards this message.  If none of the specified sleep modes are enabled via OMCI, the ONU silently discards this message. |

#### Upstream message summary

Table 9‑3 summarizes the upstream messages.

Table 9‑3 Upstream message summary

| Message ID | Message name | Function | Trigger | Effect of receipt |
| --- | --- | --- | --- | --- |
| 0x05 | Key\_Report (TBD) |  |  |  |
| 0x10 | Sleep\_Ack | To signal the ONU’s intention to change power saving modes. | Under state machine control |  |
| 0x11 | Sleep\_Indication | To signal the ONU’s intention to change power saving modes. | Under state machine control |  |

#### Downstream message formats

**Disable\_serial\_number message**

|  |  |  |
| --- | --- | --- |
| Size (octets) | Field | Value (hex) + notes |
| 6 | Destination Address | MAC Control Multicast address (0x0180C2000001) |
| 6 | Source Address | OLT MAC address |
| 2 | Length/Type | 0x8808 |
| 2 | Opcode | 0xFFFE |
| 3 | OUI | 0x0019A7 |
| 1 | Message ID | 0x0C |
| 1 | Disable/enable | 0xFF The ONU with this serial number is denied upstream access.  0x00 The ONU with this serial number is allowed upstream access.  0x0F All ONUs are denied upstream access. The content of bytes 6-13 is ignored.  0xF0 All ONUs are allowed upstream access. |
| 39 | Pad |  |
| 4 | FCS |  |

**Holdover message**

|  |  |  |
| --- | --- | --- |
| Size (octets) | Field | Value (hex) + notes |
| 6 | Destination Address | MAC Control Multicast address (0x0180C2000001) |
| 6 | Source Address | OLT MAC address |
| 2 | Length/Type | 0x8808 |
| 2 | Opcode | 0xFFFE |
| 3 | OUI | 0x0019A7 |
| 1 | Message ID | 0x0C |
| 1 | End/Start | 0x0 end, 0x1: start |
| 39 | Pad |  |
| 4 | FCS |  |

**Key\_Control message** (TBD)

**Sleep\_Allow messag**e

|  |  |  |
| --- | --- | --- |
| Size (octets) | Field | Value (hex) + notes |
| 6 | Destination Address | MAC Control Multicast address (0x0180C2000001) |
| 6 | Source Address | OLT MAC address |
| 2 | Length/Type | 0x8808 |
| 2 | Opcode | 0xFFFE |
| 3 | OUI | 0x0019A7 |
| 1 | Message ID | 0x12 |
| 1 | SleepMode | Designates the low power sleep mode the ONU to enter or requests ONU to wakeup:  0x00: Wakeup  0x01: Tx  0x02: TRx  0x03: Tx or TRx  Other values are reserved and ignored on reception  See Note a) |
| 1 | TmpSleepFlag | Indicates the TmpSleepPeriod requested to use for the multi-cycle low power sleep entered by this sleep request  0x00: False  0x01: True  Other values are reserved and ignored on reception |
| 2 | TmpSleepPeriod | Designates temporary updated sleep period to be used for T\_SLEEP.  In the units of milliseconds  See Notes below |
| 36 | Pad |  |
| 4 | FCS |  |

Notes

1. Low\_power\_sleep\_mode: designates the sleep mode that the ONU should enter. The value 0x03 Tx only or TRx requests the ONU to select the sleep mode to enter from choices of Tx only or TRx
2. TmpSleepPeriod is valid when TmpSleepFlag is true.

#### Upstream message formats

**Key\_Report** (TBD)

**Sleep\_Ack message**

|  |  |  |
| --- | --- | --- |
| Size (octets) | Field | Value (hex) + notes |
| 6 | Destination Address | MAC Control Multicast address (0x0180C2000001) |
| 6 | Source Address | ONU MAC address |
| 2 | Length/Type | 0x8808 |
| 2 | Opcode | 0xFFFE |
| 3 | OUI | 0x0019A7 |
| 1 | Message ID | 0x10 |
| 1 | SleepMode | Indicates low power sleep mode the ONU entered or ONU wakes up:  0x00: Wakeup  0x01: Tx  0x02: TRx  Other values are reserved and ignored on reception |
| 39 | Pad |  |
| 4 | FCS |  |

**Sleep\_Indication message**

|  |  |  |
| --- | --- | --- |
| Size (octets) | Field | Value (hex) + notes |
| 6 | Destination Address | MAC Control Multicast address (0x0180C2000001) |
| 6 | Source Address | ONU MAC address |
| 2 | Length/Type | 0x8808 |
| 2 | Opcode | 0xFFFE |
| 3 | OUI | 0x0019A7 |
| 1 | Message ID | 0x11 |
| 40 | Pad |  |
| 4 | FCS |  |

### 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 P1904.1].

See Clause 8.4.3 of IEEE P1904.1.

[Note: In EPON, REPORT MPCPDU format is configurable. OMCI ME for configuring the REPORT MPCPDU format of the ONU needs to be defined.]

### Performance Monitoring, Supervision, and Defects

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

#### Performance Monitoring

OMCI-EPON shall support the event monitoring functions described in the following clause of [IEEE P1904.1].

See Clause 9.3.7 of [IEEE P1904.1].

#### Defects

See Clause 9.3.8 of [IEEE P1904.1].

### 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 P1904.1].

For encryption mechanism, see Clause 11.2.3 of [IEEE P1904.1].

For authentication mechanism, see Clause 11.3.4 of [IEEE P1904.1].

[Note: In EPON, encryption capability is optional. OMCI ME for configuring encryption status needs to be defined.]

### 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 P1904.1].

For signalling protocol, see Clause 10.5.4 of [IEEE P1904.1].

[Note: OMCI ME for configuring the EPON ONU power management parameters needs to be defined.

### 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 P1904.1].

For signalling protocol, see Clause 9.4.7 of [IEEE P1904.1].

[Note: In EPON, a timer for the type-B protection is discussed as ONU holdover timer. It is similar to timer TO2 in G-PON/XG-PON, and its value is configurable. OMCI ME for configuring the ONU holdover timer value needs to be defined.]

### Rogue ONU

T.B.D

### Clock/Time synchronization

T.B.D

## EPON management

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

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