



Free choice of Modem Specification

Description of the prerequisites for an Optical Network Terminal (ONT) intended to establish a connection with the Cybernet GPON and XGS-PON network.

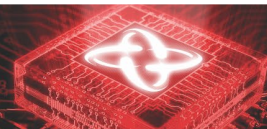


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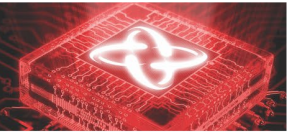
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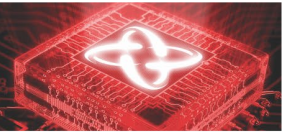
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Abbreviations

CO	Central Office
CPE	Customer Premises Equipment = End user Premises Equipment
HGW	Home GateWay
IEC	International Electrotechnical Commission
IEEE	Institute of Electrical and Electronics Engineers
IETF	Internet Engineering Task Force
LEX	Local EXchange
LT	Line Termination
MPM	Multi PON Mode
OPF	Optical Fiber Point
OLT	Optical Line Termination
OMCI	ONU Management and Control Interface
ONT	Optical Network Terminal
OTDR	Optical Time Domain Reflectometry
PON	Passive Optical Network
SFP	Small Form-factor Pluggable
UNI	User Node Interface
XGS-PON	10 Gigabit Symmetrical - PON



1 Introduction

The present document is part of the Cybernet technical specifications for its end users within the framework of the BIPT Decision of 26 September 2023 regarding the identification of the network termination point for broadband services. The information contained herein pertains to Cybernet' network specifications and is intended exclusively for Cybernet end users.

The purpose of this document is to provide insights into the current state of information and network specifications of ONTs that might be freely deployed by end users of Cybernet.

Scope:

- This document provides a simplified version of the Cybernet ONT specification of third-party ONTs when connected to the Cybernet network and a description of the main possible services.
- It outlines the standards and the Cybernet restrictions and specific points in the standards that must be adhered to by the third-party ONTs to ensure proper interoperability with the Cybernet network.

Usage Considerations:

- The information presented in this document is based on the current state of information and network specifications, subject to change. It is recommended to regularly check for updates and revisions.
- The information presented in this document may be changed at any time and may break backward compatibility with previous versions.
- The publication of a new version of this document renders all prior versions null and void, in accordance with any applicable delay periods.

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2 Summary

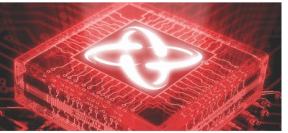
The present document lists the requirements for a GPON or XGS-PON ONT that an end user may choose to use on the Cybernet network to deliver his data, TV, and voice services.

The document refers in first instance to state-of-the-art standards and details additional requirements to ensure the ONT operation on the Cybernet network.

The document also provides information on Cybernet' technical roles and responsibilities and its right to intervene to ensure the correct network operation for all end users.

The ONT is a layer 2 device with, at the network side, a GPON or XGS-PON interface and, at the user side, an Ethernet interface. The device shall operate in an environment with a mix of GPON and XGS-PON ONTs but also a fiber monitoring system via Optical Time Domain Reflectometry (OTDR).

Cybernet operates in a so-called two-box model with separate ONT and CPE/router. The present specification only covers the ONT aspects and does not apply to an ONT integrated in a single device (CPE/router/HGW). This ONT can be a stand-alone ONT or an ONT in the form of a SFP plugged in a CPE or router.



3 The Cybernet Fiber Access – Passive Optical Network

The Cybernet optical fiber access network is a Passive Optical Network where one fiber is shared amongst several end users. The present chapter introduces the main building blocks.

Optical Line Termination (OLT)

- The Cybernet network is composed of OLTs equipped with:
 - GPON Line Termination (LT) cards
 - Multimode = “GPON + XGS-PON” LT cards
- The GPON and XGS-PON technologies are thus coexisting on the Cybernet fiber network.

Passive optical / fiber network (PON)

The Optical Distribution Network (ODN) connects the OLT and the ONTs. The fiber leaves the OLT via the PON port and is divided via a splitter to several ONTs installed at the end user premises.

Optical Network Termination (ONT)

Cybernet uses GPON and XGS-PON ONTs on its network. The end user is thus allowed to choose a GPON or XGS-PON ONT. End users wanting to use services above 1 Gbps shall subscribe to XGS-PON services and shall choose an XGS-PON ONT.

Figure 1 shows the Central Office (CO) or Local Exchange (LEX) where the OLT is installed. The splitter is in the OFP (Optical Fiber Point) and the ONTs are installed in the homes.

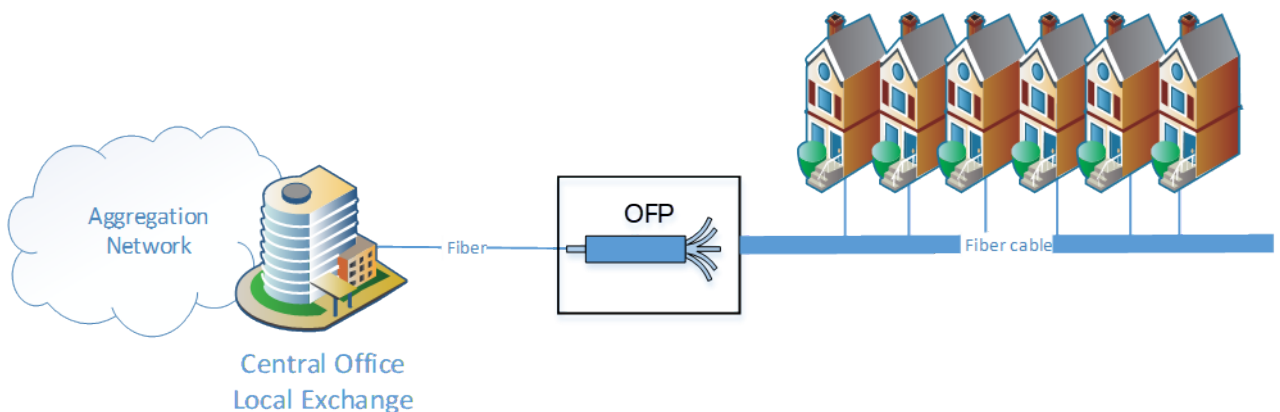


Figure 1: Cybernet Fiber Access Network

User network

At the user side, the ONT is connected to an end user Premises Equipment (CPE) or a router. The ONT works in bridge mode. Cybernet works thus in a two-box model with an ONT plus a CPE or router by opposition to a CPE or gateway that would merge both functions (one-box model).

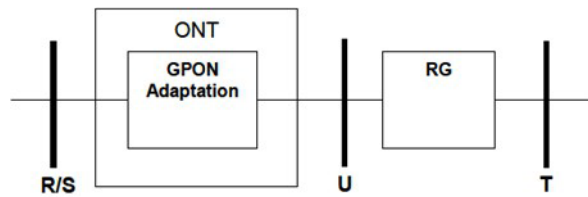
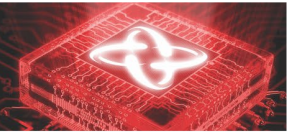


Figure 2 – ONT and RG as separate entities

Figure 2: Two-box mode

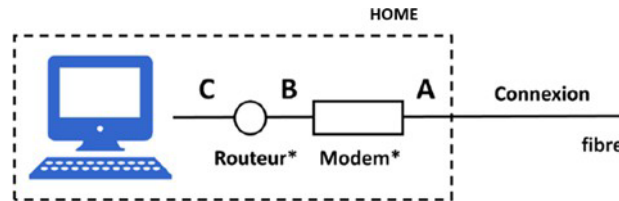
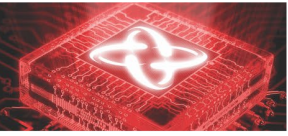


Figure 3: NTP localisation for internet service access (A=R/S and B = U), source IBPT

Optical Time Domain Reflectometry (OTDR)

Cybernet uses a permanent Optical Time Domain Reflectometry (OTDR) system monitoring the Optical Distribution Network (ODN). This system uses the 1650 nm wavelength.

- R-1 The end user shall select a GPON or an XGS-PON ONT using the same technology as used by Cybernet for his line. The ONT shall be a stand-alone ONT or an SFP ONT.
- R-2 Cybernet shall connect the GPON ONT to a GPON Line Termination card or a multimode “GPON + XGS-PON” Line Termination card. In the latter case, the ONT shall coexist with both GPON and XGS-PON ONTs.
- R-3 Cybernet shall connect the XGS-PON ONT to a multimode “GPON + XGS-PON” Line Termination card. This ONT shall coexist with both GPON and XGS-PON ONTs.
- R-4 The end user ONT shall be able to coexist with GPON & XGS-PON ONT.
- R-5 The end user ONT shall be able to coexist with an OTDR system using the 1650 nm wavelength.
- R-6 The end user ONT shall be equipped with one PON port and one Ethernet port to connect to its own End user Premises Equipment (CPE) or router.
- R-7 The end user ONT shall run in bridge mode.



4 Cybernet end users commercial services

For the commercial services on fiber, Cybernet allocates a Single VLAN unique for each end user. This VLAN combines a Sx-VLAN and Cx-VLAN and is mapped, by the ONT, into a C-VLAN (20) on the UNI side.

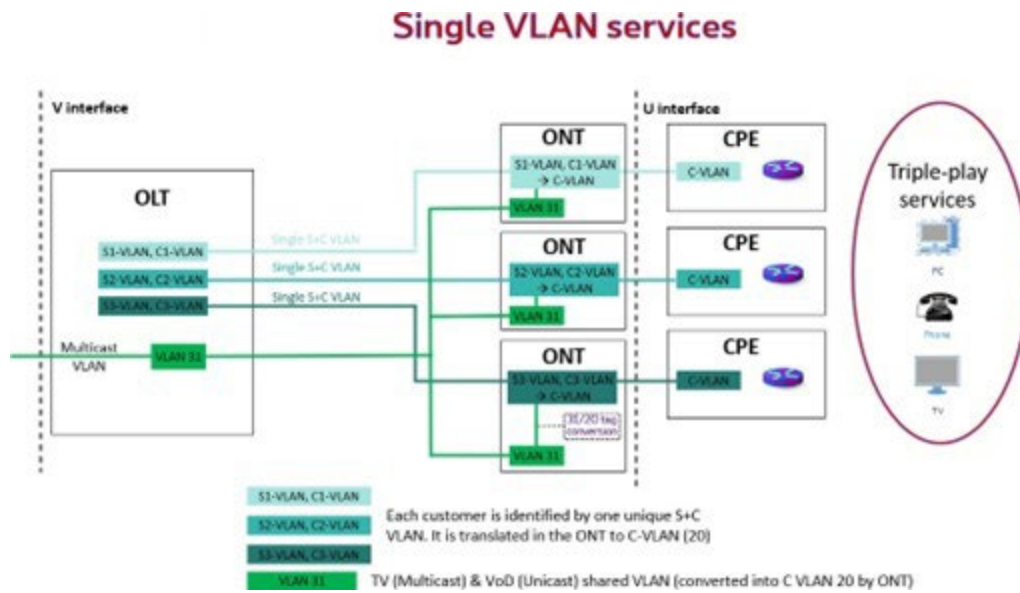
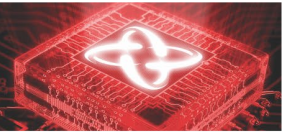


Figure 4: Single VLAN per residential or business end users for all their services

R-8 The ONT shall support the Single VLAN type of service.



5 Compliance with ITU-T, Broadband Forum, IEEE... standards

The Cybernet fiber access network is compliant with several standards. The main standards are the ITU-T GPON and XGS-PON standards, the Broadband Forum standards, and the IEEE Ethernet standards.

Cybernet requires an ONT compliant with existing but also future standards. The end user ONT shall remain compliant with all future corrigenda and errata.

5.1 ITU-T Standards

5.1.1 ITU-T GPON standards

- [1] G.984.1 General characteristics for Gigabit-Capable Passive Optical Networks (G-PON)
- [2] G.984.2 Gigabit-capable Passive Optical Networks (G-PON): Physical media dependent (PMD) layer specification
- [3] G.984.3 Gigabit-Capable Passive Optical Networks (G-PON): Transmission Convergence Layer
- [4] G.984.4 Gigabit-capable Passive Optical Networks (GPON): ONT Management and Control Interface specification
- [5] G.984.5 Enhancement band for gigabit capable optical access networks
- [6] G.984.6 Gigabit-capable Passive Optical Networks (G-PON): Reach extension
- [7] G.984.7 Gigabit-capable passive optical networks (GPON): Long reach

5.1.2 ITU-T XGS-PON standards

- [8] G.9807.1 10-Gigabit-capable symmetric passive optical network (XGS-PON)

5.1.3 ITU-T ONU Management

- [9] G.988 ONU management and control interface (OMCI) specification

5.1.4 Other ITU-T Standards

- [10] G Suppl. 46 G-PON interoperability test plan between optical line terminations and optical network units
- [11] G Suppl. 49 Rogue optical network unit (ONU) considerations
- [12] G.664 Optical safety procedures and requirements for optical transmission systems
- [13] G.902 Framework Recommendation on functional access networks (AN) - Architecture and functions, access types, management, and service node aspects

R-9 The end user ONT shall be compliant with the above ITU-T GPON and/or XGS-PON standards and supplements.

R-10 The end user ONT shall be managed via OMCI according to G.988 and G.984.4.



5.2 Broadband Forum Standards

- [14] TR-101 Migration to Ethernet-Based Broadband Aggregation
- [15] TR-156 Using GPON Access in the context of TR-101

R-11 The end user ONT shall comply with the above Broadband Forum standards.

5.3 Optical Fiber Characteristics

- [16] G.652 Characteristics of a single-mode optical fiber and cable
- [17] G.657 Characteristics of a bending-loss insensitive single-mode optical fiber and cable

R-12 The end user ONT shall work with the above fibers and a mix of them.

5.4 Combination with an Optical Time Domain Reflectometry (OTDR) system

- [18] TR-287 PON Optical-Layer Management, chapter 8.2 (OTDR)

R-13 The end user ONT will coexist with an OTDR system.

5.5 Broadband Forum certifications and tests

- [19] BBF.247 GPON ONU Interoperability and Certification Testing
- [20] TR-247/ATP-247 Abstract Test Plan for GPON ONU Conformance
- [21] TP-247 G-PON & XG-PON & XGS-PON ONU Conformance Test Plan
- [22] TR-255 GPON Interoperability Test Plan
- [23] TR-309 XG-PON and XGS-PON TC Layer Interoperability Test Plan
- [24] TR-423 PON PMD Layer Conformance Test Plan

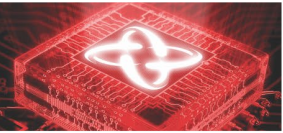
R-14 The end user ONT shall pass the above certifications and tests to ensure its operation on the Cybernet network.

5.6 IEEE Standards

This section lists standard IEEE standards for the Ethernet interface. Some of these standards do not apply to the SFP ONT.

IEEE 802.3 Ethernet standards

- [25] IEEE 802.3-2018
- [26] IEEE 802.3ab 1000BASE-T Gbit/s Ethernet over twisted pair at 1 Gbit/s
- [27] IEEE 802.3ac "Q-tag" - The Q-tag includes 802.1Q VLAN information and 802.1p priority information.
- [28] IEEE 802.3an 10GBASE-T 10 Gbit/s (1,250 MB/s) Ethernet over unshielded twisted pair (UTP)
- [29] IEEE 802.3az Energy-Efficient Ethernet
- [30] IEEE 802.3bz 2.5GBASE-T and 5GBASE-T - 2.5 and 5 Gigabit Ethernet over Cat-5e/Cat-6 twisted pair
- [31] IEEE 802.3u 100BASE-TX, 100BASE-T4 Fast Ethernet at 100 Mbit/s with auto-negotiation



R-15 The end user stand-alone ONT shall be compliant with the above IEEE 802.3 standards.

R-16 The SFP ONT shall be compliant with the IEEE 802.3 standards: [25] and [27].

IEEE 802.1 LAN, WAN, MAN

[32] IEEE 802.1AC Media Access Control (MAC) Services Definition

[33] IEEE 802.1AE MAC security

[34] IEEE 802.1P QoS at MAC layer (Traffic Class Expediting and Dynamic Multicast Filtering)

[35] IEEE 802.1Q VLAN, bridges and bridged networks

R-17 The end user ONT shall be compliant with the above IEEE 802.1 standards.

5.7 IETF Standards

IETF Internet Group Management Protocol (IGMP) & TV-related

[36] RFC 2236 Internet Group Management Protocol version 2

[37] RFC 3376 Internet Group Management Protocol version 3

[38] RFC 4541 IGMP Snooping

[39] RFC 4605 IGMP Proxy

[40] RFC 2710, Multicast Listener Discovery (MLD) for IPv6

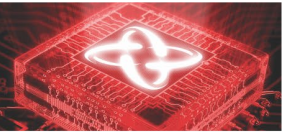
[41] RFC 3810, Multicast Listener Discovery Version 2 (MLDv2) for IPv6

[42] RFC 4604, Using Internet Group Management Protocol Version 3 (IGMPv3) and Multicast Listener Discovery Protocol Version 2 (MLDv2) for Source-Specific Multicast, 2006

R-18 The end user ONT shall be compliant with the above IGMP standards.

5.8 Additional Standards/Certifications

R-19 The end user ONT shall comply with the CE Certification (“Conformité Européenne”).



6 ONT Connectivity

6.1 PON Interface

R-20 The end user ONT shall be connected to the NTP (ONTP) with an appropriate patchcord, equipped with an SC/APC connector with an angle of 8° left-oriented and both (ONT + patchcord) shall have a Return Loss superior to 50 dB.

6.2 Ethernet Interface

In case of a stand-alone ONT where an external Ethernet port is present, it shall be compliant with the following point:

R-21 For a stand-alone ONT, the Ethernet connector shall be a standard electrical 8-contacts RJ-45 jack, compliant to IEC-60603-7-5 (RJ45). The wiring shall be compliant with TIA/EIA 568B.

7 Physical and data link layers

The present chapter clarifies or narrows down physical layer and data layer aspects.

7.1 Physical Medium Dependent Layer

This section emphasizes aspects related to the xPON.

R-22 The ONT shall be compliant with various types of SFP used at the OLT side: GPON B+, GPON C+, MPM B+, MPM C+, XGS-PON N1 and XGS-PON N2.

R-23 The ONT shall contain a wavelength blocking filter to isolate from other PON signal. The ONT shall have an excellent Return Loss at 1650 nm.

R-24 The ONT shall be compatible with the transmission medium defined below: Single-mode optical fiber, as described in ITU-T G.652. Single-mode optical fiber, as described in ITU-T G.657. Any combination (mix) of ITU-T G.652 and G.657 single-mode fiber on the same ODN.

R-25 The ONT card holder number explained in G984.4 section 9.1.5. shall be 1.

The end user ONT shall be limited to one-Ethernet Port ONTs, thus:

R-26 The ONT shall use the number 1 for the UNI port.

7.2 Transmission Convergence Layer Requirements

The ONT shall meet the following TC-Layer requirements:

R-27 The GPON ONT registration process and activation procedure shall comply with ITU-T Rec.G.984.3 [3]. The ONT registration and activation shall support the authentication mode by serial number (SN).

R-28 The XGS-PON ONT registration process and activation procedure shall support the authentication mode by serial number (SN) according to T-REC-G.9807.1 [19].

7.3 Ethernet

R-29 In case of stand-alone ONT, the Ethernet interface shall be compliant with IEEE 802.3 1GBase-T for GPON ONT and 10GBase-T for XGS-PON ONT.

R-30 In case of stand-alone ONT, the Ethernet interface shall support auto-negotiation to select a lower bitrate than 10GBase-T when it cannot be reached by the user cabling & equipment.

7.4 Quality of Service (QoS)

R-31 The ONT shall support 8 traffic classes for Ethernet frames.

R-32 The ONT shall locally perform rate limiting at the UNI.

R-33 The ONT shall support deriving P-bit markings in the upstream direction based on an arbitrary combination of: user port, VID, received P-bit markings, Ether Type, DSCP value, IP Protocol ID, Multiple field classifiers (ACL).

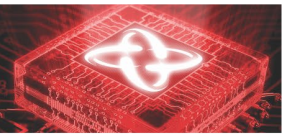
R-34 The ONT shall support 8 queues, one per traffic class, in the upstream direction. (It is thus a stricter requirement than TR-156 R-57 & R-61.).

R-35 The ONT shall support at least 8 T-CONT (but preferably 9) to transport the upstream traffic.

R-36 The ONT shall support 32 GEM ports.

7.5 VLAN Handling Requirements

See “Cybernet end users commercial services” chapter.



8 ONT Protocol Capability & Limitations

R-37 All control traffic like DHCP, ARP, IGMP, PPP, ICMP, etc. shall be handled in a transparent way by the ONT.

R-38 C-VLANs carried within the S-VLAN shall be passed transparently to the end user.

9 ONT Operations and Maintenance

Cybernet utilizes several parameters to monitor the network, some of which are provided by the ONT. Cybernet expects these same parameters to be provided by the end user's ONT. Most of these parameters are defined in the ITU-T standards, such as dying gasps and optical power levels. In the event that these parameters are not present or correctly transmitted, Cybernet will not be able to ensure proper monitoring of the end user's ONT or diagnose errors efficiently.

- The GPON-System shall be able to detect and report failures in hardware and software as well as monitor the health and performance of links according the ITU-T standard G.984.3 [3].
- The XGS-PON-System shall be able to detect failures in hardware and software as well as monitor the health and performance of links according the ITU-T standard G.9807.1 [3].

9.1 Inventory Parameters

R-39 This information is mandatory to ensure the analysis of potential misbehaviors and to compare with similar ONTs on the network.

As examples, the ONT shall supply the ONT Serial Number, parameters that allow to identify ONT HW version, ONT FW version...

9.2 Status and Performance Monitoring Parameters

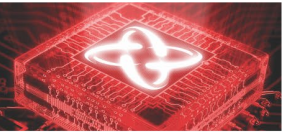
R-40 The GPON and XGS-PON ONT(s) shall support Optical Line Supervision and mandatory performance monitoring parameters, based on ITU-T standards.

These parameters are important to ensure a minimum monitoring of the ONT behavior. Any missing parameters will degrade the capacity of Cybernet to monitor and maintain the best quality for the end user.

As examples, ONTs shall support measurement of parameters like those listed below. (The precondition for this scenario is: ONTs are ranged at the OLT.)

- o ONT transmit power
- o ONT receive power
- o Optics module temperature
- o Optics module voltage
- o Laser bias current
- o XGS-PON ONT state
- o ONT UNI port states





- o ONT UNI port speed
- o ...

9.3 Signalling of Errors and Malfunctions : Alarms

Cybernet uses alarms generated by the ONT to monitor its network health and to report alarms generated at ONT level. For instance, the ONT shall support “Dying Gasp” (Switch on/off ONT) reporting.

R-41 The functionality to detect and notify alarms, based on TC-Layer shall be implemented in the ONT according to the ITU-T standards.

The alarms are not listed in the present document because they are already listed in the xPON standards.

9.4 Operational aspects

R-42 The end user ONT shall not disturb the existing infrastructure during its installation, its switch-on procedure, and the configuration of the end user services.

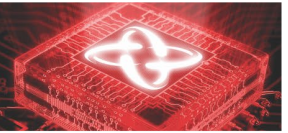
R-43 The end user ONT shall implement state-of-the art security rules.

R-44 The GPON Serial Number format shall be hard-coded. In relation of XGS-PON the SN shall be also hard-coded.

R-45 Any possibility to change or overwrite the Serial Number (e.g. via GUI or other) shall be prohibited.

R-46 The ONT shall interoperate with the Rogue ONT detection mechanism implemented in the Cybernet OLT.





10 Cybernet and end user's Roles & Responsibilities

10.1 Cybernet Roles and Responsibilities

- Cybernet regularly adapts its network by introducing new hardware and software and shall not be responsible of any service degradation following these network evolutions.
- Cybernet has the right to disconnect any ONT that is not compliant to the present specification.
- Cybernet shall disconnect any ONT that would disturb the correct operation of the network, especially if it would disturb end users connected to the same PON port. The disturbances could be for example generating abnormal numerous alarms, disturbing the monitoring system, or causing security incidents.
- Cybernet will inform the end user in case it deems it necessary to disconnect the ONT.
- On demand of the end user, Cybernet shall reconnect an ONT that was disturbing the network if the hardware or software root-cause has been eliminated by the end user.

10.2 End user Roles and Responsibilities

- The end user shall be the sole responsible for selecting its ONT hardware and software compliant to the present specification.
- The end user shall be the sole responsible for upgrading the software of its ONT. Such upgrades are not mandatory but could be necessary to interoperate correctly with recent OLT hardware equipment or software releases.
- The end user shall only use software approved by the ONT manufacturer and shall not modify it by any mean.
- The end user shall install ONT FW patch recommended for security reasons by the ONT manufacturer.
- The end user shall comply with the instructions that Cybernet may issue from time to time to ensure the security and correct operation of the Cybernet network and of any other infrastructure used in any other manner by Cybernet.

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