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## 1 **4 Nx25G-EPON architecture**

### 2 **4.1 Introduction**

3 Clause 5 describes the overall architecture of an Nx25G-EPON system. The architecture defined in this  
4 clause is then used as the basis for the MAC Client reference model (see Clause 6), the connectivity  
5 configuration model (see Clause 7), and the management model (see Clause 13 and Clause 14).

6 A comparison of the EPON system architecture with the architecture models defined in BBF TR-200 and  
7 MEF 10.2 specifications is provided in IEEE Std 1904.1, Annex 5A.

8 *Editorial Note (to be removed prior to publication):. DELETE Annex 5A*

### 9 **4.2 Optical Distribution Network**

10 The term *passive optical network* (PON) generally refers to a network architecture where multiple devices  
11 at the edge of the network are interconnected via a passive *optical distribution network* (ODN).

12 A PON ODN comprises a structure made of a single strand of a single-mode optical fiber, spliced or  
13 connected together using specialized optical connectors. The ODN typically includes one or more passive  
14 splitter/coupler devices connected such that they form a point-to-multipoint (P2MP) topology, also called a  
15 *tree* or *trunk-and-branch* topology.

16 While in general, the ODN design is operator-specific and may vary from deployment to deployment, some  
17 operational aspects of Nx25G-EPON ODN, such as the maximum distance or the maximum channel  
18 insertion loss, are mandated by IEEE Std 802.3, Clause 141.

### 19 **4.3 Nx25G-EPON devices**

20 The device connected at the root of the tree is called an *optical line terminal* (OLT) and the devices  
21 connected as the leaves are referred to as *optical network units* (ONUs). The OLT architecture and various  
22 OLT categories are further defined in . The ONU architecture and various ONU categories are  
23 defined in .

### 24 **4.4 Media access and transmission arbitration**

25 The direction of transmission from the OLT to ONUs is referred to as the *downstream* direction, while the  
26 direction of transmission from the ONU to the OLT is referred to as the *upstream* direction. Upstream and  
27 downstream transmissions over an Nx25G-EPON ODN are wavelength division multiplexed into a single  
28 strand of fiber.

29 In the downstream direction, the OLT is the only device with the access to the transmission medium. The  
30 signals transmitted by the OLT pass through a 1:N passive splitter (or cascade of splitters) and reach each  
31 ONU.

32 In the upstream direction, the signal transmitted by an ONU reaches only the OLT, but not other ONUs. To  
33 avoid upstream data collisions, transmission windows (grants) for all ONUs are controlled in such a way  
34 that only a single ONU's transmission reaches the OLT at any given time.

35 The OLT is responsible for timing and arbitrating the ONU transmissions. This arbitration is achieved by  
36 allocating transmission windows (grants) to ONUs. An ONU defers its transmission until the start of its  
37 transmission window. When the transmission window starts, the ONU transmits its queued frames at full  
38 line rate for the duration of this transmission window.

1 Reporting of a queue occupancy state or congestion by the ONUs assists the OLT in optimal allocation of  
2 the transmission windows across the PON.

### 3 **4.5 Concept of logical links**

4 OLT and ONU devices instantiate multiple MAC instances. From a connectivity perspective, an Nx25G-  
5 EPON system can be viewed as a collection of logical point-to-point (P2P) and point-to-multipoint (P2MP)  
6 links. A logical link is created by binding a MAC instance at the OLT with a MAC instance at the ONU.

7 A P2P logical link connects a single MAC instance at the OLT to a single MAC instance at the ONU. A  
8 P2MP logical link takes advantage of the broadcasting nature of the PON tree topology and connects a  
9 single MAC instance at the OLT to multiple MAC instances in different ONUs.

10 The mechanism of establishing logical links relies on tagging each frame (or frame fragment) with a logical  
11 link identification (LLID) value and mapping each instance of a MAC to a specific LLID value. See IEEE  
12 Std 802.3, 143.2.1 for the detailed explanation of the of logical link creation and operation.

13 The Nx25G-EPON architecture defines several types of LLIDs:

14 — The *Physical layer ID* (PLID) logical link carries messages used to control critical Nx25G-  
15 EPON operations, such as ONU registrations and arbitration of ONUs' access to the PON  
16 medium. All Multipoint Control Protocol data units (MPCPDUs) are transported using the  
17 PLID.

18 — *Management link ID* (MLID) logical link carries management traffic flows, such as OAM  
19 Protocol data units (OAMPDUS, see IEEE Std 802.3, 57.4) and Channel Control Protocol  
20 data units (CCPDUs, see IEEE Std 802.3, 144.4).

21 — *User link IDs* (ULIDs) carry subscriber traffic. It is expected that a single subscriber may be  
22 assigned one or more ULIDs to allow for separation of traffic classes and types. ULID values  
23 are assigned (provisioned) to an ONU by NMS.

24 — *Group link ID* (GLID) is used to consolidate several LLIDs into arbitrary groups for the  
25 purposes of bandwidth granting by the OLT and reporting by the ONU. The configuration and  
26 operation of GLID is specified in **TBD**.

27 Upon successful registration, the ONU is connected to the OLT via two point-to-point logical links:  
28 primary PLID and primary MLID. Additionally, two broadcast logical links are pre-defined:  
29 BCAST\_PLID and BCAST\_MLID (see IEEE Std 802.3, Table 144–1). Together, the two primary LLIDs  
30 and the two predefined broadcast LLIDs are referred as *system* LLIDs.

31 Additional P2P and/or P2MP logical links between the OLT and ONUs may be provisioned by the NMS  
32 based on specific access network configuration and service requirements. Provisioning of such additional  
33 logical links is accomplished using the eOAM action *acConfigLlid* (see 14.6.2.8).

34 Although at the PON-facing port the OLT and ONUs instantiate multiple MAC entities, each device may  
35 use a single MAC address. Within the EPON Network, MAC instances are uniquely identified by their  
36 LLID.

### 37 **4.6 Family of Nx25G-EPON architectures**

38 Nx25G-EPON operates at 25 Gb/s or 50 Gb/s in the downstream direction, and at 10 Gb/s, 25 Gb/s or 50  
39 Gb/s in the upstream direction. The 50 Gb/s downstream or upstream throughput is achieved by bonding  
40 two Physical Layer channels. Various flavors of Nx25G-EPON architectures are distinguished based on the  
41 specific combination of downstream/upstream data rates supported by the OLT and ONUs:

- 1 — 25/10G-EPON – an EPON architecture supporting a maximum sustained throughput of 25  
2 Gb/s in the downstream direction and 10 Gb/s in the upstream direction (asymmetric rate).
- 3 — 25/25G-EPON – An EPON architecture supporting a maximum sustained throughput of 25  
4 Gb/s in both downstream and upstream directions (symmetric rate).
- 5 — 25G-EPON – An EPON architecture supporting a maximum sustained throughput of 25 Gb/s  
6 in either downstream or both downstream and upstream directions. This term collectively  
7 refers to 25/10G-EPON and 25/25G-EPON architectures.
- 8 — 50/10G-EPON – An EPON architecture supporting a maximum sustained throughput of 50  
9 Gb/s in the downstream direction and 10 Gb/s in the upstream direction (asymmetric rate).
- 10 — 50/25G-EPON – An EPON architecture supporting a maximum sustained throughput of 50  
11 Gb/s in the downstream direction and 25 Gb/s in the upstream direction (asymmetric rate).
- 12 — 50/50G-EPON – An EPON architecture supporting a maximum sustained throughput of 50  
13 Gb/s in both downstream and upstream directions (symmetric rate).
- 14 — 50G-EPON – An EPON architecture supporting a maximum sustained throughput of 50 Gb/s  
15 in either downstream or both downstream and upstream directions. This term collectively  
16 refers to 50/10G-EPON, 50/25G-EPON, and 50/50G-EPON architectures.

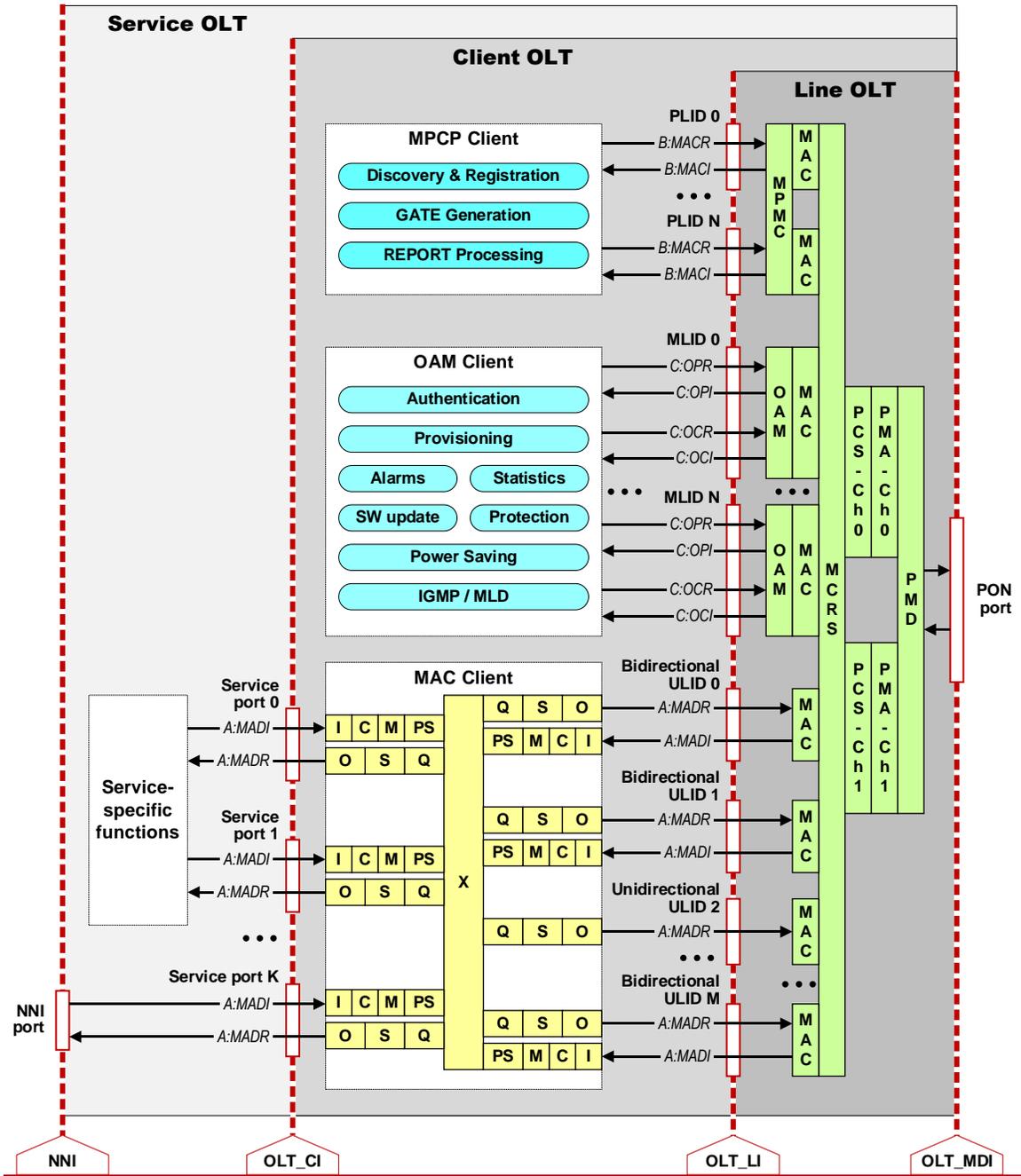
#### 17 **4.7 OLT architecture**

18 The OLT is the central network controller in EPON, providing connectivity between the EPON and the  
19 metro/aggregation network across Network-to-Network Interface (NNI). The OLT controls all connected  
20 ONUs, and it is in turn controlled by the NMS.

21 Historically, in various contexts (i.e., in different specifications), the term OLT has been used to represent  
22 different functionalities. To avoid potential ambiguities, this standard defines several OLT categories based  
23 on what functional elements are included in the OLT. The following OLT categories are defined:

- 24 — Line OLT (8-3-14.7.1),
- 25 — Client OLT (8-3-24.7.1),
- 26 — Service OLT (8-3-34.7.1).

27 The OLT categories together with the functional elements included in each category are illustrated in  
28 **Figure 8-1**.



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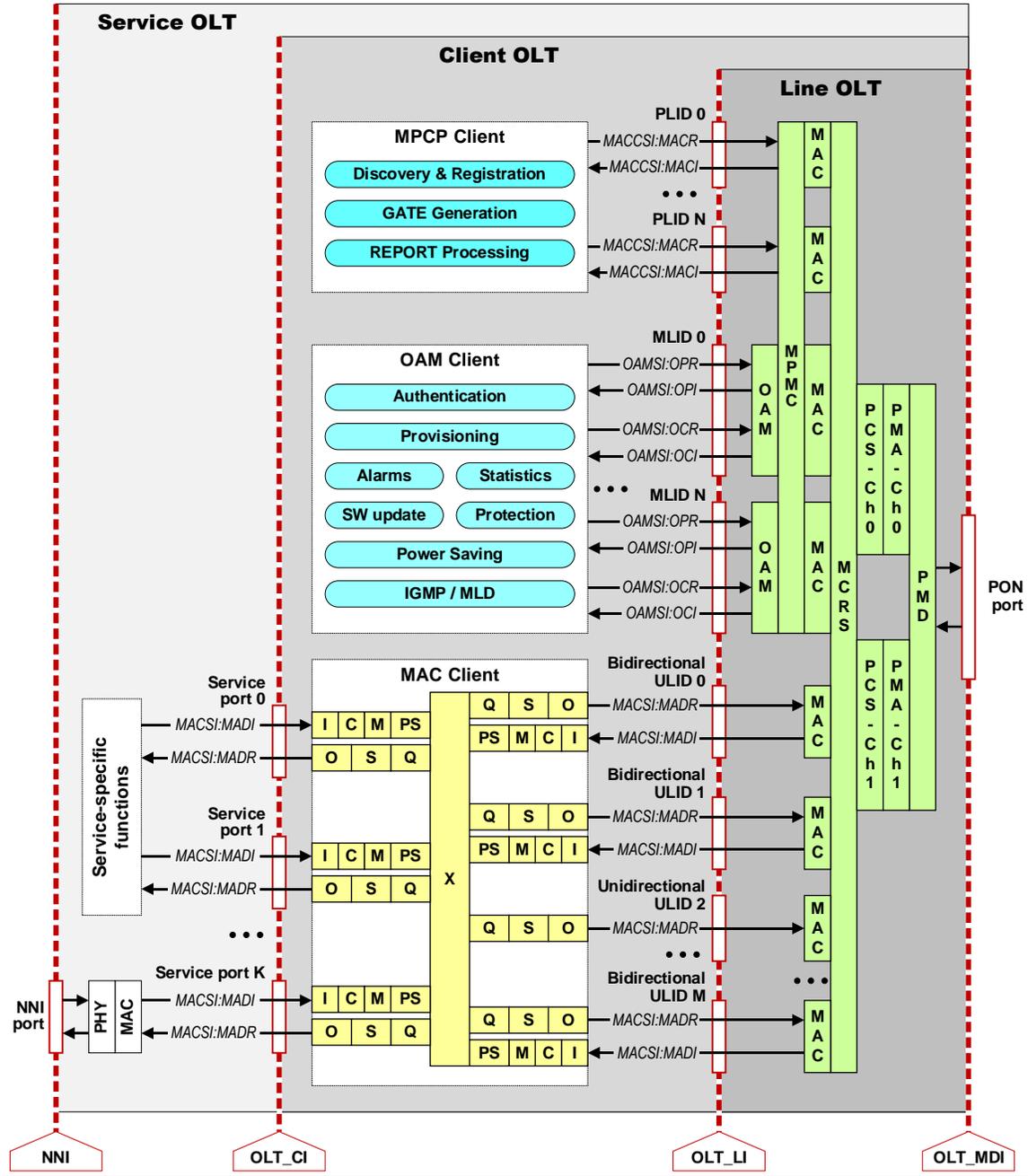
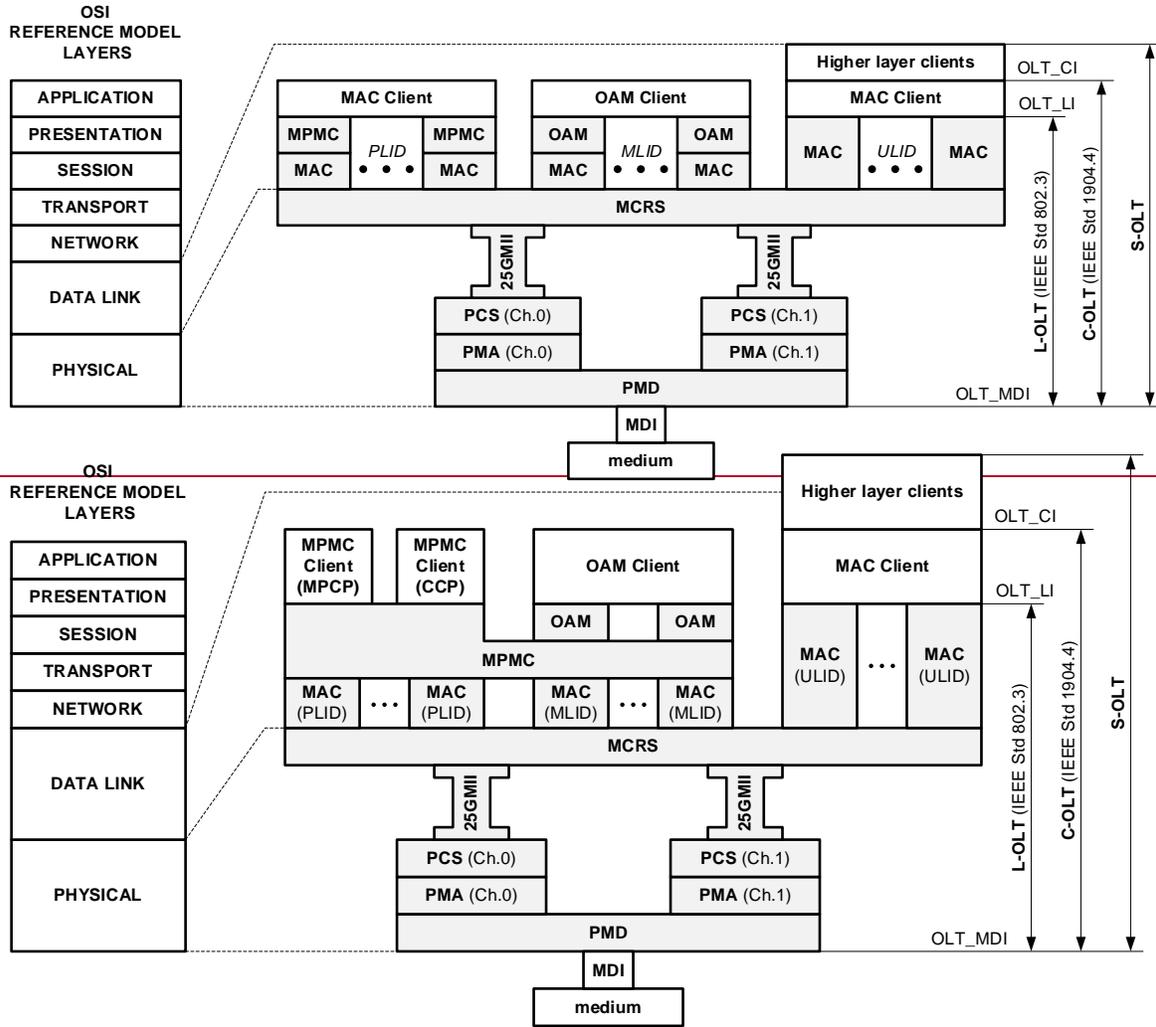


Figure 54-1—OLT architecture

### 4.7.1 Line OLT

A Line OLT (L-OLT) represents the functionality specified in IEEE Std 802.3 for 25G-EPON or 50G-EPON. This functionality includes the physical layer and portions of data link layer. Figure 84-2 illustrates the relation of the L-OLT to the reference layering model defined in IEEE Std 802.



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**Figure 54-2—Relationship of OLT interfaces to the OLT layering model defined in IEEE Std 802.3**

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The location of the L-OLT in the OLT architecture is presented in Figure 54-1.

6

An L-OLT represents the basic logical entity that is responsible for the Physical Layer connectivity in EPON. As such, the L-ONU is capable of sending and receiving various types of Ethernet frames: data frames, OAM frames, or MPCP frames, where the payload is provided via the C-OLT. The L-OLT does not initiate the process of MPCP discovery and registration of ONUs. It does not have frame buffers to store frames received from or destined to the ONUs.

7

8

As shown in Figure 54-1, the L-OLT interfaces with the PON media at the OLT\_MDI (see 55-14.9.1) and it interfaces with the higher-layer clients at the OLT\_LI (see 55-3.0.3). The OLT\_LI instantiates a number of logical ports, where each such port represents a single logical link (LLID).

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By itself, the L-OLT is not capable of establishing bidirectional connectivity with the OLT and requires the support of the C-OLT functions defined in this standard.

12

13

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## 4.7.2 Client OLT

A Client OLT (C-OLT) combines an L-OLT with higher-layer functions, such as the following:

- *OAM Client* functions: Provisioning, Statistics, Alarms, and Power Saving agents, Internet Group Management Protocol/Multicast Listener Discovery (IGMP/MLD), Authentication agents, etc.
- *MAC Control Client* functions: discovery and registration, *GATE* MPCPDU generation and *REPORT* MPCPDU processing agents
- *MAC Client* functions: see Clause 6 for details on these data path functions

These functions reside above the OLT\_LI (see 4.9.3) but below the OLT\_CI (see 4.9.5). The C-OLT is capable of establishing bidirectional connectivity with the ONU, sending and receiving subscriber frames (and providing all the necessary processing), and participating in the MPCP and OAM frame exchanges and related processes (e.g., discovery and registration, OAM discovery).

Each of the OLT\_LI logical ports, which represent LLIDs, is connected to one of the available clients. Depending on resources allocated to each LLID within its respective client, the LLID may operate as a bidirectional logical link or as a unidirectional (downstream-only) logical link. For example, in Figure 5-4-1, the ULID 1 is connected to MAC Client input [I] and output [O] blocks and it supports both the *MA\_DATA.Indication* and *MA\_DATA.Request* primitives. Therefore ULID 1 is a bidirectional LLID. In contrast, the ULID 2 is connected only to MAC Client output block and supports only the *MA\_DATA.Request* primitive. This makes the ULID 1 a unidirectional (downstream-only) LLID.

The C-OLT interfaces with the Service OLT at the OLT\_CI. The OLT\_CI instantiates a number of service ports (see Figure 5-4-1).

## 4.7.3 Service OLT

An S-OLT combines one C-OLT together with a number of functions residing above the OLT\_CI (see 5.5.3.1.5) and one or more NNI ports. The specific type, structure, and data rates supported by NNI ports are outside the scope of this standard.

Examples of additional functionalities residing above the OLT\_CI include service initiation protocols, network address translation, switching, POTS, and other elements appropriate for delivery of specific subscriber services. These elements are typically subject to separate specifications and remain outside the scope of this standard.

Elements residing above the OLT\_CI within the S-OLT are typically managed using solutions outside the scope of this standard.

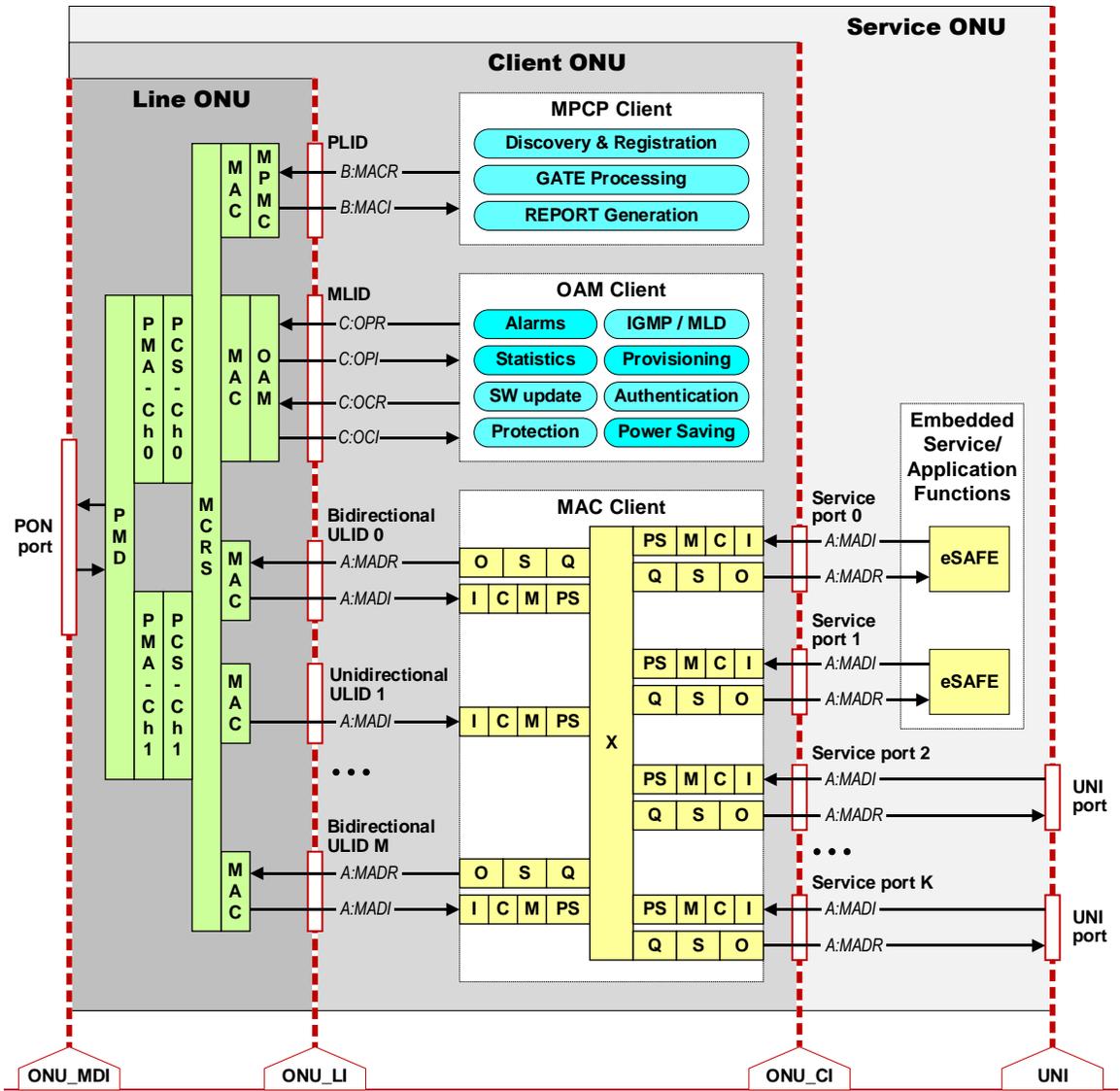
## 4.8 ONU architecture

The ONU represents the client unit in EPON, providing connectivity between CPE devices across the user network interface (UNI) and the EPON.

Historically, in various contexts (i.e., in different specifications), the term ONU has been used to represent different functionalities. To avoid potential ambiguities, this standard defines several ONU categories based on what functional elements are included in the ONU. The following ONU categories are defined:

- Line ONU (5.4.4.3.1),
- Client ONU (5.4.2.3.2),
- Service ONU (5.4.3.3.3).

- 1 The ONU categories together with the functional elements included in each category are illustrated in
- 2 **Figure 5.1-3**.



1

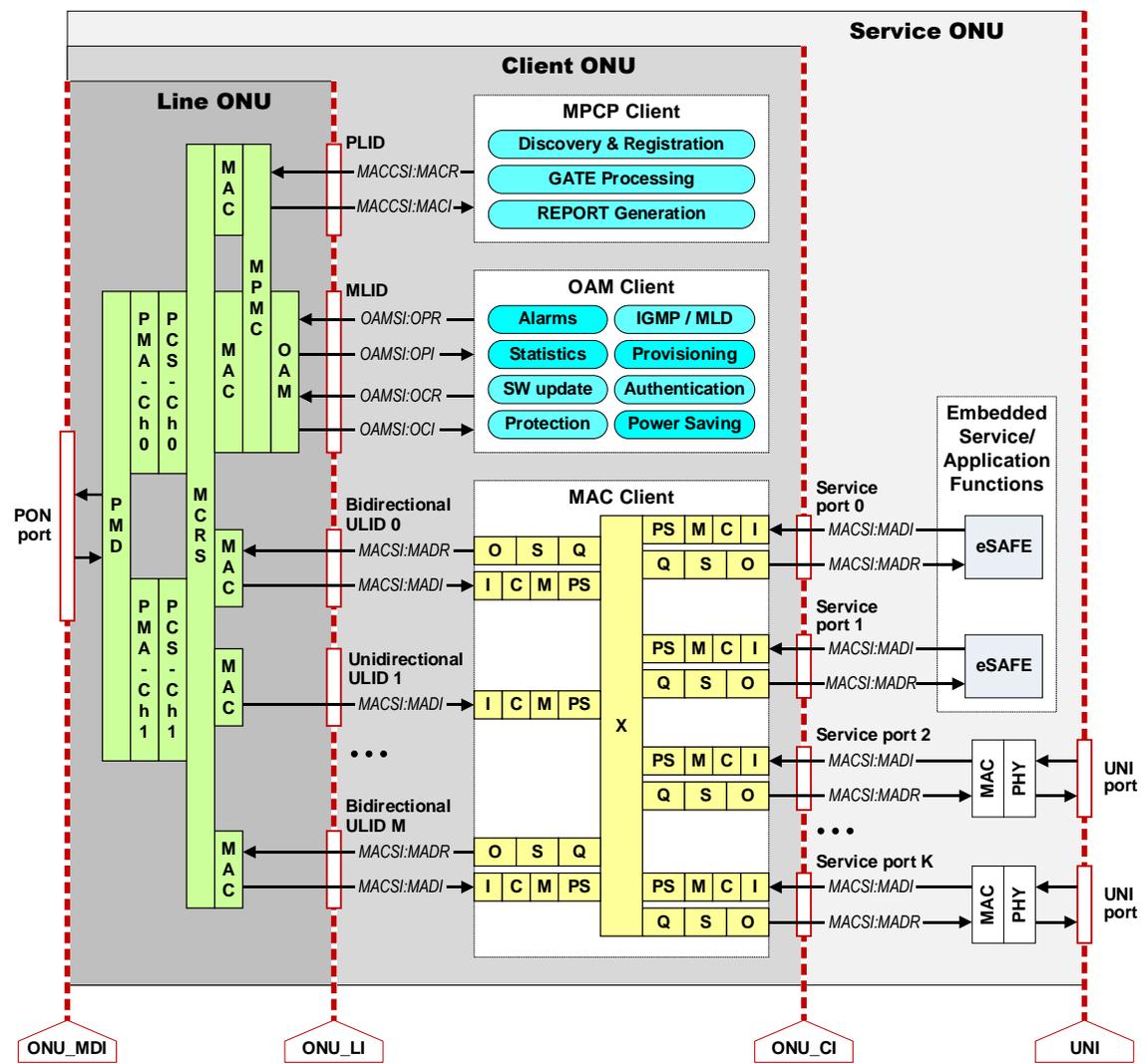


Figure 54-3—ONU architecture

#### 4.8.1 Line ONU

A Line ONU (L-ONU) represents the functionality specified in IEEE Std 802.3 for 25G-EPON or 50G-EPON. This functionality includes the physical layer and portions of data link layer. Figure 54-4 illustrates the relation of the L-ONU to the reference layering model defined in IEEE Std 802.



## 4.8.2 Client ONU

A Client ONU (C-ONU) combines a single L-ONU instance with higher-layer *client* functions, such as the following:

- *OAM Client* functions: Provisioning, Statistics, Alarms, and Power Saving agents, Internet Group Management Protocol/Multicast Listener Discovery (IGMP/MLD), Authentication agents, etc.
- *MAC Control Client* functions: discovery and registration, *GATE* MPCPDU processing and *REPORT* MPCPDU generation agents
- *MAC Client* functions: see Clause 6 for details on these data path functions

These functions reside above the ONU\_LI (see 4.4.9.4) but below the ONU\_CI (see 4.5.6.3.9.6). The C-ONU is capable of establishing bidirectional connectivity with the OLT, sending and receiving subscriber frames (and providing all the necessary processing), and participating in the MPCP and OAM frame exchanges and related processes (e.g., discovery and registration, OAM discovery).

The C-ONU interfaces with the Service ONU at the ONU\_CI. The ONU-CI instantiates a number of service ports (see Figure S4-1).

## 4.8.3 Service ONU

A Service ONU (S-ONU) combines one C-ONU together with various embedded service/application entities (eSAFEs) residing above the ONU\_CI (see 4.5.6.3.9.6) interface. The C-ONU typically includes one or more subscriber UNI ports.

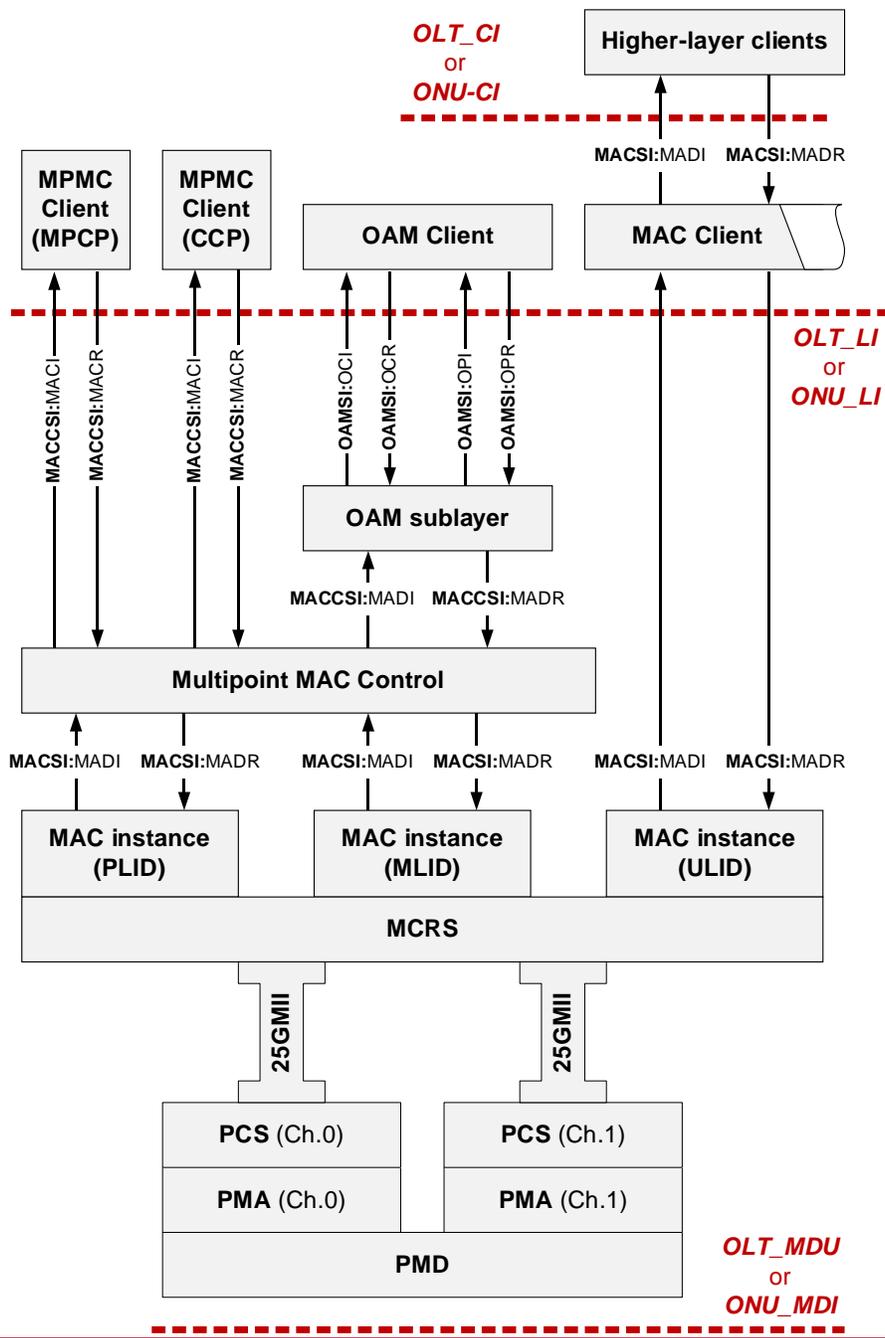
Each of the service ports instantiated by the C-ONU at the ONU\_CI interface is either connected to an eSAFE device within an S-ONU or is exposed as a physical UNI port for connecting subscriber CPE.

Examples of eSAFE devices/sub-systems residing above the ONU\_CI include embedded Router (eRouter), embedded Set-Top Box (eSTB), embedded Digital Voice Adapter (eDVA) and many others, for example as described in [eDOCSIS] (Ed. Note: add bib entry to 3-1 Annex Bib). These elements are typically subject to separate specifications and remain outside the scope of this standard.

Note that some of the eSAFE devices may have their own physical ports exposed as Ethernet or non-Ethernet UNI ports at the S-ONU. Those ports are expected to be managed as part of the eSAFE device management and are outside the scope of this standard.

## 4.9 Interfaces

This subclause provides definitions of ~~abstract-functional~~ interfaces specified ~~between individual functional blocks of for~~ the ONU and OLT devices. ~~As such, these~~ interfaces do not require any specific implementation; however, they may have corresponding primitives defined in IEEE Std 802.3, as indicated below. The positions of these interfaces and the primitives supported by each interface are illustrated in Figure 4-5. The internal sublayer interfaces MACSI, MACCSI, and OAMSI are defined in 4.5.



**Figure 4-5: Position of functional interfaces in the OLT and ONU devices**

1  
2  
3  
4  
5  
6

**4.9.1 OLT\_MDI**

The OLT\_MDI represents an interface between the L-OLT and the physical PON medium. This interface corresponds to the MDI specified in IEEE Std 802.3, Clause 141.

## 1 **4.9.2 ONU\_MDI**

2 The ONU\_MDI represents an interface between the L-ONU and the physical PON medium. This interface  
3 corresponds to the Medium Dependent Interface (MDI) specified in IEEE Std 802.3, Clause 141.

## 4 **4.9.3 OLT\_LI**

5 The OLT\_LI represents the interface between the L-OLT and C-OLT functionalities. From a practical point  
6 of view, the OLT\_LI represents the boundary of IEEE 802.3 specifications for EPON, covering the PMD,  
7 PMA, PCS, MCRS, MAC, MPMP, and OAM sublayers.

8 This interface corresponds to the following IEEE 802.3 interfaces:

- 9 — MAC data service interface (using MADI and MADR primitives, as described in 3.4) for subscriber  
10 data frames exchanged between the MAC Client and L-OLT
- 11 — MAC Control service interface (using MACI and MACR primitives, as described in 3.4) for MAC  
12 Control frames exchanged between the MAC Control Client and L-OLT
- 13 — OAM service interface (using OCI, OCR, OPI, and OPR primitives, as described in 3.4) for OAM  
14 frames exchanged between the OAM Client and L-OLT

## 15 **4.9.4 ONU\_LI**

16 The ONU\_LI represents the interface between the L-ONU and C-ONU functionalities. From a practical  
17 point of view, the ONU\_LI represents the boundary of IEEE 802.3 specifications for EPON, covering the  
18 PMD, PMA, PCS, MCRS, MAC, MPMP, and OAM sublayers, residing below the ONU\_LI.

19 This interface corresponds to the following IEEE 802.3 interfaces:

- 20 — MAC data service interface (using MADI and MADR primitives, as described in 3.4) for subscriber  
21 data frames exchanged between the MAC Client and L-ONU
- 22 — MAC Control service interface (using MACI and MACR primitives, as described in 3.4) for MAC  
23 Control frames exchanged between the MAC Control Client and L-ONU
- 24 — OAM service interface (using OCI, OCR, OPI, and OPR primitives, as described in 3.4) for OAM  
25 frames exchanged between the OAM Client and L-ONU

## 26 **4.9.5 OLT\_CI**

27 The OLT\_CI represents the interface between the C-OLT and the S-OLT functionalities. The OLT\_CI  
28 instantiates a number of service ports, which may be internal ports connected to embedded service-specific  
29 functions or external ports (i.e., NNI ports) exposed in the S-OLT for connection to the backbone network.  
30 The OLT\_CI corresponds to D/MN<sub>E</sub> interface defined in DPoE-SP-ARCH.

## 31 **4.9.6 ONU\_CI**

32 The ONU\_CI represents the interface between the C-ONU and the S-ONU functionalities. The ONU\_CI  
33 instantiates a number of service ports, which may be internal ports connected to embedded  
34 service/application functions (sSAFEs) or external ports (i.e., UNI ports) exposed in the S-ONU for  
35 connection to physical CPE devices. The ONU\_CI corresponds to S-interface defined in DPoE-SP-ARCH.  
36