3   Definitions, acronyms, and abbreviations

3.6   Notation for PICS

3.6.1   Abbreviations and special symbols
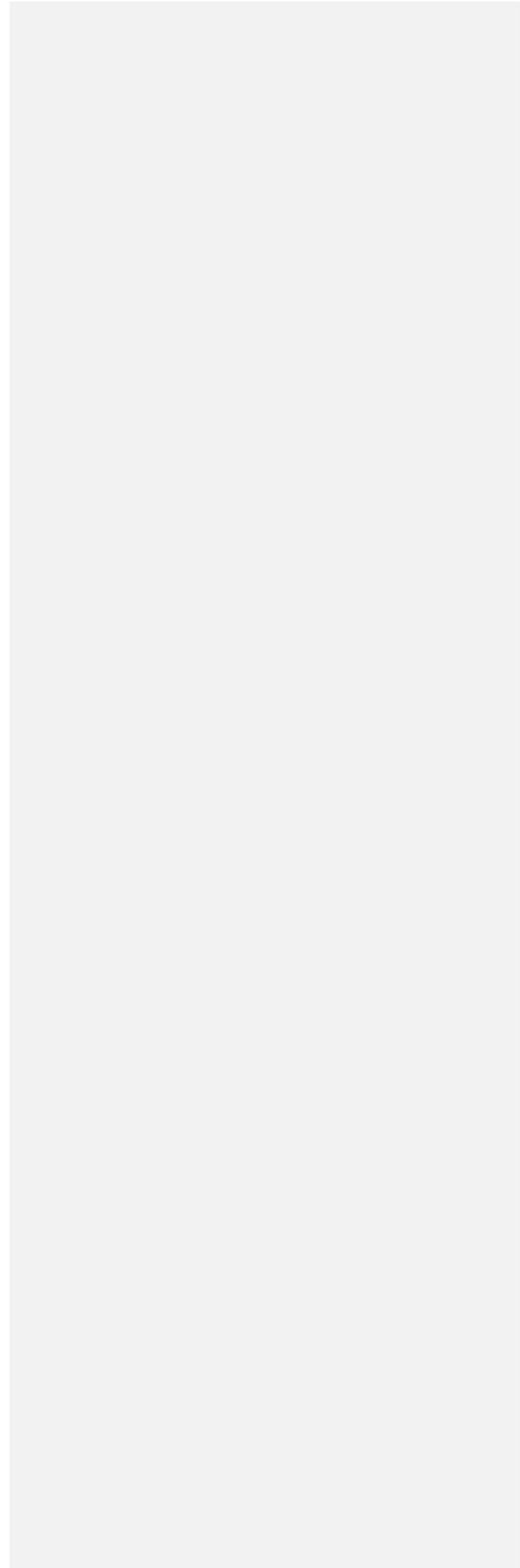
The following symbols are used in the PICS proforma:

M	mandatory field/function
!	negation
O	optional field/function
O.<n>	optional field/function, but at least one of the group of options labeled by the same numeral <n> is required
O/<n>	optional field/function, but one and only one of the group of options labeled by the same numeral <n> is required
X	prohibited field/function
<item>:	simple-predicate condition, dependent on the support marked for <item>
<item1>*<item2>:	AND-predicate condition, the requirement needs to be met if both optional items are implemented
<item1>+<item2>:	OR-predicate condition, the requirement needs to be met if at least one of optional item is implemented

4　Specification packages

4.2　SIEPON packages

Sets of features comprising Package A, Package B, and Package C are summarized in Table 4-1. Detailed specifications of each feature and the associated mandatory and optional requirements are provided in the subsequent clauses, as referenced in Table 4-1.

Table 4-1—Definition of SIEPON packages ᵃ

Item	Feature	Package		
		A	B	C
TVM	OLT VLAN modes	OLT shall support VLAN modes defined in 7.2.2.3	OLT shall support VLAN modes defined in 7.2.2.1.1, 7.2.2.1.3, and 7.2.2.1.5	OLT shall support VLAN modes defined in 7.2.2.2.1 – 7.2.2.2.7
UVM	ONU VLAN modes	ONU shall support VLAN modes defined in 7.2.2.3	ONU shall support VLAN modes defined in 7.2.2.1.2, 7.2.2.1.4, and 7.2.2.1.6	ONU shall support VLAN modes defined in 7.2.2.2.1 – 7.2.2.2.7
MA	MAC aging	N/A	N/A	shall implement MAC aging function as defined in 7.2.2.2.8
TTM	OLT tunneling modes	OLT shall support tunneling modes defined in 7.3.2	N/A	N/A
UTM	ONU tunneling modes	ONU shall support tunneling modes defined in 7.3.2	N/A	N/A
MCC	multicast connectivity, coexistence	shall support multicast connectivity, coexistence per 7.4.1.1.2		
MC	multicast connectivity	shall support multicast operation as defined in 7.4.5	shall support multicast operation as defined in 7.4.2	shall support multicast operation as defined in 7.4.3 and 7.4.4
QSD	queue service discipline	shall implement queue service discipline per 8.4.1.1	shall implement queue service discipline per 8.4.3.1	shall implement queue service discipline per 8.4.2.1
RLC	report queue length calculation	shall implement queue length calculation per 8.4.1.2	shall implement queue length calculation per 8.4.3.2	shall implement queue length calculation per 8.4.2.2
RF	*REPORT* MPCP format	shall implement *REPORT* MPCPDU format per 8.4.1.3	shall implement *REPORT* MPCPDU format per 8.4.3.3	shall implement *REPORT* MPCPDU format per 8.4.2.3
DCQ	discovery and configuration of queue parameters	N/A	should implement discovery and configuration of queue parameters per 8.4.3.4	N/A
PM	performance monitoring	N/A	N/A	shall implement performance monitoring per 8.5
USM	ONU transceiver status monitoring	shall implement transceiver status monitoring per 9.1.3	should implement transceiver status monitoring per 9.1.5	shall implement ONU transceiver status monitoring per 9.1.4, associated alarms and warnings per 9.1.6
TSM	OLT transceiver status monitoring			shall implement OLT transceiver status monitoring per 9.1.4

Item	Feature	Package		
		A	**B**	**C**
PLD	UNI port loop detection	N/A	N/A	shall implement UNI port loop detection per 9.1.8
PSL	Port Selective Loopback	shall support Port Selective Loopback per 9.1.9	N/A	N/A
E	events	shall implement events per 9.2.6	shall implement events per 9.2.6, 9.2.7, and 9.2.8	shall implement events per 9.2.3, 9.2.4, 9.2.4.5, and 9.2.6
LPTK	optical link protection, trunk type	should implement trunk optical link protection per 9.3.3 and 9.3.5.2N/A	should implement trunk optical link protection per 9.3.5	should implement trunk optical link protection per 9.3.3 and 9.3.5.1
LPTE	optical link protection, tree type	should implement tree optical link protection per 9.3.4 and 9.3.5.2N/A	N/A	should implement tree optical link protection per 9.3.4 and 9.3.5.1
RPC	remote ONU transmitter power supply control	N/A	N/A	shall implement remote ONU transmitter power supply control function per 9.4
PS	power saving	shall support power saving per 10.4 and 10.5.2	should support power saving per 10.4 and 10.5.3	shall support power saving per 10.4 and 10.5.4
DE	data encryption	shall implement data encryption and integrity protection mechanism per 11.2.2	shall implement data encryption and integrity protection mechanism per 11.2.3	N/A
AU	ONU authentication	shall implement ONU authentication and secure provisioning per 11.3.3	shall implement ONU authentication and secure provisioning per 11.3.4	shall implement ONU authentication and secure provisioning per 11.3.2
MG	management	shall implement eOAM-based management per 13.4	shall implement eOAM-based management per 13.3	shall implement eOAM-based management per 13.2
DCD	device and capability discovery	shall implement device discovery and capability discovery per 12.2.3	shall implement device discovery and capability discovery per 12.2.2	shall implement device discovery and capability discovery per 12.2.1
SU	software update	shall implement software update mechanism per 12.3.3	shall implement software update mechanism per 12.3.2	shall implement software update mechanism per 12.3.1
ME	management entities	shall implement management entities per 14.4	shall implement management entities per 14.3	shall implement management entities per 14.2
EDP	EPON Data Path	N/A	N/A	shall implement EDP per Annex 7A

[a] N/A – Not Applicable

9 Service availability

Clause 9 describes functional requirements to achieve interoperable service availability guarantees in EPON systems. Clause 9 specifically addresses functions and requirements related to device and transceiver monitoring, definitions of associated alarms and warnings, optical link protection, and remote ONU transmitter power supply control.

9.3 Optical link protection

9.3.1 Introduction

This subclause defines optical link protection mechanisms, their functional description, and the associated OLT and ONU requirements. Two types of optical link protection are introduced, namely, a trunk protection (see 9.3.3 and 9.3.5) and a tree protection (see 9.3.4), each addressing a different application space and providing different types of functionality.

9.3.1.1 Terminology

In the remainder of this subclause, the terms *primary* and *backup* are used to describe the physical modules involved in the protection scheme whereas the terms *working* and *standby* describe the state of the physical modules. The working module refers to the module currently carrying subscriber traffic, and the standby module is not carrying subscriber traffic. During the actual switch event, both the primary and backup modules may be carrying active traffic, depending on the actual implementation; however, this condition is transient.

The switching time between the working OLT and the standby OLT is defined as the time between the last bit of the last frame transmitted on the working OLT_MDI and the first bit of the first frame transmitted on the standby OLT_MDI, assuming continuous flow of data to a single connected ONU. The time taken by the switching condition detection process is accounted for in the switching time. Note that the switching time measurement may not be accurate with multiple connected ONUs.

The switching time between the working L-ONU and the standby L-ONU is defined as the maximum time interval among the following:

— Time interval between reception of the last bit of the control message (*PON Interface Administrate* TLV ~~(0xC7/0x00-0B)~~, defined in 9.3.5/~~14.2.2.9~~, or *HOLDOVER* message, defined in 9.3.5.29.3.6.2) by the working L-ONU, requesting the ONU to perform switchover, and the first bit of a *REPORT* MPCPDU reflecting the nonzero queue length transmitted by the standby L-ONU.

— Time interval between the detection of loss of signal by the working L-ONU and the first bit of a *REPORT* MPCPDU reflecting the nonzero queue length transmitted by the standby L-ONU.

— Time interval between the reception of the first bit of a data frame by the standby L-ONU and the first bit of a *REPORT* MPCPDU reflecting the nonzero queue length transmitted by the standby L-ONU.

The above time intervals are measured under continuous flow of data to a single connected ONU.

9.3.3 Trunk protection scheme

In the trunk protection scheme, the ODN span between the C-OLT and the 2:*N* optical splitter, used to join the two trunk segments, is protected. The C-ONU and the branch fiber (ODN span between the splitter and the ONU) are not protected. There are two types of trunk protection schemes, as shown in Figure 9-8 and Figure 9-9.

Figure 9-8 presents a trunk protection scheme with redundant L-OLT and trunk segments. In this scheme, the MAC, MAC Control, and OAM Clients in the C-OLT are shared by the primary and the backup L-OLTs and are not protected against failures. This trunk protection scheme reduces the implementation cost and targets protection only against the failures having highest potential impact: OLT optical transceiver failures and trunk fiber cuts. In this scheme, the OLT uses a line protection architecture (see 9.3.2.1.1).

The trunk protection with redundant L-OLT scheme supports only the *intra-chassis* protection scheme, where the primary L-OLT and backup L-OLT are located within the same chassis (either on the same line card or on separate line cards.
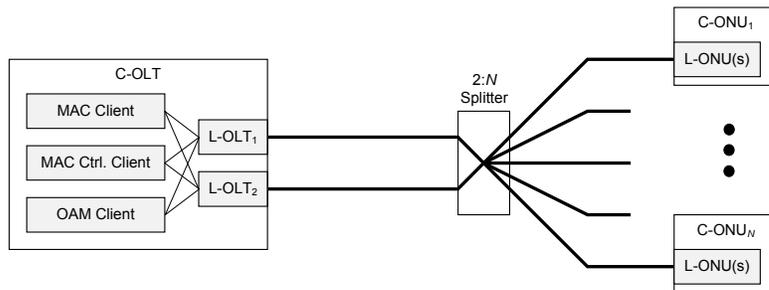

Figure 9-18—Trunk protection with redundant L-OLT

An alternative configuration of the trunk protection scheme is shown in Figure 9-9. This scheme provides added robustness as the whole C-OLT is duplicated, including the L-OLT and all MAC Clients.

In addition to intra-chassis protection, the trunk protection with redundant C-OLT scheme supports the inter-chassis protection, where the primary C-OLT and backup C-OLT are located in different chassis (either within the same central office or geographically different locations). The inter-chassis protection scheme requires coordination of the protection states and functions among the primary and backup C-OLTs comprising the trunk protection group and may require communication over LANs and/or wide area networks (WANs) using public or proprietary protocols. The nature of information, data formats, and communications protocols used to coordinate protection functions among the primary and backup C-OLTs are outside the scope of this standard.
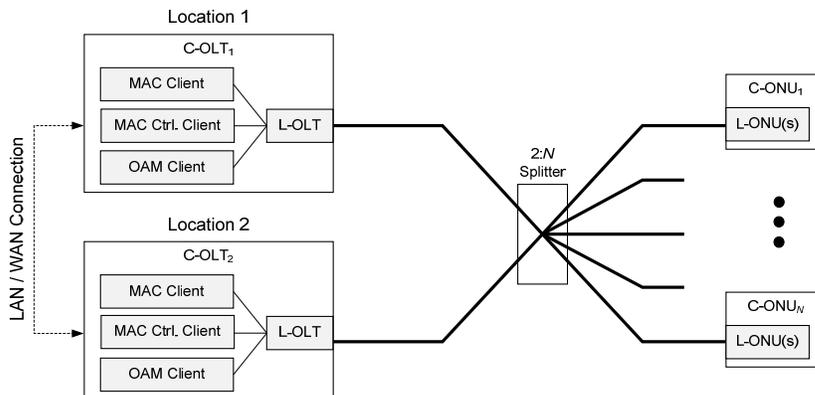

Figure 9-29—Trunk protection with redundant C-OLT

In the trunk protection scheme, the backup C-OLT acquires the round-trip time (RTT) values for individual ONUs without executing the MPCP discovery and registration process. Two possible approaches to acquire RTT are covered in Annex 9A; however, their selection and implementation details are outside the scope of this standard.

There are no ONU configuration differences between the trunk protection schemes shown in Figure 9-8 and Figure 9-9. Connected C-ONUs are configured in precisely the same manner.

The following subclauses provide technical requirements for the C-ONU and C-OLT devices participating in this protection scheme.

9.3.3.1 Functional requirements

Trunk protection in EPON requires support for the following basic functionalities:

— Ability to measure the standby path RTT (bRTT) in a way that does not affect live services. While the measurement of bRTT through re-registration of the affected ONUs is certainly possible, it would have a high impact on services (i.e., longer interruption) and is, therefore, not recommended. Annex 9A presents examples of dynamic bRTT measurement mechanisms.

— Ability to switch the ONU between working and standby paths dynamically, without requiring an extended period of downtime, thus minimizing the impact on the operating services. The switching time between working OLT and standby OLT shall be lower than or equal to 150 ms. The definition of the switching time can be found in 9.3.1.1.

The process of protection switching in the trunk protection scheme may be executed in the following ways:

— Automatically, when both the OLT and the ONU detect the fault condition on the working optical line using any of the mechanisms specified in the following subclauses; or

— On-demand, when the OLT is requested by the NMS to switch to the standby path. This protection switch is executed typically for operational reasons, e.g., fiber repairs, maintenance of OLT cards.

9.3.3.2 C-OLT requirements

In the trunk protection mechanism, as defined in 9.3.3, the OLT is connected to two optical links, the primary and backup link, from which only one is active at any time, carrying OAM, eOAM, and MPCP control frames together with subscriber traffic.

The protection function present in the Operation, Administration, and Management block is responsible for switching between the primary and backup paths for subscriber and control frames. Both the Line ONU/OLT protection and Client ONU/OLT protection schemes can be supported by the OLT in the case of trunk protection, as defined in 9.3.2.1.1 and 9.3.2.1.2, respectively.

The protection function additionally instantiates the state diagram per Figure 9-10, controlling the operation of the MAC Client and L-OLTs.

The standby OLT and the working OLT participating in the trunk protection group exchange configuration details continuously, i.e., the standby OLT is informed by the working OLT of any changes in its configuration, registration, and authentication status of individual ONUs, etc. The specific method of communication between the standby OLT and the working OLT is outside the scope of this standard.

The primary OLT and backup OLT may be provisioned by the NMS in exactly the same manner, using the same configuration parameters, except that one OLT is provisioned as working and the other OLT is provisioned as standby to minimize the preparation time for the backup OLT to come online after the protection switchover.

The standby OLT may be in cold standby mode or in warm standby mode. In the first mode, the standby OLT remains powered off until protection switching is requested. In the second mode, the standby OLT remains powered on with minimum functions enabled and operational, i.e., the OLT has the capability of receiving and parsing upstream transmissions from the PON branch it is connected to, but does not send any data downstream. It is recommended that the standby OLT operates in the warm standby mode to facilitate fast response times to the optical protection switchover events:

— Electronic subsystems are fully operational.

— Optical subsystem is partially active, i.e., transmitter is powered down (no downstream transmission is needed), while receiver is powered up (receiving upstream transmissions from connected ONUs).

Assume the initial state of the network is such that the primary OLT is in the working state and the backup OLT is in the standby state in the following discussion. The working OLT monitors the status of the optical line according to 9.3.2.2.1, and once any of the line fault conditions are detected, the working OLT disables its optical transmitter and stops any downstream transmission. The working OLT then causes the standby OLT to enter into the full operating mode. To complete the switchover process, the working OLT informs the NMS about the switchover event. It is recommended that the time between the events of the working OLT's switching its laser off and the standby OLT's switching its laser on be at least equal to the largest value of $T_{LoS\_Optical}$ for all connected ONUs, as defined in 9.3.2.2.2, to guarantee that connected ONUs can properly detect the line fault condition.

Information, notification, and alarms/warnings delivered by the working OLT to the NMS in the switchover condition, as well as message formats, are outside the scope of this standard.

The new working OLT, once the switchover process is complete, shall send one or more *GATE* MPCPDUs to force each registered ONU to resynchronize to the MPCP clock. The transmission of such *GATE* MPCPDU is recommended to take place as soon after the end of the switchover event as possible to minimize frame loss during the switchover event.

9.3.3.3   C-ONU requirements

In the trunk protection mechanism, as defined in 9.3.3, the ONU is connected to a single optical link. In this case, the C-ONU does not contain primary and backup ESPs and typically remains registered throughout the switchover event. All the necessary changes take place on the OLT side, and the ONU is required only to suspend upstream transmissions for a specific period of time and remain in the HOLD_OVER_START state (per Figure 9-11) until a *GATE* MPCPDU is received.

As a result, only one instance of the OAM Client and MAC Control Client is needed on the ONU side, and the protection function present in the Operation, Administration, and Management block instantiates the state diagram per Figure 9-11, controlling the operation of the MAC Client and L-ONU(s).

Upon detection of a line fault, the C-ONU enters the HOLD_OVER_START state per Figure 9-11, where all currently stored upstream transmission grants are purged and the transmission of data from the ONU to the OLT is suspended. All incoming subscriber upstream data frames are queued. Frame loss is allowed in trunk protection when the local ONU queues overflow.

The C-ONU leaves the HOLD_OVER_START state upon the reception of the first *GATE* MPCPDU after entering the HOLD_OVER_START state. The upstream transmission is resumed using the newly allocated upstream transmission slots.

If the C-ONU fails to receive the *GATE* MPCPDU within the provisioned duration of the HOLD_OVER_START state (expressed by the periodHoldOver variable), the ONU enters the local deregistration state by sending the MACR(DA, REGISTER_REQ, status = deregister) primitive

to the underlying MPCP sublayer, per Figure 9-11. The OLT deregisters the ONU independently, based on the observed link status.

9.3.3.3.1   Configuration messages

To configure the values for $T_{LoS\_Optical}$ and T_{LoS_MAC} parameters in the C-ONU, the C-OLT uses the *ONU Protection Configuration* TLV (0xC7/0x00-0F) per 14.2.2.13. The C-ONU shall be able to process the eOAMPDU with the *ONU Protection Configuration* TLV (0xC7/0x00-0F) and set the values for $T_{LoS\_Optical}$ and T_{LoS_MAC} parameters accordingly.

9.3.3.4   Trunk switching process

9.3.3.4.1   Variables

backupLoS

> TYPE: Boolean

> This variable indicates whether the MAC LoS or optical LoS condition is observed by the backup L-OLT, as defined in 9.3.2.2.1, or by the backup L-ONU (only in tree protection case), as defined in 9.3.2.2.2. The value of true indicates that the LoS condition is observed, and false indicates that the LoS condition is not observed. By default, this variable has the value of false.

primaryLoS

> TYPE: Boolean

> This variable indicates whether the MAC LoS or optical LoS condition is observed by the primary L-OLT, as defined in 9.3.2.2.1, or by the primary L-ONU, as defined in 9.3.2.2.2. The value of true indicates that the LoS condition is observed, and false indicates that the LoS condition is not observed. By default, this variable has the value of false.

periodHoldOver

> TYPE: 32-bit unsigned integer

> This variable represents the maximum period of time that the ONU may remain in the HOLD_OVER_START state. If the ONU does not receive at least one *GATE* MPDPDU within the periodHoldOver, it deregisters. This variable is expressed in units of milliseconds, and its value is provisioned using the management scheme specific for the given profile.

registered

> This variable holds the current result of the discovery process. It is set to true once the discovery process is completed and registration is acknowledged. This variable is defined in IEEE Std 802.3, 64.3.3.2 for 1G-EPON and 77.3.3.2 for 10G-EPON.

9.3.3.4.2   Timers

timerHoldOver

> This timer is used to force the ONU leave the HOLD_OVER_START state if the period of time spent in the HOLD_OVER_START state is longer than the provisioned value of periodHoldOver. Once this timer expires, the ONU deregisters.

9.3.3.4.3 Functions

`activateDataPath( portId )`

> This function controls the flow of subscriber data frames egressing the port identified by `portId` parameter, which can take the following values:
>
> — `primaryPonIF` identifies the primary physical port associated with OLT_MDI or ONU_MDI.
> — `backupPonIF` identifies the backup physical port associated with OLT_MDI or ONU_MDI.
> — `primaryMacPort` identifies the primary virtual port associated with OLT_LI. This port is identified by an LLID.
> — `backupMacPort` identifies the backup virtual port associated with OLT_LI. This port is identified by an LLID.
>
> When the function is called with the argument set to `primaryPonIF` or `primaryMacPort`, the identified primary port becomes the working port, and the corresponding backup port becomes the standby port. Similarly, when the function is called with the argument set to `backupPonIF` or `backupMacPort`, the identified backup port becomes the working port, and the corresponding primary port becomes the standby port. Implementations may choose to accomplish this switching by modifying the rules or reconfiguring the association between the CrossConnect entries and the queues.

`opticalTX( portId, param )`

> This function controls the status of the optical transmitter associated with the port identified by `portId` parameter. The `portId` parameter can take values as defined in the `activateDataPath( portId )` function. When the `param` variable has the value of `enable`, the optical transmitter is enabled, allowing the data transmission across the OLT_MDI or ONU_MDI. When the `param` variable has the value of `disable`, the optical transmitter is disabled (either powered down or disabled administratively), resulting in no frames being transmitted across the OLT_MDI or ONU_MDI.

`purgeGrants()`

> This function causes an L-ONU to discard all stored (pending) grants.

`sendResyncGates( portId )`

> This function is responsible for transmission of refresh *GATE* MPCPDUs to all L-ONUs connected to a port identified by `portId` parameter. The `portId` parameter can take values as defined in the `activateDataPath( portId )` function. Reception of these *GATE* MPCPDUs forces the ONUs to leave the HOLD_OVER_START state, as defined in Figure 9-11.

9.3.3.4.4 Primitives

`MACI( GATE )`

> An acronym for `MACI( GATE, start, length, force_report, discovery, status )`. It represents a reception of a nondiscovery *GATE* MPCPDU at the ONU as defined in IEEE Std 802.3, 64.3.5.5 for 1G-EPON and 77.3.5.5 for 10G-EPON. The `MACI` acronym is defined in 3.4.

```
MACR( DA,REGISTER_REQ, status )
```

> This primitive represents the transmission of a *REGISTER_REQ* MPCPDU by the ONU, as defined in IEEE Std 802.3, 64.3.3.5 for 1G-EPON and 77.3.3.5 for 10G-EPON. The `MACR` acronym is defined in 3.4.

```
NMSI( messageId, failureCode)
```

> This primitive is used to inform the NMS about the protection switching event, during which the previously working and standby L-OLTs exchange their functions. It uses the following parameters:
>
> — `messageId` identifies whether the switching event was initiated by the OLT or the ONU and what the new working port is. The following messages are defined:
>
> > — `MSG1`: The switching event was initiated at the OLT, and the `primaryPonIF` is in the working state.
> >
> > — `MSG2`: The switching event was initiated at the OLT, and the `backupPonIF` is in the working state.
>
> — `failureCode` identifies the reason for the protection switching, per 9.2.4.8.

```
NMSR( protection, switch )
```

> This primitive is used by the NMS to request the working OLT to initiate a protection switch, during which the previously working and standby OLTs exchange their functions.

9.3.3.4.5 State diagrams

The C-OLT shall instantiate the switching process state diagram as defined in Figure 9-10. In case Client protection is implemented at the OLT (i.e., when two C-OLTs are used as shown in Figure 9-9), the combined operation of both C-OLTs shall be as defined in Figure 9-10. The C-ONU shall instantiate the switching process state diagram as defined in Figure 9-11.
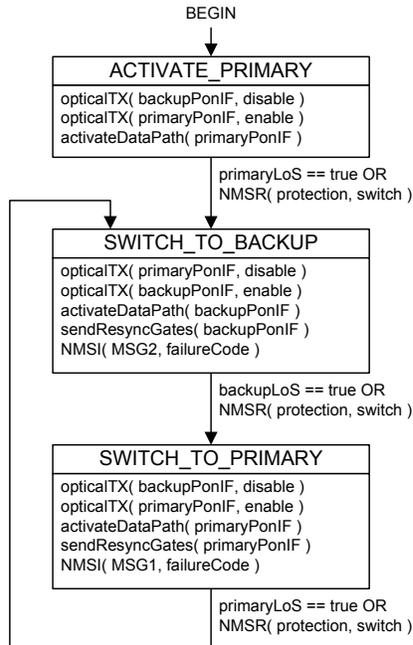
BEGIN

ACTIVATE_PRIMARY

opticalTX(backupPonIF, disable)
opticalTX(primaryPonIF, enable)
activateDataPath(primaryPonIF)

primaryLoS == true OR
NMSR(protection, switch)

SWITCH_TO_BACKUP

opticalTX(primaryPonIF, disable)
opticalTX(backupPonIF, enable)
activateDataPath(backupPonIF)
sendResyncGates(backupPonIF)
NMSI(MSG2, failureCode)

backupLoS == true OR
NMSR(protection, switch)

SWITCH_TO_PRIMARY

opticalTX(backupPonIF, disable)
opticalTX(primaryPonIF, enable)
activateDataPath(primaryPonIF)
sendResyncGates(primaryPonIF)
NMSI(MSG1, failureCode)

primaryLoS == true OR
NMSR(protection, switch)

Figure 9-~~3~~10—Trunk protection process operating on the OLT

BEGIN

WORKING

registered == true AND
primaryLoS == true

HOLD_OVER_START

opticalTX(primaryPonIF, disable)
registered = false
purgeGrants()
[start timerHoldOver, periodHoldOver]

MACI(GATE) AND
primaryLoS == false

timerHoldOver_done

HOLD_OVER_END

[stop timerHoldOver]
opticalTX(primaryPonIF, enable)
registered = true

FORCE_DEREGISTER

opticalTX(primaryPonIF, enable)
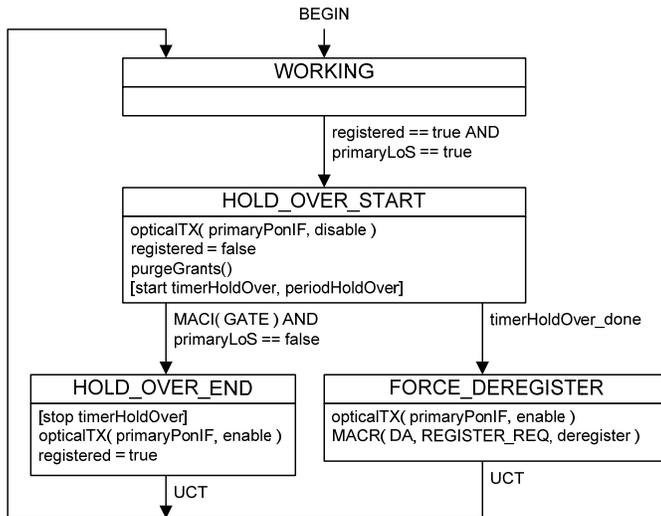MACR(DA, REGISTER_REQ, deregister)

UCT

UCT

Figure 9-~~4~~11—Trunk protection process operating on the ONU

9.3.4   Tree protection scheme

In the tree protection scheme, the entire ODN (trunk segment and branch segments) is protected against failure. There are two types of tree protection schemes, as shown in Figure 9-12 and in Figure 9-13.

Figure 9-12 presents a tree protection scheme with redundant L-OLT, L-ONU, and ODN. In this scheme, the OLT and ONUs use a line protection architecture (see 9.3.2.1.1) sharing the MAC, MAC Control, and OAM Clients among the primary and the backup L-OLTs and primary and backup L-ONUs. This scheme reduces data loss during the protection switchover event since the data frames stored in MAC Client queues are redirected to another path. However, in this scheme the MAC, MAC Control, and OAM Clients are not protected against failures.
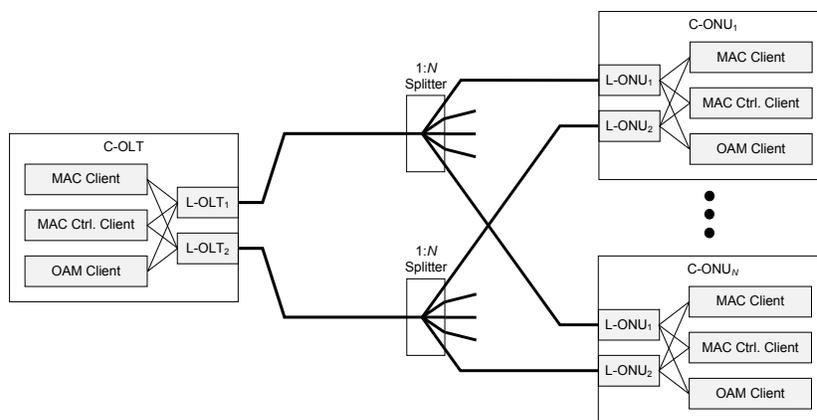

Figure 9-512—Tree protection with redundant L-OLT

An alternative configuration of the tree protection scheme is shown in Figure 9-13. This scheme provides added robustness as the whole C-OLT is duplicated, including the L-OLT and all MAC Clients. Similarly to the trunk protection scheme with redundant C-OLT, the tree protection scheme with redundant C-OLT supports the inter-chassis protection, where the primary C-OLT and backup C-OLT are located in different chassis (either within the same central office or geographically different locations). The inter-chassis protection scheme requires coordination of the protection states and functions among the primary and backup C-OLTs comprising the trunk protection group and may require communication over LANs/WANs using public or proprietary protocols. The nature of information, data formats, and communications protocols used to coordinate protection functions among the primary and backup C-OLTs are outside the scope of this standard.

ONUs participating in tree protection schemes may also implement Client ONU protection, in which MAC, MAC Control, and OAM Clients in the ONU are duplicated. Such schemes may have increased robustness due to added protection against ONU Client failures, at the expense of increased frame loss during the protection switchover event, as explained in 9.3.2.1.2. The nature of information, data formats, and communications protocols used to coordinate protection functions among the primary and backup C-ONUs are outside the scope of this standard.
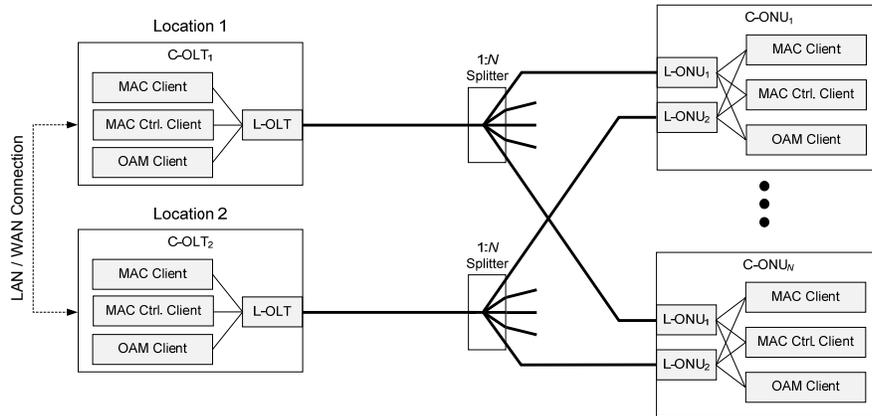
Proposal for PON protection for Package A

Figure 9-613—Tree protection with redundant C-OLT

The following subclauses provide technical requirements for the C-ONU and C-OLT devices participating in this protection scheme.

9.3.4.1 Functional requirements

Under the tree protection scheme, upon detecting a line fault condition, any ONU may be selectively switched from the working path to the standby path.

The switching time between the working OLT and standby OLT shall be less than or equal to 50 ms. The definition of the switching time is given in 9.3.1.1.

The switching time between the working ONU and standby ONU shall be less than or equal to 50 ms. The definition of the switching time is given in 9.3.1.1.

The protection switching process in the tree protection scheme may be initiated in the following ways:

— Automatically, when either the OLT or the ONU detect any of the fault conditions on the working optical line using any of the mechanisms specified in the following subclauses; or

— On-demand, when the NMS issues the request to the OLT for a particular ONU to be switched to the standby path. This protection switching process is executed typically for operational reasons, e.g., fiber repairs, maintenance of OLT cards.

An OLT may serve as a working OLT for one group of ONUs (working ONUs) and simultaneously serve as a standby OLT for another group of ONUs (standby ONUs). Therefore, the same PON port in the OLT may serve as a working PON port for a group of L-ONUs and as a standby PON port for another group of L-ONUs.

The working L-ONU shall be registered at the working L-OLT and remain fully active (including MPCP, OAM, and subscriber data flows) as long as the link between the working L-ONU and working L-OLT remains functional.

The standby L-ONU shall be registered at the standby L-OLT and remain fully active (including MPCP and OAM flows) as long as the link between the standby L-ONU and the standby L-OLT remains functional.

The link between the standby L-ONU and the standby L-OLT shall not carry any subscriber traffic as long as the link between the working L-ONU in the same C-ONU and the working L-OLT remains active.

The OLT and ONU shall execute the MPCP discovery and registration processes, basic OAM discovery (per IEEE Std 802.3, Clause 57), extended OAM discovery (~~per~~ profile-specific, see 12.2.1 or 12.2.3), and ONU authentication process (profile-specific, see 11.3.2 or 13.3.3) if it is enabled, independently for the working and standby L-ONUs.

A pair of L-ONUs comprising a protection group may be provisioned using the same configuration parameters, with the exception of their protection role: one L-ONU is designated as primary L-ONU (PON port instance 0) and the other is designated as backup L-ONU (PON port instance 1).

The OLT discovers the PON port instance number for a registered L-ONU and sets the corresponding OLT PON port (LLID) to primary if the ONU PON port instance is 0 and to backup if the ONU PON port instance is 1. Therefore, all ONU PON ports designated as primary are connected to the primary OLT ports (LLIDs), and all ONU PON ports designated as backup are connected to the backup OLT ports (LLIDs).

After designating the primary and backup LLIDs, the OLT discovers the PON port instance that is currently in the working (active) state. The OLT does so by reading the value of the *aOnuConfigPonActive* attribute using the *PON Interface Administrate* TLV (~~0xC7/0x00-0B~~see 9.3.5). The OLT then sets the corresponding LLID to the working (active) state.

9.3.4.2 C-OLT requirements

In the tree protection mechanism, the C-OLT is connected to two optical links: the primary and backup link. Both the primary and the backup links are active and carry OAM, eOAM, and MPCP control frames. The working link also carries subscriber data frames.

The protection function present in the Operation, Administration, and Management block is responsible for switching between the primary and backup paths for subscriber data frames. Both the L-OLT and C-OLT protection can be supported in the case of tree protection, as defined in 9.3.2.1.1 and 9.3.2.1.2, respectively. In the case of L-OLT protection, the same C-OLT is connected to two optical links: the primary and the backup link. Both the primary and the backup links are active and carry OAM, eOAM, and MPCP control frames. The working link also carries subscriber data frames.

The protection function instantiates the state diagram per Figure 9-18, controlling the operation of the MAC Client and L-OLTs.

The primary OLT and backup OLT may be provisioned by the NMS in exactly the same manner, using the same configuration parameters, except that different LLIDs in each OLT are provisioned as working or as standby. During the switchover event, there are no changes in the operation of the OAM and MAC Control client interfaces, i.e., only their status as working and standby changes.

The standby OLT remains fully powered on with a complete set of transport functions enabled and operational, i.e., the OLT has the capability of receiving and parsing upstream transmissions from the EPON to which it is connected and may send data downstream to connected ONUs as required by the current configuration of the given EPON branch.

The standby OLT shall allow for configuration of individual standby ONUs connected to it. The standby OLT shall enable all necessary MPCP and OAM/eOAM mechanisms defined in this standard as well as in IEEE Std 802.3 in order to maintain data link connectivity with individual standby ONUs. The standby OLT shall disallow any downstream user traffic prior to the switchover event.

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The standby OLT shall issue grants to the standby ONUs to ensure normal operation of the MPCP. The standby OLT shall suppress generation of any alarms and warnings associated with the arrival of empty/underutilized upstream transmission slots.

The working OLT monitors the status of the optical line. Several failure scenarios are possible as presented in 9.3.4.4. Unlike the trunk protection case, where all ONUs are switched from working L-OLT to standby L-OLT together, in the tree protection scheme, ONUs are switched to standby L-OLT selectively. When a line failure is detected for a particular working ONU, that ONU is switched to the standby optical path, while the working L-OLT continues operation for all remaining registered working ONUs.

The working OLT notifies the NMS about the detected line failure condition(s) and the line switch event for a particular ONU. This allows the operator to undertake any necessary repair/replacement tasks.

To request working ONUs connected to the working data path to switch traffic to the standby data path, the working OLT sends to these ONUs the *PON Interface Administrate* TLV (0xC7/0x00 0B), as defined in 14.2.2.99.3.5. The tree protection state diagrams are defined in 9.3.4.6.

Given that the standby L-ONU remains at all times registered at the standby OLT and synchronized to the respective MPCP domain clock, the transmission of the forced synchronization *GATE* MPCPDUs as defined for the trunk protection scheme is not required (see 9.3.3.2).

9.3.4.3   C-ONU requirements

In the tree protection mechanism, the C-ONU contains two L-ONUs: a primary L-ONU and a backup L-ONU. The primary L-ONU is connected to its primary L-OLT and remains at all times registered at this L-OLT and synchronized to the respective MPCP domain clock. The backup L-ONU is connected to its backup L-OLT and remains at all times registered at this L-OLT and synchronized to the respective MPCP domain clock. At all times, one of the L-ONUs is in a working state, while the other one is in the standby state. Both the working and the standby links carry OAM, eOAM, and MPCP control frames; however, the subscriber traffic is carried only on the working link.

During the switchover event, there are no changes in the registration status or operation of the primary and backup L-ONUs, except the reversing of their working and standby roles, i.e., the L-ONU previously in standby state becomes the working L-ONU and starts carrying subscriber traffic, while the L-ONU previously in working state becomes the standby L-ONU.

The protection function present in the Operation, Administration, and Management block is responsible for switching between the primary and backup paths for subscriber data frames. Both the L-ONU and C-ONU protection can be supported in the case of tree protection, as defined in 9.3.2.1.1 and 9.3.2.1.2, respectively.

The protection function instantiates the state diagram per Figure 9-19, controlling the operation of the MAC Client and L-ONUs.

In the case of an mL-ONU device supporting the tree protection mechanism, one of the L-ONUs connected to the primary optical path is designated as base L-ONU, and one of the L-ONUs connected to the backup optical path is designated as base L-ONU (see 12.2.1.4). The primary C-ONU and backup C-ONU independently go through the MPCP discovery and registration, OAM and eOAM discovery, and configuration and optional authentication on their optical link (primary and backup, respectively), as defined in 12.2.1.4.

The working L-ONU monitors the status of the upstream and downstream optical links. When the working L-ONU detects a downstream line failure using any of the mechanisms defined in 9.3.2.2.2, the working and the standby L-ONUs switch roles, and all subscriber flows are forwarded to the new working L-ONU. After the switchover completes, the new working L-ONU sends the PON_IF_Switch event as defined in 9.2.4.8, carrying the information about the type of detected failure source. This improves the reaction time

of the working L-OLT to the downstream line failure condition. No automatic switchback to the original working L-ONU is performed; the working L-ONU continues forwarding subscriber traffic until it is instructed by the NMS to perform a switchover or a failure detected on its new working path.

9.3.4.4   Examples of tree protection switching

This subclause contains examples of the tree protection switching scenarios.

9.3.4.4.1   NMS-driven tree line switchover event

Figure 9-14 represents the NMS-driven protection switching scenario, where the decision to switch user traffic from the working path to the standby path is taken by the NMS, e.g., to perform routine maintenance tasks or replace line cards in the OLT shelf. In such a situation, the NMS requests the OLT to switch traffic from the working to the standby data path. The OLT performs the necessary local actions and also transmits the *PON Interface Administrate* TLV ~~(0xC7/0x00-0B)~~, as defined in ~~14.2.2.9~~9.3.5, to the working C-ONU requesting it to perform the protection switching.
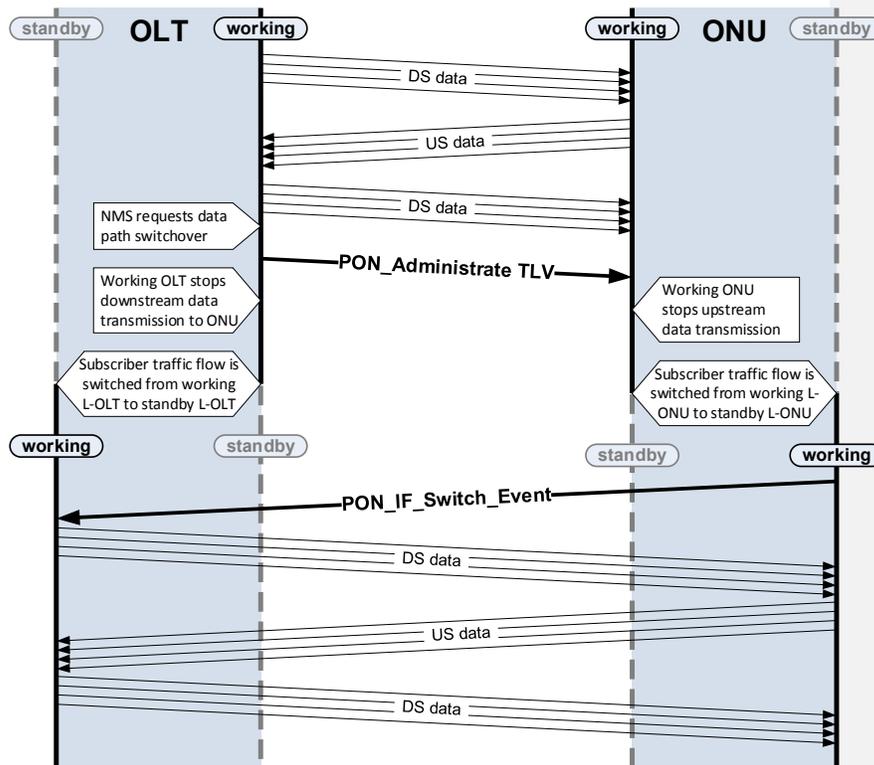
Figure 9-~~7~~14—An example of tree protection switching: NMS driven request

9.3.4.4.2 Automated tree line switching with line failure detection

When both the downstream and upstream data paths fail, both the working OLT and working ONU can detect the link fault condition. In such a case, both the working OLT and working ONU perform protection switching, as shown in Figure 9-15.

Figure 9-~~8~~15—An example of tree protection switching:
link failure detected by working OLT and working C-ONU

9.3.4.4.3   Automated tree line switching with upstream line failure detection

When the upstream data path suffers a failure (e.g., ONU transmitter fails or OLT receiver fails), the working OLT can detect such an occurrence and initiate the protection switching process. As indicated before, the working OLT sends the *PON Interface Administrate* TLV ~~(0xC7/0x00-0B)~~, as defined in ~~14.2.2.9~~9.3.5, downstream to the working ONU, forcing it to switch all its tra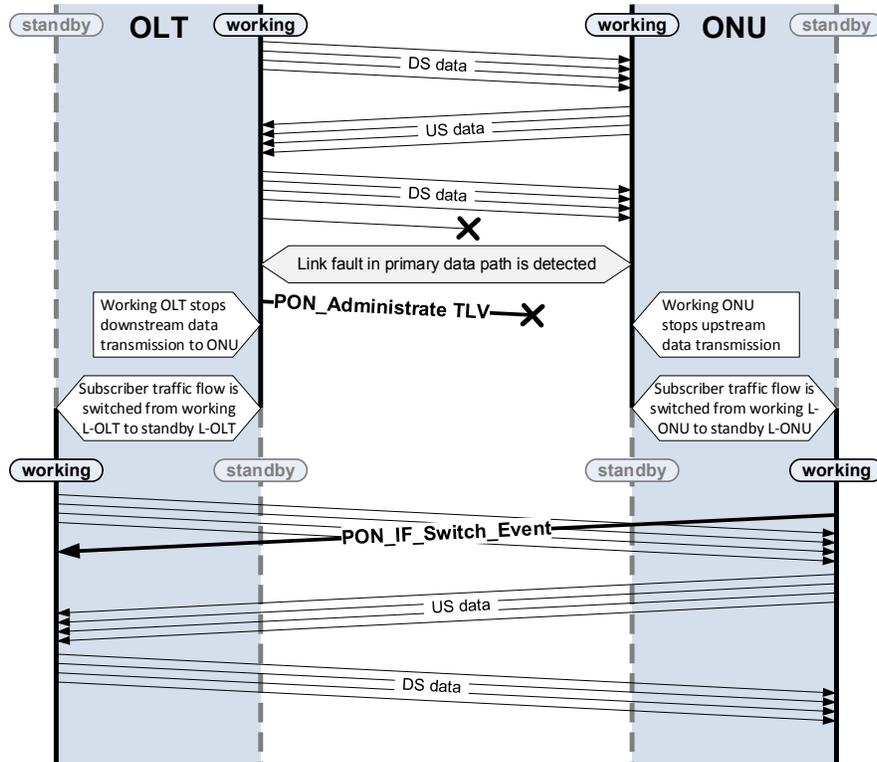ffic to the standby data path. Once the process is complete, the new working ONU sends the PON_IF_Switch event notification, allowing the OLT to confirm that the process was successfully completed on the ONU side. This scenario is shown in Figure 9-16.
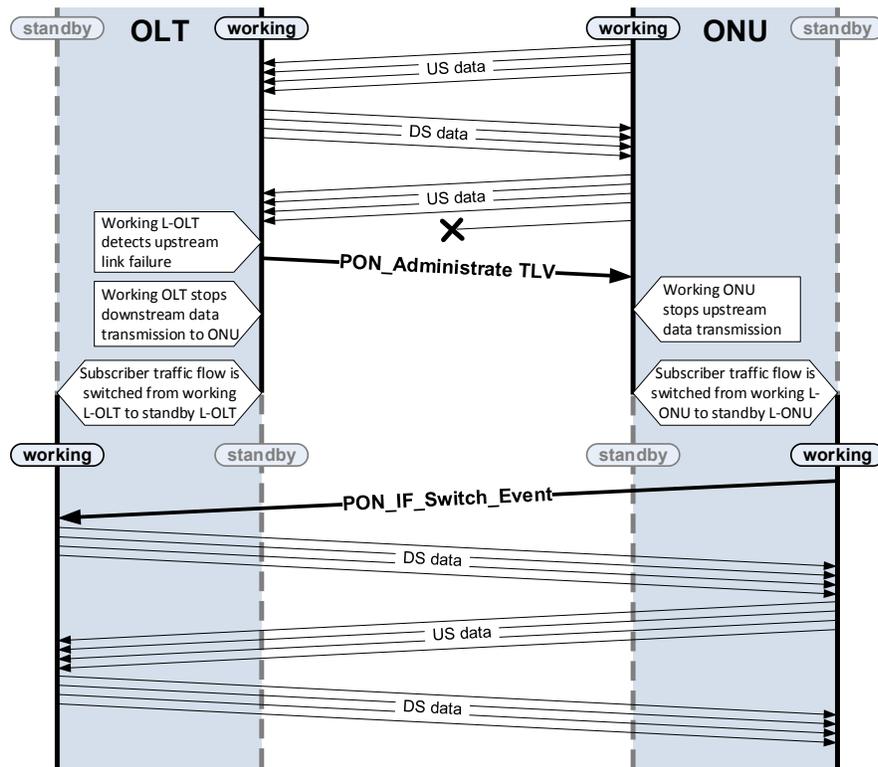
Figure 9-~~9~~16—An example of tree protection switching:
upstream link failure detected by working OLT

9.3.4.4.4   Automated tree line switching with downstream line failure detection

In a scenario when the downstream data path suffers a failure (e.g., ONU receiver fails or OLT transmitter fails), only the working ONU can detect such an occurrence and initiate the protection switching process. In this case, it is the working ONU that starts the protection switching by suspending any upstream transmissions to the working OLT once the downstream channel is found to be defective. At this stage, the working ONU switches the traffic to the standby ONU and transmits the PON_IF_Switch event notification to the working OLT. Upon reception of the PON_IF_Switch event notification from its current standby

MAC port, the OLT suspends the data transmission to the corresponding working MAC port and activates the standby MAC port. This scenario is shown in Figure 9-17.
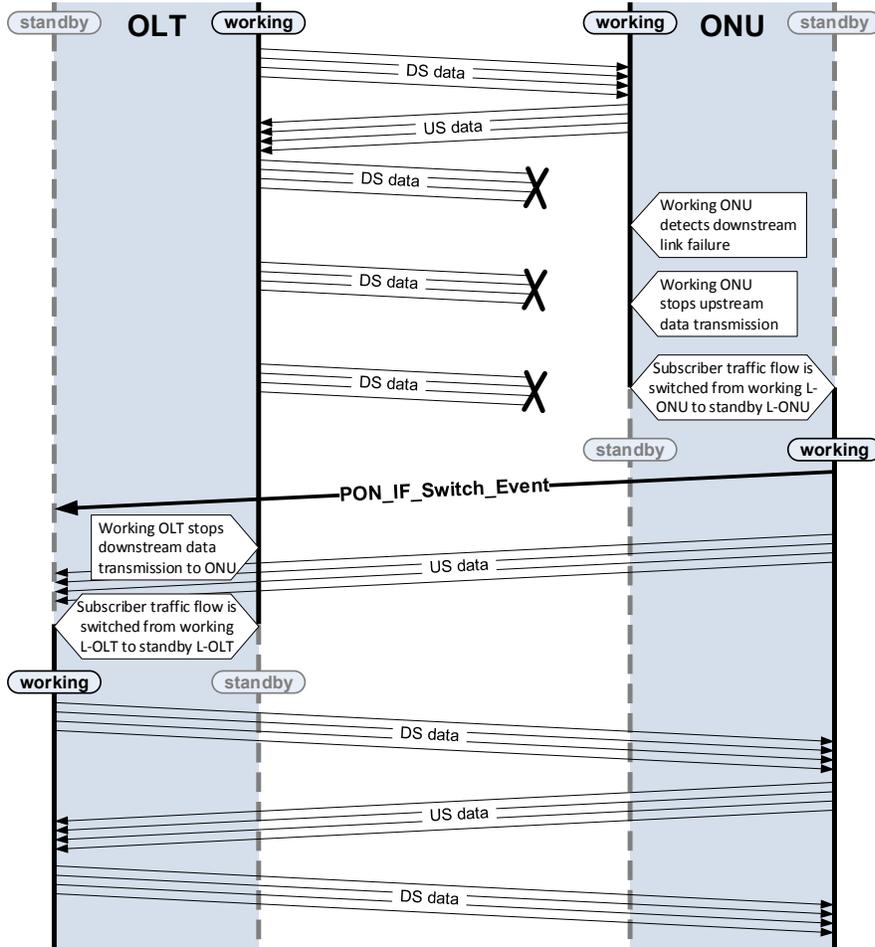
**Figure 9-1017—An example of tree protection switching:
downstream link failure detected by working ONU**

9.3.4.5   Configuration messages

To configure the values for $T_{LoS\_Optical}$ and T_{LoS_MAC} parameters in the C-ONU, the C-OLT uses the *ONU Protection Configuration* TLV (0xC7/0x00-0F) per 14.2.2.13. The C-ONU shall be able to process the eOAMPDU with the *ONU Protection Configuration* TLV (0xC7/0x00-0F) and set the values for $T_{LoS\_Optical}$ and T_{LoS_MAC} parameters accordingly.

~~9.3.4.6~~9.3.4.5   Tree protection process

~~9.3.4.6.1~~9.3.4.5.1   Constants

`backupPort`

TYPE: 8-bit unsigned integer

This constant identifies the backup port in the OLT or in the ONU. The backup port in the OLT (MAC in L-OLT) is connected to the backup port in the ONU (L-ONU), i.e., both ports are attached to the same physical media.

VALUE: 0x01

`primaryPort`

TYPE: 8-bit unsigned integer

This constant identifies the primary port in the OLT or in the ONU. The primary port in the OLT (MAC in L-OLT) is connected to the primary port in the ONU (L-ONU), i.e., both ports are attached to the same physical media.

VALUE: 0x00

~~9.3.4.6.2~~9.3.4.5.2   Variables

`backupPortStatus`

TYPE: Enumerated

This variable represents current status of the backup port in the OLT or in the ONU. It can take the following values:

— `OK` (0x00-00-00-00) – backup port operates normally.

— `LOS` (0x00-00-00-01) – indicates that the MAC LoS or optical LoS condition is observed by the backup port at the OLT, as defined in 9.3.2.2.1, or by the backup port at the ONU, as defined in 9.3.2.2.2.

— `MPCP` (0x00-00-00-02) – indicates that the `mpcp_timeout` condition, as defined in IEEE Std 802.3, 64.3.4.2, is observed by the backup L-OLT or by the backup L-ONU.

— `BER` (0x00-00-00-03) – indicates that the BER of the signal received by the backup port at the OLT or at the ONU exceeds a certain, operator-defined threshold.

— `PORT` (0x00-00-00-04) – indicates that the power levels of the signal received by the backup port at the OLT or at the ONU exceeds a certain, operator-defined high or low threshold.

— `OLT_REQ` (0x00-00-00-05) – indicates that the backup port is placed in the standby mode (deactivated) based on OLT (NMS) request. At the OLT, `backupPortStatus` is set to `OLT_REQ` upon the reception of `NMSR( switch, primaryPort, indexONU )` primitive defined in 9.3.4.6.4. At the ONU, `backupPortStatus` is set to `OLT_REQ` upon the reception of `eOAMI_Switch_Request( primaryPort )` primitive on either the primary or the backup port.

— `ONU_REQ` (0x00-00-00-06) – indicates that the OLT's backup port is placed in the standby mode (deactivated) based on the ONU's request.

`dataFrameReceived`

> TYPE: Boolean

> This variable indicates that a frame other than the OAMPDU or MPCPDU is received at the given port. When the data frame is received, this variable is set to `true`. It retains the value until explicitly reset.

`primaryPortStatus`

> TYPE: Enumerated

> This variable represents current status of the primary port in the OLT or in the ONU. It can take the following values:

> — `OK` (0x00-00-00-00) – primary port operates normally.

> — `LOS` (0x00-00-00-01) – indicates that the MAC LoS or optical LoS condition is observed by the primary port at the OLT, as defined in 9.3.2.2.1, or by the primary port at the ONU, as defined in 9.3.2.2.2.

> — `MPCP` (0x00-00-00-02) – indicates that the `mpcp_timeout` condition, as defined in IEEE Std 802.3, 64.3.4.2, is observed by the primary L-OLT or by the primary L-ONU.

> — `BER` (0x00-00-00-03) – indicates that the BER of the signal received by the primary port at the OLT or at the ONU exceeds a certain, operator-defined threshold.

> — `PORT` (0x00-00-00-04) – indicates that the power levels of the signal received by the primary port at the OLT or at the ONU exceeds a certain, operator-defined high or low threshold.

> — `OLT_REQ` (0x00-00-00-05) – indicates that the primary port is placed in the standby mode (deactivated) based on OLT (NMS) request. At the OLT, `primaryPortStatus` is set to `OLT_REQ` upon the reception of `NMSR( switch, backupPort, indexONU )` primitive defined in 9.3.4.6.4. At the ONU, `primaryPortStatus` is set to `OLT_REQ` upon the reception of `eOAMI_Switch_Request( backupPort )` primitive on either the primary or the backup port.

> — `ONU_REQ` (0x00-00-00-06) – indicates that the OLT's primary port is placed in the standby mode (deactivated) based on the ONU's request.

`workingPort`

> TYPE: 8-bit unsigned integer

> This variable represents the currently working port in the OLT or in the ONU. It can take values `primaryPort` or `backupPort` (see 9.3.4.6.1). In the ONU, this variable retains its value across the reset or reboot. By default, this variable has the value of `primaryPort`.

~~9.3.4.6.3~~9.3.4.5.3 **Functions**

`activateDataPath( portId )`

> This function activates, i.e., places into the working state, the port identified by the `portId` parameter. In the working state, a port is able to transmit MPCPDUs, OAMPDUs, and subscriber data frames.

`deactivateDataPath( portId )`

This function deactivates, i.e., places into the standby state, the port identified by the `portId` parameter. In the standby state, a port is able to transmit MPCPDUs and OAMPDUs, but not subscriber data frames.

~~9.3.4.6.4~~9.3.4.5.4   Primitives

`eOAMI_Switch_Event()`

This primitive is defined in 9.3.5~~represents the reception of an eOAMPDU containing a PON_IF_Switch event, as defined in 9.2.4.8. SIEPON_Event_TLV represents the SIEPON-specific *Event Notification* TLV as defined in 13.2.2.3.2. This primitive replaces the following code:~~

~~OPI(source_address, flags, code, sequence_number | SIEPON_Event_TLV) AND~~

~~source_address == ONU_MAC AND~~

~~code == 0x01 AND~~

~~SIEPON_Event_TLV.Type == 0xFE AND~~

~~SIEPON_Event_TLV.Length == 0x12 AND~~

~~SIEPON_Event_TLV.OUI == OUI_C AND~~

~~SIEPON_Event_TLV.ObjectType == 0xFF-FF AND~~

~~SIEPON_Event_TLV.ObjectInstance == 0xFF-FF-FF-FF AND~~

~~SIEPON_Event_TLV.EventID == 0x00-0C AND~~

~~SIEPON_Event_TLV.EventState == 0x00~~

~~The eOAMPDU containing a PON_IF_Switch event may also contain other *Link Event* TLVs, as defined in IEEE Std 802.3, 57.4.3.2.~~

`eOAMI_Switch_Request( portId )`

This primitive is defined in 9.3.5.~~represents the reception of an eOAMPDU containing the *PON Interface Administrate* TLV (0xC7/0x00-0B), as defined in 14.2.2.9. This primitive replaces the following code:~~

~~OPI(source_address, flags, code, OUI_C | Opcode | PON_IF_TLV) AND~~

~~source_address == OLT MAC AND~~

~~code == 0xFE AND~~

~~Opcode == 0x03 AND~~

~~PON_IF_TLV.Branch == 0xC7 AND~~

~~PON_IF_TLV.Leaf == 0x00-0B AND~~

~~PON_IF_TLV.Length == 0x01 AND~~

~~PON_IF_TLV.PonPortActive == portId~~

eOAMR_Switch_Event(failureCode)

This primitive is defined in 9.3.5.~~represents the transmission of an eOAMPDU containing a PON_IF_Switch event as defined in 9.2.4.8. SIEPON_Event_TLV represents the SIEPON-specific *Event Notification* TLV as defined in 13.2.2.3.2. This primitive replaces the following code:~~

~~source_address = ONU_MAC~~

~~code = 0x01~~

~~SIEPON_Event_TLV.Type = 0xFE~~

~~SIEPON_Event_TLV.Length = 0x12~~

~~SIEPON_Event_TLV.OUI = OUI_C~~

~~SIEPON_Event_TLV.ObjectType = 0xFF-FF~~

~~SIEPON_Event_TLV.ObjectInstance = 0xFF-FF-FF-FF~~

~~SIEPON_Event_TLV.EventID = 0x00-0C~~

~~SIEPON_Event_TLV.EventState = 0x00~~

~~SIEPON_Event_TLV.EventInfo = failureCode~~

~~OPR(source_address, flags, code, sequence_number | SIEPON_Event_TLV)~~

~~The eOAMPDU containing a PON_IF_Switch event may also contain other *Link Event* TLVs, as defined in IEEE Std 802.3, 57.4.3.2.~~

eOAMR_Switch_Request(portId)

This primitive is defined in 9.3.5.~~represents the transmission of an eOAMPDU containing the *PON Interface Administrate* TLV (0xC7/0x00-0B), as defined in 14.2.2.9. This primitive replaces the following code:~~

~~source_address = OLT_MAC~~

~~code = 0xFE~~

~~Opcode = 0x03~~

~~PON_IF_TLV.Branch = 0xC7~~

~~PON_IF_TLV.Leaf = 0x00-0B~~

~~PON_IF_TLV.Length   = 0x01~~

~~PON_IF_TLV.PonPortActive   = portId~~

~~OPR(source_address, flags, code, OUI_C | Opcode | PON_IF_TLV)~~

`NMSI_1( failureCode, indexONU )`

This primitive informs the NMS about the protection switching event, initiated by the OLT, that placed the `primaryPort` in the working state. This primitive uses the following parameters:

— `failureCode` identifies the reason for the protection switching, per 9.2.4.8;

— `indexONU` identifies the affected L-ONU.

`NMSI_2( failureCode, indexONU )`

This primitive informs the NMS about the protection switching event, initiated by the ONU, that placed the `primaryPort` in the working state. This primitive uses parameters identical to the parameters defined for the `NMSI_1` primitive.

`NMSI_3( failureCode, indexONU )`

This primitive informs the NMS about the protection switching event, initiated by the OLT, that placed the `backupPort` in the working state. This primitive uses parameters identical to the parameters defined for the `NMSI_1` primitive.

`NMSI_4( failureCode, indexONU )`

This primitive informs the NMS about the protection switching event, initiated by the ONU, that placed the `backupPort` in the working state. This primitive uses parameters identical to the parameters defined for the `NMSI_1` primitive.

`NMSR( switch, portId, indexONU )`

This primitive is used by the NMS to perform the protection switching of the L-ONU, identified by the `indexONU` parameter, from its current working port to the port indentified by the `portId` parameter.

~~9.3.4.6.5~~9.3.4.5.5   State diagrams

Each C-OLT shall instantiate the tree protection process state diagram as defined in Figure 9-18 for each primary port (LLID) associated with the connected and registered L-ONUs, and it shall instantiate the tree protection process state diagram as defined in Figure 9-18 for each backup port (LLID) associated with the connected and registered L-ONUs. In the case where Client OLT protection is implemented (i.e., when two C-OLTs are used as shown in Figure 9-13), the combined operation of both C-OLTs shall be as defined in Figure 9-18.

The C-ONU shall instantiate the tree protection process state diagram as defined in Figure 9-19 for the primary L-ONU instantiated in this C-ONU, and it shall instantiate the tree protection process state diagram as defined in Figure 9-19 for the backup L-ONU instantiated in this C-ONU. In the case where Client ONU protection is implemented (i.e., when two C-ONU are used), the combined operation of both C-ONUs shall be as defined in Figure 9-19.

Proposal for PON protection for Package A
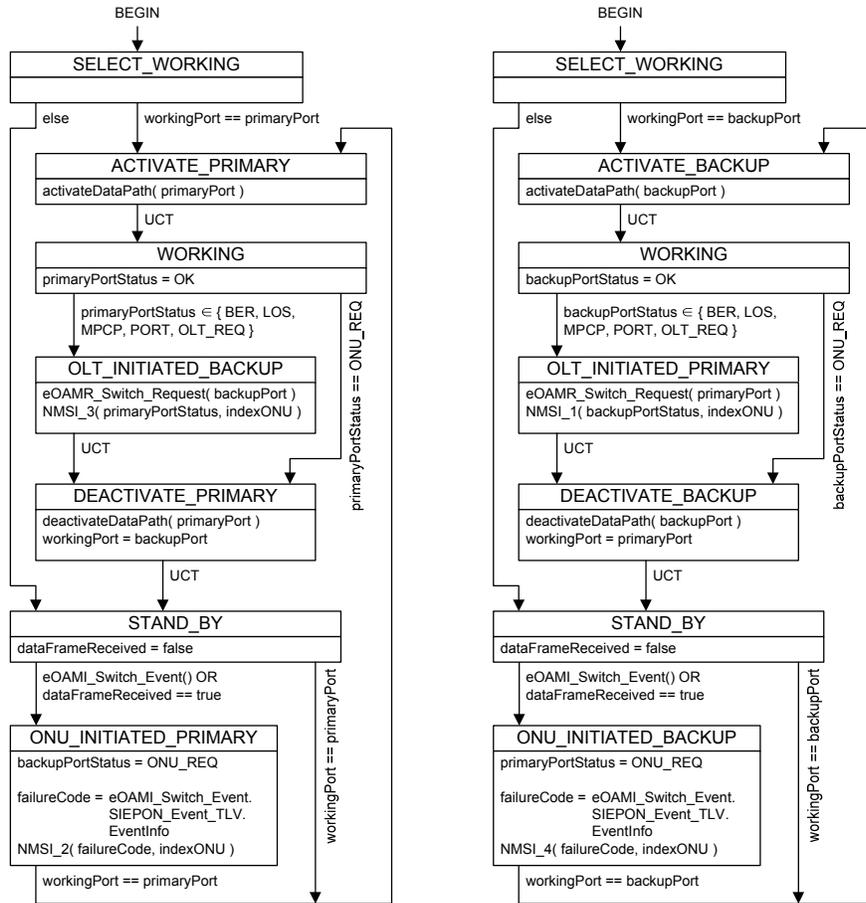
a) Primary PON Port   b) Backup PON Port

Figure 9-11~~18~~—Tree protection process operating on the OLT

Proposal for PON protection for Package A

a) Primary PON Port   b) Backup PON Port
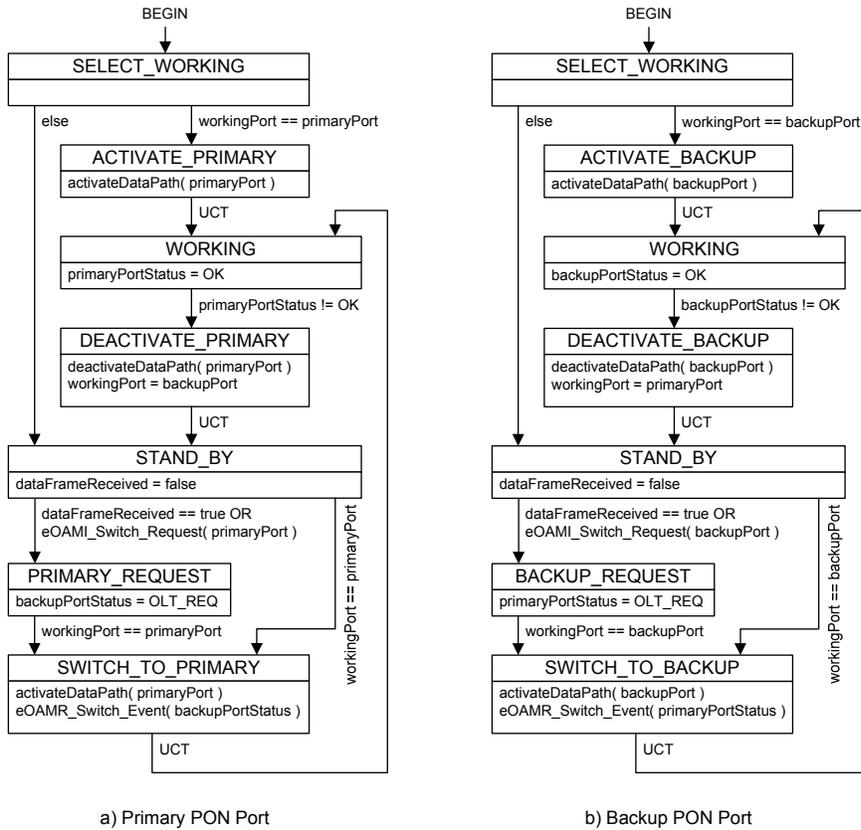
Figure 9-12 19 —Tree protection process operating on the ONU

9.3.5   Profile-specific messages

The trunk protection scheme defined in 9.3.3 and the tree protection scheme defined in 9.3.4 may be used in multiple profiles. This clause references the profile-specific messages to be used in non-SNMP-optimized eOAM profile and in DPoE eOAM profile.

9.3.5.1   Messages for non-SNMP-optimized eOAM profile

Table 9-xx1 specifies the messages that shall be used for trunk and tree protection in non-SNMP-optimized eOAM profile.

Table 9-xx1 — Non-SNMP-optimized eOAM profile-specific messages

TLV	Branch	Leaf	Defined in
ONU Capabilities	0xC7	0x00-07	14.2.2.5
ONU Protection Configuration	0xC7	0x00-0F	14.2.2.13
PON Interface Administrate	0xC7	0x00-0B	14.2.2.9

TLV	Branch	Leaf	Defined in
ONU Timestamp Drift Prevention Mechanism	0xC7	0x00-08	14.2.2.6

9.3.5.1.1   ONU Capability Discovery

The OLT may discover the capability of the connected ONU to support tree protection using the *aOnuCapabilities.sProtection* sub-attribute, carried in the *ONU Capabilities* TLV (0xC7/0x00-07).

9.3.5.1.2   Configuration of line fault detection parameters

To configure the values for $T_{LoS\_Optical}$ and T_{LoS_MAC} parameters in the C-ONU (see 9.3.2.2.2), the C-OLT uses the *ONU Protection Configuration* TLV (0xC7/0x00-0F) per 14.2.2.13. The C-ONU shall be able to process the eOAMPDU with the *ONU Protection Configuration* TLV (0xC7/0x00-0F) and set the values for $T_{LoS\_Optical}$ and T_{LoS_MAC} parameters accordingly.

9.3.5.1.3   Configuration of hold-over interval

To configure the value for the `timerHoldOver` timer (defined in 9.3.3.4.2) in the C-ONU, the C-OLT uses the *ONU Timestamp Drift Prevention Mechanism* TLV (0xC7/0x00-08) per 14.2.2.6. The C-ONU shall be able to process the eOAMPDU with the *ONU Timestamp Drift Prevention Mechanism* TLV (0xC7/0x00-08) and set the value for the `timerHoldOver` timer accordingly.

9.3.5.1.4   Primitives used in tree protection state diagram

`eOAMI_Switch_Event()`

> This primitive represents the reception of an eOAMPDU containing a PON_IF_Switch event, as defined in 9.2.4.8. `SIEPON_Event_TLV` represents the SIEPON-specific *Event Notification* TLV as defined in 13.2.2.3.2. This primitive replaces the following code:

```
OPI( source_address, flags, code, sequence_number |
SIEPON_Event_TLV ) AND

source_address                    == ONU_MAC AND
code                              == 0x01 AND
SIEPON_Event_TLV.Type             == 0xFE AND
SIEPON_Event_TLV.Length           == 0x12 AND
SIEPON_Event_TLV.OUI              == OUI_C AND
SIEPON_Event_TLV.ObjectType       == 0xFF-FF AND
SIEPON_Event_TLV.ObjectInstance   == 0xFF-FF-FF-FF AND
SIEPON_Event_TLV.EventID          == 0x00-0C AND
SIEPON_Event_TLV.EventState       == 0x00
```

> The eOAMPDU containing a PON_IF_Switch event may also contain other *Link Event* TLVs, as defined in IEEE Std 802.3, 57.4.3.2.

`eOAMI_Switch_Request( portId )`

> This primitive represents the reception of an eOAMPDU containing the *PON Interface Administrate* TLV (0xC7/0x00-0B), as defined in 14.2.2.9. This primitive replaces the following code:

```
OPI( source_address, flags, code, OUI_C | Opcode | PON_IF_TLV )
AND
```

```
source_address                      == OLT_MAC AND
code                                == 0xFE AND
Opcode                              == 0x03 AND
PON_IF_TLV.Branch                   == 0xC7 AND
PON_IF_TLV.Leaf                     == 0x00-0B AND
PON_IF_TLV.Length                   == 0x01 AND
PON_IF_TLV.PonPortActive            == portId
```

eOAMR_Switch_Event(failureCode)

This primitive represents the transmission of an eOAMPDU containing a PON_IF_Switch event as defined in 9.2.4.8. SIEPON_Event_TLV represents the SIEPON-specific *Event Notification* TLV as defined in 13.2.2.3.2. This primitive replaces the following code:

```
source_address                      = ONU_MAC
code                                = 0x01
SIEPON_Event_TLV.Type               = 0xFE
SIEPON_Event_TLV.Length             = 0x12
SIEPON_Event_TLV.OUI                = OUI_C
SIEPON_Event_TLV.ObjectType         = 0xFF-FF
SIEPON_Event_TLV.ObjectInstance     = 0xFF-FF-FF-FF
SIEPON_Event_TLV.EventID            = 0x00-0C
SIEPON_Event_TLV.EventState         = 0x00
SIEPON_Event_TLV.EventInfo          = failureCode
```

```
OPR( source_address, flags, code, sequence_number |
SIEPON_Event_TLV )
```

The eOAMPDU containing a PON_IF_Switch event may also contain other *Link Event* TLVs, as defined in IEEE Std 802.3, 57.4.3.2.

eOAMR_Switch_Request(portId)

This primitive represents the transmission of an eOAMPDU containing the *PON Interface Administrate* TLV (0xC7/0x00-0B), as defined in 14.2.2.9. This primitive replaces the following code:

```
source_address                      = OLT_MAC
code                                = 0xFE
Opcode                              = 0x03
PON_IF_TLV.Branch                   = 0xC7
PON_IF_TLV.Leaf                     = 0x00-0B
PON_IF_TLV.Length                   = 0x01
PON_IF_TLV.PonPortActive            = portId
```

```
OPR( source_address, flags, code, OUI_C | Opcode | PON_IF_TLV )
```

9.3.5.2 Messages for DPoE eOAM profile

Table 9-xx2 specifies the messages that shall be used for trunk and tree protection in DPoE eOAM profile.

Table 9-xx2— DPoE eOAM profile-specific messages

TLV	Branch	Leaf	Defined in
ONU Protection Capability	0xD7	0x09-00	14.4.1.9.1
ONU Protection Configuration	0xD7	0x09-01	14.4.1.9.2

TLV	Branch	Leaf	Defined in
PON Interface Administrate	0xD7	0x09-02	14.4.1.9.3
ONU Config HoldOver Period	0xD7	0x09-03	14.4.1.9.4

9.3.5.2.1 ONU Capability Discovery

The OLT may discover the capability of the connected ONU to support trunk or tree protection using the *aOnuProtectionCapability* attribute, carried in the *ONU Protection Capability* TLV (0xD7/0x09-00). The ONU may support trunk protection, L-ONU tree protection, or C-ONU tree protection in any combination, depending on the capabilities of the given ONU.

9.3.5.2.2 Configuration of line fault detection parameters

To configure the values for $T_{LoS\_Optical}$ and T_{LoS_MAC} parameters in the C-ONU (see 9.3.2.2.2), the C-OLT uses the *ONU Protection Configuration* TLV (0xD7/0x09-01) per 14.4.1.9.2. The C-ONU shall be able to process the eOAMPDU with the *ONU Protection Configuration* TLV (0xD7/0x09-01) and set the values for $T_{LoS\_Optical}$ and T_{LoS_MAC} parameters accordingly.

9.3.5.2.3 Configuration of hold-over interval

To configure the value for the `timerHoldOver` timer (defined in 9.3.3.4.2) in the C-ONU, the C-OLT uses the *ONU Config HoldOver Period* TLV (0xD7/0x09-03) per 14.4.1.9.4. The C-ONU shall be able to process the eOAMPDU with the *ONU Config HoldOver Period* TLV (0xD7/0x09-03) and set the value for the `timerHoldOver` timer accordingly.

9.3.5.2.4 Primitives used in tree protection state diagram

`eOAMI_Switch_Event()`

This primitive represents the reception of an eOAMPDU containing a PON_IF_Switch event, as defined in 9.2.4.8. `SIEPON_Event_TLV` represents the SIEPON-specific *Event Notification* TLV as defined in 13.4.1.3.2. This primitive replaces the following code:

```
OPI( source_address, flags, code, sequence_number |
SIEPON_Event_TLV ) AND

source_address                    == ONU_MAC AND
code                              == 0x01 AND
SIEPON_Event_TLV.Type             == 0xFE AND
SIEPON_Event_TLV.Length           == 0x06 AND
SIEPON_Event_TLV.OUI              == OUI_A AND
SIEPON_Event_TLV.EventCode        == 0x84 AND
SIEPON_Event_TLV.EventRaised      == 0x00 AND
SIEPON_Event_TLV.ObjectType       == 0x00-00 AND
SIEPON_Event_TLV.ObjectInstance   == 0x00-00
```

The eOAMPDU containing a PON_IF_Switch event may also contain other *Link Event* TLVs, as defined in IEEE Std 802.3, 57.4.3.2.

`eOAMI_Switch_Request( portId )`

This primitive represents the reception of an eOAMPDU containing the *PON Interface Administrate* TLV (0xD7/0x09-02), as defined in 14.4.1.9.3. This primitive replaces the following code:

```
          OPI( source_address, flags, code, OUI_A | Opcode | PON_IF_TLV )
          AND

          source_address                 == OLT MAC AND
          code                           == 0xFE AND
          Opcode                         == 0x03 AND
          PON_IF_TLV.Branch              == 0xD7 AND
          PON_IF_TLV.Leaf                == 0x00-16 AND
          PON_IF_TLV.Length              == 0x01 AND
          PON_IF_TLV.PonPortActive       == portId
```

eOAMR_Switch_Event(failureCode)

This primitive represents the transmission of an eOAMPDU containing a PON_IF_Switch event as defined in 9.2.4.8. SIEPON_Event_TLV represents the SIEPON-specific *Event Notification* TLV as defined in 13.4.1.3.2. This primitive replaces the following code:

```
          source_address                 = ONU_MAC
          code                           = 0x01
          SIEPON_Event_TLV.Type          = 0xFE
          SIEPON_Event_TLV.Length        = 0x06
          SIEPON_Event_TLV.OUI           = OUI_A
          SIEPON_Event_TLV.EventCode     = 0x84
          SIEPON_Event_TLV.EventRaised   = 0x00
          SIEPON_Event_TLV.ObjectType    = 0x00-00
          SIEPON_Event_TLV.ObjectInstance = 0x00-00

          OPR( source_address, flags, code, sequence_number |
          SIEPON_Event_TLV )
```
The eOAMPDU containing a PON_IF_Switch event may also contain other *Link Event* TLVs, as defined in IEEE Std 802.3, 57.4.3.2.

eOAMR_Switch_Request(portId)

This primitive represents the transmission of an eOAMPDU containing the *PON Interface Administrate* TLV (0xD7/0x09-02), as defined in 14.4.1.9.3. This primitive replaces the following code:

```
          source_address                 = OLT_MAC
          code                           = 0xFE
          Opcode                         = 0x03
          PON_IF_TLV.Branch              = 0xD7
          PON_IF_TLV.Leaf                = 0x00-16
          PON_IF_TLV.Length              = 0x01
          PON_IF_TLV.PonPortActive       = portId
```

OPR(source_address, flags, code, OUI_A | Opcode | PON_IF_TLV)

13 Extended OAM for EPON

13.4 DPoE eOAM management

13.4.1 eOAMPDU structure

This subclause defines the internal structure of the eOAMPDU frame, i.e., the size and meaning of individual fields, and describes a TLV-oriented approach to packaging data in the eOAMPDU. Two specific types of the TLVs are also specified, namely the Variable Descriptor and the Variable Container.

The eOAMPDU format is derived from the IEEE 802.3 (Clause 57) OAM frame format, through the use of Organization Specific Extension mechanism, as described in detail in IEEE Std 802.3, 57.4.2 (Figure 57-9), and further extended in the following subclauses.

13.4.1.3 TLVs for 802.3 OAMPDUs

13.4.1.3.2 *Event Notification* TLV

The basic structure of the *Organization Specific Event* TLV shall be as specified in IEEE Std 802.3, 57.5.3.5. Specific fields in the *Organization Specific Event* TLV shall be as shown in Figure 13-8 and specified below:
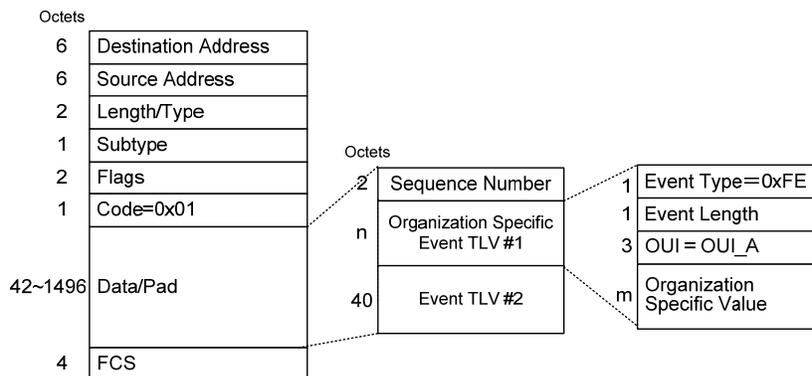

Figure 13-118—Relationship between *Organization Specific Event* TLV and the *Event Notification* OAMPDU

a) `Event Type` = 0xFE, according to the encoding of this field as defined in IEEE Std 802.3, Table 57–12.

b) `Event Length`. This one-octet field indicates the length (in octets) of this TLV-tuple.

c) `OUI` for Package A, equal to OUI_A.

d) `Organization Specific Value` carries the specific set of event-associated information. Further, the structure of the `Organization Specific Value` shall be as specified in Table 13-84 and described below.

Table 13-1584—Internal structure of the `Organization Specific Value` field

Octet(s)	Field	Notes
1	EventCode	This field identifies the type of alarm that was identified by the source OAM client. See Table 13-85 for definition of individual values for the EventCode field. These alarm codes are grouped into link faults, critical events, and Dying Gasp alarm types, with code values numbered accordingly. Only the values listed in the table are supported. Other values are reserved and ignored on reception.

1	EventRaised	This field indicates whether the given event was raised. The following values are supported:
		    0x00: The given event was cleared.
		    0x01: The given event was raised.
		    Other values are reserved and ignored on reception.

2	ObjectType	This field identifies the object element generating the alarm in question.
2	ObjectInstance	This field identifies the object element instance generating the alarm in question.

— ObjectType field identifies the object that generated the given event, as defined in 14.4.1.1.1. Other values of the ObjectType are reserved and ignored on reception.

— ObjectInstance field identifies the specific instance of the object that generated the given event, as defined in 14.4.1.1.2.

Table 13-2685—Code points for the `EventCode` field

Event Code	Value	Description
Link Fault Alarms		
LoS	11	Loss of received optical power by the transceiver (ONU EPON port). Link down on Ethernet PHY (ONU UNI port).
Key Exchange Failure	12	ONU did not observe a switch to a new key after key exchange.
Critical Event Alarms		
Port Disabled	21	Ethernet port is disabled by management action.
Dying Gasp Alarms		
Power Failure	41	Loss of power at the ONU (Dying Gasp).
Other Alarms		
Statistics Alarm	81	Statistic has crossed defined alarm thresholds.
ONU Busy	82	ONU is busy and unable to acknowledge or process further OAM until alarm clears.
MAC Table Overflow	83	ONU MAC Table has seen more addresses than it can hold.
PON_IF_Switch	84	PON interface on the ONU was switched to backup.

Insert a new subclause 13.4.1.3.2.8 as shown below

13.4.1.3.2.8 PON_IF_Switch (0x84)

The PON_IF_Switch alarm is raised by the ONU to inform the OLT that the PON interface on the ONU was switched from the active interface to backup interface, according to the tree protection mechanism defined in 9.3.4.

14 Management entities

14.4 Management entities for DPoE eOAM profile

14.4.1 Branch 0xD7 "extended attributes"

This subclause lists extended management attributes, which are not part of the definitions in IEEE Std 802.3, Clause 30. The extended attributes shown in Table 14-132 shall be supported.

The extended attributes can be part of *eOAM_Get_Request*, *eOAM_Get_Response*, *eOAM_Set_Request*, and *eOAM_Set_Response* eOAMPDUs.

Table 14-132—Extended attributes defined in branch 0xD7

Leaf	Attribute	Defined in
Object group: ONU management		
0x00-02	aOnuId	14.4.3.1.2
0x00-03	aOnuFwVersion	14.4.3.1.3
0x00-04	aOnuInfoChipset	14.4.3.1.4
0x00-05	aOnuInfoDateManufacture	14.4.3.1.5
0x00-06	aOnuInfoManufacturer	14.4.3.1.6
0x00-07	aOnuLlidCount	14.4.3.1.7
0x00-08	aOnuPonPortCount	14.4.3.1.8
0x00-09	aOnuUniPortCount	14.4.3.1.9
0x00-0A	aOnuInfoPacketBuffer	14.4.3.1.10
0x00-0B	aLlidReportThresholds	14.4.3.1.11
0x00-0C	aLlidForwardState	14.4.3.1.12
0x00-0D	aLlidOamFrameRate	14.4.3.1.13
0x00-0E	aOnuManOrgName	14.4.3.1.14
0x00-0F	aOnuCvcCvsValidity	14.4.3.1.15
0x00-10	aOnuUniPortType	14.4.3.1.16
Object group: Bridging		
0x01-01	aUniDynMacTableSize	14.4.3.2.1
0x01-02	aUniDynMacAgeLimit	14.4.3.2.2
0x01-03	aUniDynMacTable	14.4.3.2.3
0x01-04	aUniStatMacTable	14.4.3.2.4
0x01-05	aUniPortAutoNeg	14.4.3.2.5
0x01-06	aUniAdmissionControl	14.4.3.2.6
0x01-07	aUniMinLearnMacCount	14.4.3.2.7
0x01-08	aUniMaxLearnMacCount	14.4.3.2.8
0x01-09	aOnuMaxLearnMacCount	14.4.3.2.9
0x01-0A	aUniLengthDiscard	14.4.3.2.10
0x01-0B	aUniFloodUnknown	14.4.3.2.11
0x01-0C	aUniLocalSwitching	14.4.3.2.12
0x01-0D	aOnuLlidQueueConfig	14.4.3.2.13
0x01-0E	aOnuFwFileName	14.4.3.2.14
0x01-0F	aUniMacTableFull	14.4.3.2.15
Object group: Statistics and counters		
0x02-01	aCountRxFramesGreen	14.4.3.3.1
0x02-02	aCountTxFramesGreen	14.4.3.3.2
0x02-03	aCountRxFrames2Short	14.4.3.3.3
0x02-04	aCountRxFrames64	14.4.3.3.4
0x02-05	aCountRxFrames65to127	14.4.3.3.5
0x02-06	aCountRxFrames128to255	14.4.3.3.6

Leaf	Attribute	Defined in
0x02-07	aCountRxFrames256to511	14.4.3.3.7
0x02-08	aCountRxFrames512to1023	14.4.3.3.8
0x02-09	aCountRxFrames1024to1518	14.4.3.3.9
0x02-0A	aCountRxFrames1519	14.4.3.3.10
0x02-0B	aCountTxFrames64	14.4.3.3.11
0x02-0C	aCountTxFrames65to127	14.4.3.3.12
0x02-0D	aCountTxFrames128to255	14.4.3.3.13
0x02-0E	aCountTxFrames256to511	14.4.3.3.14
0x02-0F	aCountTxFrames512to1023	14.4.3.3.15
0x02-10	aCountTxFrames1024to1518	14.4.3.3.16
0x02-11	aCountTxFrames1519	14.4.3.3.17
0x02-12	aQueueDelayThr	14.4.3.3.18
0x02-13	aQueueDelayValue	14.4.3.3.19
0x02-14	aCountFramesDropped	14.4.3.3.20
0x02-15	aCountOctetsDropped	14.4.3.3.21
0x02-16	aCountOctetsDelayed	14.4.3.3.22
0x02-17	aCountUsOctetsUnused	14.4.3.3.23
0x02-1D	aPonOptMonitTemp	14.4.3.3.24
0x02-1E	aPonOptMonitVcc	14.4.3.3.25
0x02-1F	aPonOptMonitBias	14.4.3.3.26
0x02-20	aPonOptMonitTxPower	14.4.3.3.27
0x02-21	aPonOptMonitRxPower	14.4.3.3.28
0x02-22	aCounterRxFramesY	14.4.3.3.29
0x02-23	aCounterTxFramesY	14.4.3.3.30
0x02-24	aCounterTxOctetsG	14.4.3.3.31
0x02-25	aCounterRxOctetsY	14.4.3.3.32
0x02-26	aCounterRxOctetsG	14.4.3.3.33
0x02-27	aCounterTxOctetsY	14.4.3.3.34
0x02-28	aCounterTxFramesL2Unicast	14.4.3.3.35
0x02-29	aCounterTxFramesL2Multicast	14.4.3.3.36
0x02-2A	aCounterTxFramesL2Broadcast	14.4.3.3.37
0x02-2B	aCounterRxFramesL2Unicast	14.4.3.3.38
0x02-2C	aCounterRxFramesL2Multicast	14.4.3.3.39
0x02-2D	aCounterRxFramesL2Broadcast	14.4.3.3.40
0x02-2E	aOnuCounterNumber	14.4.3.3.41
0x02-2F	aCounterRxFramesL2CP	14.4.3.3.42
0x02-30	aCounterRxOctetsL2CP	14.4.3.3.43
0x02-31	aCounterTxFramesL2CP	14.4.3.3.44
0x02-32	aCounterTxOctetsL2CP	14.4.3.3.45
0x02-33	aCounterDiscardFramesL2CP	14.4.3.3.46
0x02-34	aCounterDiscardOctetsL2CP	14.4.3.3.47
0x02-35	aCounterL2TxErrors	14.4.3.3.48
0x02-36	aCounterL2RxErrors	14.4.3.3.49
Object group: Alarms		
0x03-01	aAlarmPortStatThr	14.4.3.4.1
0x03-02	aAlarmLlidStatThr	14.4.3.4.2
0x03-03	aAlarmStatusControl	14.4.3.4.3
Object group: Encryption		
0x04-01	aEncryptionKeyExpiration	14.4.3.5.1
0x04-02	aEncryptionMode	14.4.3.5.2
Object group: Frame processing		
0x05-01	aRuleSetConfig	14.4.3.6.1

Leaf	Attribute	Defined in
0x05-02	aRuleCustomField	14.4.3.6.2
0x05-03	aRuleTpidCAlter	14.4.3.6.3
0x05-04	aRuleTpidSAlter	14.4.3.6.4
0x05-05	aRuleIpmcFwrConfig	14.4.3.6.5
0x05-06	aRuleTpidIAlter	14.4.3.6.6
0x05-07	aRuleTpidBAlter	14.4.3.6.7
Object group: Service-level agreements		
0x06-01	aRateLimitBroadcast	14.4.3.7.1
0x06-04	aQueueCIR	14.4.3.7.2
0x06-05	aFecMode	14.4.3.7.3
0x06-06	aQueueEIR	14.4.3.7.4
0x06-07	aQueueColorMarking	14.4.3.7.5
0x06-08	aQueueRateLimiterCap	14.4.3.7.6
0x06-09	aCouplingFlag	14.4.3.7.7
Object group: Clock transport		
0x07-01	aClockTranspCapab	14.4.3.9.1
0x07-02	aClockTranspStatus	14.4.3.9.2
0x07-03	aClockTranspTransfer	14.4.3.9.3
0x07-04	aClockTranspPropagParam	14.4.3.9.4
0x07-05	aClockTranspRtt	14.4.3.9.5
Object group: Demarc auto-configuration		
0x08-00	aDacConfig	14.4.3.10.1
0x08-01	aDacConfigFlags	14.4.3.10.2
0x08-02	aDacPassChallenge	14.4.3.10.3
0x08-03	aDacStatus	14.4.3.10.4
Object group: Power saving		
0xFF-FF	aOnuPwrSavingCap	14.4.3.8.1
Object group: Optical Line Protection		
0x09-00	aOnuProtectionCapability	14.4.1.9.1
0x09-01	aOnuConfigProtection	14.4.1.9.2
0x09-02	aOnuConfigPonActive	14.4.1.9.3
0x09-03	aONUConfigHoldoverPeriod	14.4.1.9.4

All other `Leaf` values are reserved and ignored on reception.

14.4.1.1 ONU management

14.4.1.2 Bridging

14.4.1.3 Statistics and counters

14.4.1.4 Alarms

Individual alarms are exchanged between the ONU and the OLT using DPoE *Event Notification* TLVs, carried in the *Event Notification* OAMPDU, as defined in IEEE Std 802.3, Clause 57.

14.4.1.5 Encryption

14.4.1.6 Frame processing

14.4.1.7 Service-level agreements (SLAs)

14.4.1.8 Power saving

14.4.1.9 Optical Link Protection

14.4.1.9.1 Attribute *aOnuProtectionCapability* (0xD7/0x09-00)

This attribute represents the ONU's optical link protection capabilities, including support for trunk and tree protection modes. This attribute consists of the following sub-attributes: *sSupportTrunk*, *sSupportTreeLine*, and *sSupportTreeClient*.

Sub-attribute *aOnuProtectionCapability.sSupportTrunk*:
Syntax:	Boolean
Remote access:	Read-Only
Description:	This sub-attribute indicates whether the ONU supports the trunk protection scheme (9.3.3). The following values are defined:
	supported: Trunk protection scheme is supported.
	not_supported: Trunk protection scheme is not supported.

Sub-attribute *aOnuProtectionCapability.sSupportTreeLine*:
Syntax:	Boolean
Remote access:	Read-Only
Description:	This sub-attribute indicates whether the ONU supports the tree protection scheme (9.3.4) utilizing L-ONU protection switching (9.3.2.1.1). The following values are defined:
	supported: Tree protection scheme with L-ONU protection switching is supported.
	not_supported: Tree protection scheme with L-ONU protection switching is not supported.

Sub-attribute *aOnuProtectionCapability.sSupportTreeClient*:
Syntax:	Boolean
Remote access:	Read-Only
Description:	This sub-attribute indicates whether the ONU supports the tree protection scheme (9.3.4) utilizing C-ONU protection switching (9.3.2.1.2). The following values are defined:
	supported: Tree protection scheme with C-ONU protection switching is supported.
	not_supported: Tree protection scheme with C-ONU protection switching is not supported.

The *aOnuProtectionCapability* attribute is associated with the ONU object (see 14.4.1.1). The Variable Container TLV for the *aProtectionCapability* attribute shall be as specified in Table 14-xx1.

Table 14-xx1—*ONU Protection Capability* TLV (0xD7/0x09-00)

Size (octets)	Field (name)	Value	Notes
1	Branch	0xD7	Branch identifier
2	Leaf	0x09-00	Leaf identifier

Size (octets)	Field (name)	Value	Notes
1	Length	0x03	The size of TLV fields following the `Length` field
1	SupportTrunk	Varies	Value of *sSupportTrunk* sub-attribute, defined as follows: `supported:` 0x01 `not_supported:` 0x00
1	SupportTreeLine	Varies	Value of *sSupportTreeLine* sub-attribute, defined as follows: `supported:` 0x01 `not_supported:` 0x00
1	SupportTreeClient	Varies	Value of *sSupportTreeClient* sub-attribute, defined as follows: `supported:` 0x01 `not_supported:` 0x00

14.4.1.9.2 Attribute *aOnuConfigProtection* (0xD7/0x09-01)

This attribute represents the protection function configuration of the ONU, including the duration of the optical and MAC loss-of-signal detection thresholds. This attribute consists of the following sub-attributes: *sLosOptical* and *sLosMac.*

Sub-attribute *aOnuConfigProtection.sLosOptical*:
Syntax:	Unsigned integer
Range:	0x00-00 to 0x03-E8 (1 second)
Default value:	0x00-02
Unit:	1 ms
Remote access:	Read/Write
Description:	This sub-attribute indicates the period of time that has to elapse before the ONU moves to the HOLD_OVER_START state (see 9.3.3.3) if no optical signal is detected.

Sub-attribute *aOnuConfigProtection.sLosMac*:
Syntax:	Unsigned integer
Range:	0x00-00 to 0x03-E8 (1 second)
Default value:	0x00-32 (50 ms)
Unit:	1 ms
Remote access:	Read/Write
Description:	This sub-attribute indicates the period of time that has to elapse before the ONU moves to the HOLD_OVER_START state if no *GATE* MPCPDU is received. This attribute corresponds to the `gate_timeout` as specified in IEEE Std 802.3, 64.3.5.1 and 77.3.5.1.

The *aOnuConfigProtection* attribute is associated with the ONU object (see 14.4.1.1). The Variable Container TLV for the *aOnuConfigProtection* attribute shall be as specified in Table14-xx2.

Table 14-xx2—*ONU Protection Configuration* TLV (0xD7/0x09-01)

Size (octets)	Field (name)	Value	Notes
1	Branch	0xD7	Branch identifier
2	Leaf	0x09-01	Leaf identifier
1	Length	0x04	The size of TLV fields following the `Length` field

Size (octets)	Field (name)	Value	Notes
2	LosOptical	Varies	Value of *sLosOptical* sub-attribute
2	LosMac	Varies	Value of *sLosMac* sub-attribute

14.4.1.9.3   Attribute *aOnuConfigPonActive* (0xD7/0x09-02)

This attribute represents the active PON port on the ONU.

Attribute *aOnuConfigPonActive*

Syntax:	Unsigned integer
Size (octets):	1
Default value:	0x00
Remote access:	Read/Write
Description:	This attribute represents the index of the active PON port on the ONU. Individual PON ports are numbered sequentially starting with 0x00. For ONU supporting the tree protection mode, the PON port 0x00 is designated as the primary port, and the PON port 0x01 is designated as the backup port. Either the primary or the backup port can be in active (i.e., working) state. A port that is not in the working state is in the standby state.

The *aOnuConfigPonActive* attribute is associated with the ONU object (see 14.4.1.1). The Variable Container TLV for the *aOnuConfigPonActive* attribute shall be as specified in Table14-xx3.

Table 14-xx3—*PON Interface Administrate* TLV (0xD7/0x09-02)

Size (octets)	Field (name)	Value	Notes
1	Branch	0xD7	Branch identifier
2	Leaf	0x09-02	Leaf identifier
1	Length	0x01	The size of TLV fields following the `Length` field
1	PonPortActive	Varies	Value of *aOnuConfigPonActive* attribute

14.4.1.9.4 Attribute *aOnuConfigHoldoverPeriod* (0xD7/0x09-03)

This attribute represents the support for the timestamp drift prevention mechanism on the ONU, including its administrative status and duration of the holdover status, loaded to `timerHoldOver`, as defined in 9.3.3. This attribute consists of the following sub-attributes: *sAdminStatus* and *sHoldOverPeriod*.

Sub-attribute *aOnuConfigHoldoverPeriod.sAdminStatus*:

Syntax:	Boolean
Remote access:	Read/Write
Default value:	`enabled`
Description:	This sub-attribute represents the administrative status of the timestamp drift prevention mechanism on the given ONU. Individual values have the following meanings:
	`disabled`: timestamp drift prevention mechanism is disabled.
	`enabled`: timestamp drift prevention mechanism is enabled.

Sub-attribute *aOnuConfigHoldoverPeriod.sHoldOverPeriod*:

Syntax:	Unsigned integer
Range:	0x00-00 to 0x03-E8 (1 second)
Remote access:	Read/Write
Unit:	1 ms
Default value:	0x00-C8

Description: This sub-attribute represents the value loaded into the `timerHoldOver` timer, as defined in 9.3.3.

The *aOnuConfigHoldoverPeriod* attribute is associated with the ONU object (see 14.2.3.1). The Variable Container TLV for the *aOnuConfigHoldoverPeriod* attribute shall be as specified in Table 14-xx4.

Table 14-xx4— *ONU Config HoldOver Period* TLV (0xD7/0x09-03)

Size (octets)	Field (name)	Value	Notes
1	Branch	0xD7	Branch identifier
2	Leaf	0x09-03	Leaf identifier
1	Length	0x08	The size of TLV fields following the `Length` field
4	AdminStatus	Varies	Value of *sAdminStatus* sub-attribute, defined as follows: `disabled:` 0x00-00-00-01 `enabled:` 0x00-00-00-02
4	HoldOverPeriod	Varies	Value of *sHoldOverPeriod* sub-attribute, mapped into the 4-octet-wide value, right justified.

Annex 4A
(normative)
Protocol implementation conformance statement (PICS) for Package A

4A.1 Introduction

This subclause specifies the PICS proforma for Package A, as specified in Table 4-1, separated into ONU and OLT specific requirements.

The supplier of an EPON ONU or OLT implementation that is claimed to conform to SIEPON Package A shall complete the following PICS proforma.[11]

A detailed description of the symbols used in the PICS proforma, along with instructions for completing the PICS proforma, can be found in 3.6.

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[11] *Copyright release for PICS proformas*: Users of this standard may freely reproduce the PICS proforma in this subclause so that it can be used for its intended purpose and may further publish the completed PICS.

4A.2 ONU-specific PICS

4A.2.13 Management entities

Insert the following entries at the end of table in 4A.2.13

Item	Description	Subclause	Value/Comment	Status	Support
AU-ME145	*ONU Protection Capability* TLV (0xD7/0x09-00)	14.4.1.9.1	Meets the requirements of Table 14-xx1.	M	[ ] Yes
AU-ME146	*ONU Protection Configuration* TLV (0xD7/0x09-01)	14.4.1.9.2	Meets the requirements of Table 14-xx2.	AU-LPTE0+ AU-LPTK0:M	[ ] Yes
AU-ME147	*PON Interface Administrate* TLV (0xD7/0x09-02)	14.4.1.9.3	Meets the requirements of Table 14-xx3.	AU-LPTE0:M	[ ] Yes
AU-ME148	*ONU Configuration Holdover Period* TLV (0xD7/0x09-03)	14.4.1.9.4	Meets the requirements of Table 14-xx4.	AU-LPTK0:M	[ ] Yes

Insert new subclauses 4A.2.19 and 4A.2.20, as shown below

4A.2.19 Trunk protection

Item	Description	Subclause	Value/Comment	Status	Support
AU-LPTK0	Implement trunk optical link protection	Table 4-1	ONU implements trunk optical link protection per 9.3.3 and 9.3.5.2	O	[ ] Yes [ ] No
AU-LPTK1	Fault condition detection	9.3.2.2.2	Detect the fault condition on the optical line using Optical LoS or MAC LoS mechanism.	AU-LPTK0:M	[ ] Yes
AU-LPTK2	Switching time	9.3.3.1	Be lower than or equal to150 ms.	AU-LPTK0:M	[ ] Yes
AU-LPTK3	$T_{LoS\ Optical}$ and $T_{LoS\ MAC}$ Configuration	9.3.3.4	The values for $T_{LoS\ Optical}$ and $T_{LoS\ MAC}$ parameters are configured via eOAM, as specified in using the *ONU Protection Configuration* TLV (0xD7/0x09-01) per 14.4.1.9.2.	AU-LPTK0:M	[ ] Yes [ ] No
AU-LPTK4	ONU operation	9.3.3.4.5	Meet the requirements of Figure 9-11.	AU-LPTK0:M	[ ] Yes

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4A.2.20 Tree protection

Item	Description	Subclause	Value/Comment	Status	Support
AU-LPTE0	Implement tree optical link protection	Table 4-1	ONU implements tree optical link protection per 9.3.4 and 9.3.5.2	O	[ ] Yes [ ] No
AU-LPTE1	Line monitoring mechanisms (ONU)	9.3.2.2.2	Detect the fault condition on the working optical line using Optical LoS or MAC LoS mechanisms.	AU-LPTE0:M	[ ] Yes
AU-LPTE2a	Switching time	9.3.4.1	Be lower than or equal to 50 ms.	AU-LPTE0:M	[ ] Yes
AU-LPTE2b	Working L-ONU registration status	9.3.4.1	The working L-ONU is registered at the working L-OLT and remain fully active (including MPCP, OAM and subscriber data flows) as long as the link between the working L-ONU and working L-OLT remains functional.	AU-LPTE0:M	[ ] Yes
AU-LPTE2c	Standby L-ONU registration status	9.3.4.1	The standby L-ONU is registered at the standby L-OLT and remain fully active (including MPCP and OAM flows) as long as the link between the standby L-ONU and the standby L-OLT remains functional.	AU-LPTE0:M	[ ] Yes
AU-LPTE2d	Data flows on backup path	9.3.4.1	The link between the standby L-ONU and the standby L-OLT does not carry any subscriber traffic.	AU-LPTE0:M	[ ] Yes
AU-LPTE2e	Device discovery and registration	9.3.4.1	MPCP discovery and registration processes, IEEE 802.3 (Clause 57) OAM discovery, eOAM discovery, and ONU authentication process if configured to do so by the operator exeAUted independently for the primary and backup links.	AU-LPTE0:M	[ ] Yes
AU-LPTE3	$T_{LoS\ Optical}$ and $T_{LoS\ MAC}$ Configuration	9.3.4.5	The values for $T_{LoS\ Optical}$ and $T_{LoS\ MAC}$ parameters are configured via eOAM, as specified in using the *ONU Protection Configuration* TLV (0xD7/0x09-01) per 14.4.1.9.2.	AU-LPTE0:M	[ ] Yes [ ] No
AU-LPTE4a	ONU operation	9.3.4.5.5	Meet the requirements of Figure 9-19.	AU-LPTE0:M	[ ] Yes
AU-LPTE4b	ONU state diagram count	9.3.4.5.5	State diagram per Figure 9-19 is instantiated per each registered C-ONU.	AU-LPTE0:M	[ ] Yes

4A.3 OLT-specific PICS

4A.3.11 Management Entities

Insert the following entries at the end of table in 4A.3.11

Item	Description	Subclause	Value/Comment	Status	Support
AT-ME144	*ONU Protection Capability* TLV (0xD7/0x09-00)	14.4.1.9.1	Meets the requirements of Table 14-xx1.	M	[ ] Yes
AT-ME145	*ONU Protection Configuration* TLV (0xD7/0x09-01)	14.4.1.9.2	Meets the requirements of Table 14-xx2.	AT-LPTE0+ AT-LPTK0:M	[ ] Yes
AT-ME146	*PON Interface Administrate* TLV (0xD7/0x09-02)	14.4.1.9.3	Meets the requirements of Table 14-xx3.	AT-LPTE0:M	[ ] Yes
AT-ME147	*ONU Configuration Holdover Period* TLV (0xD7/0x09-03)	14.4.1.9.4	Meets the requirements of Table 14-xx4.	AT-LPTK0:M	[ ] Yes

Insert new subclauses 4A.3.18 and 4A.3.19, as shown below

4A.3.18 Trunk protection

Item	Description	Subclause	Value/Comment	Status	Support
AT-LPTK0	Implement trunk optical link protection	Table 4-1	OLT implements trunk optical link protection per 9.3.3 and 9.3.5.2	O	[ ] Yes [ ] No
AT-LPTK1	Fault condition detection	9.3.2.2.1	The working OLT detects the fault condition on the working optical line using Optical LoS or MAC LoS mechanism.	AT-LPTK0:M	[ ] Yes
AT-LPTK2	Switching time	9.3.3.1	Be lower than or equal to 150 ms.	AT-LPTK0:M	[ ] Yes
AT-LPTK3	*GATE* MPCPDU transmission	9.3.3.2	The backup OLT, once the switchover process is complete, sends one or more *GATE* MPCPDUs to force each registered ONU to resynchronize to the MPCP clock.	AT-LPTK0:M	[ ] Yes
AT-LPTK4a	OLT state diagram count (Trunk_1)	9.3.3.4.5	State diagram per Figure 9-10 is instantiated per C-OLT.	AT-LPTK0:M	[ ] Yes

Item	Description	Subclause	Value/Comment	Status	Support
AT-LPTK4b	OLT state diagram count (Trunk_2)	9.3.3.4.5	State diagram per Figure 9-10 is instantiated per L-OLT.	AT-LPTK0:M	[ ] Yes

4A.3.19 Tree protection

Item	Description	Subclause	Value/Comment	Status	Support
AT-LPTE0	Implement tree optical link protection	Table 4-1	OLT implements tree optical link protection per 9.3.4 and 9.3.5.2	O	[ ] Yes [ ] No
AT-LPTE1	Line monitoring mechanisms (OLT)	9.3.2.2.1	The working OLT deteATs the fault condition on the working optical line using Optical LoS or MAC LoSi mechanisms.	AT-LPTE0:M	[ ] Yes
AT-LPTE2a	Switching time	9.3.4.1	Be lower than or equal to 50 ms.	AT-LPTE0:M	[ ] Yes
AT-LPTE2b	Data flows on backup path	9.3.4.1	MPCP and OAM data flows only	AT-LPTE0:M	[ ] Yes
AT-LPTE2c	Device discovery and registration	9.3.4.1	MPCP discovery and registration processes, IEEE 802.3 (Clause 57) OAM discovery, eOAM discovery and ONU authentication process if configured to do so by the operator executed independently for the primary and backup links.	AT-LPTE0:M	[ ] Yes
AT-LPTE3a	Configuration of backup ONUs	9.3.4.2	Backup OLT supports configuration of backup ONUs connected to backup path.	AT-LPTE0:M	[ ] Yes
AT-LPTE3b	Maintain data link connectivity with backup ONU	9.3.4.2	The standby OLT enables all necessary MPCP and OAM/eOAM mechanisms defined in this standard as well as in IEEE Std 802.3 in order to maintain data link connectivity with individual standby ONUs.	AT-LPTE0:M	[ ] Yes
AT-LPTE3c	Upstream grants to backup ONUs	9.3.4.2	The standby OLT issues grants to the standby ONUs to ensure normal operation of the MPCP.	AT-LPTE0:M	[ ] Yes
AT-LPTE3d	Suppress alarms and warnings	9.3.4.2	The standby OLT suppresses generation of any alarms and warnings associated with the arrival of empty/underutilized upstream transmission slots.	AT-LPTE0:M	[ ] Yes
AT-LPTE3e	Downstream traffic for standby ONUs	9.3.4.2	The standby OLT disallows any downstream user traffic prior to the switchover event.	AT-LPTE0:M	[ ] Yes
AT-LPTE4a	OLT operation	9.3.4.5.5	Meet the requirements of Figure 9-18.	AT-LPTE0:M	[ ] Yes
AT-LPTE4b	OLT state diagram count	9.3.4.5.5	State diagram per Figure 9-18 is instantiated per each registered C-ONU.	AT-LPTE0:M	[ ] Yes

Proposal for PON protection for Package A

Proposal for PON protection for Package A