13 Extended OAM for Nx25G-EPON

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13.4.6.1 eOAMPDU codes

eOAMPDUs shall be as defined in Table 13-10. These eOAMPDUs use the Organization Specific Extension mechanisms defined in IEEE Std 802.3, Clause 57. Other values are reserved and ignored on reception.

Table 13-10—eOAMPDUs and assignment of Opcode values

Opcode	eOAMPDUs	Defined in
0x01	*eOAM_Get_Request*	13.4.6.2
0x02	*eOAM_Get_Response*	13.4.6.3
0x03	*eOAM_Set_Request*	13.4.6.4
0x04	*eOAM_Set_Response*	13.4.6.5
0x09	*eOAM_Software*	13.4.6.6
0x0A	*eOAM_Certificate_Request*	13.4.6.7
0x0B	*eOAM_Certificate_Response*	13.4.6.7

13.4.6.2 *eOAM_Get_Request* eOAMPDU

13.4.6.3 *eOAM_Get_Response* eOAMPDU

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13.4.6.6 *eOAM_Software* eOAMPDU

13.4.6.7 *eOAM_Certificate_Request* and *eOAM_Certificate_Response* eOAMPDUs

The *eOAM_Certificate_Request* and *eOAM_Certificate_Response* eOAMPDUs are specific types of the generic eOAMPDU, as defined in Table 13-2. These eOAMPDUs allow the OLT/NMS to retrieve the

1 Device Authentication Credential (DAC) certificate from the ONU (see 11.2.2.1.3) and to perform remote
2 management (i.e., installation, removal, and/or retrieval) of the Network Authentication Credential (NAC)
3 certificates installed inat the ONUs.

4 The term "NAC certificate" used in this sub-clause may represent a single end-entity certificate as defined
5 in 11.2.2.1.4 or a certificate chain consisting of an end-entity certificate and one or more intermediate
6 certificates, as defined in 11.2.2.1.5.

7 The *eOAM_Certificate_Request* eOAMPDUs are issued by the OLT to request an ONU to perform a
8 certificate-related management action. The OLT shall not generate any *eOAM_Certificate_Response*
9 eOAMPDUs.

10 The *eOAM_Certificate_Response* eOAMPDUs are issued by the ONU to report the result of the taken
11 action. The ONUs shall not generate *eOAM_Certificate_Request* eOAMPDUs.

12 A specific certificate-related management action requested by the *eOAM_Certificate_Request* eOAMPDU
13 is identified by the ActionCode field that follows the Opcode field. The *eOAM_Certificate_Response*
14 eOAMPDU shall carry the same value of ActionCode field as was received in the corresponding
15 *eOAM_Certificate_Request* eOAMPDU. Table 13-21 illustrates the available actions and identifies the
16 related *eOAM_Certificate_Request* and *eOAM_Certificate_Response* eOAMPDU sub-types.

17 **Table 13-21—Certificate management actions and related eOAM**
18 **message sub-types**

Action	ActionCode value	Requests (Opcode = 0x0A)	Responses (Opcode = 0x0B)
Install NAC	0x00	*eOAM_Install_NAC_Request* (see 13.4.6.7.1)	*eOAM_Install_NAC_Response* (see 13.4.6.7.2)
Retrieve DAC	0x01	*eOAM_Retrieve_DAC_Request* (see 13.4.6.7.3)	*eOAM_Retrieve_DAC_Response* (see 13.4.6.7.4)
Retrieve NAC	0x02	*eOAM_Retrieve_NAC_Request* (see 13.4.6.7.3)	*eOAM_Retrieve_NAC_Response* (see 13.4.6.7.4)

13.4.6.7.1

19 *eOAM_Install_NAC_Request* eOAMPDUNAC certificate installation

20 **13.4.6.7.1.1 *eOAM_Install_NAC_Request* eOAMPDU**

21 The *eOAM_Certificate_Request* eOAMPDU with the ActionCode field value of 0x00 (Install NAC) is
22 referred to as *eOAM_Install_NAC_Request* eOAMPDU. The *eOAM_Install_NAC_Request* eOAMPDU is
23 used by the NMS to remotely install a-the NAC certificate into an ONU (see 11.2.2.1.4). If the size of the
24 NAC certificate exceeds the payload capacity of the *eOAM_Install_NAC_Request* eOAMPDU, multiple
25 such OAMPDUs may be used to complete the installation procedure.

26 The structure of the *eOAM_Install_NAC_Request* eOAMPDU shall be as presented in Table 13-22.

27 **Table 13-22—Structure of the *eOAM_Install_NAC_Request* eOAMPDU**

Size (octets)	Field name	Value and notes
21	eOAMPDU header	See Table 13-2

Size (octets)	Field name	Value and notes
1	Opcode	0x0A (see Table 13-10)
1	ActionCode	0x00 (see Table 13-21)
4	Sequence	Bit 31: ~~Start~~ indicator. When set to 1, identifies the first eOAMPDU in a sequence of one or more OAMPDUs that carry the NAC certificate. Bits 30-0: `ResidualOctets` sub-field represents the number of remaining certificate data octets, not counting the octets in the `BlockData` field. This sub-field is equal to 0 if the entire NAC certificate can fit within a single `DataBlock` field.
2	~~CertificateLength~~BlockLength	The length of the ~~Certificate~~ `DataBlock` field. ~~The value of 0x00 indicates that this is a request to remove the existing NAC certificate~~
≤ ~~1489~~1485	~~Certificate~~Data`Block`	NAC certificate data (records) as defined in 11.2.2.1.4. This field is not present if the ~~Certificate~~`Block`Length is 0x00~~-00~~.
≤ ~~35~~31	Pad	This field is optional; it is included only when needed to satisfy the minimum OAMPDU size requirements. When included, the `Pad` value is 0x00-…-00.
4	FCS	See 13.4.2

1 ~~If the ONU that received the *eOAM_Install_NAC_Request* eOAMPDU already has a NAC installed, the~~
2 ~~existing NAC shall be replaced (overwritten) with the new NAC.~~

3 ~~The action of overwriting of the existing NAC certificate takes place even in the situation when no new~~
4 ~~NAC certificate is supplied by the *eOAM_Install_NAC_Request* eOAMPDU (i.e., when the value of the~~
5 ~~CertificateLength field is set to 0x00). Essentially, such zero-length *eOAM_Install_NAC_Request*~~
6 ~~eOAMPDU serves as a request to remove the existing NAC certificate.~~

7 ~~13.4.6.7.1.1~~13.4.6.7.1.2 *eOAM_Install_NAC_Response* eOAMPDU

8 The *eOAM_Certificate_Response* eOAMPDU with the `ActionCode` field value of 0x00 (Install NAC) is
9 referred to as *eOAM_Install_NAC_Response* eOAMPDU. The *eOAM_Install_NAC_Response* eOAMPDU
10 is issued by an ONU to acknowledge the processing of each *eOAM_Install_NAC_Request* eOAMPDU.

11 The last *eOAM_Install_NAC_Response* eOAMPDU in the certificate installation sequence also conveys the
12 results of NAC installation or NAC removal actions and the status of the stored certificate(s).

13 The structure of the *eOAM_Install_NAC_Response* eOAMPDU shall be as presented in Table 13-23.

14 **Table 13-23—Structure of the *eOAM_Install_NAC_Response* eOAMPDU**

Size (octets)	Field name	Value and notes
21	eOAMPDU header	See Table 13-2
1	Opcode	0x0B (see Table 13-10)

Size (octets)	Field name	Value and notes
1	ActionCode	0x00 (see Table 13-21)
4	Sequence	Bit 31: `Start` indicator. This sub-field value is equal to the value of `Start` sub-field in the *eOAM_Install_NAC_Request* that this response acknowledges. Bits 30-0: `ResidualOctets` sub-field confirms the number of remaining certificate data octets or signals missing data (see 13.4.6.7.1.3).
1	ActionStatus	Value encoding the status of a taken/attempted action, as defined in Table 13-24
1	CertificateStatus	Value encoding the status of the installed certificate, as defined in Table 13-25. This field is only present if `ResidualOctets` == 0x00-00-00-00, i.e., in the last response in a sequence, after the entire NAC certificate or certificate chain has been installed.
3531 or 32	Pad	0x00-…-00
4	FCS	See 13.4.2

1   The `ActionStatus` field carries the response code, as defined in Table 13-24. Only the values specified
2   in Table 13-24 are allowed. Other values are reserved and cause the *eOAM_Install_NAC_Response*
3   eOAMPDU to be ignored by the OLT/NMS.

4   **Table 13-24—Values carried in `ActionStatus` field**

Code	Name	Description
0x00	Download in progress	ONU acknowledges that it received all NAC certificate octets without gaps and omissions, except for the remaining `ResidualOctets`. This code is reported only while `ResidualOctets` > 0.
0x010	Install - success	The received NAC certificate was successfully stored in ONU's non-volatile storage. This code is reported only when `ResidualOctets` == 0.
0x021	Replace - success	The existing NAC certificate stored in ONU's non-volatile repository was successfully replaced by a new certificate. This code is reported only when `ResidualOctets` == 0.
0x032	Remove - success	The existing NAC certificate was successfully removed, i.e., it was overwritten by an empty (zero-length) certificate. This code is reported only when `ResidualOctets` == 0.
0x043	Remove - no action	A request to remove certificate is received, however no certificate is stored in ONU's secure non-volatile storage. This code is reported only when `ResidualOctets` == 0.
0x04	Incompatible format	Unable to parse the message and extract certificate. An existing certificate, if any, remains in place.

Code	Name	Description
0x05	Insufficient storage	Storage is insufficient to hold the new NAC certificate. An existing certificate, if any, remains in place.
0x06	~~Operation timeout~~Busy, request declined	Cannot perform the requested action due to other activity. The ~~~~ONU will not attempt to perform this action again unless it received another request. An existing certificate, if any, remains in place.
0x07	Invalid message format	Unable to parse the *eOAM_Install_NAC_Request* eOAMPDU and extract the `DataBlock` field.
0x08~~7~~	Illegal operation	ONU cannot recognize the request. No action is taken.
0x09~~8~~	Undefined	Unknown error or one not covered above.

1　The `CertificateStatus` field conveys the status of the installed certificate after performing the
2　requested action (i.e., after installing a new certificate or after removing an existing certificate). Only the
3　values specified in Table 13-25 are allowed. Other values are reserved and cause the
4　*eOAM_Install_NAC_Response* eOAMPDU to be ignored by the OLT/NMS.

5　**Table 13-25—Values carried in `CertificateStatus` field**

Code	Name	Description
0x00	No certificate	No NAC certificate is present in ONU's secure non-volatile storage.
0x01	Valid certificate	A valid ~~Network Authentication Credential~~ (NAC~~)~~ certificate is present in ONU's secure non-volatile storage.
0x02	Expired certificate	An expired ~~Network Authentication Credential~~ (NAC~~)~~ certificate is present in ONU's secure non-volatile storage.
0x03	Invalid format	A NAC certificate is present in ONU's secure non-volatile storage, but its format does not comply with requirements in 11.2.2.1.4
0x04	Corrupted data	Data stored in ONU's secure non-volatile storage is corrupted.

6　**13.4.6.7.1.3 NAC certificate installation protocol**

7　The ONU generates an *eOAM_Install_NAC_Response* eOAMPDU for every *eOAM_Install_NAC_Request*
8　it received.

9　When the ONU receives the initial *eOAM_Install_NAC_Request* (i.e., with `Sequence.Start == 1`), it
10　should verify that it has sufficient secure non-volatile storage to store the number of octets equal to
11　`Sequence.ResidualOctets + BlockLength`. In case of insufficient storage, the ONU's response
12　shall include the `ActionStatus` value of 0x05 "Insufficient storage" (see Table 13-24).

13　If the ONU successfully parsed and stored i[th] `DataBlock`, it generates *eOAM_Install_NAC_Response #i*
14　containing the same value of `Sequence.ResidualOctets[i]` as was received in the
15　*eOAM_Install_NAC_Request #i* being acknowledged.

16　When the OLT receives ONU's response *#i* with `Sequence.ResidualOctets[i] = N`, it generates
17　the next request *#i+1* with `Sequence.ResidualOctets[i+1] = N − BlockLength[i+1]`.

The ONU verifies that all certificate octets are received in order and without gaps using the following criteria:

a) For the first received *eOAM_Install_NAC_Request* eOAMPDU, verify that `Sequence.Start == 1`.

b) For every subsequent *eOAM_Install_NAC_Request* message #*i (i>0)*, verify the unbroken chain `ResidualOctets[i] + BlockLength[i] == ResidualOctets[i-1]`

If ONU missed one or more *eOAM_Install_NAC_Request* eOAMPDUs that included the initial request (i.e., the first request that ONU received had `Sequence.Start == 0`), it sends a response with `Sequence = 0xFF-FF-FF-FF` (i.e., `Start == 1` and `ResidualOctets == 0x7F-FF-FF-FF`). This response tells the OLT to restart the sequence from the beginning.

If ONU successfully received one or more *eOAM_Install_NAC_Request* eOAMPDUs that included the initial request, but a subsequent request indicates a gap in the received certificate octets, the ONU response repeats the `ResidualOctets` value from the last request message for which the condition a) or b) above holds true.

The OLT delays the issuance of *eOAM_Install_NAC_Request* eOAMPDU until the next `DataBlock` is available.

The ONU generally issues an *eOAM_Install_NAC_Response* eOAMPDU as soon as the OLT's request is completed, but it may delay such eOAMPDUs to prevent overflow of its receive buffer.

The OLT shall maintain a 15-second timer for receiving a response from the ONU. The timer is started every time the OLT issues an *eOAM_Install_NAC_Request* eOAMPDU and it is stopped every time the OLT receives an *eOAM_Install_NAC_Response* eOAMPDU. Expiration of this timer may indicate a lost request or a lost response message, or it may be caused by the ONU taking a longer time to complete an operation, such as flash memory erasure or certificate validation.

Upon timer expiration, the OLT may retransmit the last *eOAM_Install_NAC_Request* eOAMPDU.

If the ONU has received an *eOAM_Install_NAC_Request* eOAMPDU while it is still processing the previous request, it shall respond with `ActionStatus` value of 0x06 "Busy, request declined" (see Table 13-24).

In the last request and the last response in a sequence, `Sequence.ResidualOctets` is equal to 0x00-00-00-00. The ONU shall commit the downloaded NAC certificate (i.e., the entire chain of certificates at once) to the secure non-volatile memory (i.e., the trust store) only after it received the last `DataBlock` in the sequence. The last response in a sequence contains the `CertificateStatus` field that conveys the status of the NAC certificate in the trust store.

13.4.6.7.2 The OLT may initiate a new certificate installation sequence before the current sequence has been completed. If ONU receives an *eOAM_Install_NAC_Request* eOAMPDU with `Sequence.Start == 1`, it shall discard any partially-downloaded NAC certificate it may have. Such interruption of the certificate installation sequence shall not affect the NAC certificate that has been already committed to the trust store.

NAC certificate removal

The ONU that successfully received a complete new NAC certificate replaces the existing NAC certificate in the trust store with the with the new NAC certificate.

The action of overwriting of the existing NAC certificate takes place even in the situation when no new NAC certificate is supplied by the *eOAM_Install_NAC_Request* eOAMPDU (i.e., when the value of the

1   `Sequence` field is 0x80-00-00-00 and the value of the `BlockLength` field is 0x00-00). Essentially, such
2   *eOAM_Install_NAC_Request* eOAMPDU with the zero-length certificate serves as a request to remove the
3   existing NAC certificate.

NAC or DAC certificate retrieval

5   ~~13.4.6.7.1.2~~13.4.6.7.3.1 *eOAM_Retrieve_DAC_Request* and *eOAM_Retrieve_NAC_Reque*st
6   eOAMPDUs

7   ~~13.4.6.7.3~~The *eOAM_Certificate_Request* eOAMPDU with the `ActionCode` field value of 0x01 (Retrieve DAC) is
8   referred to as *eOAM_Retrieve_DAC_Request* eOAMPDU. The *eOAM_Retrieve_DAC_Request* eOAMPDU
9   is used to retrieve the DAC certificate from an ONU (see 11.2.2.1.3).

10 The *eOAM_Certificate_Request* eOAMPDU with the `ActionCode` field value of 0x02 (Retrieve NAC) is
11 referred to as *eOAM_Retrieve_NAC_Request* eOAMPDU. The *eOAM_Retrieve_NAC_Request* eOAMPDU
12 retrieves a previously-installed NAC certificate from the ONU (see 11.2.2.1.4).

13 The structure of the *eOAM_Retrieve_DAC_Request* and *eOAM_Retrieve_NAC_Request* eOAMPDUs shall
14 be as presented in Table 13-26.

15   **Table 13-26—Structure of *eOAM_Retrieve_DAC_Request* and**
16   ***eOAM_Retrieve_NAC_Request* eOAMPDUs**

Size (octets)	Field name	Value and notes
21	eOAMPDU header	See Table 13-2
1	Opcode	0x0A (see Table 13-10)

1	ActionCode	Identifies the message type as follows:
		  0x01: a request to retrieve the DAC certificate
		  0x02: a request to retrieve the NAC~~.~~ certificate

4	Sequence	Bit 31: `Start` indicator. When set to 1, identifies a request to send the first block of DAC or NAC certificate. Bits 30-0: `ResidualOctets` sub-field represents the number of remaining certificate data octets. The OLT requests the ONU to send the next block that is at the head of the remaining `ResidualOctets`.
~~37~~33	Pad	0x00-…-00
4	FCS	See 13.4.2

17 ~~13.4.6.7.1.3~~13.4.6.7.3.2 *eOAM_Retrieve_DAC_Response* and
18   *eOAM_Retrieve_NAC_Response* eOAMPDUs

19 The *eOAM_Certificate_Response* eOAMPDU with the `ActionCode` field value of 0x01 (Retrieve DAC)
20 is referred to as *eOAM_Retrieve_DAC_Response* eOAMPDU. The *eOAM_Retrieve_DAC_Response*
21 eOAMPDU is used by the ONU to convey the contents of the DAC certificate to the OLT/NMS (see
22 11.2.2.1.3).

23 The *eOAM_Certificate_Response* eOAMPDU with the `ActionCode` field value of 0x02 (Retrieve NAC)
24 is referred to as *eOAM_Retrieve_NAC_Response* eOAMPDU. The *eOAM_Retrieve_NAC_Response*

1 eOAMPDU is used by the ONU to convey the contents of the NAC certificate, if one is present (see
2 11.2.2.1.4).

3 The structure of the *eOAM_Retrieve_DAC_Response* and *eOAM_Retrieve_NAC_Response* eOAMPDUs
4 shall be as presented in Table 13-27.

5 **Table 13-27—Structure of *eOAM_Retrieve_DAC_Response* and**
6 ***eOAM_Retrieve_NAC_Response* eOAMPDUs**

Size (octets)	Field name	Value and notes
21	eOAMPDU header	See Table 13-2
1	Opcode	0x0B (see Table 13-10)

1	ActionCode	Identifies the message type as follows:
		    `0x01`: a response carrying the DAC certificate data
		    `0x02`: a response carrying the NAC certificate data

4	Sequence	Bit 31: `Start` indicator. This sub-field value is equal to the value of `Start` sub-field in the corresponding request (i.e., *eOAM_Retrieve_NAC_Request* or *eOAM_Retrieve_NAC_Request* eOAMPDU). Bits 30-0: `ResidualOctets` sub-field represents the number of remaining certificate data octets, not counting the octets in the `BlockData` field. This sub-field is equal to 0 if the entire DAC/NAC certificate can fit within a single `DataBlock` field.
2	~~Certificate~~BlockLength	The length of the ~~Certificate~~ `DataBlock` field. ~~The value of 0x00 indicates that the requested certificate (NAC or DAC) is not present or cannot be retrieved.~~
< 148~~59~~	~~Certificate~~DataBlock	A block of DAC or NAC certificate data (records) ~~as defined in or 11.2.2.1.4 respectively~~. This field is not present if the ~~Certificate~~BlockLength is 0x00-00.
< 3~~15~~	Pad	This field is optional; it is included only when needed to satisfy the minimum OAMPDU size requirement. When included, the `Pad` value is 0x00-…-00.
4	FCS	See 13.4.2

7

8 **13.4.6.7.3.3 NAC/DAC certificate retrieval protocol**

9 The OLT requests one certificate block at a time. The ONU generates an *eOAM_Retrieve_DAC_Response*
10 eOAMPDU for every *eOAM_Retrieve_DAC_Request*, and it generates an *eOAM_Retrieve_NAC_Response*
11 eOAMPDU for every *eOAM_Retrieve_NAC_Request* it received.

12 In the initial retrieve request, the value of the `Sequence` field is equal to 0xFF-FF-FF-FF (i.e.,
13 `Sequence.Start == 1` and `Sequence.ResidualOctets == 0x7F-FF-FF-FF`).

14 When the ONU receives OLT's initial retrieve request, it generates the initial retrieve response with
15 `Sequence[0].ResidualOctets = CertificateSize - BlockLength[0]`. The initial

ONU response with `Sequence[0].ResidualOctets == 0` and `BlockLength[0] == 0` indicates to the OLT/NMS that the requested certificate (NAC or DAC) is not present or cannot be retrieved.

When the OLT receives ONU's response #*i* with `Sequence[i].ResidualOctets == N` with $N > 0$, it generates the next request #*i+1* with `Sequence[i+1].ResidualOctets = N`.

When the ONU receives the OLT's subsequent retrieve request #*i* (*i>0*) with `Sequence[i].ResidualOctets == N`, it generates the response #*i* with `Sequence[i].ResidualOctets = N - BlockLength[i]`.

The OLT controls the frequency of the *eOAM_Retrieve_DAC_Request* and *eOAM_Retrieve_NAC_Request* eOAMPDUs to prevent overflow of its receive buffer.

If the ONU is unable to retrieve the next certificate block from memory within 1 second OAM timeout interval (see 13.2.3), it generates a response message with `BlockLength == 0` and the `Sequence.ResidualOctets` value the same as in the received request.

The OLT treats the ONU response with `Sequence.ResidualOctets > 0` and `BlockLength == 0` as a "keep alive" message. A keep-alive message indicates to the OLT that the ONU is going to transmit the requested block as soon as it can and without another OLT request. There could be several keep-alive messages before the next block becomes available at the ONU.

The OLT may signal to the ONU that it has aborted the certificate retrieval procedure by issuing a retrieve request with `Sequence[i].ResidualOctets == 0`. The ONU acknowledges such request by issuing a response with `Sequence[i].ResidualOctets == 0` and `BlockLength[i] == 0`.