Super-PON PCS Options

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Possible PCS Options for Super-PON

- Leverage the current 10G-EPON PCS
  - Frame based with 64/66b encoding
  - Uses RS(255, 223) as FEC downstream and upstream
    - ~13% overhead
    - ~7.1 dB coding gain
  - Commercially available in current 10G-EPON solutions
- Leverage the P802.3ca 25G-EPON PCS
  - Envelope based with 256/257b encoding
  - Uses LDPC(16952,14392) as FEC downstream and upstream
    - ~same overhead (higher FEC overhead (~15%), lower encoding overhead)
    - >1dB coding gain over RS(255, 223)
  - Not yet available in commercial implementations

Related Event

- ITU-T Q2/SG15 consented last week a new project to standardize Super-PON also in the ITU-T set of recommendations for PON
  - Recommendation G.9807.3, Wavelength multiplexed point-to-multipoint 10-Gigabit-capable passive optical network
- The idea is to leverage as much as possible the Super-PON PMD we are developing here to support the XGS-PON TC layer
  - In this way the same PMD can be used by the two protocol stacks
  - Higher volumes, lower costs
- XGS-PON uses RS(248, 216), a truncated form of RS(255, 223), as FEC for downstream and upstream
- This creates a preference for the 10G-EPON PCS for Super-PON
  - Unless we absolutely need the additional gain of the LDPC FEC

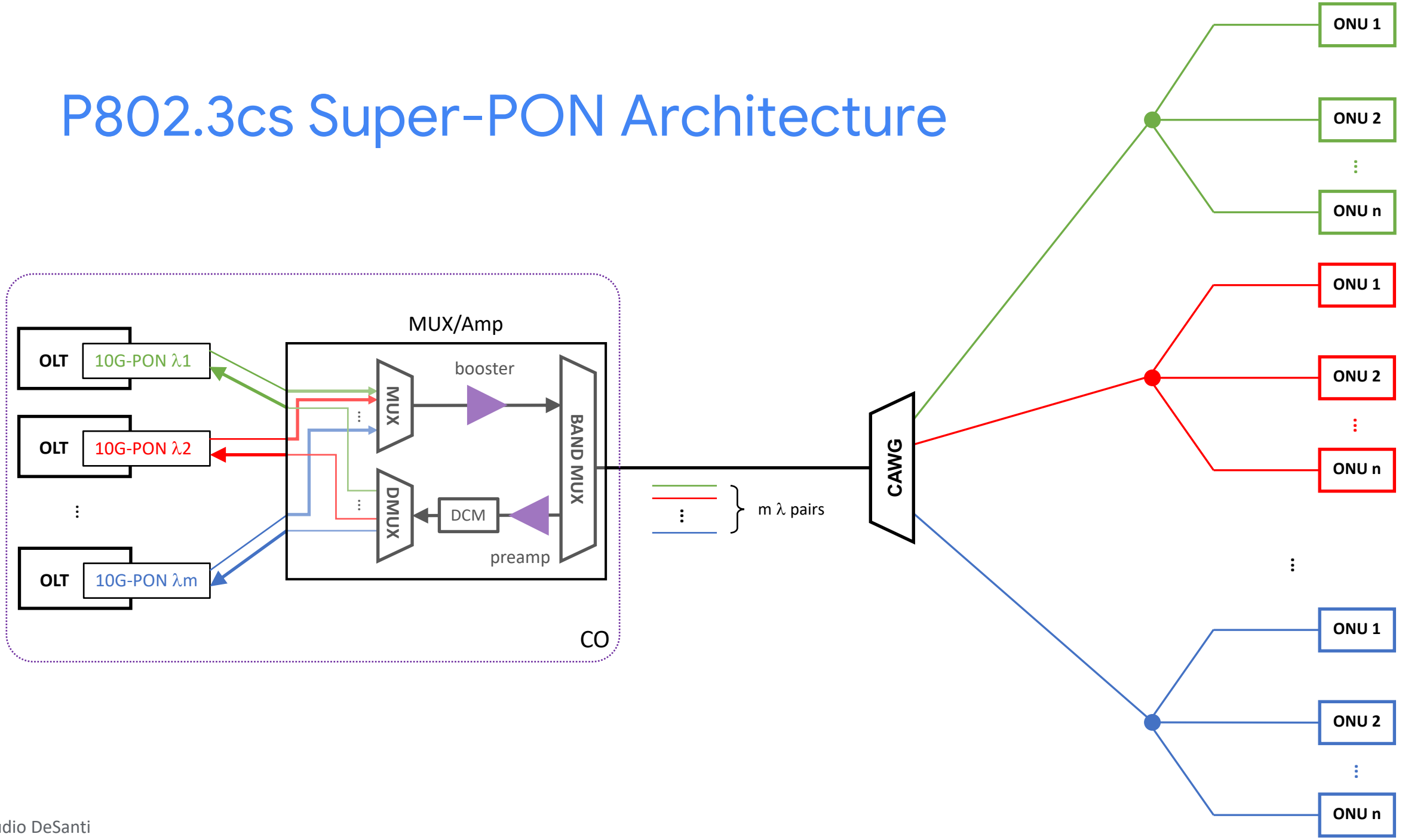
Super-PON Additional PCS Requirements

- Support tunable transmitters
- Support the 2.5G upstream speed
  - 1/4 of the 10G-EPON clock, or
  - 1/10 of the 25G-EPON clock

Support Tunable Transmitters

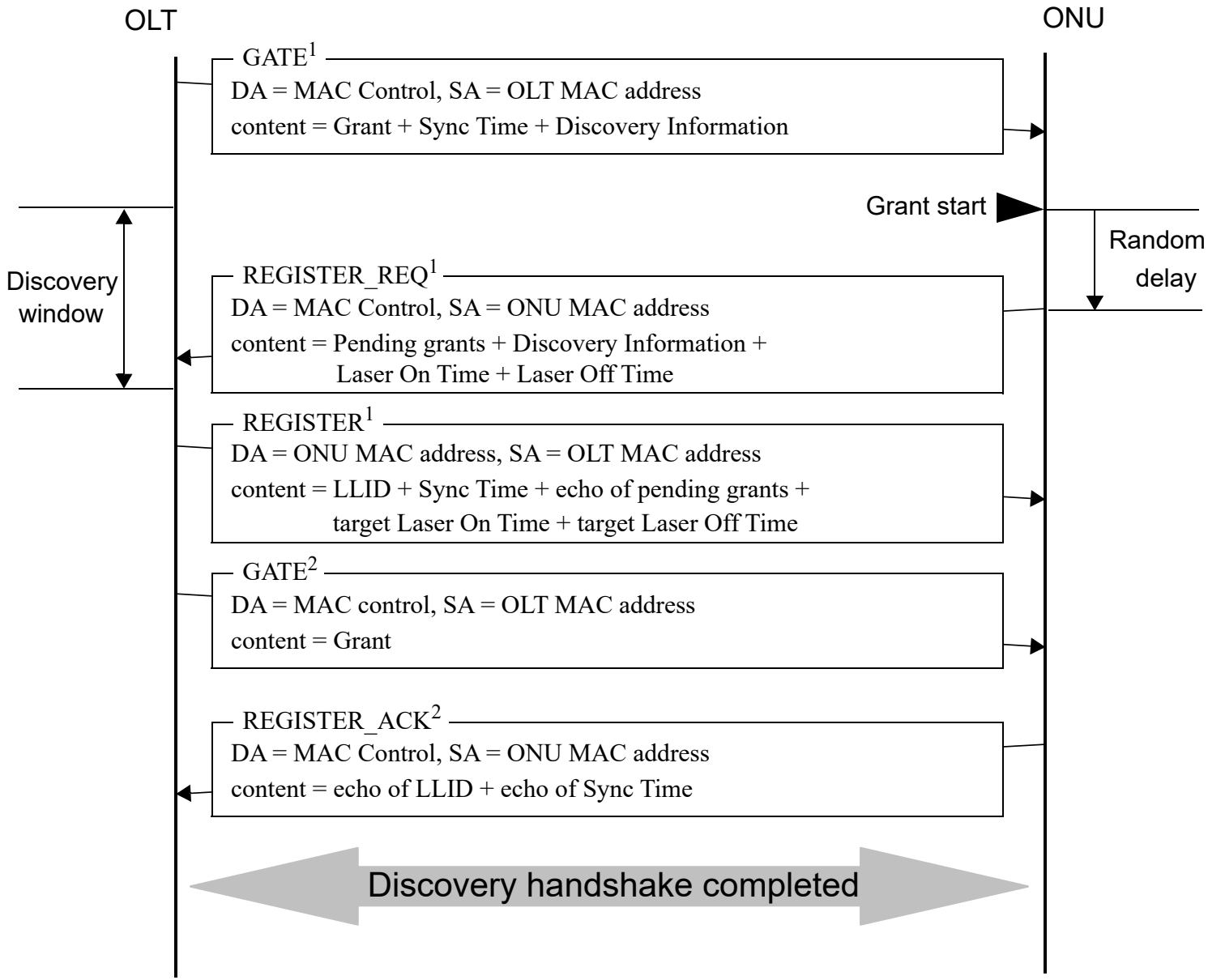
- Super-PON operates over a wavelength routed ODN
- On a wavelength routed ODN the wavelength pair over which an ONU operates depends only on the point of attachment to the ODN topology
  - And does not change during operation
- A way to support tunable transmitters is for the OLT port to communicate to all its connected ONUs the channel they should use for operation
  - This should be carried in the first message the OLT sends to the ONU
  - Otherwise no upstream communication is possible

P802.3cs Super-PON Architecture



10G-EPON Discovery

- We need to leverage the discovery GATE MPCPDU



[1] Messages sent on a broadcast channel
[2] Messages sent on unicast channels

Figure 77–15—Discovery handshake message exchange

GATE MPCPDU

- We can leverage the Discovery Information field

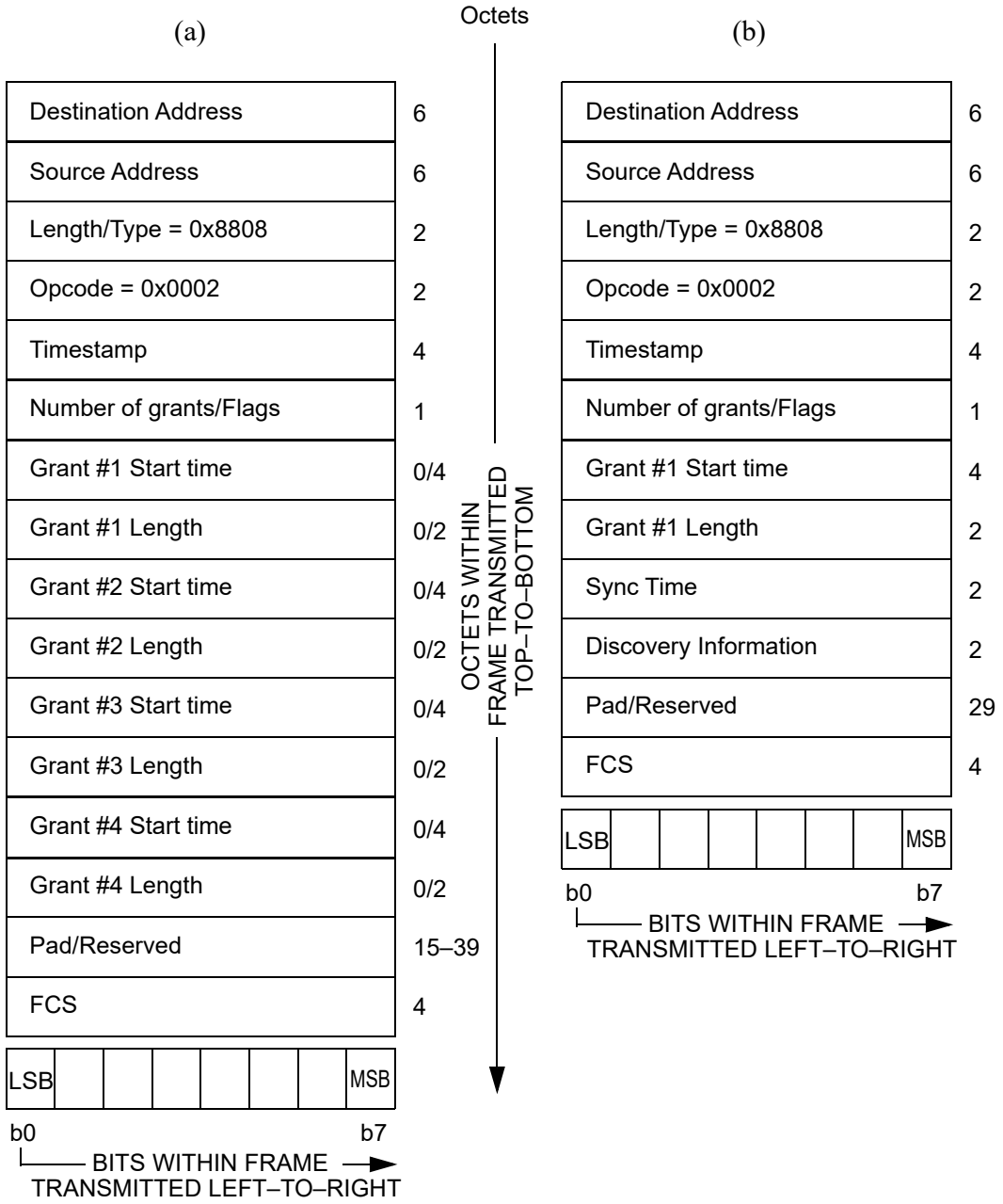


Figure 77–32—GATE MPCPDU: (a) normal GATE MPCPDU, (b) discovery GATE MPCPDU

GATE MPCPDU Discovery Information Field

Table 77–3—GATE MPCPDU discovery information fields

Bit	Flag field	Values
0	OLT is 1G upstream capable	0 – OLT does not support 1 Gb/s reception 1 – OLT supports 1 Gb/s reception
1	OLT is 10G upstream capable	0 – OLT does not support 10 Gb/s reception 1 – OLT supports 10 Gb/s reception
2–3	Reserved	Ignored on reception
4	OLT is opening 1G discovery window	0 – OLT cannot receive 1 Gb/s data in this window 1 – OLT can receive 1 Gb/s data in this window
5	OLT is opening 10G discovery window	0 – OLT cannot receive 10 Gb/s data in this window 1 – OLT can receive 10 Gb/s data in this window
6–15	Reserved	Ignored on reception

5 bits needed:

- 4 to identify the channel
- 1 to identify the FSR Set

Support the 2.5G Upstream Speed

- 2.5G is supported by XGMII
  - Excerpt from 46.1

The XGMII has the following characteristics:

a) It is capable of supporting at least one of the following rates of operation: 2.5 Gb/s, 5 Gb/s, or 10 Gb/s.
b) Data and delimiters are synchronous to clock reference.
c) It provides independent 32-bit-wide transmit and receive data paths.
d) It uses signal levels compatible with common digital ASIC processes.
e) It provides for full duplex operation only.

46.1.1 Summary of major concepts

The following are the major concepts of XGMII:

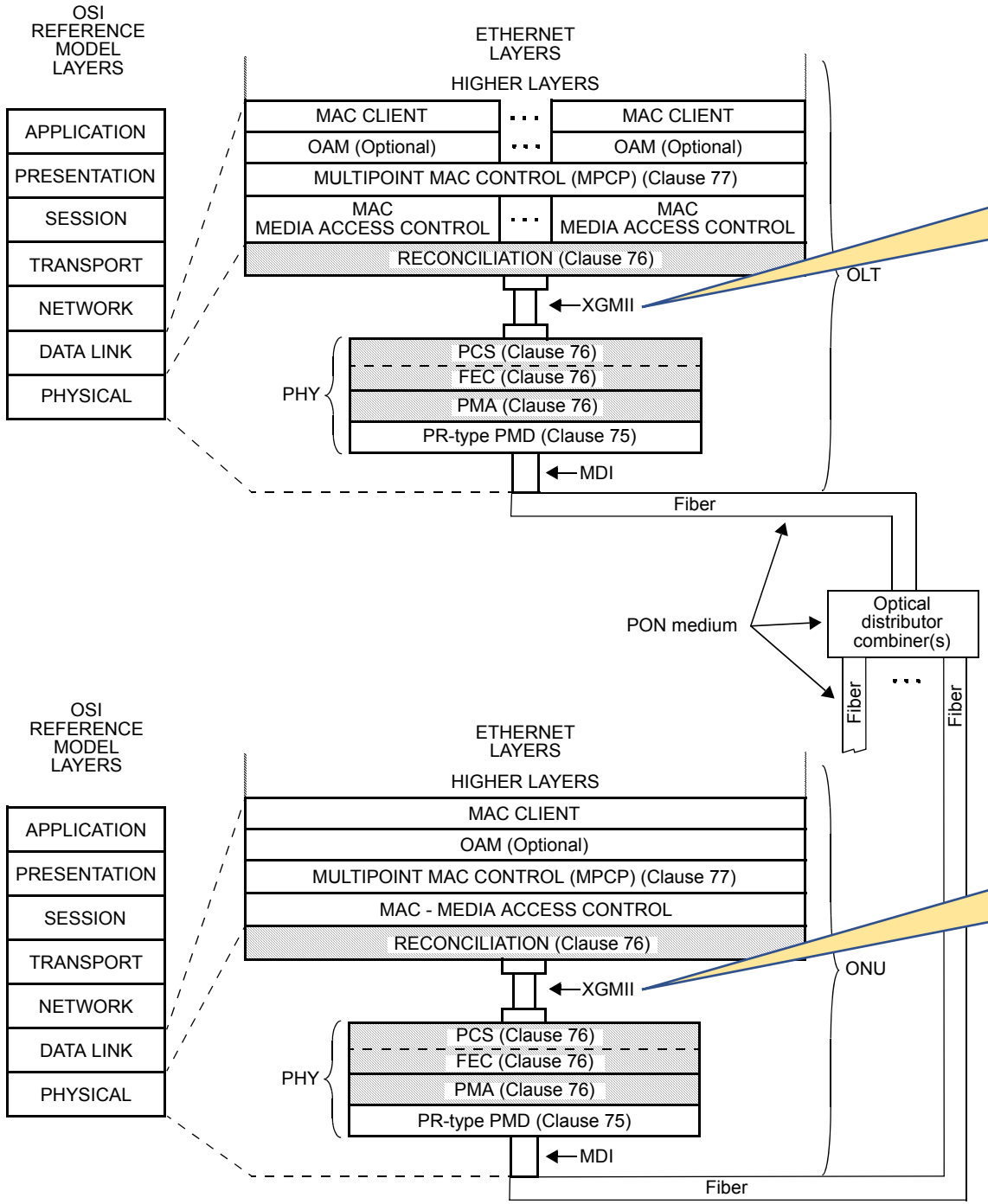
a) The XGMII is functionally similar to the MII defined in Clause 22 and GMII defined in Clause 35 as they all define an interface allowing independent development of MAC and PHY logic.
b) The RS converts between the MAC serial data stream and the parallel data paths of the XGMII.
c) The RS maps the signal set provided at the XGMII to the PLS service primitives provided at the MAC.
d) Each direction of data transfer is independent and serviced by data, control, and clock signals.
e) The RS generates continuous data or control characters on the transmit path and expects continuous data or control characters on the receive path.
f) The RS participates in link fault detection and reporting by monitoring the receive path for status reports that indicate an unreliable link, and generating status reports on the transmit path to report detected link faults to the DTE on the remote end of the connecting link.
g) When the XGMII is optionally extended with XAUI, two XGMII interfaces logically exist (see Figure 46–1). The transmit path signals are from the RS to the DTE (top) XGXS of the XAUI via one XGMII and from the PHY (bottom) XGXS to the PCS via the other XGMII. The receive path signals are from the PCS to the PHY XGXS of the XAUI via one XGMII and from the DTE XGXS to the RS via the other XGMII. The descriptions of the XGMII as between the RS and the PCS are, therefore, equally applicable between the RS and the DTE XGXS or the PHY XGXS and the PCS.
h) The XGMII may also support Low Power Idle (LPI) signaling for PHY types supporting Energy-Efficient Ethernet (EEE) (see Clause 78).
i) The XGMII is rate scalable and may support rates of 2.5 Gb/s, 5 Gb/s, and 10 Gb/s.

46.1.2 Application

This clause applies to the interface between the MAC and PHY. The physical implementation of the interface is primarily intended as a chip-to-chip (integrated circuit to integrated circuit) interface implemented with traces on a printed circuit board. The XGMII may also be used in other ways, for example, as a logical interface between ASIC logic modules within an integrated circuit.

This interface is used to provide media independence so that an identical media access controller may be used with all 2.5GBASE, 5GBASE, and 10GBASE PHY types.

2.5G-EPON from 10G-EPON



TX_CLK: 1/64 × f_{MAC} ± 100ppm
- TX f_{MAC} : 10Gb/s → 156.25 MHz

RX_CLK: 1/64 × f_{MAC} ± 100ppm
- RX f_{MAC} : 2.5Gb/s → 39.0625 MHz

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- TX f_{MAC} : 2.5Gb/s → 39.0625 MHz

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- RX f_{MAC} : 10Gb/s → 156.25 MHz

Updated GATE MPCPDU Discovery Information

Updated GATE MPCPDU discovery information fields

	Bit	Flag field	Values	
10G-EPON Parameters	0	OLT is 1G upstream capable	0 – OLT does not support 1 Gb/s reception 1 – OLT supports 1 Gb/s reception	Ignored for Super-PON
	1	OLT is 10G upstream capable	0 – OLT does not support 10 Gb/s reception 1 – OLT supports 10 Gb/s reception	Super-PON Parameters
	2	OLT is 2.5G upstream capable	0 – OLT does not support 2.5 Gb/s reception 1 – OLT supports 2.5 Gb/s reception	
	3	Reserved	Ignored on reception	
10G-EPON Parameters	4	OLT is opening 1G discovery window	0 – OLT cannot receive 1 Gb/s data in this window 1 – OLT can receive 1 Gb/s data in this window	Ignored for Super-PON
	5	OLT is opening 10G discovery window	0 – OLT cannot receive 10 Gb/s data in this window 1 – OLT can receive 10 Gb/s data in this window	Super-PON Parameters
	6	OLT is opening 2.5G discovery window	0 – OLT cannot receive 2.5 Gb/s data in this window 1 – OLT can receive 2.5 Gb/s data in this window	
	7-10	Reserved	Ignored on reception	
	11	Supported FSR Set	0 – OLT supports FSR Set 1 1 – OLT supports FSR Set 2	Super-PON Parameters
	12-15	Channel information	Encodes the channel number the OLT is operating on	

REGISTER_REQ MPCPDU

Table 77–6—REGISTER_REQ MPCPDU Discovery Information Fields

Bit	Flag field	Values
0	ONU is 1G upstream capable	0 – ONU transmitter is not capable of 1 Gb/s 1 – ONU transmitter is capable of 1 Gb/s
1	ONU is 10G upstream capable	0 – ONU transmitter is not capable of 10 Gb/s 1 – ONU transmitter is capable of 10 Gb/s
2–3	Reserved	Ignored on reception
4	1G registration attempt	0 – 1 Gb/s registration is not attempted 1 – 1 Gb/s registration is attempted
5	10G registration attempt	0 – 10 Gb/s registration is not attempted 1 – 10 Gb/s registration is attempted
6–15	Reserved	Ignored on reception

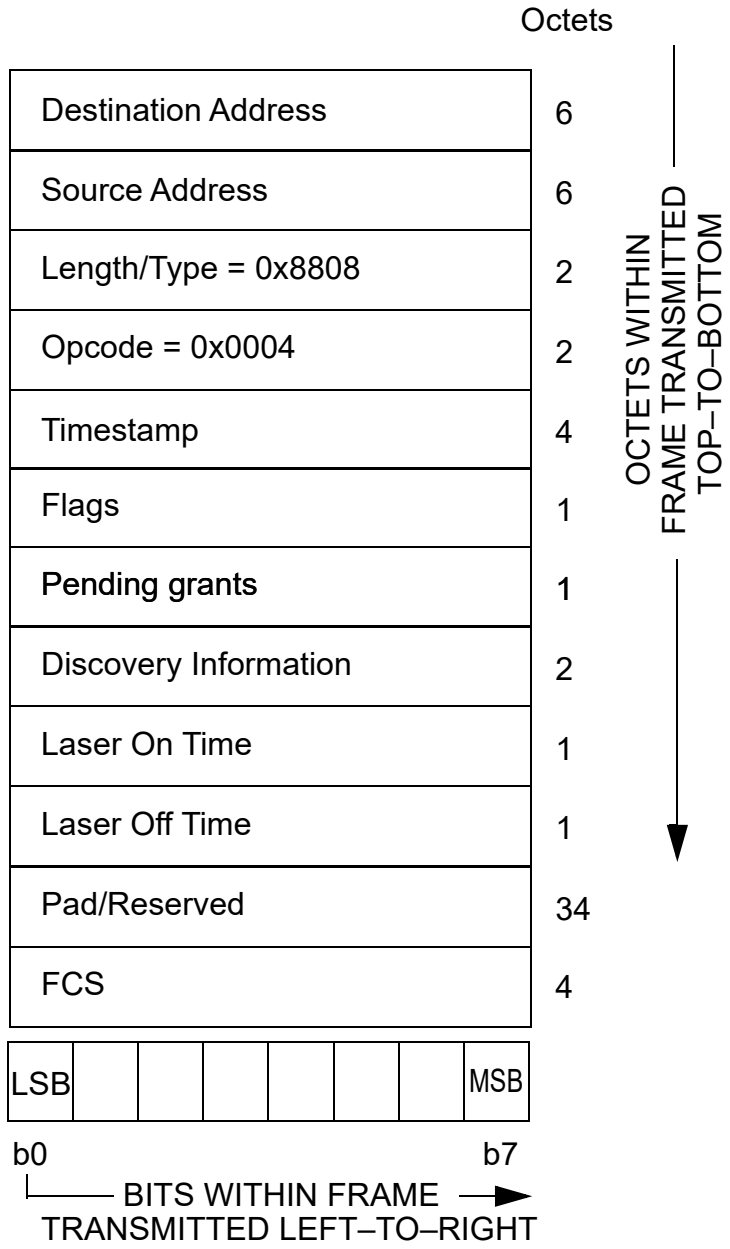


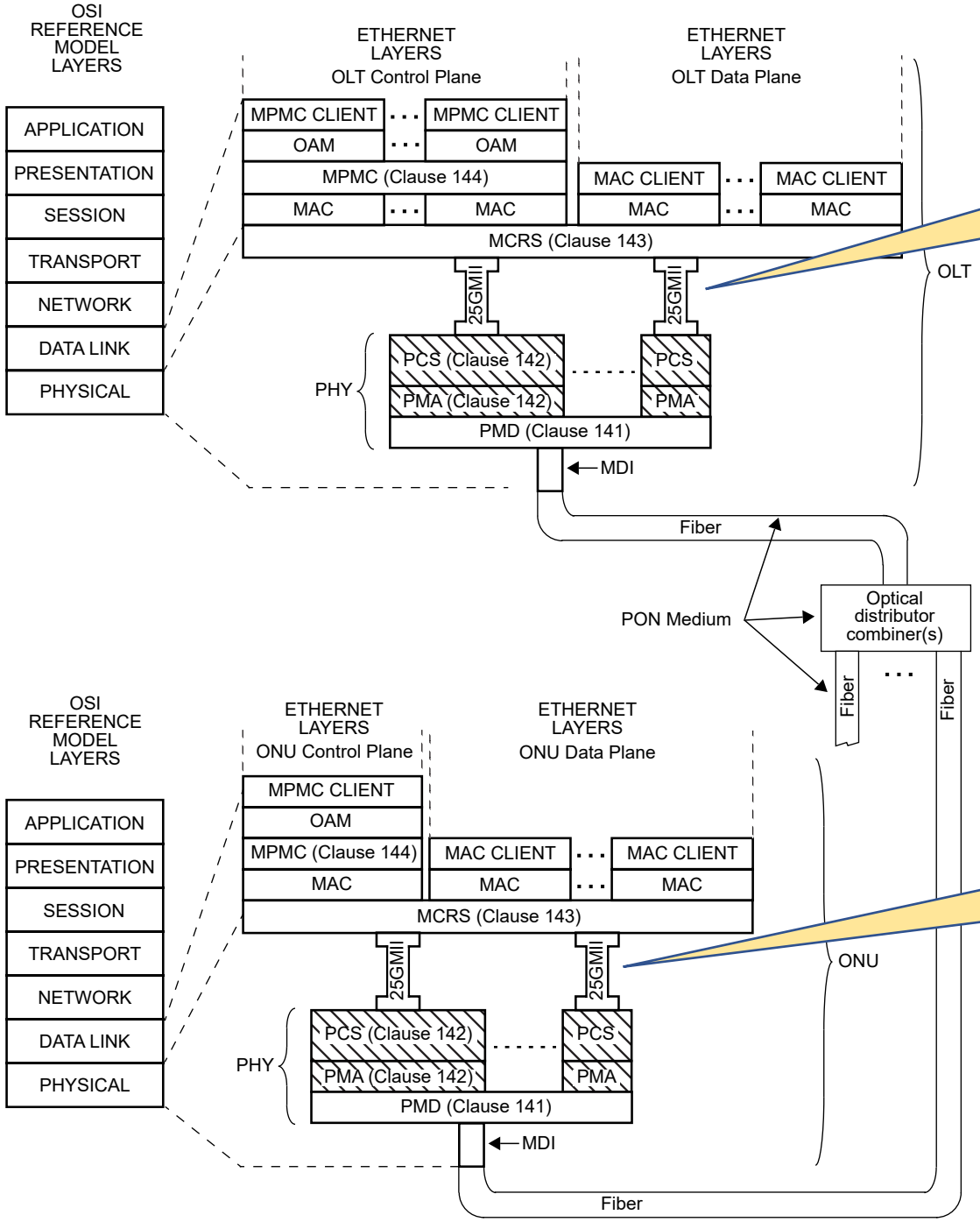
Figure 77–34—REGISTER_REQ MPCPDU

Updated REGISTER_REQ MPCPDU Discovery Information

Updated REGISTER_REQ MPCPDU discovery information fields

	Bit	Flag field	Values	
10G-EPON Parameters	0	ONU is 1G upstream capable	0 – ONU transmitter is not capable of 1 Gb/s 1 – ONU transmitter is capable of 1 Gb/s	Ignored for Super-PON
	1	ONU is 10G upstream capable	0 – ONU transmitter is not capable of 10 Gb/s 1 – ONU transmitter is capable of 10 Gb/s	Super-PON Parameters
	2	ONU is 2.5G upstream capable	0 – ONU transmitter is not capable of 2.5 Gb/s 1 – ONU transmitter is capable of 2.5 Gb/s	
	3	Reserved	Ignored on reception	
10G-EPON Parameters	4	1G registration attempt	0 – ONU transmitter is not capable of 1 Gb/s 1 – ONU transmitter is capable of 1 Gb/s	Ignored for Super-PON
	5	10G registration attempt	0 – ONU transmitter is not capable of 10 Gb/s 1 – ONU transmitter is capable of 10 Gb/s	Super-PON Parameters
	6	2.5G registration attempt	0 – ONU transmitter is not capable of 2.5 Gb/s 1 – ONU transmitter is capable of 2.5 Gb/s	
	7-15	Reserved	Ignored on reception	

2.5G-EPON from 25G-EPON



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- TX f_{MAC} : 10Gb/s → 156.25 MHz

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- RX f_{MAC} : 2.5Gb/s → 39.0625 MHz

TX_CLK: 1/64 × f_{MAC} ± 100ppm
- TX f_{MAC} : 2.5Gb/s → 39.0625 MHz

RX_CLK: 1/64 × f_{MAC} ± 100ppm
- RX f_{MAC} : 10Gb/s → 156.25 MHz

MAC Control Opcodes

Table 31A–1—MAC Control opcodes

Opcode (Hexadecimal)	MAC Control function	Specified in	Value/Comment	Timestamp[a]
00-00	Reserved			
00-01	PAUSE	Annex 31B	Requests that the recipient stops transmitting non-control frames for a period of time indicated by the parameters of this function.	No
00-02	GATE	Clause 64, Clause 77, Clause 103	Request that the recipient allows transmission of frames at a time, and for a period of time indicated by the parameters of this function.	Yes
00-03	REPORT	Clause 64, Clause 77, Clause 103	Notify the recipient of pending transmission requests as indicated by the parameters of this function.	Yes
00-04	REGISTER_REQ	Clause 64, Clause 77, Clause 103	Request that the station be recognized by the protocol as participating in a gated transmission procedure as indicated by the parameters of this function.	Yes
00-05	REGISTER	Clause 64, Clause 77, Clause 103	Notify the recipient that the station is recognized by the protocol as participating in a gated transmission procedure as indicated by the parameters of this function.	Yes
00-06	REGISTER_ACK	Clause 64, Clause 77, Clause 103	Notify the recipient that the station acknowledges participation in a gated transmission procedure.	Yes
00-07 through 0~~1~~0-~~00~~11	Reserved			
00-12	GATE	144.3.6.1	Request that the recipient allows transmission of frames at a time, and for a period of time indicated by the parameters of this function.	Yes
00-13	REPORT	144.3.6.2	Notify the recipient of pending transmission requests as indicated by the parameters of this function.	Yes
00-14	REGISTER_REQ	144.3.6.3	Request that the station be recognized by the protocol as participating in a gated transmission procedure as indicated by the parameters of this function.	Yes

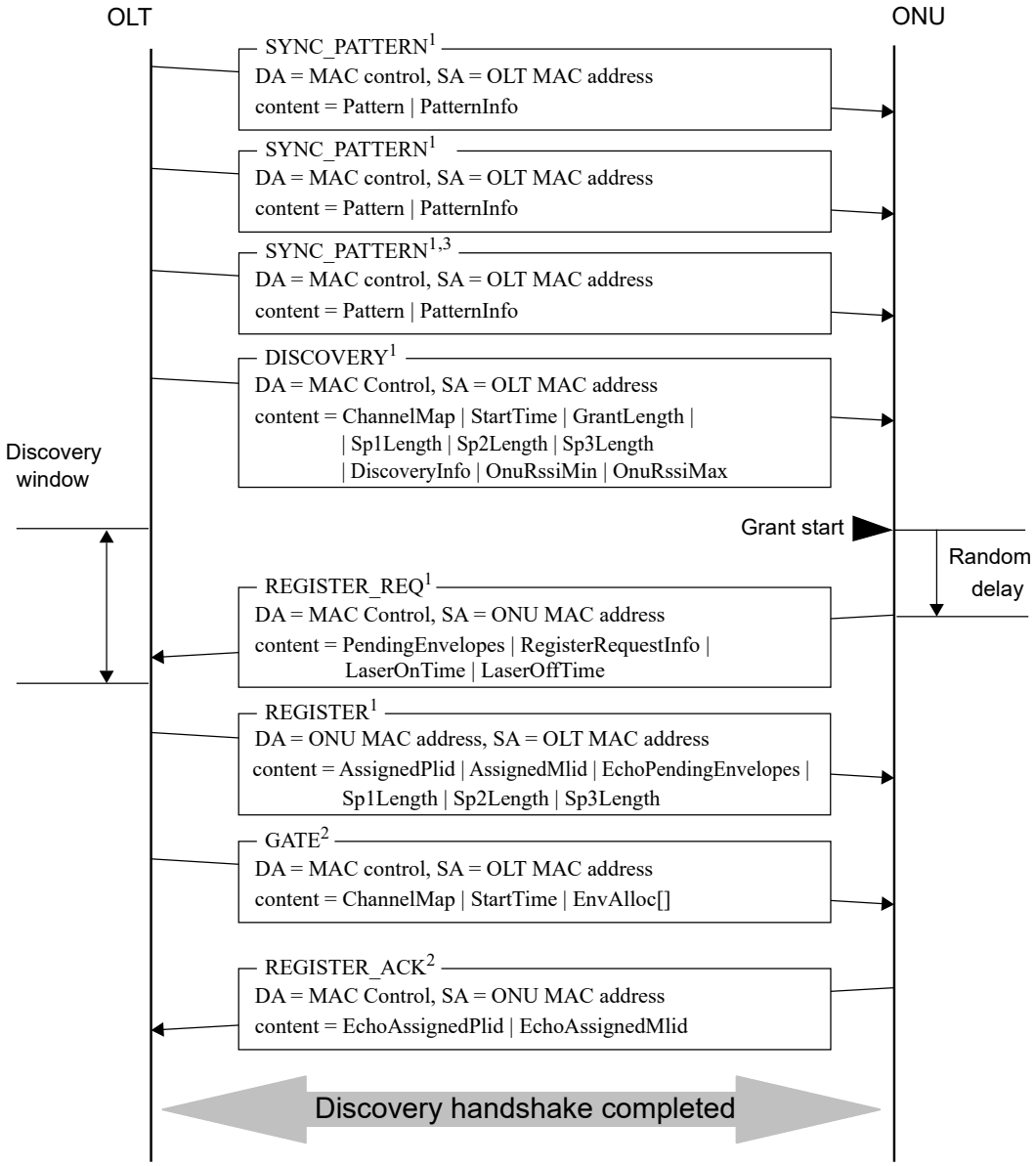
Table 31A–1—MAC Control opcodes *(continued)*

Opcode (Hexadecimal)	MAC Control function	Specified in	Value/Comment	Timestamp[a]
00-15	REGISTER	144.3.6.4	Notify the recipient that the station is recognized by the protocol as participating in a gated transmission procedure as indicated by the parameters of this function.	Yes
00-16	REGISTER_ACK	144.3.6.5	Notify the recipient that the station acknowledges participation in a gated transmission procedure.	Yes
00-17	DISCOVERY	144.3.6.6	Request that recipients attempt registration during the discovery window.	Yes
00-18	SYNC_PATTERN	144.3.6.7	Announces burst synchronization patterns to all unregistered ONUs, multiple/all registered ONUs, or individual registered ONUs.	Yes
00-19 through 00-1f	Reserved			
00-20	CC_REQUEST	144.4.3.1	Query or change the state of ONU channel(s)	No
00-21	CC_RESPONSE	144.4.3.2	Report current channel(s) state and action result code	No
00-22 through 01-00	Reserved			
01-01	PFC	Annex 31D and IEEE Std 802.1Q	Requests that the recipient stops transmissions in the priorities indicated in the parameters of the function for a period of time also indicated in the parameters.	No
01-02 through FF-FD	Reserved			
FF–FE	EXTENSION	Annex 31C	This frame is used for Organization–Specific Extension. Upon reception of this message, the MAC Control generates MA_CONTROL.Indication informing the MAC Control Client to perform the relevant action.	No
FF-FF	Reserved			

[a]The timestamp field is generated by MAC Control and is not exposed through the client interface.

25G-EPON Discovery

- We need to leverage the DISCOVERY MPCPDU



[1] Messages sent on discovery PLID (DISC_PLID)
[2] Messages sent on unicast PLID
[3] Present only when *Count* in SYNC_PATTERN MPCPDU is equal to 3

Figure 144–19—Discovery handshake message exchange

DISCOVERY MPCPDU

- We can leverage the ChannelMap and DiscoveryInfo fields

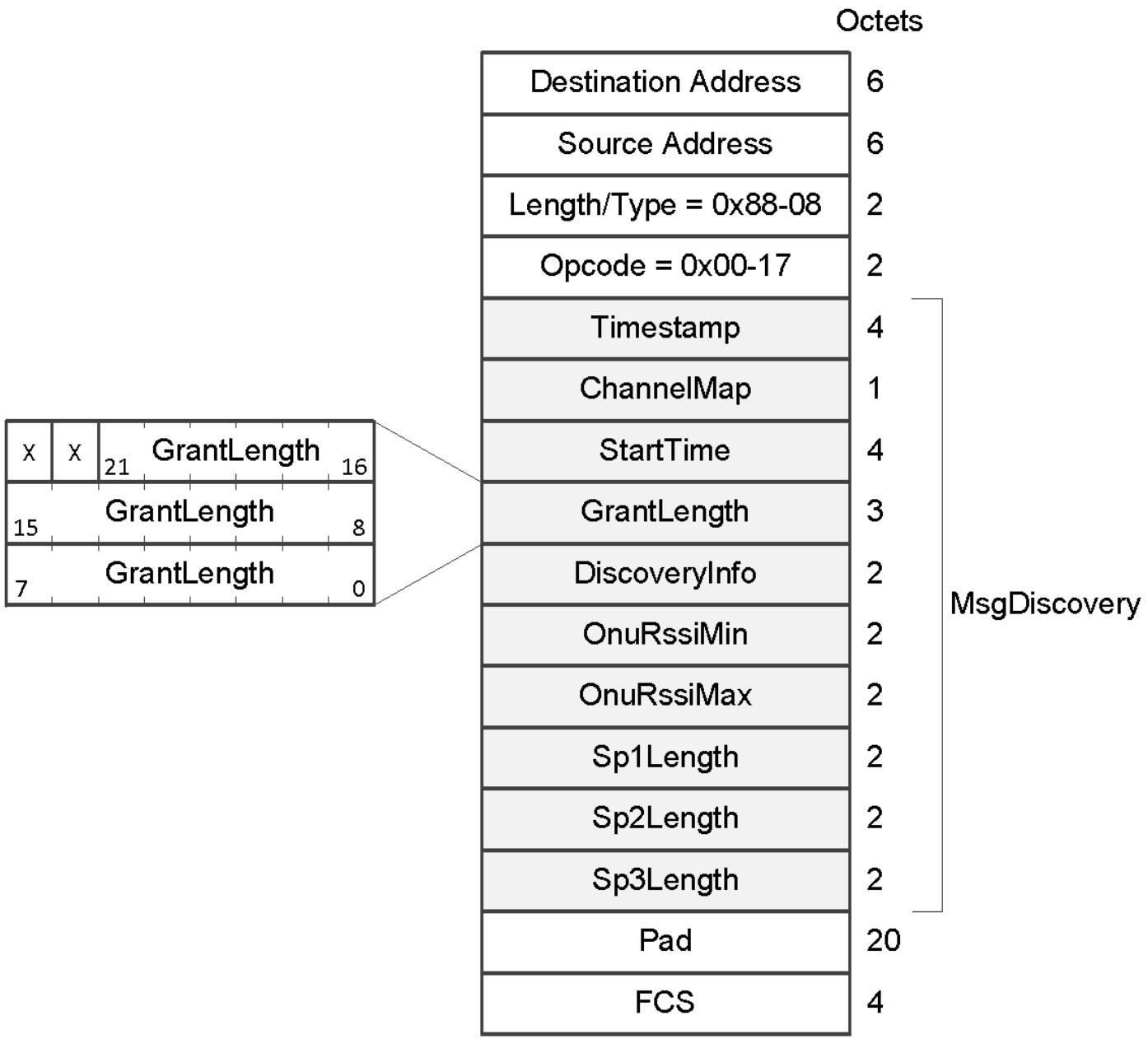


Figure 144–17—DISCOVERY MPCPDU

ChannelMap Field

Table 144–2—*ChannelMap* bit assignment

Bit	Channel field	Values
0	Upstream channel 0	0 – do not use upstream channel 0 for transmission 1 – use upstream channel 0 for transmission
1	Upstream channel 1	0 – do not use upstream channel 1 for transmission 1 – use upstream channel 1 for transmission
2-7	Reserved	set to 0

5 bits needed:

- 4 to identify the channel
- 1 to identify the FSR Set

Updated ChannelMap Field

Updated ChannelMap bit assignment

Bit	Channel field	Values
0	Upstream Channel 0	0 – do not use upstream channel 0 for upstream 1 – use upstream channel 0 for upstream
1	Upstream Channel 1	0 – do not use upstream channel 1 for upstream 1 – use upstream channel 1 for upstream
2	Reserved	Set to 0
3	Supported FSR Set	0 – OLT supports FSR Set 1 1 – OLT supports FSR Set 2
4-7	Channel information	Encodes the channel number the OLT is operating on

10G-EPON Parameters

Super-PON Parameters

DiscoveryInfo Field

Table 144–7—*DiscoveryInfo* field

Bit	Flag field	Values
0	Reserved	Ignored on Reception
1	OLT is 10G upstream capable	0 – OLT does not support 10 Gb/s reception 1 – OLT supports 10 Gb/s reception
2	OLT is 25G upstream capable	0 – OLT does not support 25 Gb/s reception 1 – OLT supports 25 Gb/s reception
3-4	Reserved	Ignored on Reception
5	OLT is opening 10G discovery window	0 – OLT cannot receive 10 Gb/s data in this window 1 – OLT can receive 10 Gb/s data in this window
6	OLT is opening 25G discovery window	0 – OLT cannot receive 25 Gb/s data in this window 1 – OLT can receive 25 Gb/s data in this window
7-13	Reserved	Ignored on Reception
14	Coexistence class G	0 – ONUs supporting PMDs coexistence class G are not allowed to register 1 – ONUs supporting PMDs coexistence class G are allowed to register
15	Coexistence class X	0 – ONUs supporting PMDs coexistence class X are not allowed to register 1 – ONUs supporting PMDs coexistence class X are allowed to register

Updated DiscoveryInfo Field

Updated DiscoveryInfo field

	Bit	Flag field	Values	
	0	Reserved	Ignored on reception	
25G-EPON Parameters	1	OLT is 10G upstream capable	0 – OLT does not support 10 Gb/s reception 1 – OLT supports 10 Gb/s reception	Super-PON Parameters
25G-EPON Parameters	2	OLT is 25G upstream capable	0 – OLT does not support 25 Gb/s reception 1 – OLT supports 25 Gb/s reception	Super-PON Parameters
	3	OLT is 2.5G upstream capable	0 – OLT does not support 2.5 Gb/s reception 1 – OLT supports 2.5 Gb/s reception	Super-PON Parameters
	4	Reserved	Ignored on reception	
25G-EPON Parameters	5	OLT is opening 10G discovery window	0 – OLT cannot receive 10 Gb/s data in this window 1 – OLT can receive 10 Gb/s data in this window	Super-PON Parameters
25G-EPON Parameters	6	OLT is opening 25G discovery window	0 – OLT cannot receive 25 Gb/s data in this window 1 – OLT can receive 25 Gb/s data in this window	Super-PON Parameters
	7	OLT is opening 2.5G discovery window	0 – OLT cannot receive 2.5 Gb/s data in this window 1 – OLT can receive 2.5 Gb/s data in this window	Super-PON Parameters
	8-13	Reserved	Ignored on reception	
	14	Coexistence class G	0 – ONUs supporting PMDs coexistence class G are not allowed to register 1 – ONUs supporting PMDs coexistence class G are allowed to register	
	15	Coexistence class X	0 – ONUs supporting PMDs coexistence class X are not allowed to register 1 – ONUs supporting PMDs coexistence class X are allowed to register	

REGISTER_REQ RegisterRequestInfo Field

Table 144–4—*RegisterRequestInfo* field

Bit	Flag field	Values
0	Reserved	Ignored on Reception
1	ONU is 10G upstream capable	0 – ONU transmitter is not capable of 10 Gb/s 1 – ONU transmitter is capable of 10 Gb/s
2	ONU is 25G upstream capable	0 – ONU transmitter is not capable of 25 Gb/s 1 – ONU transmitter is capable of 25 Gb/s
3-4	Reserved	Ignored on Reception
5	10G registration attempt	0 - 10 Gb/s registration is not attempted 1 - 10 Gb/s registration is attempted
6	25G registration attempt	0 - 25 Gb/s registration is not attempted 1 - 25 Gb/s registration is attempted
7-15	Reserved	Ignored on Reception

Updated REGISTER_REQ RegisterRequestInfo Field

Updated REGISTER_REQ MPCPDU discovery information fields

	Bit	Flag field	Values	
	0			
25G-EPON Parameters	1	ONU is 10G upstream capable	0 – ONU transmitter is not capable of 10 Gb/s 1 – ONU transmitter is capable of 10 Gb/s	
	2	ONU is 25G upstream capable	0 – ONU transmitter is not capable of 25 Gb/s 1 – ONU transmitter is capable of 25 Gb/s	Super-PON Parameters
	3	ONU is 2.5G upstream capable	0 – ONU transmitter is not capable of 2.5 Gb/s 1 – ONU transmitter is capable of 2.5 Gb/s	
	4	Reserved	Ignored on reception	
25G-EPON Parameters	5	10G registration attempt	0 – ONU transmitter is not capable of 10 Gb/s 1 – ONU transmitter is capable of 10 Gb/s	
	6	25G registration attempt	0 – ONU transmitter is not capable of 25 Gb/s 1 – ONU transmitter is capable of 25 Gb/s	Super-PON Parameters
	7	2.5G registration attempt	0 – ONU transmitter is not capable of 2.5 Gb/s 1 – ONU transmitter is capable of 2.5 Gb/s	
	8-15	Reserved	Ignored on reception	

Summary

- Super-PON has some specific PCS requirements
  - Support tunable transmitters
  - Support the 2.5G upstream speed
- Both 10G-EPON and 25G-EPON PCS and associated control protocols can be made to work
- Selecting the 10G-EPON PCS allow sharing the IEEE P802.3cs PMDs with the ITU-T Super-PON project
- Question: could we allow both?
  - Select the 10G-EPON PCS as the preferred one
  - Allow reusing the 25G-EPON PCS for the future

Thank you!