IEEE 50 Gb/s EPON (50G-EPON)

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***Abstract**: Much has transpired over the past several years for passive optical network (PON) technology. The era of higher speed PON will soon be upon us as the IEEE 802.3ca Task Force puts the finishing touches on the standard for 25 Gb/s PON and 50 Gb/s PON. This paper discusses the next generation of IEEE optical access, the 50 Gb/s Ethernet Passive Optical Network (50G-EPON), capable of symmetric or asymmetric rates up to 50 Gb/s while coexisting with legacy PON technologies on the same optical distribution network.*

1. Introduction

Nobody knows the extent to which broadband speeds will continue to increase over the next 5-10 years. The only certainty is that broadband speeds *will continue* to increase. Just two years ago only 5% of cable subscribers had gigabit broadband speeds available to them, whereas at the end of 2019 more than 90% of cable subscribers had gigabit broadband speeds available to them. This equates to over 80% of the US population now having the option to subscribe to broadband speeds of 1 Gb/s!

With the announcement of the 10G Platform [1], the cable industry has set a new target for future broadband speeds of at least 10 Gb/s, with symmetry being a key component of that new speed target. Additionally, there is no question that latency is becoming the new network differentiator, and so the 10G Platform also promises lower latency connections. Finally, higher reliability and better security complete the set of four key pillars of the 10G Platform as announced by the cable industry.

Thus, with the continually increasing broadband speeds and a new speed target, the standardization of the next generation of 25 Gb/s and 50 Gb/s PON technology is very timely. The remainder of this paper discusses the updated standards objectives and a few key capabilities included in this new technology.

2. 50 Gb/s EPON Objectives

Almost four years ago, at Optical Fiber Communications Conference 2016, the objectives for the next generation of IEEE PON were communicated [2]. In 2017 the scope of the standardization activity was reduced from 100 Gb/s to 50 Gb/s. The motivation for this scope reduction revolved around both technical and economic feasibility - two very important criteria for standards development within the IEEE 802.3 Working Group. In brief, the 802.3ca Task Force arrived at the conclusion that a four-wavelength solution was not economically feasible, primarily because of a requirement to use optical amplifiers to support the required power budget in such a multi-wavelength solution. Thus, in November 2017 the Task Force agreed to reduce the scope of the objectives and focus on a two-wavelength 50 Gb/s PON solution. The objectives for symmetric and asymmetric data rates are as follows:

Support symmetric and/or asymmetric MAC data rates of:

- *25 Gb/s in downstream and 10 Gb/s or 25 Gb/s in upstream (25G-EPON)*
- *50 Gb/s in downstream and 10 Gb/s, 25 Gb/s, or 50 Gb/s in upstream (50G-EPON)*

A critical component of any next-generation optical technology is the ability to coexist with legacy technology on the same fiber plant. IEEE 802.3 Working Group had already standardized two generations of PON technology: 1G-EPON and 10G-EPON. When a 1G-EPON optical network unit (ONU) employed a 20nm upstream transmitter, which was often the case, then both EPON technology generations can coexist on a single fiber plant because their operating wavelengths are sufficiently separated to avoid interference. However, the 802.3ca Task Force was less concerned about a 25 Gb/s or 50 Gb/s PON coexisting with a 1 Gb/s PON due to at least 25x difference in data rate; the prevailing sentiment at the time was an operator wishing to deploy 25G-EPON or 50G-EPON will likely be less concerned about coexisting with a 1 Gb/s technology. An objective to coexist with only 10G-EPON, and not coexist with 1G-EPON, remains consistent with objectives adopted in 2016 [2].

One significant scope increase occurred when the task force recognized the importance of coexisting with other types of PON technologies, specifically GPON, XG-PON1, and XGS-PON, all of which are developed by the ITU. Motivation for coexisting with these PON technologies lies in the recognition that past deployers of legacy ITU PON technologies may find significant benefit switching to a superior and more cost effective 25G-EPON or 50G-EPON technology that meets their own customer's growing high-speed data requirements. Thus, in addition to an objective related to operation over existing optical distribution networks, the coexistence objectives were modified as follows:

- *Wavelength allocation allowing concurrent operation with 10G-EPON, XG-PON1, and XGS-PON PHYs (1575nm-1580nm downstream, 1260nm-1280nm upstream)*
- *Wavelength allocation allowing concurrent operation of 25G-EPON and GPON reduced wavelength set (1480nm-1500nm downstream, 1290nm-1330nm upstream) PHYs*

3. 50G-EPON Architecture

After considering many aspects of technical and economic feasibility, the 802.3ca Task Force settled on an architecture that leverages a pair of wavelengths each operating at 25 Gb/s, one wavelength for upstream transmission, one wavelength downstream transmision). A single wavelength pair is suitable for a symmetric 25G-EPON, while two wavelength pairs are required for 50G-EPON. The architecture is shown in Figure 1. Notably, a 25G-EPON optical line terminal (OLT) will support a symmetric ONU with 25 Gb/s downstream and 25 Gb/s upstream, and the OLT will also support an asymmetric ONU with 25 Gb/s downstream and only 10 Gb/s upstream.

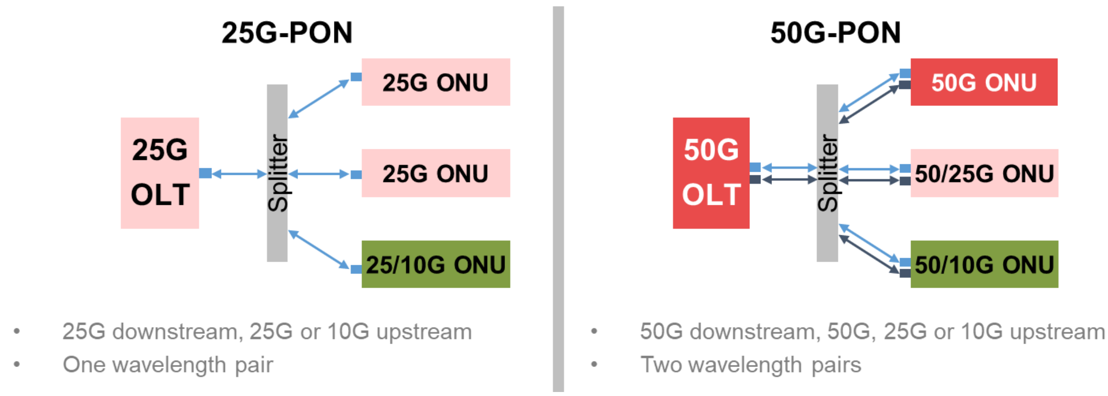

Figure 1: 25G-EPON and 50G-EPON Architecture

Similarly, a 50G-EPON OLT will be required to support five types of ONUs: symmetric 50 Gb/s, asymmetric with 50 Gb/s downstream and either 25 Gb/s or 10 Gb/s upstream, symmetric 25 Gb/s, and asymmetric with 25 Gb/s downstream and 10 Gb/s upstream.

4. Operating Wavelengths

Accommodating the coexistence objectives while striving to maintain cost efficiency by avoiding wavelength tunability and leveraging the low-dispersion region of the O-band was not a trivial task. There were many proposals for center wavelength and wavelength range that were rejected. Again, in the consideration of economic feasibility, the 802.3ca Task Force agreed on three upstream wavelengths and two downstream wavelengths, as shown in Table 1.

Table 1: Upstream and downstream wavelengths

Wavelength Name	Upstream/Downstream	Center Wavelength (nm)	Wavelength Range (nm)
DW0	Downstream	1358	±2
DW1	Downstream	1342	±2
UW0	Upstream	1270	±10
UW1	Upstream	1300	±10
UW2	Upstream	1320	±2

These wavelengths and their relation to one another are shown in Figure 2.

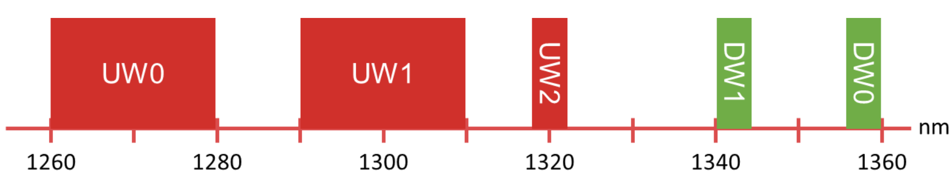

Figure 2: 25G-EPON and 50G-EPON wavelengths

5. Supporting Coexistence Objectives

It may seem strange that three upstream wavelengths were selected when only two were needed for the full 50 Gb/s. Motivation for selecting the two wideband upstream wavelengths revolved around a desire to keep a greenfield 25G-EPON or 50G-EPON as low cost as possible. Realizing the upstream transmitter on an optical network unit needs to be kept inexpensive, using a wider wavelength puts the cost of a 25 Gb/s transmitter on a path to be on par with 10G-EPON upstream transmitters. If only a 25G-EPON is desired without coexisting with another legacy PON, then upstream wavelength UW0 is used with downstream wavelength DW0. This keeps the diplex filter simpler since the wavelengths are farther apart. For 50G-EPON without coexisting with another legacy PON, then the two wideband wavelength ranges can be used for a cost-effective solution. The wavelength plan for a 50G-EPON without coexistence requirements is shown in Figure 3.

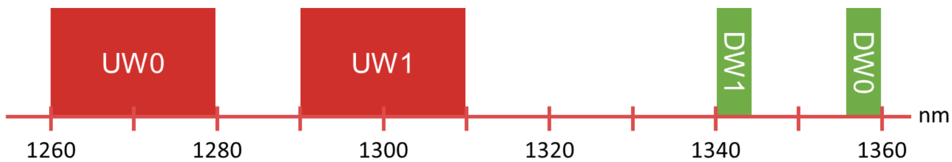

Figure 3: Wavelengths for 50G-EPON with no coexistence requirements.

First generation PON technologies, 1G-EPON and GPON, have been the most widely deployed PON technologies in the world. For operators requiring coexistence with GPON, upstream wavelength UW0 and downstream wavelength DW0 can be added to provide a solution offering 10x more capacity. In fact, operators may also add DW1 to the solution to achieve an asymmetric 50G/25G-EPON that coexists with GPON or 1G-EPON. This wavelength plan for coexisting with GPON or 1G-EPON is shown in Figure 4.

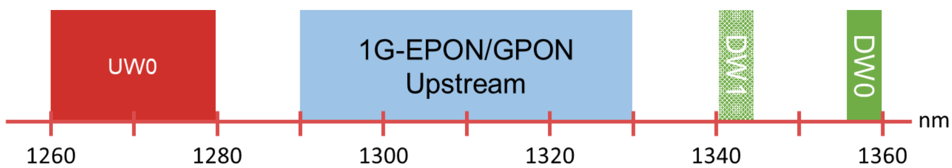

Figure 4: Wavelength plan for coexistence with GPON.

It is expected that year 2020 will be the year that 10G PON technologies surpass annual deployments of first generation PON technologies (1G-EPON, GPON). Therefore, as 25G-EPON and 50G-EPON become available, this newer and higher capacity technology may have to coexist with legacy 10G-PON. An additional 25Gb/s capacity is easily added by using UW1 and DW0, and a full 50 Gb/s can be added using UW1+UW2 and DW0+DW1, as shown in Figure 5.

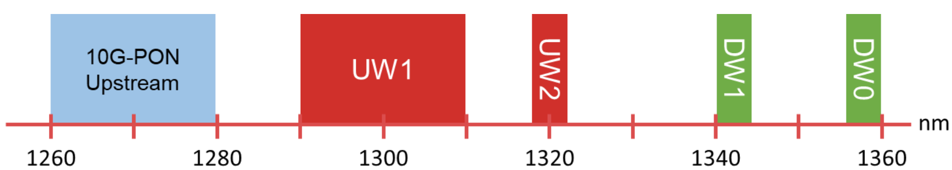

Figure 5: Wavelength plan for coexistence with 10G PON (10G-EPON, XGS-PON).

6. Conclusions

Speed and coexistence requirements are only two of the outstanding capabilities built into the next generation of EPON. Look for the standard to be completed by mid-2020, and devices to become available in early 2021.

7. References

[1] www.10gplatform.com
[2] *IEEE 100 Gb/s EPON*, Curtis Knittle, OFC 2016, https://www.osapublishing.org/abstract.cfm?uri=OFC-2016-Th1I.6