Calix

WHITE PAPER

Next-Generation PON: Eliminating physical constraints from the access network

ABSTRACT

In response to the voracious consumer demand for bandwidth, two new next-generation passive optical network (PON) technologies have been standardized and are ready for deployment: XGS-PON and NG-PON2.

Like previous PON technologies, both transmit data through fiber-optic cables, offering very high-capacity connections to multiple subscribers. Intentionally designed to use different wavelengths than GPON, XGS-PON and NG-PON2 can co-exist on the same fiber, allowing for the re-use of many portions of the optical distribution network (ODN).

XGS-PON is the most recent standard (ITU G.9807.1) and can deliver up to 10 Gbps of symmetrical bandwidth. NG-PON2 (ITU-T G.989) utilizes multiple wavelengths and can deliver 40 Gbps — with 80 Gbps possible in the future — on a single fiber.

MEET THE NEW PONS; THEY'RE NOT THE SAME AS THE OLD PONS

As we look toward 2020, one thing is clear: bandwidth demands will grow at a faster pace than ever before. Market forecasts predict that, within three years, the number of global Internet users will surpass 4 billion. There will be more than 26 billion networked devices and connections; an average of 3.4 for each person on the planet. Further, it is projected that these devices will be used primarily for watching video content, which will account for 82 percent of all Internet Protocol (IP) traffic by 2020, generating nearly three times the volume of traffic transported in 2015.[1]

In response, much progress has been made in the standardization of next-generation passive optical network (PON) standards as communications service providers (CSPs) look to move from Gigabit to 10G services. Developed as successors to Gigabit PON (GPON) — which has been lighting up the world's optical access networks with 2.5 Gbps downstream and 1.25 Gbps upstream for the past decade — the two most recent 10G PON standards are XGS-PON (ITU G.9807.1) and NG-PON2 (ITU-T G.989).

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[1]Cisco Visual Networking Index (VNI) Forecast and Methodology, 2015-2020; June 2016; http://www.cisco.com/c/en/us/solutions/collateral/service-provider/visual-networking-index-vni/complete-white-paper-c11-481360.html

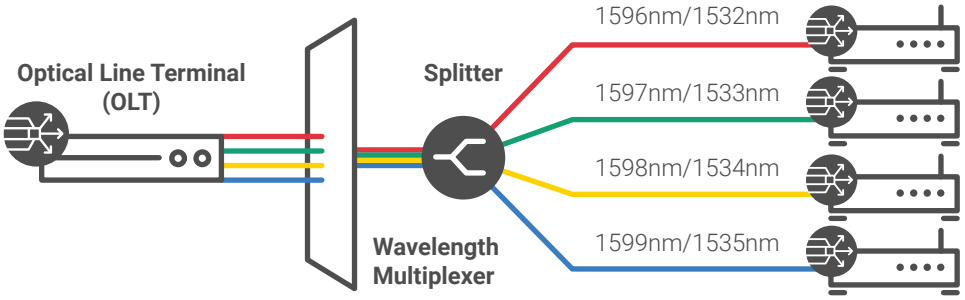

Figure 1: Multi-wavelength NG-PON2 OLT, connected to ONUs with tunable lasers and receivers.

As the voracious consumer appetite for bandwidth continues to grow, the ability to deliver 10 Gbps to individual businesses and households will be paramount for CSPs to deliver the subscriber experience and services required to compete – and win.

FOREVER CHANGING THE ACCESS NETWORK

With either XGS-PON and NG-PON2, CSPs now have technology options that provide more than just significantly enhanced speed. Both technologies offer extensive improvements over previous generations of PON that make them ideal for delivering new advanced services to multi-dwelling units (MDUs), delivering mission-critical business applications, and readying the network for 5G mobile technologies. Their most valuable application, however, may be as a catalyst to access network transformation.

Both XGS-PON and NG-PON2 are being deployed in 2017. The key difference between the two technologies is the multiple wavelengths supported on NG-PON2 — which can provide some very exciting benefits to CSPs, including the elimination of all remaining physical constraints within the access network.

NG-PON2: USING FOUR WAVELENGTHS TO STAY AHEAD OF THE CURVE

The first of the two next-generation PON standards, NG-PON2 allows for the convergence of multiple services networks onto a single ODN, resulting in significant total cost of ownership (TCO) reduction, while enabling the introduction of new, efficient architectures that are highly tuned to meet emerging subscriber demands.

GPON transmits data using a single wavelength on each fiber. NG-PON2 utilizes time and wavelength division multiplexing (TWDM) and supports a minimum of four wavelengths on each fiber, making it the industry's first multi-wavelength access standard. Each wavelength within a single fiber can deliver 10 Gbps symmetrical speed (upstream and downstream). When four wavelengths are combined, throughput can reach 40 Gbps and, in the future, it will be possible to combine eight wavelengths to deliver 80 Gbps. For this reason, NG-PON2 is often referred to 40G (or 80G) PON.

With the ability to deliver 10 Gbps (and beyond) to an individual subscriber, new business opportunities are possible, including:

- **MDUs and mission-critical business services:** Many existing structures lack in-building fiber optic cabling. When it is not possible to run fiber to each individual unit, existing 'last mile' technology — like G.fast over copper — is used to deliver connectivity. With the continued growth in MDU populations, and as the capacity of copper continues to increase, it becomes increasingly important to have a technology like NG-PON2 to deliver 10 Gbps to the building demarcation point. With the use of channel bonding, throughput can be increased to 40 Gbps and 80 Gbps in the future.
- **G mobile backhaul:** As the industry continues its rapid movement toward 5G cellular technology, wireless data rates may reach as high as 10 Gbps. To backhaul traffic from the mobile base station, connections exceeding 10 Gbps will be required. With NG-PON2, as the demand for bandwidth to a mobile base station increases, adding capacity is simply a matter of utilizing another wavelength over the existing fiber to the tower.

In addition to increased capacity, NG-PON2 has three advantages over other PON technologies.

- On-demand capacity management enables new service delivery opportunities and load balancing improvements.
- Multiple wavelengths can be used to manage PON capacity. As utilization grows, PON capacity can be easily redistributed, with new channels turned on and optical network units (ONUs) switched over to different wavelengths, without impacting the delivery of existing services.
- Support of 8 point-to-point overlay wavelengths that can be used for dedicated services such as enterprise businesses, fronthaul, etc.

These changes can be done instantly, shifting and allocating capacity on demand, enabling new time-of-day services and maintaining load balancing. Physical resources within the access network will be able to meet the dynamic needs of subscribers, without human intervention.

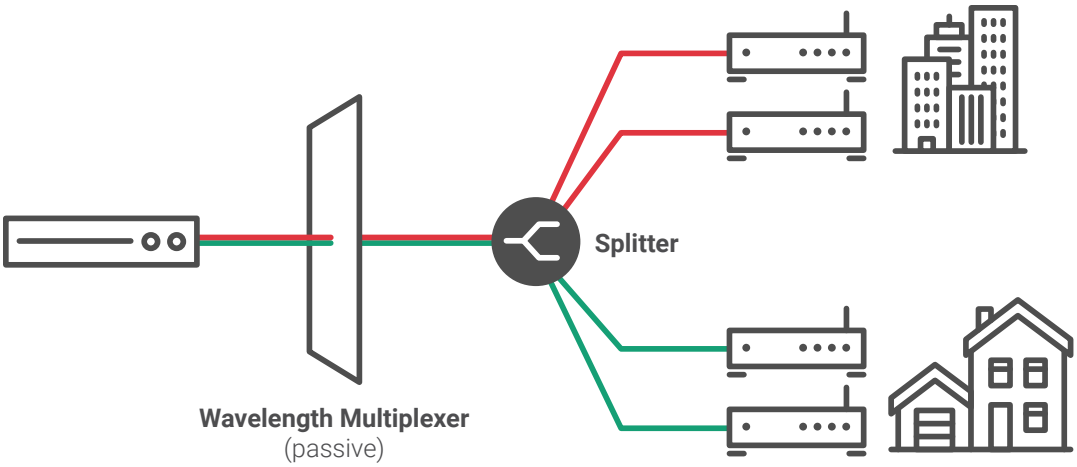

Figure 2: On-demand capacity management allows wavelengths to be redistributed, without impacting existing services.

When migrating from GPON to NG-PON2, there are two primary investments that need to be made:

1. New ONUs with tunable lasers (that can be programmed to different channels, or wavelengths), filters and receivers are required to support compliant wavelength plans. Some existing ONUs are already equipped with tunable lasers, as well as filters that allow for the co-existence of GPON and NG-PON2.
2. New OLT line cards are required to support compliant wavelength plans (as with the ONUs). In some cases, new OLTs are also required to ensure non-blocking support of NG-PON2 and to enable the desired density in the central office (CO).

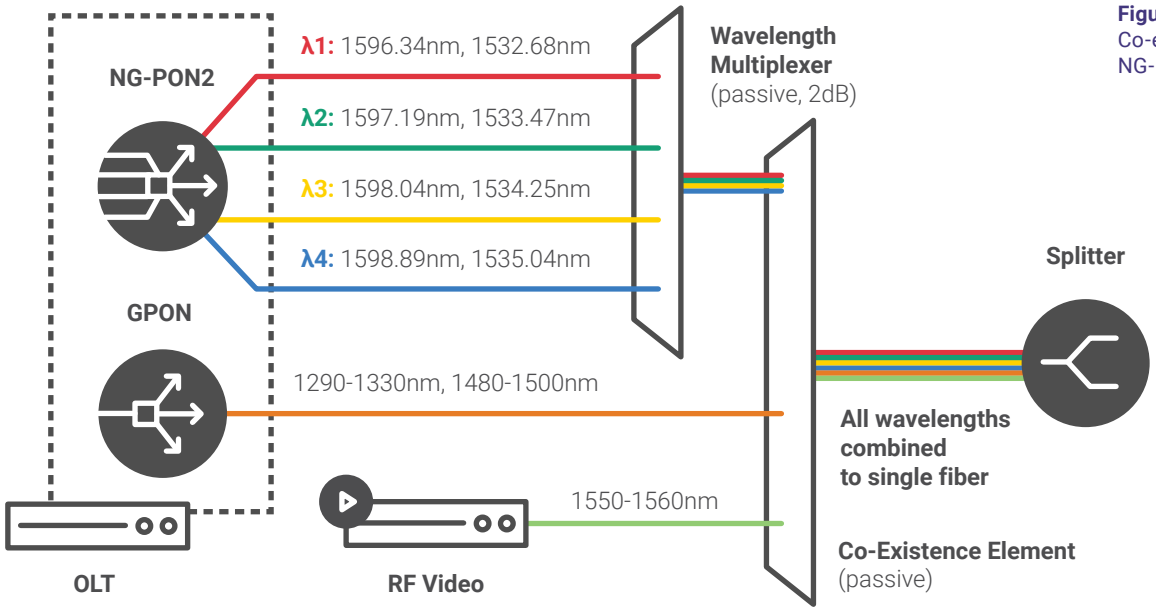

Figure 3: GPON Co-existence with NG-PON2

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With the use of NG-PON2 technology, and the ability to converge the services networks onto a single ODN, there is a significant TCO reduction.

XGS-PON: BRIDGING THE GAP BETWEEN GPON AND NG-PON2

XGS-PON (X=10, G=Gigabit, S=symmetrical) is the most recent standard and is very similar to existing GPON technology, except that it can deliver up to 10 Gbps of symmetrical bandwidth. It is considered to be a simplified version of NG-PON2, because the technology uses a fixed wavelength, meaning that it cannot harness multiple wavelengths in a single fiber to deliver more than 10 Gbps.

For some CSPs, XGS-PON will bridge the gap from GPON, providing a temporary solution, with NG-PON2 being the ultimate goal of virtually every global CSP. Because XGS-PON uses wavelengths outside of the spectrum allocated to NG-PON2 or GPON, the three technologies can co-exist on the same fiber. This allows CSPs to deploy XGS-PON to offer 10 Gbps services quickly, immediately capturing 10 Gbps service opportunities. NG-PON2 can be introduced later, without a forklift upgrade to the network and without disrupting existing XGS-PON or GPON services. Alternatively, NG-PON2 can be introduced wavelength by wavelength, allowing for a gradual investment strategy that is linked to customer demand. The Calix AXOS E7-2 Modular Access System supports the deployment of both XGS-PON and NG-PON2 in a single line card.

An overview of the two standards is shown in Table 1.

STANDARD	NG-PON2	XGS-PON
Standard Approved	June 2015	February 2016
PON Wavelengths	Up to 8 down, 8 up	1 down, 1 up
P2P Wavelenghts	Up to 8 down, 8 up	None
Bandwidths	10G/10G 10G/2.5G	10G/10G 10G/2.5G (XG-PON1)

Table 1: Next-generation ITU PON standards, comparing NG-PON2 with XGS-PON

TRANSFORMING ACCESS NETWORKS FOR THE NEXT GENERATION

NG-PON2 is gaining momentum around the world. To date, NG-PON2 has been deployed in a live network by Northpower Fibre (New Zealand) and Pilot in Manhattan using the Calix AXOS E7-2 Intelligent Modular System and in advanced testing with Verizon who has indicated intent to deploy NG-PON2 in 2017. All Calix solutions support both XGS-PON and NG-PON2 with the simple change of the optical transceiver, therefore service providers have the opportunity to choose the technology that is right for them at the time they are ready to deploy.

While there are varying rates of adoption between XGS-PON and NG-PON2, NG-PON2 technology is key to the transformation of the access network. With the use of NG-PON2 technology, and the ability to converge the services networks onto a single ODN, there is a significant TCO reduction. Add to NG-PON2 new access network architectures like Central Office Re-defined as the Datacenter (CORD), Software Defined Networking (SDN) and, more specifically for the access network, Software Defined Access (SDA) with Network Functions Virtualization (NFV) and CSPs will have transformed their access network to not only reduce their TCO but also meet the needs of the ever more demanding subscriber.