Calix

White Paper

Drive Down Costs and Accelerate Service Innovation with Next Generation PON

EXECUTIVE SUMMARY

To meet the surging consumer demand for bandwidth-heavy data services, two new next-generation passive optical network (PON) technologies have been standardized and are now being deployed by broadband service providers (BSPs): XGS-PON and NG-PON2.

Like previous PON technologies, both transmit data through fiber-optic cables, offering very high-capacity connections to multiple subscribers. However, because they are 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, which was officially standardized by the ITU in 2016 (ITU G.9807.1), can deliver up to 10 Gbps of symmetrical bandwidth. NG-PON2 (ITU-T G.989), standardized a year earlier, utilizes multiple wavelengths, and can deliver 40 Gbps—with 80 Gbps possible in the future—on a single fiber. The move to even higher-speed PONs is already underway, notably via 25G/50G-EPON (IEEE 802.3ca) and 50G-PON, the former being officially standardized in 2020.

MEET THE 10G PONS

According to the latest market forecasts[1], by 2023, nearly two-thirds of the global population (around 5.3 billion people) will have internet access, up from 3.9 billion (51 percent) in 2018. Meanwhile, the number of connected devices is expected to be more than three times the global population by 2023. This means there will be 29.3 billion networked devices by 2023—or 3.6 devices for every person on the planet, up from 2.4 devices per person in 2018. Globally, the consumer segment's share of total devices and connections will be 74 percent, with the business segment claiming the remaining 26 percent.

These new subscribers and devices are coming online as data traffic is surging. Video viewing is the main driver, accounting today for about 80 percent of all global internet traffic. These trends have been further accelerated by the impact of the COVID-19 pandemic, fueled by millions of people relying on bandwidth-consuming applications while working and schooling from home and accessing latency-sensitive online entertainment such as streaming and gaming. Zoom, a leading video conferencing platform, reported an astounding 535% rise in daily traffic in 2020. Work from anywhere and advanced home entertainment will continue to drive utilization as the world settles into the new normal–these social changes are not expected to decline. Network reliability, bandwidth capacity, and security have come under pressure as a result.

In response, BSPs are deploying next-generation PON networks to make the move from single gigabit to 10G services. Developed as successors to GPON—which for most of the past decade enabled BSPs to offer 2.5 Gbps downstream and 1.25 Gbps upstream—the two next-generation PON standards being deployed today are XGS-PON (ITU G.9807.1) and NG-PON2 (ITU-T G.989).

Like previous PON technologies, both transmit data through fiber-optic cables, offering very high-capacity connections to multiple subscribers. However, as they are intentionally designed to use different wavelengths other than GPON, XGS-PON and NG-PON2 can co-exist on the same fiber, allowing for the re-use of many portions of the ODN.

As the consumer appetite for bandwidth continues to rise, the ability to deliver 10 Gbps speeds to both businesses and households will be critical for fiber-based BSPs to deliver the subscriber experience and next-generation services required to compete—and win—in an increasingly crowded marketplace.

A CATALYST FOR TRANSFORMATION

By deploying XGS-PON or NG-PON2, BSPs now have technology options that provide more than just significantly enhanced speeds. Both technologies offer extensive improvements over previous generations of PON that make them ideal for delivering new, advanced services to multi-dwelling units (MDUs), supporting mission-critical business applications, and readying for the widespread adoption of 5G mobile technologies.

Their most valuable application, however, is as a catalyst for access network transformation. More than 225 BSPs are deploying 10G-PON from Calix today, including both XGS-PON and NG-PON2. The key technical difference between the two technologies is the fixed wavelength supported on XGS-PON versus the multiple wavelengths supported on NG-PON2. There are also costs, hardware development and availability, and speed-to-market considerations when choosing between the two.

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

Standard	Nomenclature	Bandwidth Options	Wavelengths	Primary Focus
XGS-PON (ITU G.9807.1)	10G GPON	10G Down 10G Up	1577nm Down 1270nm Up	Residential/ Business/MDU
NG-PON2 (ITU G.989)	NG-PON2	4 to 8 X 10G TDM Down 4 to 8 X 2.5G or 10G TDM up 8 P2P Up and Down @100GHz	1596-1603nm 1532-1539nm 1610-1625nm	Residential/ Business/ MDU 5G Transport

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

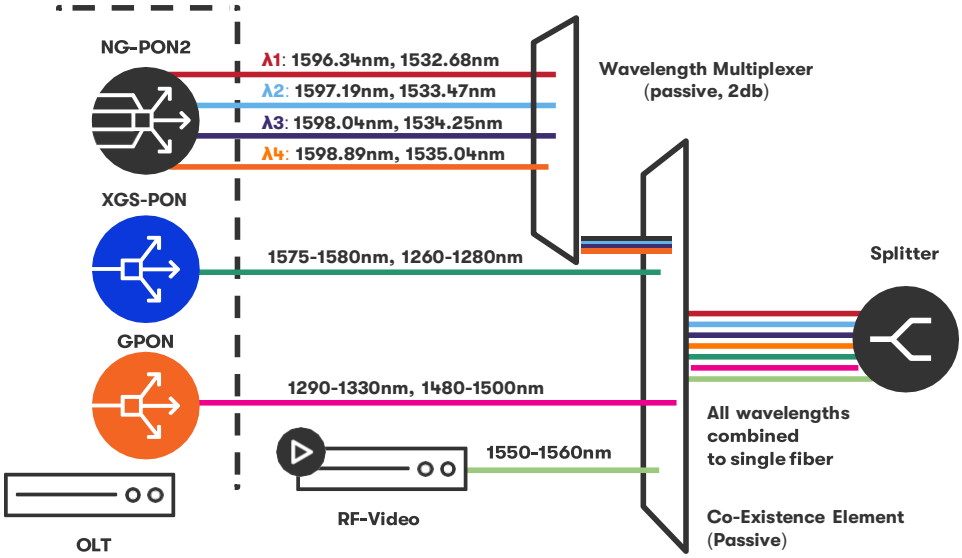
XGS-PON: THE PATH OF LEAST RESISTANCE TO 10G

XGS-PON (X=10, G=Gigabit, S=symmetrical) is the most recent standard and is similar to previous-generation GPON technology, except that it can deliver up to 10 Gbps of symmetrical bandwidth. It is therefore considered a simplified version of NG-PON2, because the technology uses a fixed wavelength. This means that it cannot harness multiple wavelengths in a single fiber to deliver more than 10 Gbps like NG-PON2 but provides more than enough bandwidth for the average needs of BSPs today and into the future.

WHY CHOOSE XGS-PON OVER OTHER PON TECHNOLOGIES:

- **XGS-PON simplifies deployment and upgrades**, you'll save time and money, and your subscribers get their new services in days, not weeks.
- 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 positions BSPs to deploy XGS-PON in a shortened timeframe, helping them to **immediately capture the benefits of offering a 10 Gbps service**. But it will not inhibit them from future network enhancements.

Figure 1: GPON Co-existence with NG-PON2 and XGS-PON



- NG-PON2 can be introduced later, without requiring a major 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 can be set according to customer demand.**

With the ability to deliver 10 Gbps to an individual subscriber, new business opportunities are now 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" technologies—such as G.fast over copper—or newer Wi-Fi technologies are used to deliver connectivity. With the continued growth in MDU populations, and as the capacity of Wi-Fi continues to increase, it becomes increasingly important to have a technology like XGS-PON to deliver 10 Gbps to the building demarcation point. With NG-PON2 and the use of channel bonding, you can go even further with throughput increased to 40 Gbps and 80 Gbps in the future.
- **Marketing competition, and brand perception:** Let's be real, the average user does not need a 10 Gbps connection. But we live in a bigger is better society, so you must take that brand perception into account as you design your network and service offerings. Your network design impacts your marketing messaging and competitive advantage. Not to mention that you do not want to build an access network that will no longer be suitable in less than 10 years. Planning today for the bandwidth consumptions of tomorrow is smart business.

NG-PON2: COMBINING THE POWER OF FOUR WAVELENGTHS

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

Previous generation GPON transmits data using a single wavelength on each fiber. By contrast, 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 as 40G (or 80G) PON.

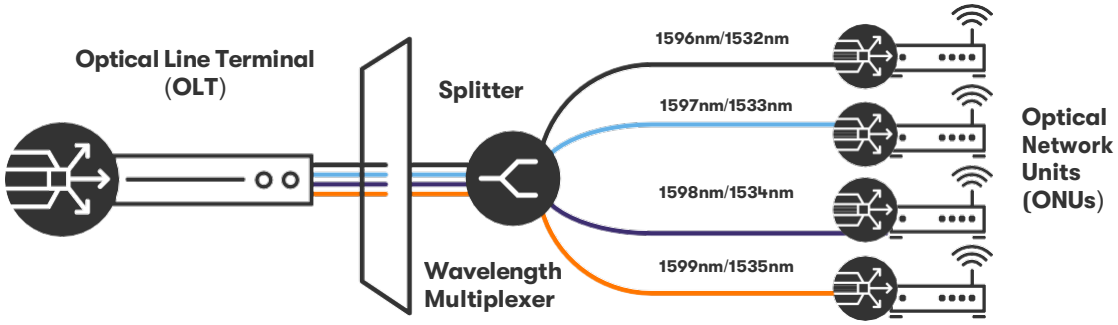


Figure 2: Multi-Wavelength NG-PON2 OLT, connected to ONUs with tunable lasers and receivers

As the industry continues its rapid migration to 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. Provide operational protection by moving customers to another wavelength while fixing/resetting a card.
- Multiple wavelengths can be used to manage PON capacity. As utilization grows, PON capacity can be easily redistributed, with new channels turned on and ONUs switched over to different wavelengths without impacting the delivery of existing services.
- Support of eight 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.

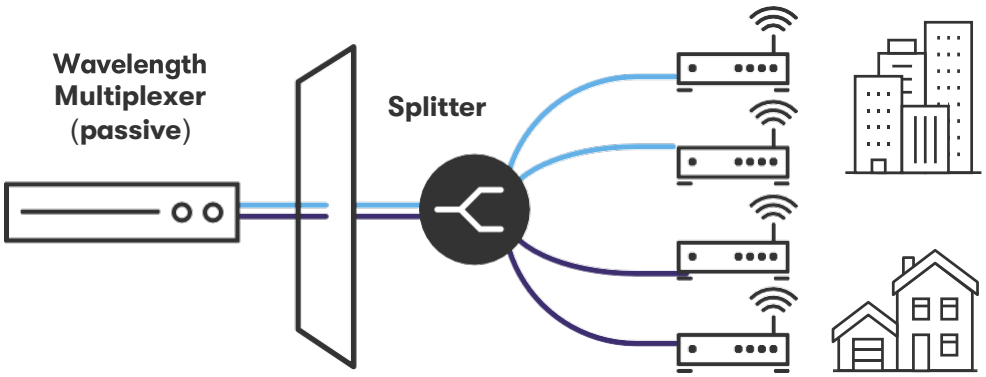


Figure 3: On-demand capacity management allows wavelengths to be redistributed, without impacting existing services

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

- 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.
- 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).

WHAT'S NEXT FOR PON

The standards bodies IEEE and ITU are always substantially in front of the actual market need. The IEEE, which focuses on Ethernet-based PON standards mostly used in Asian service providersand by cable operators, released the 25G / 50G EPON standards in 2020. The ITU, which focuses on the traditional time division multiplexed (TDM) PON like GPON, is expected to complete its 50G PON standard in 2021. Both standards bodies are already looking at 100G PON and beyond. Whilethere is some identified need for PON beyond 10G, mostly in the areas of business services and mobile backhaul and fronthaul, the need for bandwidth greater than 10G is not likely to drive volume deployments for several years. Even with the need being limited there is still quite a bit of noise in theindustry around these higher bandwidth PONs. This noise is mostly around a version of 25G PON that is not an actual standard. This 25G PON utilizes a combination of capabilities between the IEEE and ITU to enable the deployment of 25G PON that co-exists with GPON and XGS-PON networks. The benefit claimed by the 25G PON MSA (multi-source agreement), an agreement between multiplevendors, is to enable service providers to deploy true 10G services over PON. While this can be a benefit for business services and some 5G backhaul applications, it is important to note that non- standard technologies have the challenge of gaining market momentum over time. There is a risk thatwhile it is deployable today, it may not be technically or commercially viable over the long term.

White Paper

DRIVING ACCESS NETWORK TRANSFORMATION

10G-PON is gaining momentum around the world. More than 225 BSPs around the world are building Calix-powered fiber access networks with XGS-PON and NG-PON2 technology to deliver high-speed 10G services to both residences and businesses. With this infrastructure, BSPs can easily support high-bandwidth applications such as HD and 4K content streaming, video surveillance services, and cloud-enabled interactive gaming. The Calix Intelligent Access EDGE systems, powered by the Network Innovation Platform (AXOS®), supports the deployment of both XGS-PON and NG-PON2 in a single line card or GPON and XGS-PON in a single line card.

Examples include North Dakota-based BSPs MLGC[2] and ReadiTech[3], which are both upgrading to 10G PON from Calix to deploy exciting new services and ensure their networks are sufficiently future-proofed. Both are using the Calix Intelligent Access EDGE solution, built on the award-winning Calix Network Innovation Platform (AXOS) software platform. All Calix solutions support both XGS-PON and NG-PON2 via a simple change of the optical transceiver, giving BSPs 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, XGS-PON is expected to dominate the market through 2026. There are pros and cons to each. Through the use of NG-PON2 technology, and the ability to converge the services networks onto a single ODN, BSPs can significantly reduce TCO. XGS-PON technology provides substantially more bandwidth than GPON–without a forklift upgrade. This allows for the fastest deployment and lowest cost per bit per mile.

The ability to offer ultra-high-speed broadband is set to become a key differentiator for BSPs in an era that has seen bandwidth demands rise rapidly because of the increase in remote working and greater use of high-bandwidth home entertainment services. In a recent Calix survey, approximately half of the respondents said that the COVID-19 pandemic had prompted them to accelerate plans to deploy 10G PON[4]. The move to next-generation 10G-PON will therefore be a key strategy for innovative BSPs to simplify their networks and accelerate the rollout of new-generation technologies and services.

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Learn how other Broadband Service Providers are using Calix Intelligent Access EDGE to simplify and grow their businesses:

MLGC Powers Past Competition with Ultra-Fast 10-Gigabit Fiber Network From Calix

ReadiTech Doubles Down with Calix 10G-PON Network, Bets Big for the Future

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1 https://www.cisco.com/c/en/us/solutions/collateral/executive-perspectives/annual-internet-report/white-paper-c11-741490.html
2 https://www.calix.com/content/dam/calix/marketing-documents/public/case-study/cs_Intelligent-Access-EDGE_MLGC.pdf
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