Challenges in Next-Gen PON Deployment

Passive optical networks (PONs) are increasingly viewed as a crucial element of current and future broadband access networks. The massive deployment of PONs is driven by growing bandwidth demand, primarily fuelled by high-speed internet traffic. This evolution is driving a need for higher bandwidth in the downstream. Adding to that, growing services such as online gaming, file sharing, and cloud computing will generate more symmetrical traffic. It's apparent that in the long-term, optical access will have to evolve towards symmetrical traffic transport.

For next-generation networks (NG-PON), service providers expect improved bandwidth and service support capabilities over their existing PONs. While NG-PON2 networks are considered the most promising approach, service providers do have to deal with evolving standards.

Evolving Standards

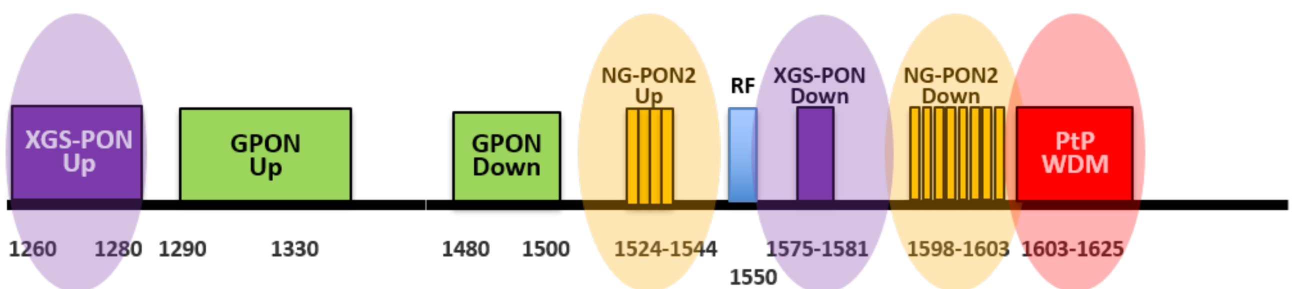
As with any network, the equipment used with PON must adhere to standards for operation. These are set by the ITU and IEEE groups and, in the case of the ITU, will address GPON (Gigabit PON), XGS-PON (10-Gbps PON), and NG-PON2 standards. For the most part, GPON is what we see in use today. But current GPON and IEEE EPON standards do not enable further scaling of subscriber count or capacity to reach end-user bandwidth requirements.

The next steps will be to increase service capacity and become symmetrical. The table below illustrates the standards and rates and how next-generation PON will increase capacity (and revenue). Current GPON delivers data rates of 2.4 Gbps downstream and 1.2 Gbps upstream. For satisfying high-bandwidth demands NG-PON2 standard G.689 was established by ITU-T. A time- and wavelength-division multiplexing approach (TWDM) was selected, bundling multiple wavelengths in the downstream and upstream directions. The overall bandwidth can therefore be increased to 40 Gbps downstream/10 Gbps upstream using four channel/wavelengths at 10/2.5 Gbps rates.

The optical distribution networks (ODNs) account for 70% of the total investments in deploying PONs. Therefore, it is crucial for the NG-PON evolution to be compatible with the deployed networks such as GPON. With NG-PON2 using multiple wavelengths, there is a need for tunable transceivers in the optical network terminals (ONTs) at the customer premises. Currently, low-cost tunable receivers are not yet available; therefore many operators envision an intermediate step using XGS-PON before migrating to NG-PON2. XGS-PON uses less expensive fixed lasers and receivers in the C-Band and therefore provides a better business case.

	G-PON	XGS-PON (sym)	NG-PON2	GE-PON	10G-EPON	100G-EPON
Standards	ITU-T G.984 (2003)	ITU-T G.9807.1 (2016)	ITU-T G.989 (2015)	IEEE 802.3ah (2004)	IEEE 802.3av (2009)	IEEE 802.3ca (2019 TBD)
Downstream/Upstream Data Rates	2.4 / 1.2 GBps	10 / 10 GBps	40 / 10 GBps	1.25/1.25 GBps	10 / 10 GBps	Up to 100 /100
Splitting Ratio	up to 1:64 (128)	up to 1:128 (256)		up to 1:64	up to 1:128	TBD
Co-existence	N/A	Yes, with G-PON		N/A	Yes, with GE-PON	

Today's GPON systems use 1490 nm as a downstream channel and 1310 nm as the upstream. XGS-PON uses 1578 nm downstream and 1270 nm upstream, which means you can overlay the XGS-PON service on the same plant as the GPON service. NG-PON2 uses the G.989 standard, which is a multi-wavelength access standard that supports TWDM technologies (see Figure 1).



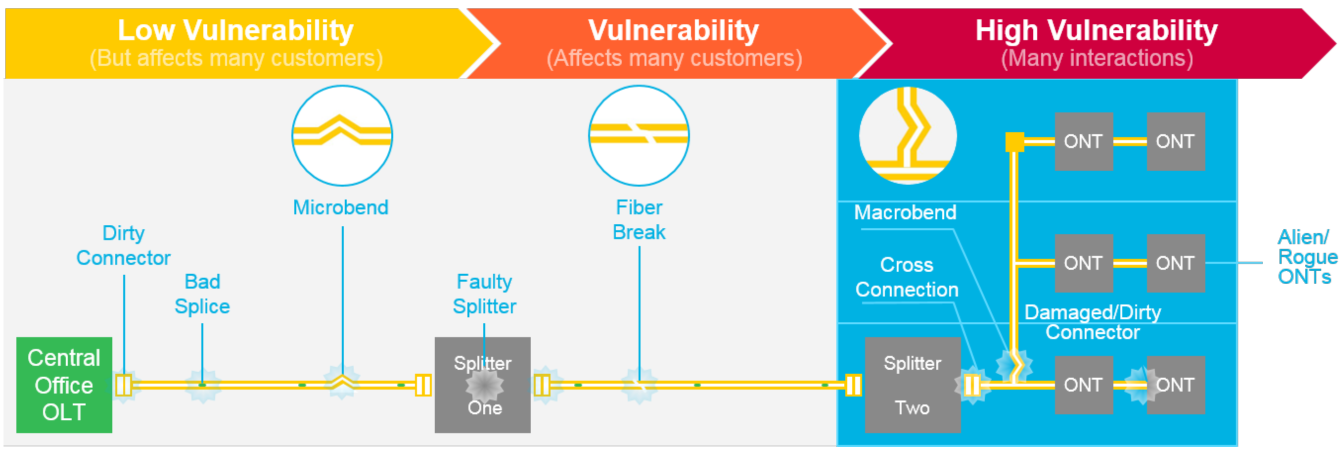
Source: FTTH EMEA D&O Committee FTTH Poland 2015

To physically implement the migration or activation of newer PON services requires network changes, especially in the central office. For leveraging existing ODNs, a coexistence element is needed. This can have different configurations depending on the technologies that the service provider wants to deliver. Essentially, it's a passive optical coupler to combine GPON, XGS-PON, and NG-PON2 services up and downstream.

The new NG-PON2 transmissions enable service providers to increase the FTTH networks' bandwidth capacities and reduce deployment costs by sharing the same fiber with more connected customers, or even by sharing networks with multiple operators. The new NG-PON2 standard, using transmission wavelengths in the 1535-nm region for upstream transmission and in the 1600-nm region for downstream transmission, employs more of the same fiber deployed and allows seamless overlays of new services to existing GPONs.

New Challenges

No matter where you are in the ODN, connector cleanliness and condition is critical. Fiber is often installed in harsh environments (e.g. dirty cellars) and damaged or dirty connectors can severely degrade service performance. Despite this, service providers or their contractors might opt not to test completely. One of the rationales is time—time per job, per inspection, and per number of connectors. Without testing, the risk is poor-quality installations and therefore poor service. Simply put, the impact of faulty installations will be customer churn.



There are several failure risks that can affect the success of roll out plans, migration timelines, service quality, and churn rates (see Figure 2). Here are some of the vulnerabilities exposed with all variants of PON services/standards:

- Dirty connectors, bad splices, and microbends that add loss, which means the total ODN loss no longer meets the standards; such conditions lead to intermittent or poor service (or no service)
- Splitter elements can be faulty
- Transposed fibers caused by human error when connecting a fiber to a wrong splitter port
- Rogue ONTs that transmit outside of their allocated upstream time slot, which results in upstream clashes with other ONTs and service disruption
- Alien devices, where a subscriber has accidentally installed other devices than an ONT (e.g., a media converter). These devices may send continuous upstream traffic that interferes with other ONTs in the PON and degrades or interrupts the service.

Even greater vulnerabilities exist around in-house cabling. As with any fiber connection, making sure end faces are clean and free from any damage is key. Macrobends due to bad cable installation practices are a key issue to be aware of for XGS- and NG-PON2 deployments. Those services are using higher wavelength bands (>1550 nm) that are more sensitive to bending loss. Installers, contractors, and subscribers may simply not be aware of the issue that small bending radius in indoor cable installation will cause excessive loss and degrade service performance. Even when using new bend-insensitive G.657B fibers, bending loss may reach more than 1 dB when cabling radius reaches values <7.5 mm (e.g., around corners). Having an installer perform this check as part of an install is relatively easy to implement, but subscriber self-installs remove that assurance. In fact, self-install may not be the best approach for higher-speed, higher-revenue services like XGS-PON and NG-PON2.

While evolving networks and standards mean things are getting more complicated, test equipment should remain simple to use to ensure job and workflow efficiency. Testing does take time, but bad installations result in re-work, repeat truck rolls, and delays in activation. Installers need to inspect every time they make a connection. Proper qualification during construction means doing testing not only at 1310/1550 nm but also at 1625 for NG-PON2, storing of test results, and for contractors, easy submission of results (to get paid quicker).

For service activation, power levels of all downstream and upstream services must be verified. With the use of new wavelengths for XGS-PON as well as for NG-PON2, there is a need for new PON power meters, like Viavi's OLP instruments, that enable wavelength-selective, through-mode power measurements.

Support for on-going operations requires troubleshooting tools that won't disrupt those existing services, in order to be used in-service and be future proofed avoiding those XGS-PON and NG-PON2 wavelengths means using 1650nm.

There is also a case to be made for centralized PON monitoring to reduce service outage time, Mean Time To Repair (MTTR) and guarantee high quality of service for high-speed access networks.

Next-generation PONs will help service providers launch and sell in-demand, on-demand services to their customers. However, as we know, innovative technologies can bring new challenges – especially during the time of evolution from one standard to another. While NG-PON2 is a very promising approach, it does come with new considerations that are best mitigated with consistent, basic testing during construction, installation, and deployment. After all, higher capacities mean more services are riding on their networks—which means more reward, but also more risk.

Wolfgang Moench is senior product line manager and **Douglas Clague** is fiber solutions manager at Viavi Solutions.

Contact Us **+1 844 GO VIAVI**
(+1 844 468 4284)

To reach the Viavi office nearest you, visit viavisolutions.com/contacts.

nextgenpon-wp-lab-tm-ae
30186180 900 0818