How Next-Gen PON Actively Transforms Networks

Service providers have a wide variety of last-mile optical PON platforms to converge multiple wireline consumer broadband, business and wireless services.

By Ray Hagen / *ProLabs*

The explosion of residential bandwidth growth driven by critical applications of telemedicine, distance learning and telecommuting may mark the tipping point toward service convergence on passive optical networks (PONs). These applications have greater demands on upstream bandwidth than traditional residential services, resembling business or wireless backhaul services.

Leveraging existing passive fiber networks for commercial business, wireless backhaul and residential services has been hampered by limitations in bandwidth and native quality-of-service capabilities. Past generations of PON upgrades have an expensive history of blanket upgrades to each subscriber, regardless of revenue level.

Next-generation PON technologies offer service providers a pathway toward converged networks, with multiple services coexisting on the same fiber network infrastructure. Operators can boost network capabilities while protecting revenue for an efficient, secure and effective upgrade process. Offering several upgrade approaches, including incremental components and full-scale systems, the portfolio of next-generation PON solutions allows for adaptable, stable network transformations.

LEARNING FROM THE PAST

The early adopters of the broadband PON (BPON) technology felt the pain of the "forklift" upgrade. Both technologies occupied the 1490nm downstream and 1310nm upstream portions of the optical spectrum, meaning they could not coexist on the same fiber. The migration from BPON to gigabit PON (GPON) services offered bandwidth and technical improvements but required substantial network upgrades at the optical line terminal (OLT) and at the client premises equipment optical network terminal (CPE ONT), resulting in costly truck rolls and upgrades not tied to incremental revenues. The challenge in upgrading from BPON to GPON drove efficiencies and directly aligned expenses to revenue. Centralized optical splitter architectures and the introduction of OLT transceivers brought flexibility to the network to defer the cost of adding OLT electronics and splitters to the network until there was revenue to support them.

GPON and BPON services were aptly titled fiber-to-the-home (FTTH) services because they were suited quite well for traditional asymmetrical residential bandwidth patterns (2.5 Gbps downstream/1.25 Gbps upstream). Business and wireless backhaul services require dedicated bandwidth and quality-of-service features that turned service providers to segregate PON OLTs for residential and business services, increasing costs across the PON network.

PON networks are also an attractive infrastructure for 5G wireless deployments.

5G wireless promises data rates up to 10 times that of current LTE services and will rely upon fiber-fed small cells located closer to subscribers. Much like next-generation PON, 5G will coexist with LTE wireless and existing broadband services. With huge data increases expected to follow the deployment of 5G and consumer anticipation for the innovation mounting, network transmission capabilities must increase to match as a matter of urgency. Next-gen PON networks are ideal for providing the fiber access and data rates required for this 5G fronthaul and backhaul, making the technology a valuable future-proofing resource.

THE NEXT-GENERATION PON ALPHABET SOUP

This tipping point on the residential side and the desire to leverage existing PON infrastructure for business and wireless backhaul services is quickly driving 10 Gbps upgrades. 10 Gbps PON technologies are a mix of both symmetrical and asymmetrical variants that must be understood to avoid making costly deployment mistakes; a single letter can make a large difference in the available service levels. Table 1 offers a quick summary of current and next-generation PON technologies.

The next-generation 10 Gbps PON technologies were designed to specifically coexist on existing PON infrastructure with legacy GPON and Ethernet PON (EPON) technologies by operating and coexisting over separate wavelengths on the next-generation wavelength plan (Figure 1).

PASSIVE COEXISTENCE

Coexistence offers service providers the flexibility to offer differentiated services on the PON without massive upgrades.

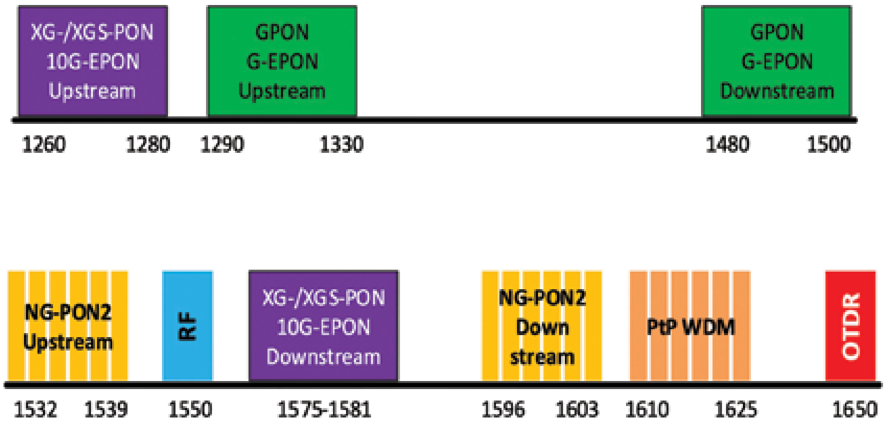

Figure 1. Next-generation PON wavelength allocations

This flexibility becomes important to leverage existing fiber assets across residential, business and wireless backhaul services. Passive wavelength division multiplexing (WDM) components, called coexistence elements, are a key technology to cost-effectively weave together these services. Installed near the OLT, the passive coexistence element optically multiplexes and demultiplexes the wavelength of each service on to a single fiber.

In addition to being relatively low-cost, coexistence elements offer service providers substantial benefits:

- The existing passive infrastructures, including splitters, are reused. This ensures that next-generation upgrades are incremental to revenue, protecting providers from leakages and budgetary limitations.
- New service technologies can be added in a disaggregated manner. If a service provider so wishes, coexistence provides the opportunity to deploy multiple vendors' equipment to coexist with legacy services. This increases the flexibility of networks, allowing customizable infrastructures to be built for ideal performance.
- Service providers have found many ways to deploy residential and business services side by side over PON networks. Deploying ONTs and splitters dedicated for residential or business, or even passing through dedicated fibers, consumes valuable feeder fibers. Coexistence across a single feeder fiber allows better utilization of this valuable fiber asset, lengthening the lifespan of the technology and protecting revenue.

Considerations for passive coexistence include the case of existing longer-length connections that may need to be re-engineered to account for additional link loss introduced by elements.

COMBO PON TRANSCEIVER SOLUTIONS

Combo PON is a relatively new term for PON networks. Combo PON transceivers combine discrete optics for multiple PON technologies and

TECHNOLOGY	GPON	XG(S)-PON	NGPON-2	EPON	10G-EPON
Data Rates (Gbps) Downstream/Upstream	2.5/1.25	XG-PON: 10/2.5 XGS-PON: 10/10	10/10	1/1	PRX: 10/1 PR: 10/10
Split Ratios	Up to 64	Up to 128	Up to 128	Up to 64	Up to 128

Table 1

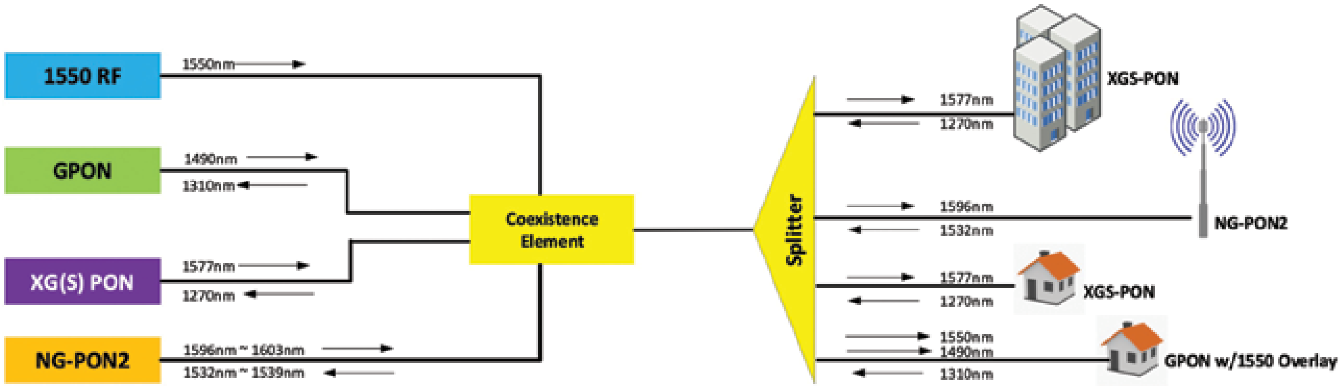

Figure 2. Coexistence topology

multiplex the services to a single fiber interface. Combo PON transceivers consist of XGS-PON and GPON, 10G and 1G EPON, and even XGS-PON, XG-PON and GPON originating from the same transceiver.

In addition to many of the same benefits of the coexistence scenario, combo PON offers cost reductions, including a reduced footprint at the wire center and the efficiencies of utilizing a single client-side card for multiple services.

The efficiencies of combo PON may come at the price of flexibility. The power dissipation of dual optics limits the optical power capabilities, impacting the ability to fit into long-reach applications. Delivering business and residential services through the same switch port may not support differentiated service levels as intended. In addition, combo PON transceivers are not a retrofit to existing platforms – the PON platform must have the specific capabilities to support these optics.

Next-generation PON services offer service providers the tools to leverage the substantial investment in PON networks. The coexistence of multiple services on a single fiber infrastructure offers flexibility and the ability to align upgrades to revenue. Providers can effectively upgrade their networks when they are ready and immediately cater to the subsequent data influx and increased customer expectation.

The utilization of intermediate components, such as OLT transceivers to ensure a prolonged upgrade period – balancing costs and performance – is key to achieving and delivering the desired results from introducing next-generation PON. The stability of networks' capabilities is of paramount importance in next-generation PON upgrades to successfully maintain anticipated performance levels. Upgrading in a cost-effective manner is vital for service providers to remain current and competitive in the market. ❖

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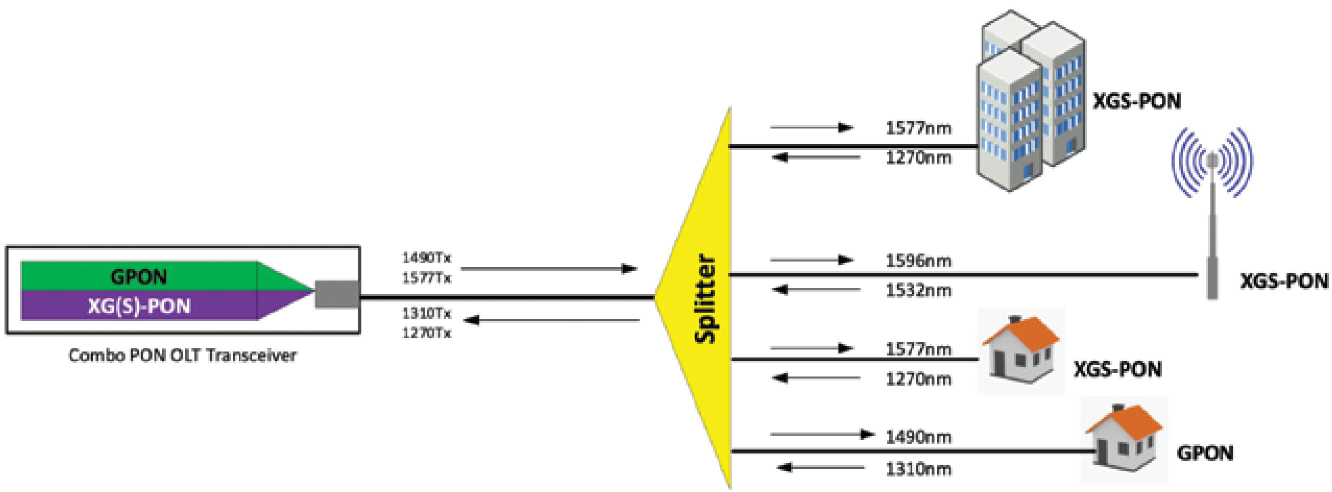

Figure 3. Combo PON OLT topology