broadband
forum

The Future of Passive Optical
Networking is Here

# NG-PON2

# NG-PON2

## The future of Passive Optical Networking is Here

# Introduction

As Internet usage continues to evolve, subscriber demand for bandwidth is skyrocketing. A key driver is the availability of a wide variety of increasingly sophisticated connected devices, such as laptops, smartphones, tablets, wearables, and a growing list of "smart home" devices and sensors all exhibiting different usage connectivity needs from deterministic low latency, to sustained high bandwidth, guaranteed throughput or highly reliable. For service providers, the large-scale adoption of these new technologies presents enormous growth opportunities, but also poses significant challenges.

One of these challenges results from the limitations of existing technologies, such as copper and Gigabit Passive Optical Networks (GPON), which do not provide enough capacity to support this growth. One of the latest iterations of the PON standard, Next-Generation Passive Optical Networking 2 (NG-PON2), however, provides powerful new capabilities that will help service providers meet the unprecedented demands being placed on their networks. This paper describes the key features and benefits of NG-PON2 technology and highlights important considerations for service providers who are deploying it.

# The Evolution of Passive Optical Networking

Optical Access Networks (OAN) have typically been deployed using one of three different architectures: point-to-point (P2P) or point-to-multipoint (P2MP or ring), as shown in Figure 1.
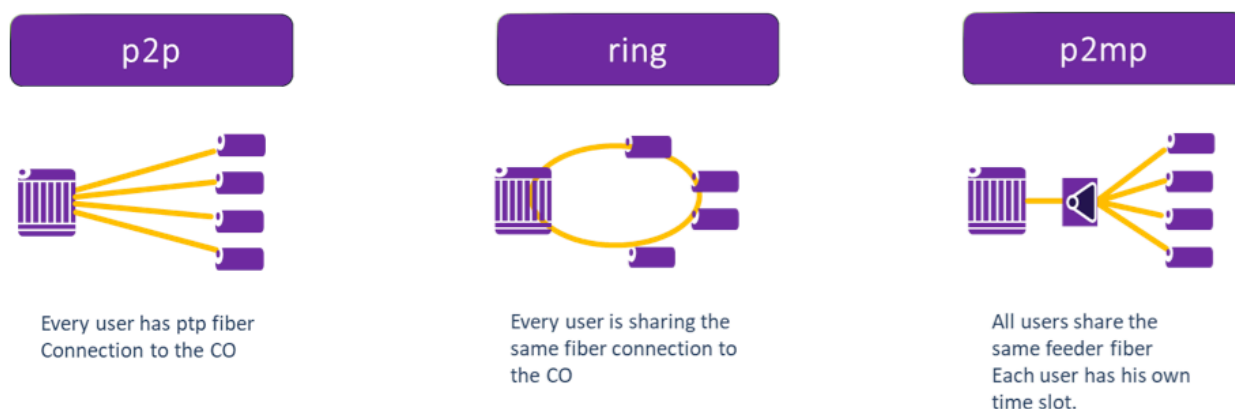


Figure 1 – Optical Access Network Architectures

Of these three architectures, P2MP (PON based architectures) has proven to be the most popular among operators for Fiber to the X (FTTx) deployments because it typically results in lower infrastructure costs. With P2MP, a shared fiber carries traffic to a passive splitting complex close to the end-customers, which a can be single stage or cascaded.  Consequently, there is no need to deploy a single dedicated fiber all the way to the customer premises from the central office This architecture was standardized in the first ATM-PON G.983.1 spec, which was released in 1998 by the ITU Telecommunication Standardization Sector (ITU-T)., Since then, the standard has been updated regularly to meet the ever-increasing demand for bandwidth.

This has resulted in several different implementations of PON over the years, with the most recent PON standards providing shared bandwidth capacity of 10 Gbps / 10 Gbps symmetrical.

Figure 2 shows how the PON standard has evolved since the initial release.
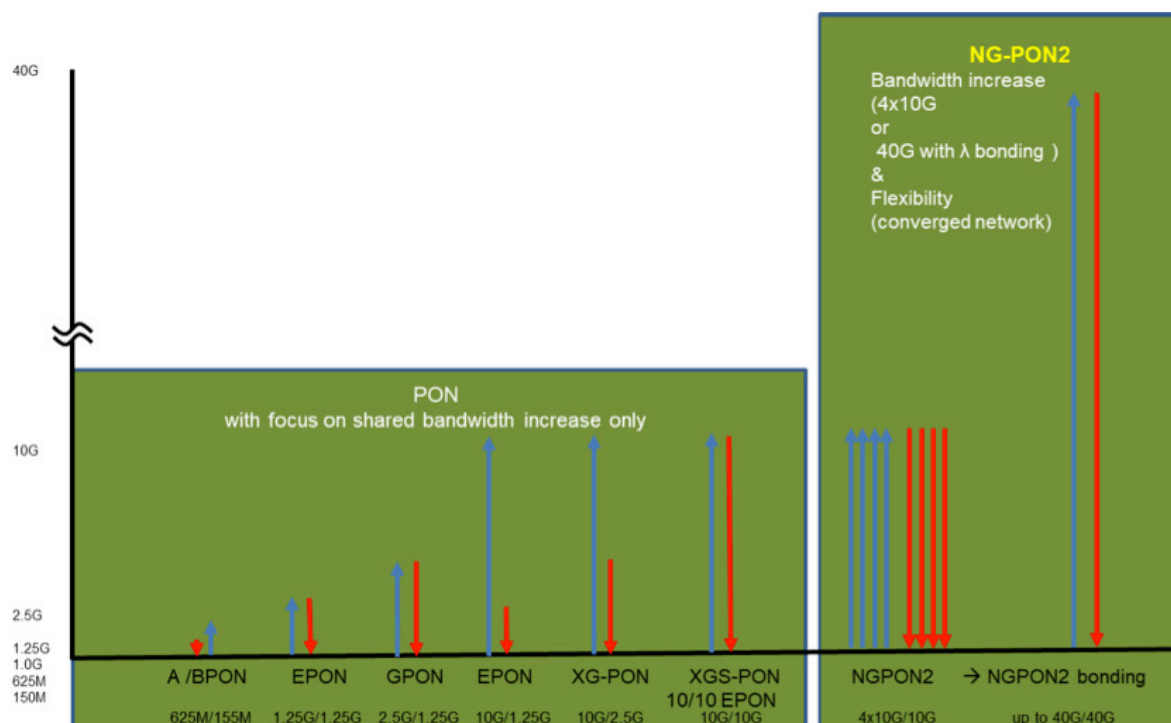


Figure 2 - Passive Optical Networks (PON) standards timeline

# From GPON to NG-PON2

The major driving force behind PON standardization is a tandem of FSAN, Full Service Access Network industry group comprising major telecommunication operators and system vendors, and ITU-T, a Telecommunications Standardization Sector of the International Telecommunications Union. Over the years they have focus on developing specifications for a series of PON systems providing increased bandwidth and improved service support capabilities. After finalizing the GPON specification in 2004, which provides a capacity of 2.5 Gbps / 1.25G, FSAN focused on providing higher bandwidth PONs. The XG-PON specification, which supports 10 Gbps downstream and 2.5 Gbps upstream, was released in 2010. This was followed in 2015, by release of NG-PON2, the true next-generation architecture, was released. By using wavelength division multiplexing, it provides an increase in bandwidth up to 40 Gbps downstream and 40 Gbps upstream today through multiple 10 Gbps / 10 Gbps channels on a single fiber infrastructure. A year later, a simpler, but much less capable system was standardized – a 10 Gbps symmetric XGS-PON.

NG-PON2 offers service providers significant advantages over other 10G PON technologies.  XG-PON1 and XGS-PON are single channel technologies which share the bandwidth provided, depending on the split ratio. Because of their simplicity, fixed wavelength technologies typically have lower cost optics. On the other hand, NG-PON2 is a multi-channel PON system, which not only increases the available capacity on the fiber by a factor of 4, but also through support of tunability of customers' Optical Network Units (ONUs) provides unparalleled advantages to both operators and users.

These include improved performance and service availability, pay-as-you-grow deployment model, wavelength channel protection switching, seamless software and hardware upgrades in the Central Office, power conservation capabilities. As a result of this flexibility and improved performance, more service providers are deploying NG-PON2, which will assist in reducing the price of the optics over time.

## NG-PON2 capabilities:

- Provides bandwidth flexibility
- Supports a "pay as you grow" model, which allows service providers to add more wavelengths as needed
- Supports seamless service upgrades using tunable optics
- Supports Lambda bonding up to 40/40 Gbps (80/80Gbps in the future)
- Supports "fiber unbundling", which enables service providers to assign wavelengths
- Provides a converged network that enables support for any service, including:
    - Business services
    - Transport services (mobile backhaul)
    - Residential services

Given the intense competition for subscribers, service providers need to move fast to deliver innovative new services to differentiate themselves from the competition, even as prices for those services continue to drop.  In addition, to meet the increased demands for more bandwidth, service providers must deploy new technologies such as NG-PON2 and look at new, innovative ways to be fast and flexible while reducing costs.

## NG-PON2 - Technology Overview

The Next-Generation Passive Optical Network 2 (NG-PON2) standard allows for the convergence of multiple services networks onto a single ODN. This results in a significant reduction in total cost of ownership (TCO), while enabling the introduction of new, efficient architectures that are deeply adjusted to meet emerging subscriber demands.

Figure 4 illustrates the main building blocks of NG-PON2. These include:

- **Optical Line Terminals (OLT)**
    - OLT line cards support compliant wavelength plans. Line cards provide lambda-specific (1 … 4) pluggable transceivers.
- **Optical Networking Units (ONU)**
    - ONUs with tunable lasers, filters and receivers to support compliant wavelength plans, allowing Wavelength Mobility.
- **Wavelength Multiplexer (WM1)**
    - The Wavelength Multiplexer is a passive wavelength MUX device that combines 4 NG-PON2 wavelengths onto a single fiber (with future support for 8 wavelengths).
- **Co-existence Element (CE)**
    - The coexistence element is a passive wavelength MUX device that combines most access technologies onto a single fiber.

 NG-PON2 utilizes time and wavelength division multiplexing (TWDM) and supports a minimum of one wavelength, that can grow up to 4 wavelengths (1 … 4) or 8 wavelengths (future) in a pay-as-you grow model 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), which allows a throughput of 40 Gbps on the fiber connection. The standard allows for a maximum of eight wavelengths, allowing NG-PON2 to deliver up 80 Gbps.
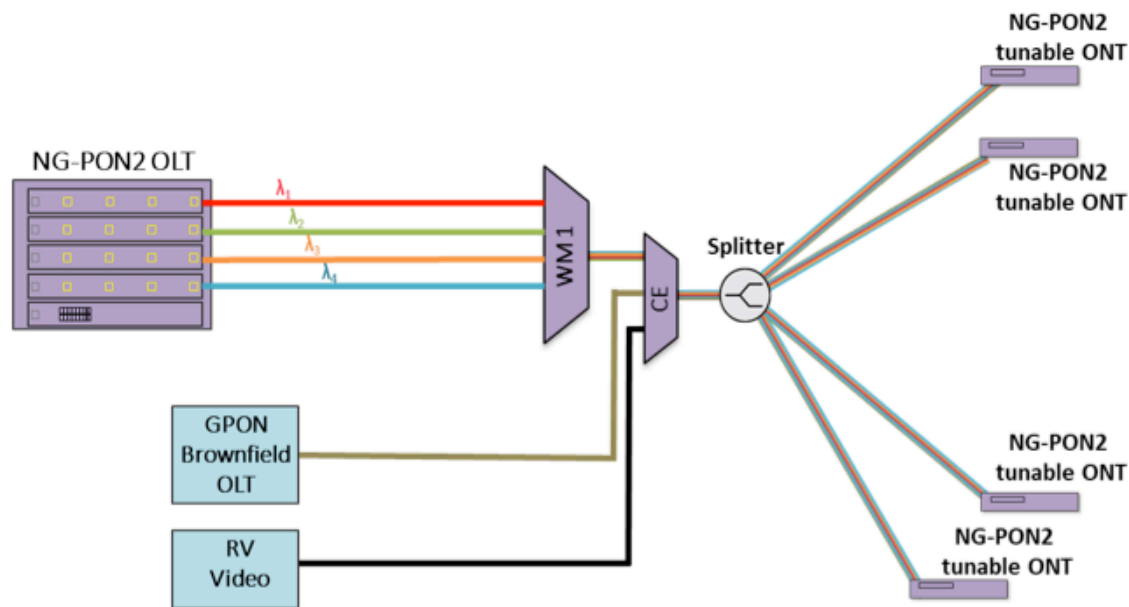
Figure 4 - NG-PON2 block diagram

## Benefits of NG-PON2 technology

· Provides 10 Gbps symmetric line rates per wavelength, up to 8 wavelengths on the ODN

· Supports four wavelengths in the initial release, with the standard providing the option to move to 8 wavelengths

· Supports co-existence with GPON and XGS-PON / XG-PON1 technologies

· Supports tunable optics, which enable Wavelength Mobility

· Allows bandwidth on demand

## Characteristics of NG-PON2

### Wavelength Mobility

Wavelength mobility enables ONUs to see all the wavelengths on the ODN and provides the ability to use tunable optics in the ONT to tune to any of the available wavelengths. Wavelength mobility allows service providers to create rules that define how ONTs can transition between channel terminations for the purpose of performing maintenance in the PON network.

Wavelength mobility provides the following capabilities:

- Incremental bandwidth upgrade (Pay-as-you-Grow)
- Redundancy – the ONU will fall back to another provisioned line card if the current one fails
- Load balancing – provides the ability to manage traffic peaks in service areas
- Split ratio adjustment – ONUs can be provisioned to move to another wavelength, effectively reducing the split ratio in one wavelength and increasing the ratio in another wavelength.
- Protection functionality use another wavelength for protection as failover
- Seamless maintenance work and upgrades – ONUs can be provisioned to move to another wavelength on another system during maintenance and upgrades
- Channel bonding – Because multiple wavelengths exist on the ODN, an ONU can be created to deliver more than 10 Gbps of bandwidth

## Channel Bonding

Channel bonding provides the ability to use multiple wavelengths supported on the ODN to get more bandwidth to an ONU.  For instance, if a business service needs to provide true 10 Gbps throughput, the service provider will need to deliver more than 10G to achieve the required throughput. This can be achieved by delivering two wavelengths to a single ONU.

## Service Convergence

By leveraging its multiple wavelengths, NG-PON2 gives service providers the ability to support service convergence by putting all their services onto a common ODN. This enables service providers to:

- separate mobile, business and residential services onto different wavelengths, while delivering them to different OLTs.
- reduce maintenance and operations costs due to maintaining fibers or WDM components to separate services.

# NG-PON2 - Applications

Changes in the telecommunications industry are being driven by rapidly evolving communication requirements in the market and growing subscriber expectations. NG-PON2 is gaining momentum around the world. To date, NG-PON2 has been deployed in live networks by Verizon, SK Broadband, Portugal Telecom, Northpower Fibre (New Zealand) and several other service providers around the globe. 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.

Figure 5 shows how service providers can converge their business, residential and mobile services onto a common ODN using NG-PON2.
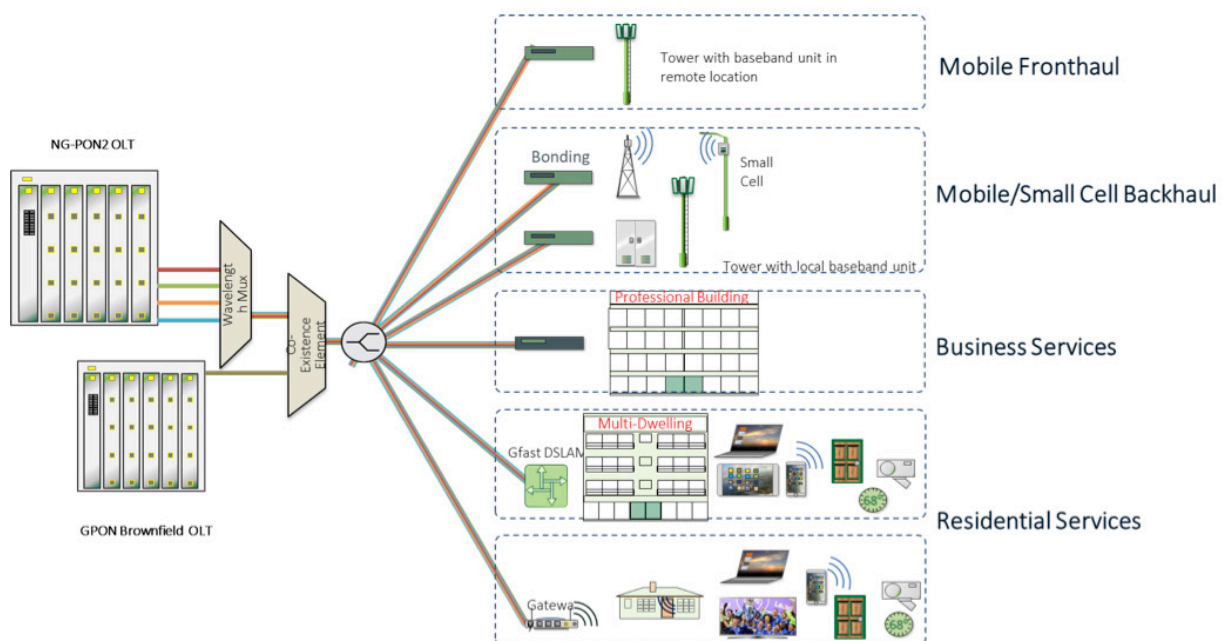


Figure 5 - NG-PON2 Service Implementation services

With its support for tunable ONTs, NG-PON2 provides the flexibility for service providers to virtual move ONTs around in the service area to provide load balancing.  As shown in Figure 4, multiple NG-PON2 lambda sub-networks share one ODN by using wave division multiplexing (WDM). Each NG-PON2 wavelength PON can work independently or can be combined through wavelength bonding to a high bandwidth PON (max 80G downstream and 80G upstream). This flexible architecture allows service providers to move to a converged ODN, which allows different applications on the same fiber.

With the ability to deliver 10 Gbps (and beyond) to an individual subscriber, NG-PON2 enables new business opportunities for service providers. NG-PON2 supports the following applications and services:

### Residential services

- High-ARPU - deliver high bandwidth to be shared in service areas leveraging high split ratios to lower the cost per subscribers
- Multi-dwelling unit (MDU) services – deliver high bandwidth to MDUs (10 Gbps to the building demarcation point) leveraging fiber in the building or G.fast over copper for in building connectivity.

### Business Services and small enterprises

- High bandwidth services (10 Gbps to 40/80 Gbps through lambda bonding) to support growing bandwidth needs
- New applications, including redundancy
- Lambda-based services

### Mobile Backhaul and fronthaul

- Mobile backhaul – growing demand as wireless data usage continues to explode
- Strong fit for small cell mobile backhaul by providing higher bandwidth and lower latency than any other PON standard
- Supports wholesaling of mobile backhaul services with assignment of wavelength to customer

### Smart City applications

- Connect high numbers of devices by increasing split ratios

### Smart Home/building applications

- Aggregate low latency and high bandwidth use cases by slicing and increasing split ratios for large number of devices

### Passive optical LANs (POL)

- Provide high bandwidth service in local area networks for universities, hospitals, and hotels

# Conclusion

NG-PON2 technology offers numerous benefits for service providers looking to provide an "always on" network experience for their subscribers. It provides them with the speeds they need to use a wide range of ever more bandwidth-intensive applications. For service providers, NG-PON2 provides a future-proof architecture that improves efficiency and flexibility and reduces operations costs. Upgrades can be performed seamlessly, without impacting subscriber services, and the network can be expanded using a pay-as-you-grow approach. What's more, bandwidth can be easily rebalanced in the network as required by assigning users to different wavelengths.

In addition to these operational benefits, the NG-PON2 standard also enables service providers to support a wide variety of new revenue-generating converged services—business, residential, and mobile—on a single fiber network.

The Broadband Forum is also leading the way in many initiatives complementing operational and revenue generation aspects of NG-PON2 deployments. For more information on the Broadband Forum's open source Broadband Access Abstraction initiative (OB-BAA), its work in addressing virtualization of the optical line terminal (OLT), or it's groundbreaking extension of TR-069, User Services Platform (USP), please visit www.broadband-forum.org.

# Summary

NG-PON2 is an exciting technology that has the potential to dramatically change the operational models of service providers, while at the same time giving them the flexibility to be more agile to market demands than ever. The Broadband Forum is currently playing a key role in helping to define the how service providers will adopt this new technology and use it for network and business transformation. We will also be active in organizing plugfests and orchestrating certification programs similar to what we've done in the past with technologies like GPON and Gfast.

Now is the ideal time to get involved, whether you are a network operator, service provider, system, software or hardware vendor, test system vendor, or other stakeholder. The BBF's NG-PON2 activities are still in early stages, so participants have a great opportunity to influence the course of the work. In addition, BBF participants can be involved in development discussions, and have access to pre-publication drafts, giving you a head start on understanding and using materials developed. Full details can be found on the BBF Wiki (BBF members only), or at  the public BBF Papers and Tutorials page.  If you are interested in joining the Broadband Forum and shaping the future of broadband through this initiative and a wide variety of other activities, contact our Membership Development Manager at info@broadband-forum.org or visit us at our membership page.