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COEN 335: High Performance Networking

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Gigabit Passive Optical Networks

Audience

This document covers the purpose, need, design, and usage of Passive Optical Networks (PON) with a specific deep dive into the realm of Gigabit Passive Optical Networks (GPON). This document covers the various standards, changes to standards, and variants PON and GPON have and the importance of each.

The reader is expected to have basic knowledge of networks to be able to understand the PON and GPON technologies. Some prior knowledge in types of data, types of access technologies, and specifically fiber would be beneficial.

This document can be used by network architects, system architects, developers, network engineers, scholars, researchers, and technical authors.

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1. Introduction

PON, or Passive Optical Networks, is a fiber-based network access technology used for Fiber to the "x" (FTTx) applications. PON has a dominant position in the network access market as it and technologies based off of it have had the most effective shared fiber architectures in terms of deployment and costs. PON is flexible when it comes to bandwidth and user expansion and its signal rate and format transparency cause service providers/carriers to deploy PON rather than other technologies. Variants and newer standards of PON have caused it to still be a viable access technology even today however the there was a need for a complete rework therefore causing the creation of GPON.

GPON, or Gigabit Passive Optical Networks, is also a fiber-based network access technology used for FTTx applications and can be viewed as an upgraded version of PON. Its performance and flexibility are drastically increased from that of PON causing an eight to ten times increase in effectiveness. With its standards still being amended and future technologies like XG-PON and NG-PON2 being based off it, GPON is a modern-day staple in fiber-based network access technologies.

This paper is divided into 3 chapters:

Section 2 talks about PON. Section 2.1 covers the origin and history of PON including those who invented it and those who standardized it. Section 2.2 talks about the reasoning behind the adoption of PON and how it differs from other types of access technologies. Section 2.3 briefly talks about how PON is deployed and shows an example of a base PON architecture. Section 2.4 talks about the different G.983 standards released by the ITU and their significance. Section 2.5 talks about technology variants that followed and expanded on PON to increase its effectiveness and flexibility as an access technology.

Section 3 talks about GPON. Section 3.1 covers the covers the origin and history of GPON and talks about its connected history to PON. Section 3.2 talks about the reasoning behind the adoption of GPON after PON and how it aims to expand on its predecessor. Section 3.3 discusses the aspects of a GPON architecture and talks about the differences between a PON architecture and a GPON architecture. Section 3.4 talks about the different G.984 standards released by the ITU and their significance. Section 3.5 talks about modern day improvements on the GPON standards. Section 3.6 includes tables that compare various PON technologies. Section 3.6 talks about future variants that may take GPON's place as GPON took PON's place.

Section 4 include the closing remarks as well as what to look for in the future regarding PON/GPON technology.

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2. Passive Optical Networks (PON)

2.1 Origin and History

Passive Optical networks were developed by a team of three individuals within British Telecommunications in 1987. This team consisted of David Faulkner, David Payne, and Jeffrey Stern. As per their research, the three continue to develop the concept together over the coming years and were able to show the usefulness of the technology in area like telephony networks and broadband evolution. In 1995, a working group was created by various system vendors and telecommunications service providers by the name of Full-Service Access Network. Their main objective was to do work on FTTH (fiber to the home) architectures. FSAN’s work continued for the coming years until the International Telecommunications Union decided to continue FSAN’s and BT’s work through the actual development of PON. Their initial work led them to develop the ATM-PON generation which was commonly known as APON. In 1998, the ITU released the G.983.1 standard which was known as both BPON and PON. APON and BPON provided a downstream bandwidth of 622 Mbit/s and an upstream bandwidth of 155 Mbit/s. The downstream used the optical carrier 12 specification while the upstream only used the optical carrier 3 specification.

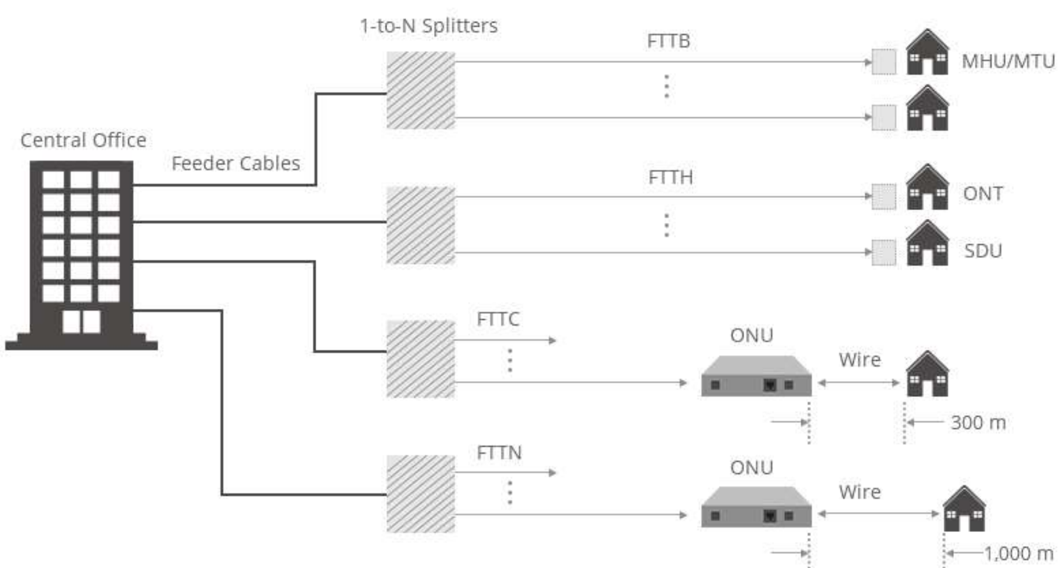


Figure 1: Fiber to the x (FTTx) Network

(Source - Margaret)

2.2 Why use PON?

When a service provider needs to upgrade network equipment, they must strike a balance between equipment cost and bandwidth. Finding the right balance between minimizing the cost and maximizing the bandwidth is the key to maximizing future revenue. Passive Optical Networks (PON) is an access technology that happens to juggle the tasks of minimizing cost and maximizing bandwidth while retaining increased flexibility in terms of upgradability and deployment. Access technologies are generally split into 3 categories which are:

- Wireless
- Copper
- Fiber

The most used wireless standards currently include WiFi (802.11) and WiMAX (802.16) and tend to have the lowest deployment cost due to no costs outside of plant costs. WiFi has a range of about 100m with a bandwidth of about 10-50 Mb/s over all subscribers while WiMAX has a range of 5km with a bandwidth of about 70 Mb/s over all subscribers. Not including newly emerging standards like 5G and other highband technologies, wireless access networks tend to lack the bandwidth to support the growing demand for high resolution video streaming and video conferencing.

Table 1: Comparison between Fiber and Copper

Parameter	Fiber Optics	Copper
Bandwidth	60 Tbps and beyond	10 Gbps
Future-Proof	Evolving towards the desktop	CAT7 in development
Distance	12 Miles+ @ 10,000Mbps	300 Ft. @ 1,000Mbps
Noise	Immune	Susceptible to EM/RFI interference, crosstalk and voltage surges
Security	Nearly impossible to tap	Susceptible to tapping
Handling	Lightweight, thin diameter, strong pulling strength	Heavy, thicker diameter, strict pulling specifications
Lifecycle	30-50 Years	5 Years
Weight/1,000 ft.	4 Lbs.	39 Lbs.
Energy Consumed	2W per User	>10W per User

(Source – Multicom)

The most used copper standard used is digital subscriber line or DSL. DSL is a point-to-point architecture so instead of sharing the bandwidth over multiple users, they provide that bandwidth to each user. It supports 50 Mb/s for lengths 300ft and under while only being able to provide 10 Mb/s for lengths at 10000ft. It is possible to use multiple short lengths to ensure higher bandwidth over longer distances however the cost of deployment approaches the cost of an all-fiber solution.

The third and final access network option is fiber. Much like copper, fiber can be a point-to-point architecture where there is a dedicated fiber from the central office (CO) and each subscriber. Dedicated fiber however tends to be 1.2 to 2 times more costly per subscriber in comparison to shared fiber. Within the realm of shared fiber, there are two ways to break out the signals. One of these methods is known as active Ethernet (AE) in which signals are split near the subscriber using electronic equipment. The other method is known as PON in which a splitter passively replicates the signals.

Although both methods come from the same type of shared fiber technology, one is significantly better than the other. Unlike the deployment of AE, PON doesn't have to use any of the electronic equipment that AE does. This both decreases the cost and the possible sources of failure for PON. Expanding the bandwidth for both methods means having to upgrade electronics at both the CO and the subscriber however PON does not have to further upgrade electronics on an outside plant like AE. PON allows ISPs to deliver "triple-play" services to residential customers. Triple-play services include voice, video, and data meaning that it was essential to have a reasonably high bandwidth per subscriber. PON was able to do just this with fewer fiber runs than non-shared fiber and was able to do so without extra power to transmission equipment between the CO and each subscriber. PON was initially meant for FTTH or FTTB/C however it is now used in the "last mile" connectivity.

The rate, signal format transparency, flexibility, and minimized costs and points of failure led PON to be easy to deploy by service providers. There are various types of PON technologies and standards currently which can vary in data formats, signaling rates, or protocols they use.

2.3 How does PON work?

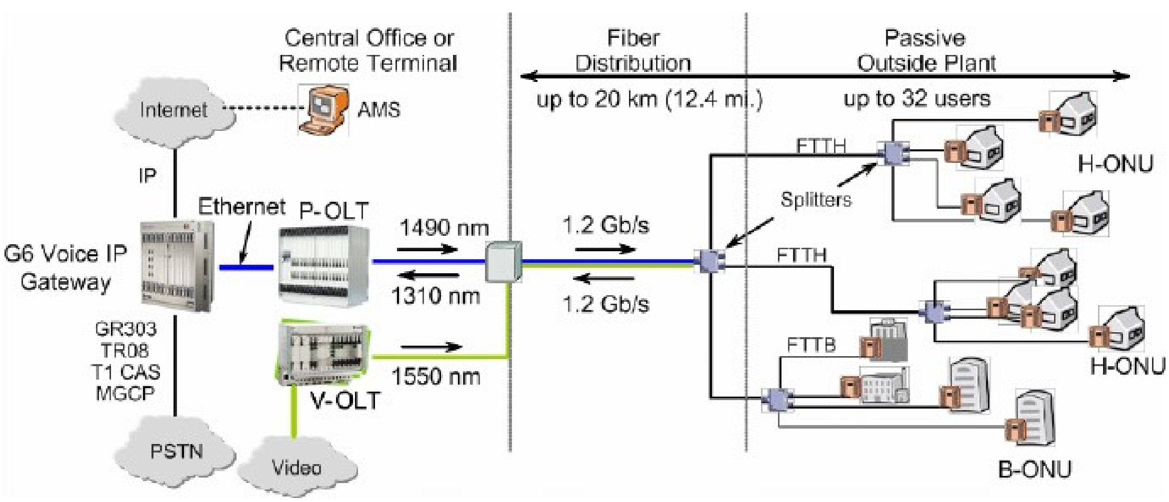


Figure 2: Example of Typical PON Architecture

(Source – Savoie)

There are three major components in a PON network: the Optical Line Terminals (OLT), the Optical Network Terminals (ONT a.k.a. ONU), and the Optical Splitters. A CO pulls the triple-play data from the designated sources (i.e. Internet for data and PSTN or VoIP for voice) and feeds that data into purpose built OLT's. These OLT's then distribute the data via fiber to optical splitters for FTTH and FTTB purposes. After the final splitters, an ONT/ONU is used on the subscriber side to receive the sent data. Original PON used TDM for relaying information where TDM was specifically used on downstream (CO to users) and TDMA was used on upstream (users to CO) as there is need for multiple access on upstream.

2.4 New Versions

ITU released G.983.1 as the standard for PON and BPON in 1998 and proceeded to release new version updates up until 2007 where the G.983.2 became the foremost standard for basic PON (G.983.2 encompasses the updates from G.983.6 to G.983.10.

G.983.2

The G.983.2 standard was originally published in 2000 however with the consolidation of G.983.6 to G.983.10 into G.983.2 in 2005, there have been amendments up until 2007. The G.983.2 standard specifies the ONT management and control interface specification (OMCI) for BPON/ATM-PON to facilitate multi-vendor exchange and use of data between the OLT and the ONT. This OMCI spec is for FTTH and FTTB ONTs and talks about a protocol to support all of the capabilities for these ONTs as well as optional components and future extensions. The specification addresses performance measurement for BPON system operation, fault management, and ONT configuration management. For reference, standards G.983.6 – G.983.10 were denoted as follows:

- G.983.6: Protection features
- G.983.7: Dynamic bandwidth Assignment (DBA BPON)
- G.983.8: BPON OMCI support for IP, ISDN, video, VLAN tagging, VC cross-connections, etc.
- G.983.9: BPON OMCI support for wireless LAN interfaces
- G.983.10: BPON OMCI support for DSL interfaces

G.983.3

The G.983.3 standard was initially released in 2001 however it was further amended until 2005 and primarily focuses on extensions on the BPON/ATM-PON systems. One of these extensions is a version of BPON/ATM-PON that uses the Wavelength Division Multiplexing (WDM). Another extension is new wavelength allocations to allow for ATM-PON signals and other services' signals to be able to transmit simultaneously. Other extensions include changes to parameters to incorporate the new WDM and optimizations to the OLT/ONU sites.

G.983.4

The G.983.4 standard was initially released in 2001 however it was further amended until 2005 and primarily focuses on extensions on the BPON/ATM-PON systems' flexibility. One of the main features introduced was Dynamic Bandwidth Assignment (DBA) on newer systems however there was a heavy focus on making systems with DBA compatibly with legacy OLTs and ONUs. The extensions include performance objectives, application functionality, fairness criteria and protocols, and backwards compatibility and interoperability.

G.983.5

The G.983.5 standard was initially released in 2002 and primarily focuses on extensions on the BPON/ATM-PON systems' protection and survivability. The extensions in this standard talks about several protection functions and feature choices and mentions how it would be able to implement these changes in the PON layer. This includes changes in the switching criteria and switching protocols along with a focus on highly reliable services for FTTCab and FTTO deployments.

2.5 PON Variants

EPON/GEPON

Ethernet Passive Optical Networks (EPON) or Gigabit Ethernet Passive Optical Networks (GEPON) are both variants of PON meant for short distance data transfer through the use of single protocol layer, fiber optic cables, and ethernet packets. EPON is flexible in that it can be used for data-oriented networks as well as "full-service" voice, video, and data networks and is fully compatible with other ethernet standards (for the newer 10G-EPON standard). EPON is naturally a symmetrical 1 Gbit/s link however the amendment of 10G-EPON supports 10 Gbit/s downstream and 1 Gbit/s upstream. Using downstream wavelength plan/frequency plan support, 10G-EPON is able to support a 10 Gbit/s and 1 Gbit/s downstream concurrently on the same PON.

DPoE

Data Over Cable Service Interface Specification (DOCSIS) Provisioning of Ethernet Passive Optical Network, or DPoE is a CableLabs specification released in 2016 specifying the integration of DOCSIS on EPON. As EPON was a version of PON that increased flexibility, DPoE is an extension on top of EPON technology to help flexibility with IP and to help scale up EPON-based services using DOCSIS back-office infrastructure.

WDM-PON

Wave Division Multiplexing Passive Optical Networks (WDM-PON) is a technique that can be used by PON to split ONUs into several virtual PONs on the same physical infrastructure. WDM-PON allows for reduced ONU delays along with higher security and scalability compared to regular PON. There should be an expected increase in cost however due to the need of new WDM components in the architecture. As there is an increased number of wavelengths, there is an additional factor of the wavelength drift based on environmental temperatures.

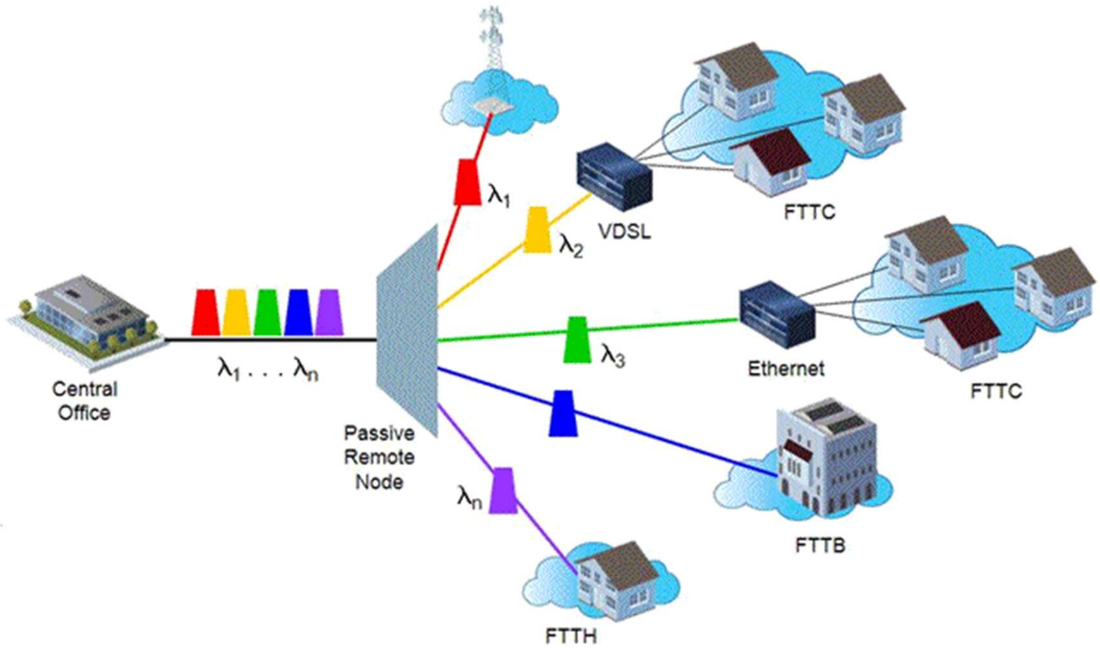


Figure 3: Visual Representation of WDM-PON in FTTx Applications

(Source - Fiber Optics Solutions Admin)

3

3. Gigabit Passive Optical Networks (GPON)

3.1 Origin and History

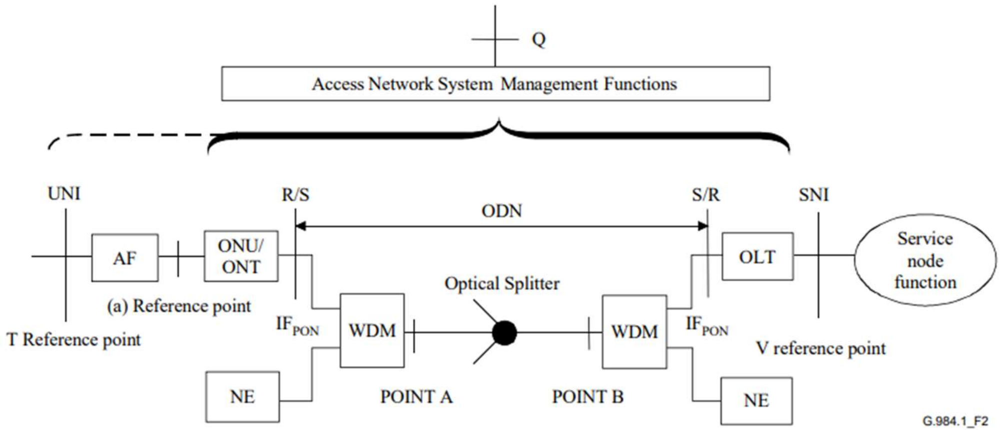
After the existence of PON for some time, the need for a higher bandwidth and longer distance solution was needed. Full Service Access Network (FSAN) was the group to take upon the task by defining GPON in their consortium in 2001. After some years, the International Telecommunications Union made GPON a standard right after PON therefore it being referred to as G.984. In early 2003 the standards of G.984.1 and G.984.2 were approved by the ITU. These standards were later amended to allow for future WDM PON technology to have compatibility.

3.2 Why use GPON?

PON is a point-to-multi point architecture as it is a way to have shared/split fiber. GPON is basically an upgraded version of PON where costs are even further minimized, and bandwidth is further maximized. GPON allows twice the number of users served per fiber, twice the bandwidth per user, twice the distance (both total and differential), Voice using TDM, and Video using IP. This means that a single GPON implementation is about eight to ten times more effective than a single base PON implementation. With GPON's introduction of software protocols along with upgraded hardware, costs will be relatively low compared to other "last mile" technologies.

3.3 How does GPON work?

As previously mentioned, GPON functions like an upgraded version of PON. This means the three major components of PON (OLTs, ONTs/ONUs, Optical Splitters) are also seen in use for GPON however all of the components would be upgraded to equipment that can handle the specifications of GPON. These new specifications include metrics like 60 km range with 20 km differential reach between ONUs, 1 gigabit per second bandwidth, and up to 128 ONUs per GPON. The figure below shows an example architecture of GPON:



ONU	Optical Network Unit
ONT	Optical Network Terminal
ODN	Optical Distribution Network
OLT	Optical Line Termination
WDM	Wavelength Division Multiplex Module (If WDM is not used, this function is not necessary.)
NE	Network Element which uses the different wavelength from the OLT and the ONU
AF	Adaptation Function (Sometimes, it may be included in the ONU.)
SNI	Service Node Interface
UNI	User Network Interface
S	Point on the optical fibre just after the OLT (Downstream)/ONU (Upstream) optical connection point (i.e., optical connector or optical splice)
R	Point on the optical fibre just before the ONU (Downstream)/OLT (Upstream) optical connection point (i.e., optical connector or optical splice)
(a) Reference point	If AF is included in the ONU, this point is not necessary.
POINT A/B	If WDM is not used, these points are not necessary.

NOTE – Whether or not the AF is an operating object of the Q interface depends on the service.

Figure 4: G.984.1 GPON Reference Configuration

(Source – ITU-T)

3.4 New Versions

G.984.2

The G.984.2 standard was originally published in 2003 however there have been amendments up until 2019. The G.984.2 standard specifies the Physical Media Dependent (PMD) layer specification of an Optical Access network (OAN). The standard further states that the OAN used should allow the operator to give a flexible upgrade to future customer requirements. This standards also helps to further future proof the xDSL G.99x standards and the PON G.983.x standards to support higher data transfer rates especially for the transport of data services.

G.984.3

The G.984.3 standard was originally published in 2006 however there have been amendments up until 2020. The G.984.3 standard specifies the transmission convergence layer specification. This specification aims to support plain old telephone service (POTS, data, video, leased line and distributive services. It also aims to cover transmission coverage (TC) issues between the service node interface and the user-network interface. This standards also continues to help future proof the xDSL G.99x standards and the PON G.983.x standards even more than the G.984.2 standard.

G.984.4

The G.984.4 standard was originally published in 2004 however there have been amendments up until 2010. The G.984.4 standard specifies the ONT management and control interface specification. This OMCI specification's focus is FTTH and FTTBusiness ONTs as well as support for ONUs as well. This OMNI specification aims to address the ONT configuration management, performance management and fault management for G-PON system operation for many services including the following:

- GPON encapsulation method (GEM) adaptation layers
- ATM adaptation layers
- Ethernet services
- Voice services
- Circuit emulation service
- WDM

G.984.5

The G.984.5 standard was originally published in 2007 however there have been amendments up until 2020. The G.984.5 standard specifies the enhancement band specification. For maximizing the value of optical distribution networks (ODN), this specification defines wavelength ranges for additional signals via WDM in future GPONs and PONs (PON additions based on G.983.3).

G.984.6

The G.984.6 standard was originally published in 2008 however there have been amendments up until 2012. The G.984.6 standard specifies the reach extension specification. This standard concerns itself with GPON optical limits up to the logical limits of the TC layer. It also talks about mid-span extension through the use of an active extension node. All the addition and changes in this standard are also checked so that they remain compatible with existing OLTs.

G.984.7

The G.984.7 standard was originally published in 2010 and there have been no amendments up until now. The G.984.7 standard specifies the long reach specification. This standard talks about the physical GPON and TC layer requirements needed to extend the maximum differential fiber distance of a G-PON system to 40 km compared to the 20 km differential fiber distance of G.984.1.

3.5 GPON Improvements

Error Correction, Encryption, and Authentication Additions

GPON specifies protocols for error correction, encryption, and authentication. For error correction GPON uses the Reed-Solomon error correction method like many other technologies and uses the Advanced Encryption Standard (AES) for data encryption.

For line control and authentication, GPON uses the G.988 standard put into place by the ITU. The G.988 standard specifies ONU management and control interface (OMCI).

Security

As PON had a dominant position in the fiber optical access technology space, GPON was surely a priority for many government agencies looking for secure, flexible, and fast network connections. This need brought upon the development of Secure Passive Optical Networks in 2009 to meet the Secure Internet Protocol Router network (SIPRNet) of the US Air Force. SPON was a project that used the flexibility of GPON and the security of Protective Distribution Systems (PDS) to enable confident, closed-loop networks used for mission critical data. PDS is a fiber optics system that has adequate safeguards like for electric, acoustic, electromagnetic, and physical attacks on data. This is to ensure its use for transmitting unencrypted information through areas with lesser classification or control therefore making it ideal for secure government agencies.

Future Possible GPON Additions

- As the number of wavelengths on one PON/GPON increases with newer and newer standards, the definition of wavelength blocking filters is needed. These filters would ensure that at G-PON ONUs, next-generation ONUs using additional wavelengths could in the future be installed on currently deployed G-PON ODNs side by side with G-PON ONUs.
- An extension of GPON’s optical budget will allow the deployment of longer reach (more than the differential 40 km in the G.984.7 standard) and higher split ratio (greater than 1:128 ONUs). This extension may require an active extender box to be deployed at ODNs.
- GPON along with most other network access technologies have a high downstream bandwidth but are lackluster on the upstream bandwidth. GPON can currently support 10 Gbit/s downstream however in the future improvements to 2.5 or even 10 Gbit/s upstream is highly advised.

3.6 PON Comparison Tables

Table 2: Characteristics of PON Technologies

	A/BPON	EPON (GEPON)	GPON	10 GEPON	WDM PON
Standard	ITU G.983	IEEE802ah	ITU G.984	IEEE P802.3av	ITU G.983
Data Packet Cell Size	53 bytes	1518 bytes	53 to 1518 bytes	1518 bytes	Independent
Maximum Downstream Line Rate	622 Mbps	1.2 Gbps	2.4 Gbps	IP; 2.4 Gbps, Broadcast; 5 Gbps On-demand; 2.5 Gbps	1-10 Gbit/s per channel
Maximum Upstream Line Rate	155/622 Mbps	1.2 Gbps	1.2 Gbps	2.5 Gbps	1-10 Gbit/s per channel
Downstream wavelength	1490 and 1550 nm	1550 nm	1490 and 1550 nm	1550 nm	Individual wavelength/channel
Upstream wavelength	1310 nm	1310 nm	1310 nm	1310 nm	Individual wavelength/channel
Traffic Modes	ATM	Ethernet	ATM Ethernet or TDM	Ethernet	Protocol Independent
Voice	ATM	VoIP	TDM	VoIP	Independent
Video	1550 nm overlay	1550 nm overlay/IP	1550 nm overlay/ IP	IP	1550 nm overlay/ IP
Max PON Splits	32	32	64	128	16/100's
Max Distance	20 Km	20 Km	60 Km	10 Km	20 Km
Average Bandwidth per User	20 Mbit/s	60 Mbit/s	40 Mbit/s	20 Mbit/s	Up to 10 Gbit/s

(Source – Savoie)

Table 3: Different Classes of PON

	Class A (622 Mbps only)	Class B	Class C
Minimum loss	5 dB	10 dB	15 dB
Maximum loss	20 dB	25 dB	30 dB
ONUs Max. No.	Up to 8	Up to 16	Up to 32

(Source – Savoie)

EPON vs GPON vs 10G-PON

Table 4: Table comparing various parameters of EPON, GPON, and 10G-PON

Name	GPON	EPON	10G-PON
Usable Bandwidth	Downstream: 1.25 Gbit/s or 2.5 Gbit/s, Upstream: 155 Mbit/s – 2.5 Gbit/s	1-Gbit/s symmetrical bandwidth	10Gbit/s
Reach	128 ONUs	32 ONUs per OLT, or 64 FEC	128 users per PON, or more using reach extenders/amplifiers
Per-subscriber costs	Higher	Lower	Highest
Support for CATV Overlay	Yes	Yes	Yes
Popular Area	U.S.	Asia and Europe.	N/A (not widespread enough)
FTTx Deployment	FTTH	FTTP or FTTH	In development

(Source – RS-Tech)

WDM-PON vs GPON

Table 5: Table comparing various parameters of 10 Gbit/s GPON and WDM-PON

Parameters	GPON (10 Gbit/s)	WDM-PON
Standard	ITU G.984	No Standard
Maximum Downstream Line Rate	10 Gbps shared (320 Mbps/Home)	10 Gbps shared (320 Mbps/Home)
Maximum Upstream Line Rate	2.5 Gbps shared	1-10 Gbit/s per channel
PON Splits	1:64	1:128
Reach	20 Km	120 Km
Power Saving	18W per OLT	7W per OLT

(Source - Bhagat)

3.7 Future Tech

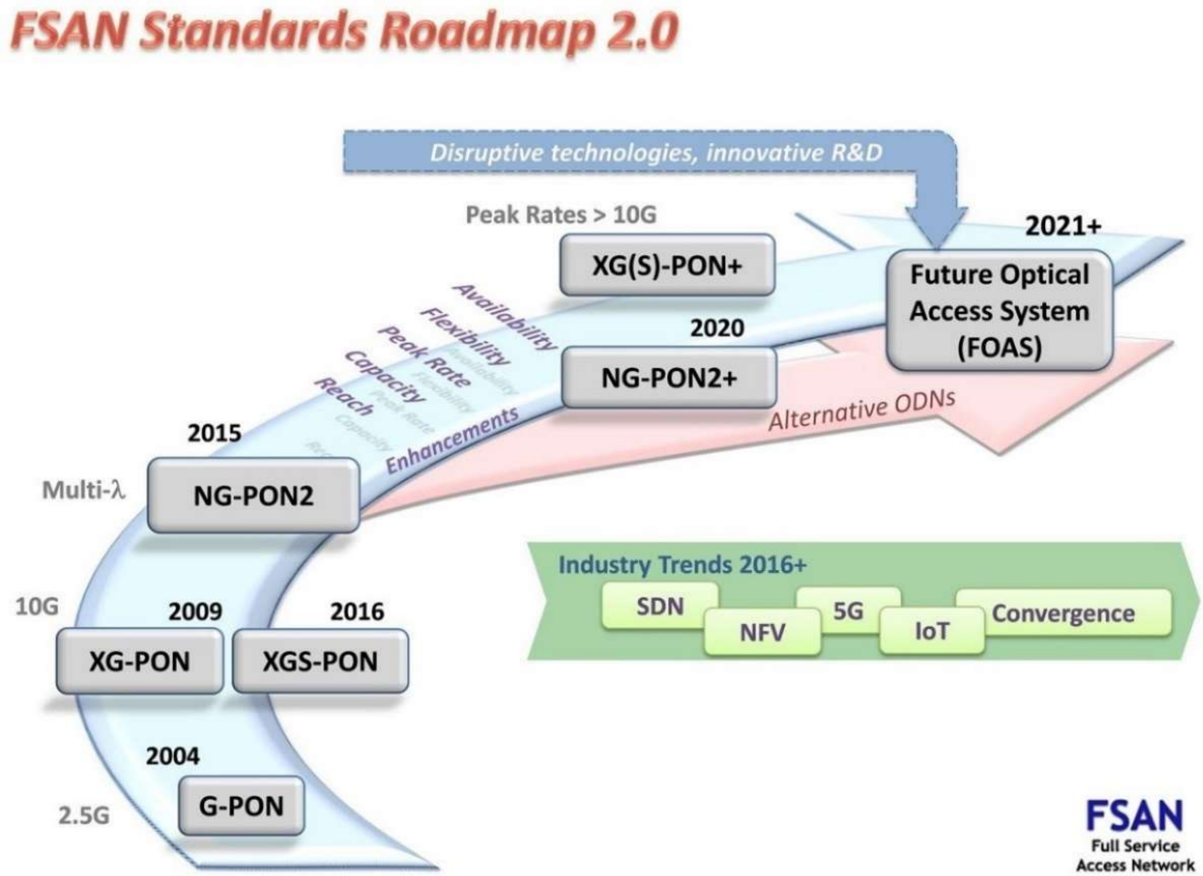


Figure 5: FSAN PON Standards Roadmap

(Source – FSAN)

XG-PON (G.987.x)

10 Gigabit Passive Optical Networks, or XG-PON/10G-PON, is the next step up from GPON in the line of optical access technologies and was made a standard by ITU in 2010 (G.987.x). As the demand for network speed grows, the need for faster, more flexible technologies is needed. Triple play services along with high resolution on-demand video and video conferencing becoming the norm leads service providers to look ahead in the performance and upgradability of their networks. XG-PON is a step up from both GPON and 10G-EPON (10 Gbit/s downstream with 1 Gbit/s upstream) as it can support 10 Gbit/s downstream and 2.5 Gbit/s upstream asymmetrically (XG-PON1) and can support up to 10 Gbit/s symmetrically in newer versions (XG-PON2). Much like GPON, XG-PON also has many ITU standards focusing on the PMD and TC layer specifications.

NG-PON2 (G.989.x)

Next Generation Passive Optical Networks 2, or NG-PON2, is the next even further step up from GPON and XG-PON in the line of optical access technologies and was made a standard by ITU in 2015 (G.989.x). This technology is also known as Time- and Wavelength-Division Multiplexing, or TWDM-PON, as the use of WDM is used in the downstream direction while the use of TDM is used in the upstream direction. In NG-PON2, each subscriber is able to have a symmetrical 10 Gbit/s bandwidth and through the WDM downstream, can provide a 40 Gbit/s throughput to the entire optical network. NG-PON2 isn't meant to completely replace other optical access technologies like GPON, 10G-PON, and RF Video therefore it supports the coexistence of these technologies through the use of specifically chosen wavelengths. The step-up in performance and legacy architecture compatibility truly allows NG-PON2 to live up to its "Next Generation" name.

4

4. Closing

4.1 Final Thoughts and Conclusion

Passive Optical Networks are a staple in the way businesses and consumers access data, voice, and video. PON technologies aim to be a future proof access technologies with legacy compatibility and flexible upgradability. Most of the costs in PON are on initial setup so it is essential to get it right the first time therefore leading to the constant evolution of PON-based standards. Although there may be numerous standards and versions of each standard, all PON technologies share basic inherent architectures. All these technologies share the same shared-fiber medium and physical topology, and most differences are based on different design styles and varying protocols used to enhance security, encryption, etc. As shown in the FSAN Roadmap figure, although NG-PON2 isn’t fully deployed in many areas, the development of newer standards like FOAS and NG-PON2+ continues at full force. As PON grows to serve millions and millions of homes and businesses, it can be seen that a new era of network access technologies is upon us. Gone is the era of copper networks and even old fiber networks, and the age of high-speed fiber per subscriber has begun.

Acronyms

10GPON	10 Gigabit Passive Optical Network
AE	Active Ethernet
AES	Advanced Encryption Standard
APON	Asynchronous Transfer Mode Passive Optical Network
ATM	Asynchronous Transfer Mode
BPON	Broadband Passive Optical Network
CO	Central Office
DBA	Dynamic Bandwidth Assignment
DOCSIS	Data Over Cable Service Interface Specification
DPoE	DOCSIS Provisioning of EPON
DSL	Digital Subscriber Line
EPON	Ethernet Passive Optical Network
FEC	Forward Error Correction
FSAN	Full Service Access Network
FTTB	Fiber to the Block
FTTC	Fiber to the Curb
FTTH	Fiber to the Home
FTTO	Fiber to the Office
FTTP	Fiber to the Premises
FTTx	Fiber to the "x"
GEM	GPON Encapsulation Method
GEPON	Gigabit Ethernet Passive Optical Network
GPON	Gigabit Passive Optical Network
IA	Information Assurance
IP	Internet Protocol
ISDN	Integrated Services Digital Network
ISP	Internet Service Provider
LAN	Local Area Network
NG-PON2	Next Generation Passive Optical Networks 2
OAN	Optical Access Network
ODN	Optical Distribution Networks
OLT	Optical Line Terminal
OMCI	ONT Management and Control Interface
ONT	Optical Network Terminal
ONU	Optical Network Unit
PDS	Protective Distribution Systems
PMD	Physical Media Dependent
PON	Passive optical Network
POTS	Plain Old Telephone Service
PSTN	Public Switched Telephone Network
RF	Radio Frequency

SIPRNet	Secure Internet Protocol Router Network
SPON	Secure Passive Optical Network
TC	Transmission Coverage
TDM	Time Division Multiplexing
TDMA	Time Division Multiple Access
TWDM	Time and Wavelength Division Multiplexing
VC	Virtual Circuits
VLAN	Virtual Local Area Network
VoIP	Voice over Internet Protocol
WDM	Wavelength Division Multiplexing

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