GPON - THE BEST KNOWN INFORMATION HIGHWAY!

GPON Is The Best Known Transport System For CATV, Telephony & Internet At Affordable Prices!
By Ashish Jain, MCBS

INTRODUCTION
GPON and EPON are popular versions of Passive Optical Networks (PONs). These short-haul networks of fiber optical cable provide Internet access, Voice over Internet protocol (VoIP), and digital TV delivery in metropolitan areas.

Other uses include backhaul connections for cellular base-stations, Wi-Fi hotspots, and even distributed antenna systems.

The primary differences between these 2 PON systems (GPON and EPON) lie in the protocols used for downstream and upstream communications.

PASSIVE OPTICAL NETWORKS - FTTH
A PON is a fiber network that only uses fiber and passive components like splitters and combiners rather than active components like amplifiers, repeaters, or shaping circuits. Such passive networks cost significantly less than those using active components. While an Active Optical Network (AON) can cover a range to about 100 kms, a PON is typically limited to fiber cable runs of up to 20 kms. PONs are also called Fiber To The Home (FTTH) networks.

PON STANDARDS
Over the years, various PON standards have been developed. In the late 1990s, the International Telecommunications Union (ITU) created the APON standard, which used the Asynchronous Transfer Mode (ATM) for long-haul packet transmission.
Since ATM is no longer used, a newer version was created called the Broadband PON, or BPON. Designated as ITU-T G.983, this standard provided for 622 Mbits/s downstream and 155 Mbits/s upstream.

While BPON may still be used in some systems, most current networks use GPON, or Gigabit PON.

**GPON BASICS**

GPON supports triple-play services, high-bandwidth and has long reach!

GPON stands for 'Gigabit Passive Optical Networks'.

GPON is defined by ITU-T recommendation series G.984.1 through G.984.6. GPON can transport not only Ethernet, but also ATM and TDM (PSTN, ISDN, E1 and E3) traffic.

It delivers 2.488 Gbits/s downstream and 1.244 Gbits/s upstream.

![Figure 1: FTTx Network Architecture](image_url)

**FTTB** = Fibre To The Business  
**FTTCab** = Fibre To The Cabinet  
**FTTH** = Fibre To The Home
Any GPON network consists of mainly 2 active transmission equipments, namely:

- Optical Line Termination (OLT) and
- Optical Network Unit (ONU) or Optical Network Termination (ONT).

**GPON ARCHITECTURE**

A single fibre from the OLT runs to a passive Optical Splitter (passive means, it does not require any power to operate) which is located near the users' locations.

1. The Optical Splitter merely divides the optical power into N (multiple) separate paths to the users. The optical paths can vary between 2 to 128.

2. From the Optical Splitter, a Single Mode (SM) fibre strand run to each user. This is shown in figure 2. (All Cable TV distribution uses Single Mode optical fiber, so GPON also uses the same type of fiber.)

3. GPON adopts 2 multiplexing mechanisms:
   a) In the Downstream direction (i.e. from OLT to users), data packets are transmitted in an broadcast manner, i.e. the same signal is sent to all. However, AES encryption is used to ensure that only the intended recipient receives the signal. The AES encryption prevents any other used from decrypting the signal and eavesdropping.
   b) In the Upstream direction (i.e. from users to OLT), data packets are transmitted with Time Division Multiple Access (TDMA). In TDMA, all users utilise the same frequency, but are allotted different time slots when they can send their signals from each user, back to the OLT.
WHAT IS XGPPON

GPON uses optical Wavelength Division Multiplexing (WDM) so a single fiber can be used for both downstream and upstream data, at different wavelengths.

A laser on a wavelength of 1490 nm transmits downstream data.

Upstream data is transmitted on a wavelength of 1310 nm. If 1310 is already being used for Cable TV transmission on the same fibre, then the XGPPON upstream data is sent on a wavelength of 1550 nm.

While each ONU gets the full downstream rate of 2.488 Gbits/s, GPON uses a time division multiple access (TDMA) format to allocate a specific timeslot to each user. This divides the bandwidth so each user gets a fraction such as 100 Mbits/s depending upon how the service provider allocates it.

The upstream rate is less than the maximum because it is shared with other ONUs in a TDMA scheme. The OLT determines the distance and time delay for each subscriber. Then software provides a way to allot timeslots to upstream data for each user.

<table>
<thead>
<tr>
<th>Split Ratio</th>
<th>OLT 1490 nm</th>
<th>ONU / ONT TV</th>
<th>ONU / ONT PC</th>
<th>ONU / ONT VoIP</th>
</tr>
</thead>
<tbody>
<tr>
<td>1:32 or 1:64</td>
<td>Download</td>
<td>TV</td>
<td>PC</td>
<td>VoIP</td>
</tr>
<tr>
<td></td>
<td>Upload</td>
<td>PC</td>
<td>VoIP</td>
<td></td>
</tr>
</tbody>
</table>

Figure 3: GPON Network Diagram
The typical split of a single fiber is 1:32 or 1:64. That means each fiber can serve up to 32 or 64 subscribers. Split ratios up to 1:128 are possible in some systems.

As for data format, the GPON packets can handle ATM packets directly. Recall that ATM packages everything in 53-byte packets with 48 for data and 5 for overhead.

GPON also uses a generic encapsulation method to carry other protocols. It can encapsulate Ethernet, IP, TCP, UDP, T1/E1, video, VoIP, or other protocols as required for data transmission. The minimum packet size is 53 bytes, and the maximum is 1518.

AES encryption is used in the downstream only.

**XGPON / 10-PON**

The latest version of GPON is a 10-Gigabit version called XGPON, or 10G-PON.

As the demand for video and Over The Top (OTT) TV services has increased, there is an increasing need to boost line rates to handle the massive data of High-Definition (HD) video. XGPON serves this purpose.

**XGPON STANDARD**

The ITU standard is G.987. XGPON's maximum rate is 10 Gbits/s (9.95328) downstream and 2.5 Gbits/s (2.48832) upstream.

Different WDM wavelengths are used, 1577 nm downstream and 1270 nm upstream. This allows 10-Gbit/s service to coexist on the same fiber with standard GPON.

The Optical split is 1:128. That means each fiber can serve up to 128 subscribers. A separate fiber is to be used for each set of 128 subscribers.

The data format used in XGPON is the same as GPON.

The maximum range is still 20 km. XGPON is not yet widely implemented but provides an excellent upgrade path for service providers and customers.
**DOCSIS OR GPON?**

DOCSIS and GPON are different animals. DOCSIS is specifically for optical transmission. However, DOCSIS is how you transport data, whether via Coax or Optical Cable.

In DOCSIS, the entire Cable TV network must be 2-way; meaning the CATV RF amplifiers, nodes and transmitters/EDFA should each have return path capability for 5 MHz to 47 MHz Reverse Path bandwidth.

If you do not have a full 2-way return path network from Headend up to the subscribers end or if you are not already running a DOCSIS plant, my suggestion is not to consider building one today unless you have some specific advantage that would lead you in that direction.

Since telcos also use GPON networks, the ONU prices will steeply reduce due to higher production quantities.

Further, when cable operators embrace the VNO (Virtual Network Operators) concept i.e. Cable operator becomes a part of a Telco to distribute telephony under the Telco's license, GPON would be the preferred choice.

Since GPON is a passive network, the reliability of the GPON network is much higher!

**BANDWIDTH COMPARISON - GPON VERSUS DOCSIS:**

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<th>DOCSIS</th>
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<td>From a high-speed Internet (HSI) perspective, GPON has an enormous amount of bandwidth that can be delivered in both the upstream and downstream. In the past couple of years, services evolution and bandwidth requirements have become increasingly unpredictable. New Internet applications such as YouTube and Slingbox and new video services, including high-definition TV (HDTV), HD-video-on-demand (HD-VoD), and network DVR, have emerged and created new demand for both upstream and downstream bandwidth. GPON provides 2.488 Gbits/sec of downstream bandwidth over the 1,490 nm wavelength; 1.244 Gbits/sec of upstream bandwidth over the 1,310 nm wavelength; and can provide more than 1 GHz of cable-TV broadcast over the 1,550 nm wavelength. This allows for a <strong>maximum sustained bandwidth under full system load (100% simultaneous burst traffic)</strong>, compared to 1.244 Gbits/sec of downstream bandwidth and 0.576 Gbits/sec of upstream bandwidth for DOCSIS.</td>
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usage) of more than 75 Mbits/sec in the downstream and nearly 40 Mbits/sec in the upstream (using a 1.32 split and 1,550-nm overlay for broadcast video).

DOCSIS

DOCSIS-based HFC networks, by comparison, do not have the ability to match GPONs with respect to the maximum bandwidth under full system load.

From a downstream perspective, this is mainly due to the fact that the downstream spectrum is dominated by a variety of different video services, and there is only a limited amount of bandwidth available for HSI service.

From an upstream perspective, there is a limited amount of bandwidth available due to the way the coax spectrum is divided. Also, it is not always possible to use the lower portion of this spectrum due to noise issues.

COST/BIT FOR HFC/DOCSIS AND GPON:

Using rough market estimates HFC/DOCSIS costs about ₹3 Lakhs (approx.) per port for 160Mbits per sec which converts to approximately ₹1800 using Modular-CMTS, EQAM, and DOCSIS 3.0.

GPON costs approximately ₹150/Mbit/sec for first-generation equipment!

**DOCSIS Cost/160 MBps = ₹ 1800**

**But Only ₹ 150 For GPON!**

VIDEO SERVICES CAPABILITIES

DOCSIS VERSUS GPON:

GPON allows service providers to support a traditional cable-TV mode of operation, an end-to-end IPTV offering, or a hybrid (mix) of traditional cable TV and IPTV.

However, GPON's 1550nm for video services model, requires a video return channel mechanism that is compatible with cable TV Set Top Boxes (STBs) & does not require additional wiring in the home.

With GPON, this is accomplished using Multimedia over Coax Alliance (MoCA) technology, which is integrated into GPON optical network terminals (ONTs/ONUs) as well as residential gateways in the home and Set Top Boxes from leading cable vendors.

The upstream communications from these devices is sent to the ONU using MoCA and is passed on by the ONU upstream on the 1,310 nm wavelength.
IPTV VIA GPON

In addition to 1550-nm overlay video, GPON can also support a pure IPTV model, which supports broadcast services in a switched digital broadcast model over the 1490-nm wavelength, while supporting VoD and other interactive video services in an end-to-end IPTV model.

The video services support in GPON is considerably more robust than in HFC. And GPON systems can retain compatibility with existing cable TV Headends and new cable STBs by using the 1550-nm overlay with MoCA-supported ONUs.

SUMMARY

In summary, as services migrate to "everything on demand" and individual streams are sent to different devices in the home, the migration to IPTV over GPON will provide a lower cost/bit than QAM-based schemes on HFC networks. As this happens, the video economics begins to look a lot like the high-speed Internet economics, where GPON is the most efficient network for delivering large amounts of dedicated IP traffic.

ABOUT THE AUTHOR

Mr. Ashish Jain is an Electronics and telecom engineer and has completed his post-graduation in MBA-Finance from University of Bombay. He has 20 years of experience in CableTV, Satellite-communications, Distance-education, CCTV, DTH, Digital Headends, CAS/DRM, IPTV-Broadband and convergence technologies.

He has successfully set up India’s largest antenna manufacturing automatic plant in 2010. Also set-up India’s fastest and largest single-line Set-top-box SMT-facility recently for Made-In-India products carefully choosing and selecting world’s best technology.

Ashish Jain has presented a number of technical papers on various national & international forums & seminars. He has visited many countries and attended technical trainings for advanced technologies and inducted these new technologies, benefiting the Indian-industry.

He currently heads MCBS; providing exclusive services to Space Communications Technology. He has been responsible for the development of many training-modules & activities at the National Institute of Communication & IT institute.