FTTx Technology - A Solutions Perspective

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This document discusses FTTx (Fiber-To-The-'X') from both Technology and Solutions perspectives. It starts with a basic primer to the technology and moves on to discuss many under-the-hood details of the same.

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"If you think patience is a virtue, try surfing the internet without a high-speed connection" - Unknown

Introduction

The growing clout of fiber optics has finally percolated into the last mile providing extremely reliable architectures that promise both high speeds and long-haul delivery.

FTTH (Fiber to the Home), FTTC (Fiber to the Cabinet) and FTTN (Fiber to the Node) are all examples of FTTx network architectures that aim to provide what was thought of as impossible through copper media at one time - high availability alongside high speeds and long distances.

Up until recently, carriers and service providers were searching for answers to the time-long problem of increasing costs with transmission distances as far as copper media was concerned. Traditional architectures utilizing Fiber media only partly solve this problem since they provide high bandwidth, but most important at a larger cost rendering their scalability suspect.

With the advent of Passive Optical Networks (PON), this barrier has been breached with gusto. A multitude of applications (online conferencing, cloud-based solutions, on-demand HD streaming) and user requirements in equal measure have been constantly testing the limits of bandwidth since inception of the internet; FTTx now finally solves this problem in a win-win fashion.

While FTTx and PON are terms that are often used interchangeably, it is important to note that while FTTH is the idea (or service you provide), PON is the actual technology infrastructure and its implementation.

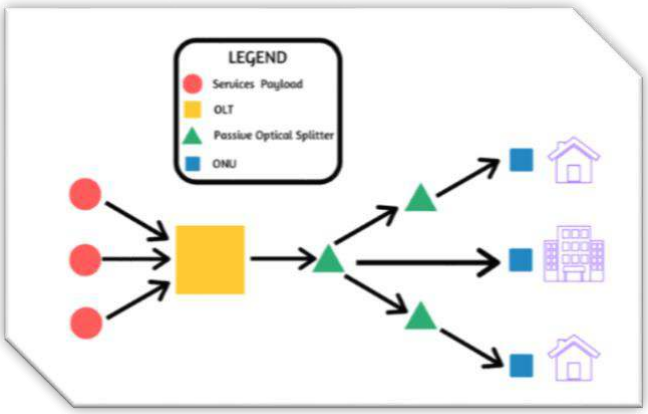
PON (Passive Optical Networks)

A PON is a point to multipoint, passive architecture used by carriers and service providers for providing long haul, last mile connectivity to subscribers.

Typical components of a PON implementation include below elements:

- Optical Line Terminal (OLT) – Central office
- Optical Network Unit (ONU) – Subscriber end
- Passive Optical Splitter – Midway in-between the central office and subscriber end

Fig 1. PON Architecture



Business Benefits

- Great Value for Users - Triple play services bundle of Video, Voice and Data
- Enhanced User experience through QoS and a high bandwidth experience
- Reduced Capital & Operational expenses for Carriers - Cabling ROI, Maintenance cost of passive components
- Enhanced resource sharing - A mind-blowing 64-128 subscribers synced over a single fiber link!
- Breaking the copper barrier – long haul links up to 20 Kms providing huge economy of scale through reach.

PON Types

The most common types of PON you are likely to see in todays and future carrier infrastructures are

- GPON (Gigabit Passive Optical Network) &
- GEPON (Gigabit Ethernet Passive Optical Network) – more commonly referred to as EPON

These are very similar in many respects yet differ in ways that are important to understand.

Picking a Winner - GPON vs GEPON

Fig 2. GPON vs GEPON

EPON	GPON
Uses Ethernet protocol	Uses ATM, Ethernet, TDM, GEM
1:64 Splitting ratio	1:128 Splitting Ratio
Upto 20 Kms	Upto 20 Kms
Uplink max of 1.25 Gbps @1310nm	Uplink max of 1.25 Gbps @1310nm
Downlink max of 1.25 Gbps @1490nm	Downlink max of 2.5 Gbps @1490 or 1550nm
Follows IEEE 802.ah Standard	Follows ITU TG 984 standard
Lesser Speed, Security & no QoS	Faster, More Secure & inclusive of QoS
Simple & less expensive to scale	Complex and costly to scale

While GPON tops on performance, QoS and security, GEPON offers absolute leverage in terms of time and cost to scale and operate. Both are undoubtedly winners in their respective playing fields. Both of them provide excellent ROI to scale vis-à-vis your existing infrastructure assets.

GPON Standards

GPON is based on ITU's G.984 family of standards while GEPON draws from established IEEE 802.3 Ethernet standards.

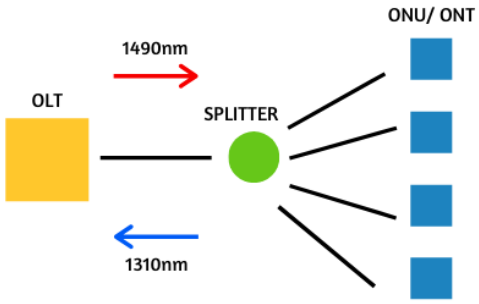
Fig 3. GPON Standards depiction.

Behind the Scenes – How does it all work?

GPON/ GEPON uses WDM (Wavelength Division Multiplexing) to ensure bidirectional communication for multiple users over a single fiber. To separate downstream and upstream signals of multiple users over a single fiber:

- In downstream direction, data is broadcasted.
- In upstream direction, data is transmitted via TDMA.

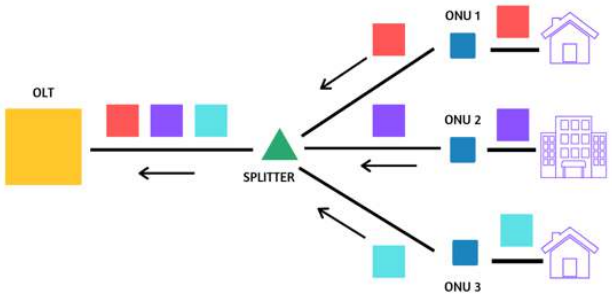
Fig 4. Upstream & Downstream data flows



Upstream

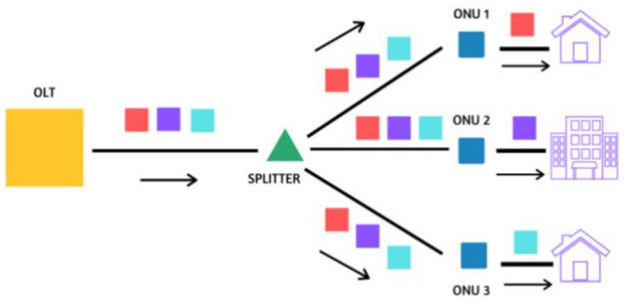
Upstream works on the principle of Time Division Multiple Access (TDMA) where each User device is given a time slot to upload. Given the bursty nature of upstream traffic, this works out just fine. Upload speeds as high as 1.25 Gbps are supported on a wavelength of 1310 / 1550nm.

Fig 5. Upstream flow using TDMA



Downstream

Fig 6. Downstream flow using Broadcasts



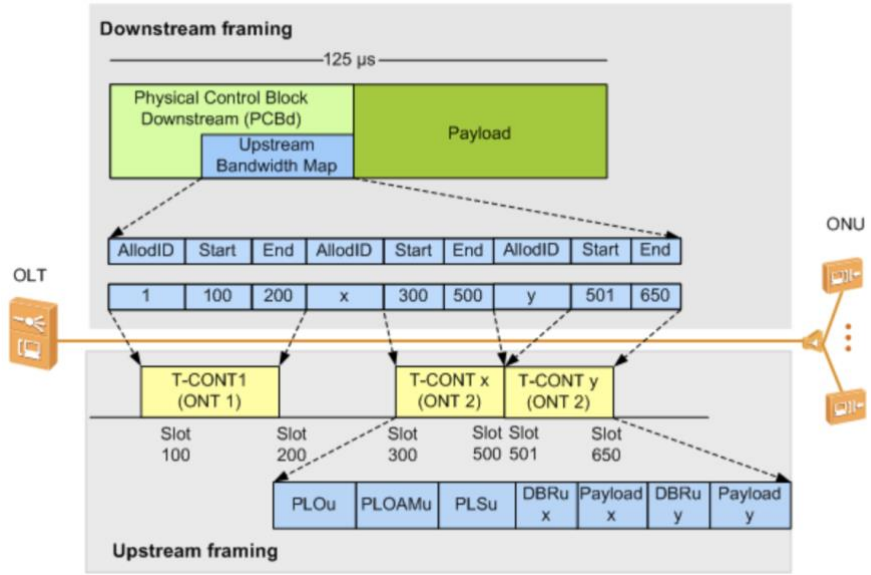
Downstream communication operates through Broadcasts. The OLT will send every frame to each subscriber, however the ONU filters out frames not relevant to the specific user. Download speeds of upto 2.4 Gbps are achievable downstream over a wavelength of 1490nm for GPON and upto 1.25 Gbps in case of GEPON.

GPON Security through AES

Given the vulnerable nature of downstream broadcasts which go to each and every node before being discarded, GPON uses AES (Advanced Encryption Security) protocol (Standard G.984.3) to encrypt and protect traffic at all times.

GPON Frame Structures

Fig 7. GPON Framing & Packet Structure[1]



Advanced GPON Techniques

- **Ranging**
  Through use of quiet zones (opportunity window), OLT obtains the round-trip delay (RTD) through this process to avoid possibility of collision.
- **Burst mode**
  Burst mode (BM) transmission is adopted for upstream channel. Any given ONU only transmits an optical packet when it is allocated a time slot and it needs to transmit, and all the ONUs share the upstream channel in the time division multiplexing (TDM) mode.
- **FEC**
  Based off the Reed-Solomon cipher, here Forward Error Correction (FEC) is implemented for downstream direction to improve transmission quality.
- **DBA**
  Dynamic Bandwidth Assignment enhances utilization of PON ports and uplink bandwidth utilization. This happens across time intervals as small as nanoseconds and microseconds.
- **Encryption**
  GPON uses Advanced Encryption Standard (AES) – upto 128 bits. In case of GEM protocol, only the payload is encrypted. AES key exchanged is built-in at periodic intervals to enhance security.
- **QoS**
  Traffic classification of services based on VLAN/ 802.1p. Combined with DBA feature to provide boost to user experience.
- **Transmission Containers**
  Use of upto 5 different types of Transmission Containers to manage upstream bandwidth allocation among subscriber nodes. Types of bandwidth requirements covered include: Fixed, Assured, Non-assured, Best-effort, and Reserved for QAM reporting.
- **High Availability Structure**
  Redundancy can be designed at the fiber and interface levels to provide reliable, high-availability connections.

DIGISOL's FTTx Product Stack

Digisol offers the finest-in-class GPON/ GEPON equipment and Fiber cabling.

- DG-GO4308-14E2SFPP - DIGISOL GPON OLT with 8 PON SFP ports, 8 Giga Ethernet Ports and 6 Giga SFP ports and 2 Giga SFP+ Ports
- DG-GR1321 – GPON/ GEPON ONU 300Mbps Wi-Fi Router with 1 PON, 1 GE and 1 FE Port, 1 FXS Port
- DG-GR4010 - GPON ONU Router with 1 PON and 1 Giga Port
- DG-GR4342L – Dual Mode GPON/ GEPON ONU 300Mbps Wi-Fi Router with 1 PON, 1 GE Port, 3 FE Port & 2 FXS Port

Complete FTTX solution matrix is available here for review and study.

Some of our category products represented by the models that follow.

GEPON TECHNOLOGY

OLT

DG-G04204-8E

GEPON OLT with 4 PON SFP Ports,
4 Giga Ethernet Ports and
4 Giga SFP/ SFP+ Ports

DG-GO4208-12E4SFPP

GEPON OLT with 8 PON SFP Ports,
8 Giga Ethernet Ports and 4 Giga SFP Ports
and 4 Giga SFP+ Ports

ONU

DG-GR1010

GEPON ONU Router with 1 PON
and 1 Giga Port

DG-GR1310

GEPON ONU 300Mbps Wi-Fi Router
with 1 PON and 1 Giga Port

GPON TECHNOLOGY

OLT/ONU

DG-GR4010

GPON ONU Router with 1 PON
and 1 Giga Port

DG-GO4308-14E2SFPP

GPON OLT with 8 PON SFP Ports,
8 Giga Ethernet Ports and 6 Giga SFP
Ports and 2 Giga SFP+ Ports

GEPON/GPON TECHNOLOGY

ONU

2 in 1

DG-GR1321

GEPON/GPON ONU 300Mbps
Wi-Fi Router with 1 PON, 1 GE and
1 FE Port, 1 FXS Port

2 in 1

DG-GR4342L

GEPON/GPON ONU 300Mbps
Wi-Fi Router with 1 PON, 1 GE and
3 FE Port, 2 FXS Port

Status Quo & Future GPON Trends

The World Fixed Broadband Statistics – Q2 2019 quarterly audit reports positively about the FTTH market growth. One key finding absolutely deserves a mention:

"Between Q2 2018 and Q2 2019 the number of copper lines fell by 6.6 per cent, while FTTH connections increased by 18.6 per cent and FTTx/VDSL by 7.1 per cent."

This has happened consistently over the last many quarters.

Fig 8. FTTH vs Copper[2]

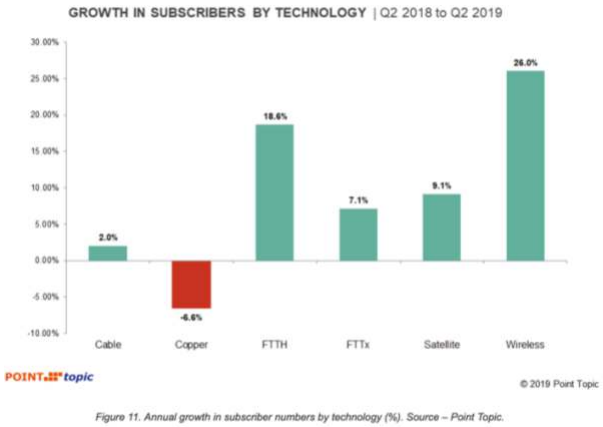
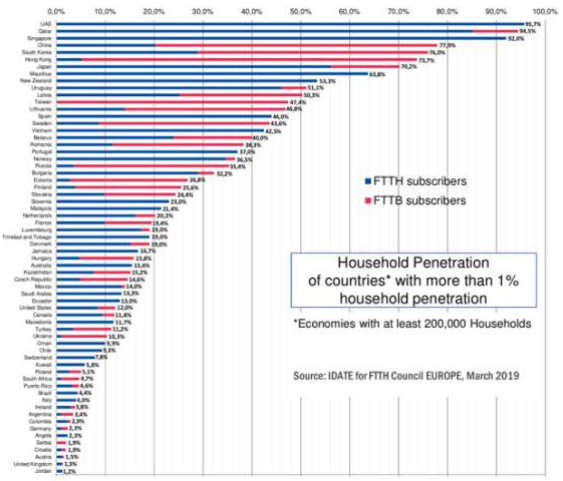


Figure 11. Annual growth in subscriber numbers by technology (%). Source – Point Topic.

Fig 9. FTTH Global ranking by Country[3]



Summary

GPON & GEPON are currently the ring leaders and here to stay the course for a very long time.

If you are an ardent technologist, it might please you to know that XGPON (also called 10G-PON) is the upcoming level up for GPON and it promises upto 10 Gbps downstream and 2.5 Gbps upstream.

Most service providers and carriers are already on course to gain maximum ROI from their investments. Likewise, users are excited to welcome a technology that offers voice, data and video at never seen before speeds.

References

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2. http://point-topic.com/free-analysis/world-fixed-broadband-statistics-q2-2019/
3. https://www.ftthcouncil.eu/documents/Reports/2019/FTTHB%20Ranking%20Sep%202018%20v2.pdf