

FTTH

Fiber to the Home



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About the Tutorial

More commonly known as "Future Proof," Fiber to the home (FTTH) is a new technology to deliver a communication signal over optical fiber. It is an efficient and economic substitute of existing copper infrastructure including telephone and coaxial cable.

This technology is effectual enough to provide much higher bandwidth to consumers and businesses. Therefore, this tutorial covers all the technical and economic aspects of FTTH and describes relevant terms in details.

Audience

This tutorial has been designed for all those readers who want to learn the basics of FTTH. It is developed in a simple language and all the technical terms are explained in detail with the objective to make it understandable to a wide range of readers.

This tutorial is intended to make you comfortable in getting started with Fiber to the home technology and its various utilities.

Prerequisites

Before starting with this tutorial, we expect that the reader to have a basic understanding of the FTTH technology as well as its associated terms.

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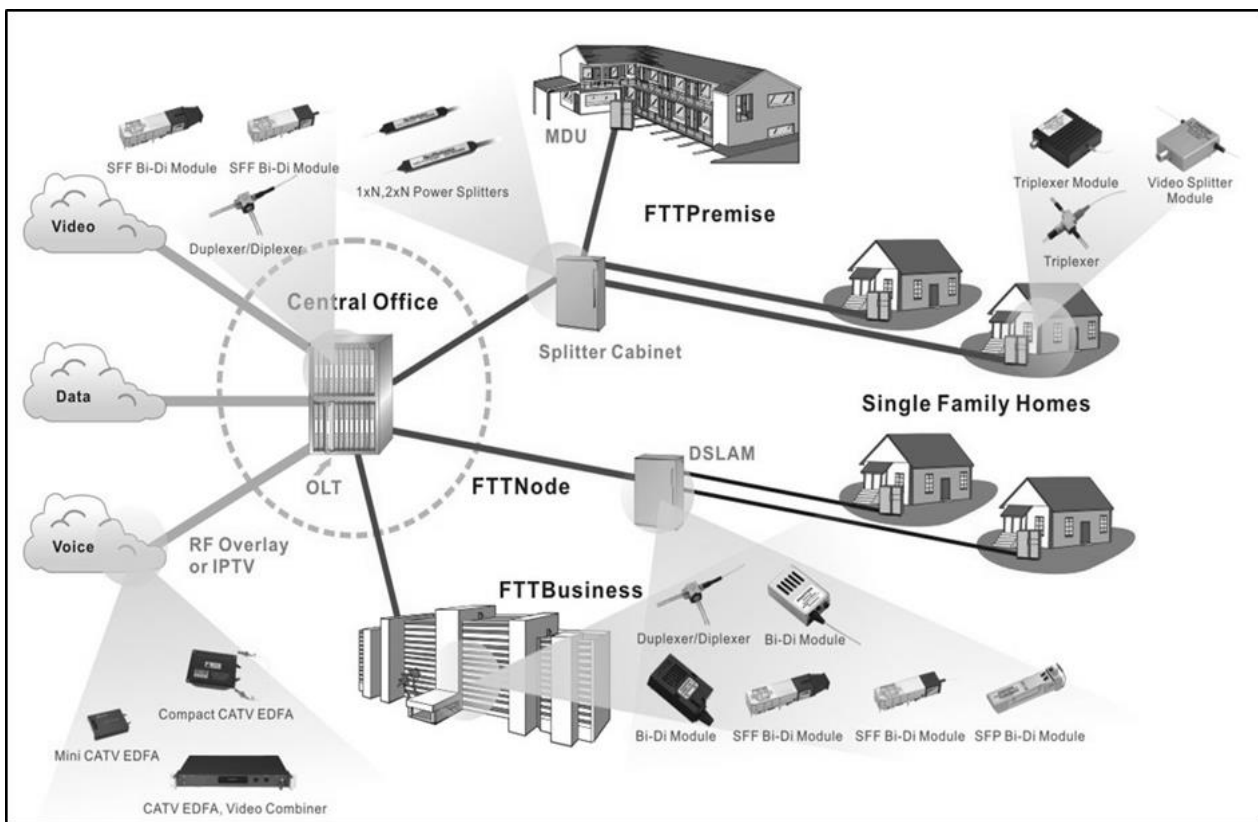
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1. FTTH – Introduction

For the access of network technologies, there are normally two ways i.e. **Fixed** and the second is the **Wireless** way. In this tutorial, we will discuss the 'Fixed' method, technically called as the **FTTH** Technology.

What is FTTH?

Fiber to the Home or simply **FTTH** is a technology that uses optical fiber directly from the central point to the residential premises (as shown in the following image). It provides uninterrupted high-speed internet service. Here, "H" includes both home and small business.



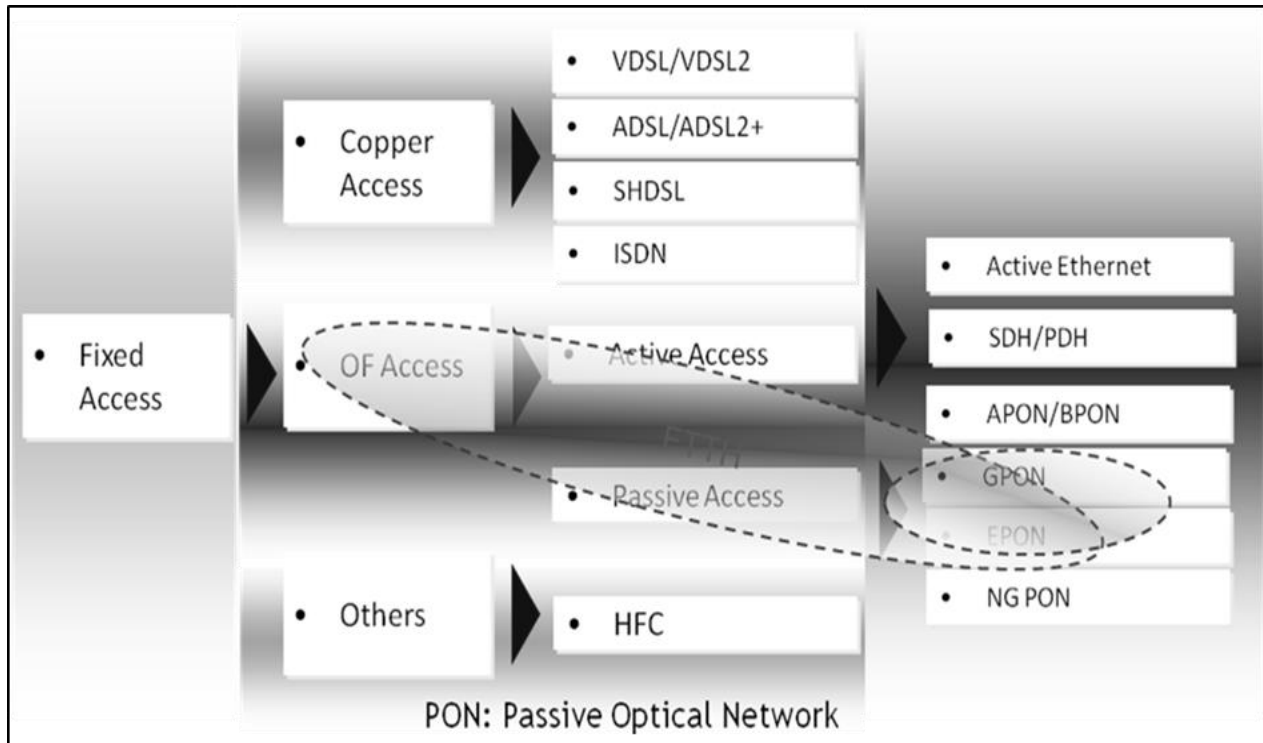
FTTH is the ultimate fiber access solution where each subscriber is connected to an optical fiber. The deployment options discussed in this tutorial are based on a complete optical fiber path from the **Optical Line Termination** (OLT) right to the subscriber premises.

This choice facilitates high bandwidth services and content to each customer and ensures maximum bandwidth for future demands of new services. Therefore, Hybrid options involving 'part' fiber and 'part' copper infrastructure networks are not included.

As an access to the home over fiber, Fiber to The Home (FTTH) scenario is mainly for the single family unit (SFU), providing a comparatively small number of ports, including the following types – POTS, 10/100/1000 BASE-T, and RF (18dBmV).

Optical Fiber Method can be deployed in two ways: Active Method and Passive Method. The current mass FTTH deployment is based on the passive method. Hence, let's discuss the Passive Method in detail.

Passive Method: The two typical technologies used in this method are **Ethernet Passive Optical Network (EPON)** & **Gigabit-capable Passive Optical Networks (GPON)**. Refer the following image.



- **Very high bit rate digital subscriber loop (VDSL)** supports a maximum bit rate of 55 bps. VDSL2 has better QoS and better SNR.
- ADSL (asymmetric digital subscriber line) supports a maximum bit rate of 8Mbps, however ADSL2 can go up to 12Mbps.
- SHDSL stands for **symmetric high bit rate digital subscriber line**. The larger the diameter of the telephone, the longer the distance it could reach. The transmission rate depends on the diameter of the telephone wire.
- **Integrated service digital network (ISDN)** is based on circuit-switched network.

Why FTTH?

Fiber offers a number of advantages over the previous technologies (Copper). The most important ones are as follows:

- Enormous information carrying capacity
- Easily upgradeable
- Easy to install
- Allows fully symmetric services

- Reduces operations and maintenance costs
- Covers very long distances
- Strong, flexible, and reliable
- Allows small diameter and lightweight cables
- Safe and secure
- Immune to electromagnetic interference (EMI)
- Lower cost

The following table lists the advanced services that can be provided through FTTH along with their bandwidth.

| Services | Bandwidth |
|--------------------------------------|-----------|
| Data Download | 10 Mbps |
| VoIP and videoconference | 1 Mbps |
| Music on demand, multimedia contents | 2 Mbps |
| On-line Gaming | 1 Mbps |
| SD Digital TV | 3 Mbps |
| HD Digital TV | 8 Mbps |
| Additional TV channels | 16 Mbps |

FTTH vs xDSL

The following table shows a typical comparison between FTTH and xDSL devices in terms of bandwidth and distance (maximum reach):

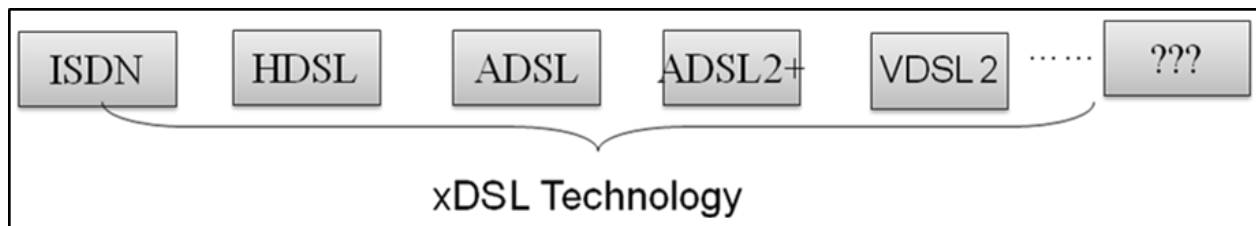
| Transport | ADSL | ADSL2 | ADSL2+ | VDSL | VDSL2 | FTTH PON |
|----------------------|-------|-------|--------|---------|-------|----------|
| Max bandwidth | D:8M | 12M | 24M | 55M | 100M | 100+ |
| | U:1M | 3.5M | 1M | 19M | 100M | 100+ |
| Distance | 3-5KM | | | <=1.3KM | | <=100KM |

- Distance affects the performance of xDSL profoundly.
- Distance is not a problem for FTTH, as the maximum reach is more than 20 kms.
- FTTH supports all the available services.

Distance and Bandwidth

The following points explain the distance and bandwidth parameters:

- ISDN: $2B + D = 2 \times 64 + 16 = 144$ Kbps
- HDSL: American standard 0.51mm, 2M max 5km.
- ADSL: 3-5 km 8 Mbps
- ADSL2: 3-5 km 12 Mbps
- ADSL2+: 3-5 km 24 Mbps
- VDSL: ≤ 1.3 km, 55 Mbps; VDSL2 upstream/downstream 100 Mbps



FTTH Terminologies

Let us now discuss in brief about the terminologies normally associated with FTTH.

Differential Fiber Distance

An OLT is connected to several ONU/ONTs. The differential fiber distance is the difference in the distance between the nearest and the farthest ONU/ONT from the OLT. In GPON, the **maximum differential fiber distance is 20 kms**. This affects the size of the ranging window and it is in accordance with ITU-T G.983.1.

Logical Reach

Logical reach is defined as the maximum distance that can be covered for a particular transmission system, regardless of the optical budget. Since, Logical reach is the maximum distance between ONU/ONT and OLT except for the limitation of the physical layer - In GPON, the **maximum logical reach is defined as 60 kms**.

Mean Signal Transfer Delay

The mean signal transfer delay is the average of the upstream and downstream delay values between reference points. This value is determined by measuring round-trip delay and then dividing by 2. GPON must accommodate services that require a maximum mean signal transfer delay of 1.5 Ms. Specifically, GPON system must have a maximum mean signal transfer delay time of less than 1.5 Ms between T-V reference points.

Optical Access Network (OAN)

The Optical Access Network is an access network towards the network side, it is also known as SNI (Service Network Interface). Uplink ports of OLT connects with L2 Switch Ring of access

network. All other in-between components such as ODF/FDMS connected towards SNI comes under the Optical Access Network.

Optical Distribution Network (ODN)

In a PON Technology towards downstream side, all passive components from the PON Port of OLT to the PON Port of ONT come under Optical Distribution Network. Normally, Splitter and ODF/FDMS come under this category.

Optical Line Termination (OLT)

A Central Office (CO) equipment provides PON with the various network interfaces. One OLT serves multiple ONTs through PON Downstream transmission, i.e., from OLT to ONT is usually TDM. Upstream traffic, i.e., from ONT to OLT is usually TDMA. PON system may be either symmetrical or asymmetrical.

Optical Network Termination (ONT)/ Optical Network Unit (ONU)

An Optical Network Termination is a Customer Premises Equipment that provides user interfaces to the customer.

Physical Reach

Physical reach is defined as the maximum physical distance that can be achieved for a particular transmission system. 'Physical reach' is the maximum physical distance between the ONU/ONT and the OLT. In GPON, two options are defined for the physical reach: 10 km and 20 km.

Service

Service is defined as a network service required by the operators. Service is described by a name that is clearly recognized by everyone, regardless of whether it is a frame structure name or a general name.

Bit Rate

GPON aims at transmission speeds greater than or equal to 1.2 Gbps. Accordingly, GPON identifies two transmission speed combinations as follows:

- 1.2 Gbps up, 2.4 Gbps down
- 2.4 Gbps up, 2.4 Gbps down

The most important bit rate is 1.2 Gbps upstream and 2.4 Gbps downstream, constituting nearly all of the deployed and planned deployment of the GPON systems.

Split Ratio

Larger the split ratio is for GPON, the more economical it is from cost perspective. However, a larger split ratio implies greater optical power and bandwidth splitting, which creates the need for an increased power budget to support the physical reach.

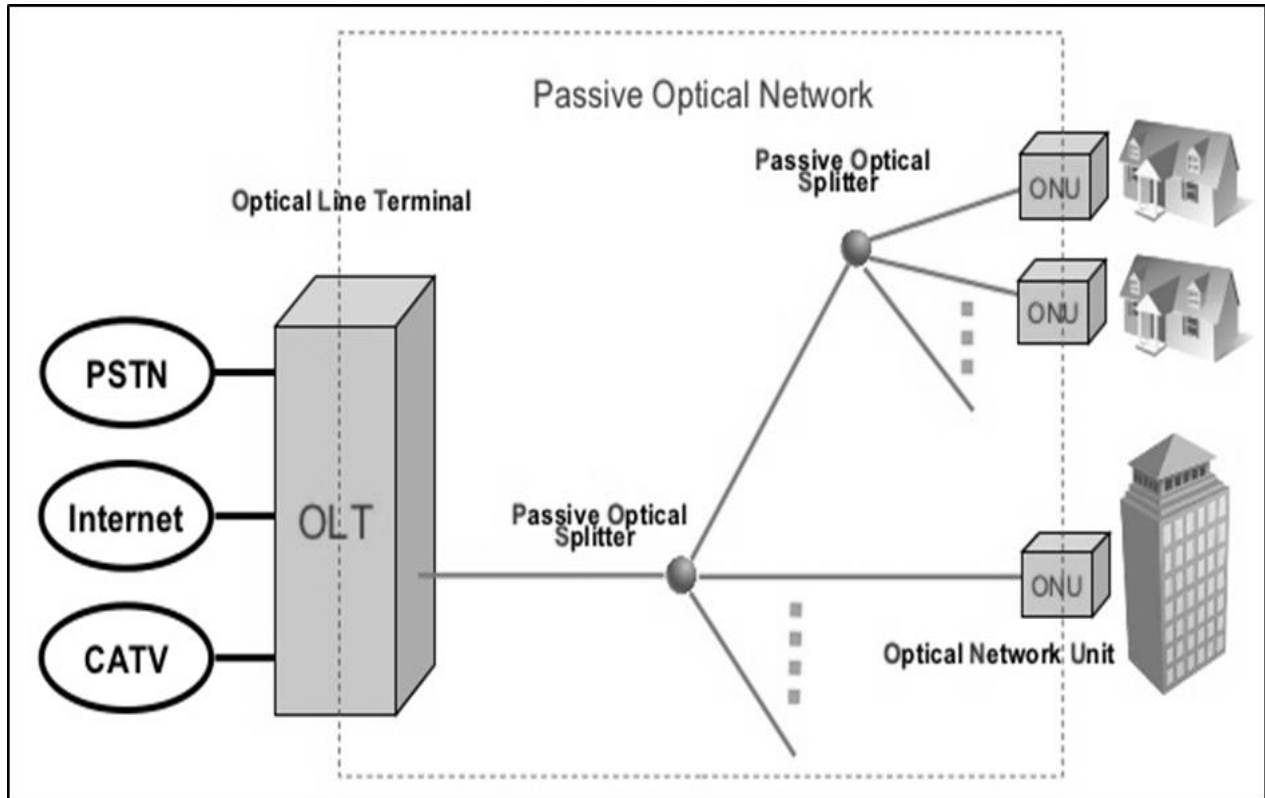
Split ratios of up to 1:64 are realistic for the physical layer, given current technology. However, anticipating the continued evolution of optical modules, the TC layer must consider split ratios up to 1:128.

Data Rates

| PON | DS (Mbps) | US (Mbps) |
|----------------------|------------------|------------------|
| BPON | 155.52 | 155.52 |
| Amd 1 | 622.08 | 155.52 |
| | 622.08 | 622.08 |
| Amd 2 | 1244.16 | 155.52 |
| | 1244.16 | 622.08 |
| GPON | 1244.16 | 155.52 |
| | 1244.16 | 622.08 |
| | 1244.16 | 1244.16 |
| | 2488.32 | 155.52 |
| | 2488.32 | 622.08 |
| | 2488.32 | 1244.16 |
| 2488.32 | 2488.32 | |
| EPON | 1250 | 1250 |
| 10GEPON [†] | 10312.5 | 10312.5 |

2. FTTH – PON

PON is **Passive Optical Network** featured with one-to-multiple-point architecture. As shown in the following image, it comprises of Optical Line Terminal (OLT), Optical Network Unit and Passive Optical Splitter.

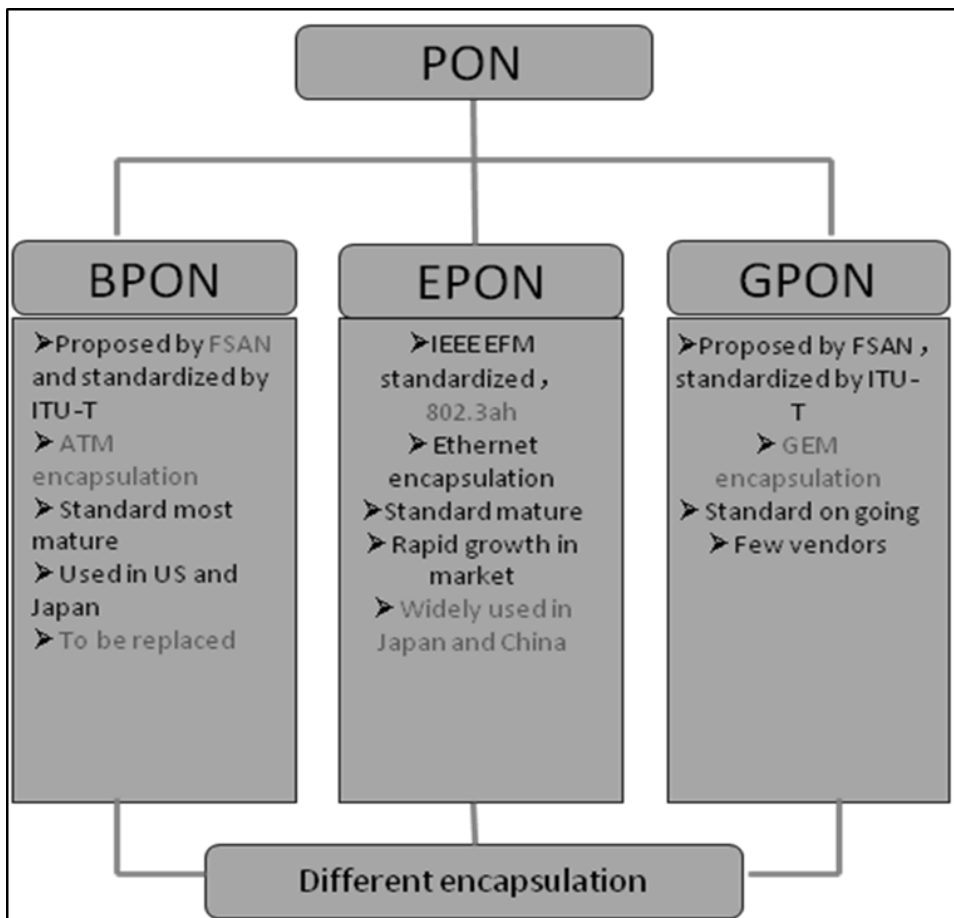


History of PON

The first Passive Optical Network (PON) activity was initiated by the FSAN group in the mid-1990s. The initial standard covered 155 Mbps transmission based on ATM known as the **APON/BPON** standard. Later on, the standard enhanced to cover 622 Mbps.

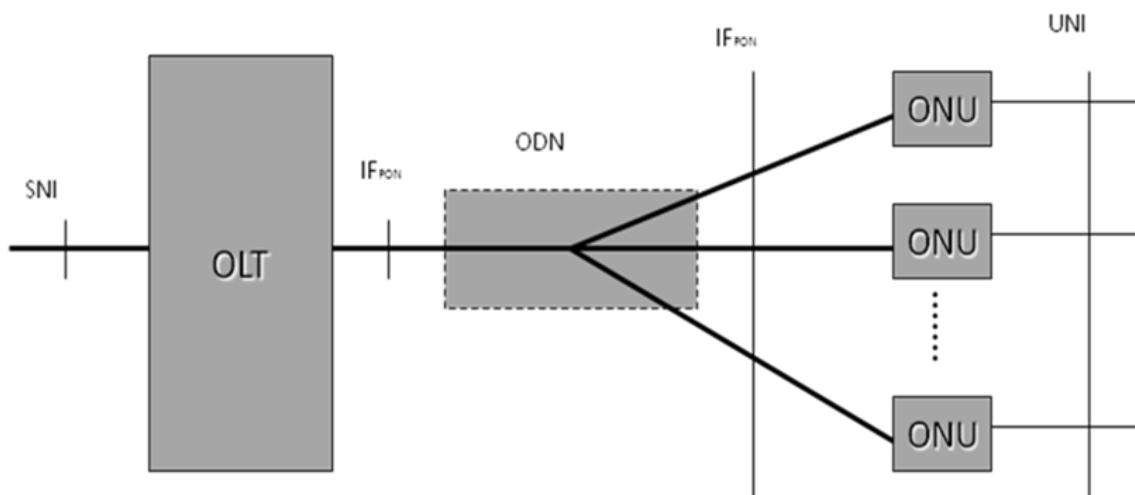
In 2001, the IEEE started the development of an Ethernet based standard known as **EPON**.

In 2001, the FSAN group started the development of a gigabit speed standard, i.e., **GPON**, to be ratified by the ITU-T.



PON Network Architecture

The following illustration shows the network architecture of PON:



SNI: Service Node Interface
 UNI: User Node Interface
 IF_{PON}: Interface for PON

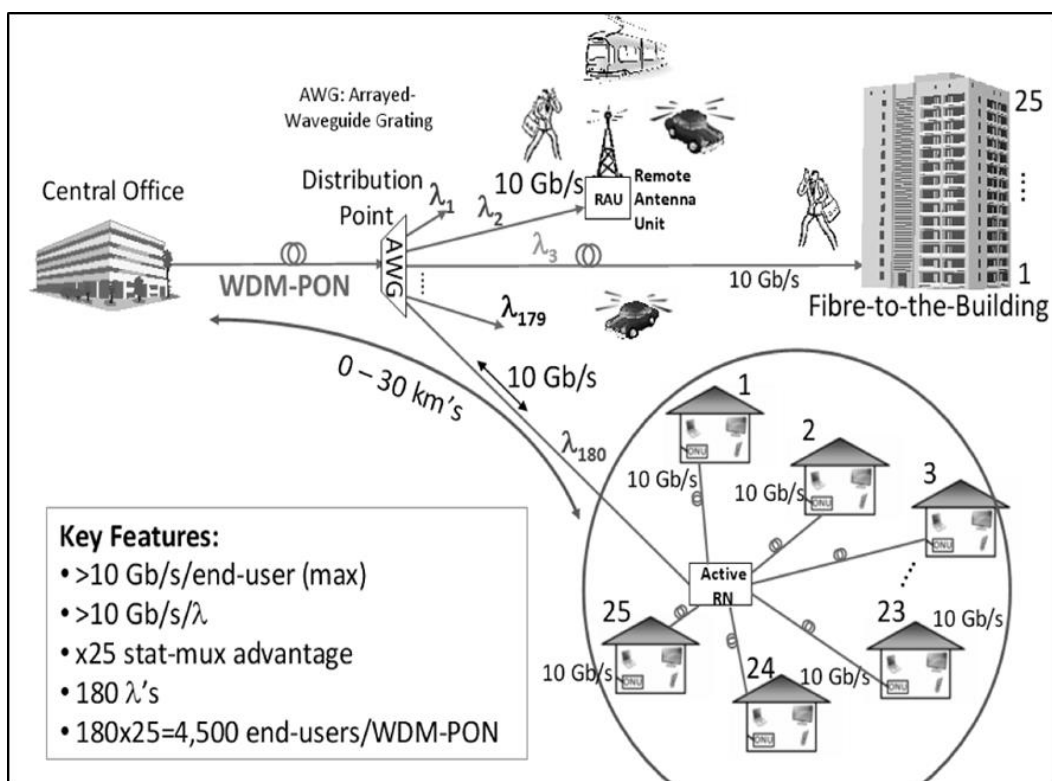
Where,

- **SNI**: Service Node Interface
- **IFPON**: Interface for PON
- **UNI**: User Node Interface

As shown in the above illustration, the ODN may be configured with one or multiple splitters with several cascades.

PON – Multiplexing

PON uses WDM to realize bi-directional transport on a single fiber (see the illustration given below):

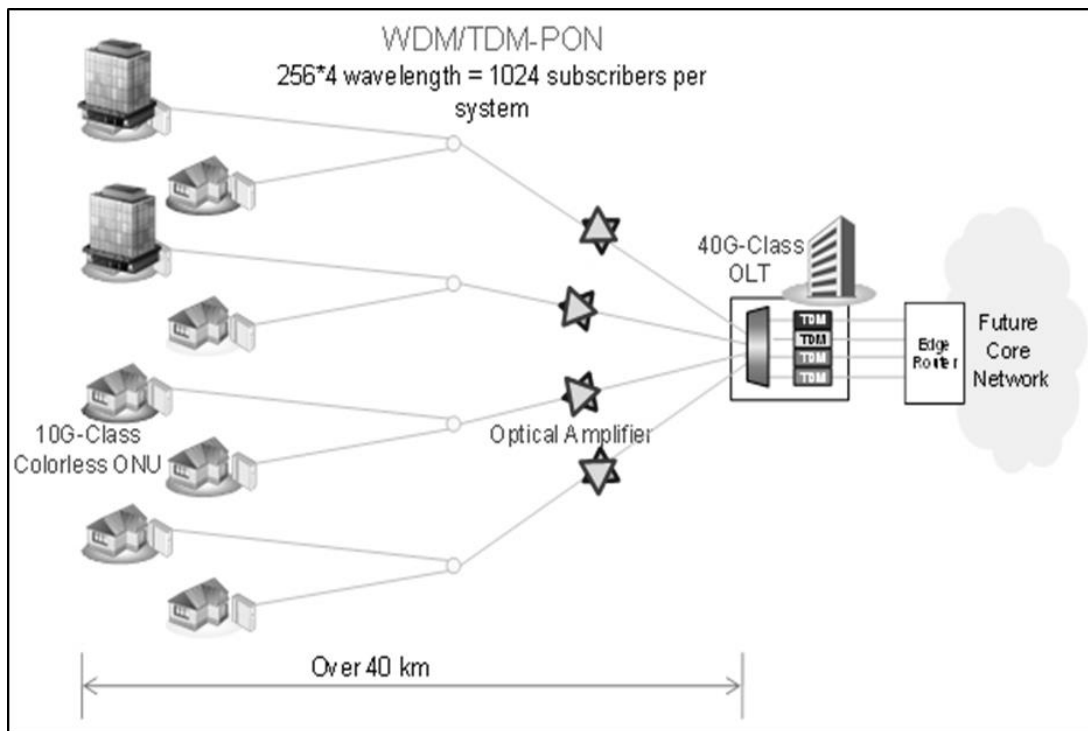


In order to distinguish the signals in two different directions, two multiplexing technologies are adopted, which are –

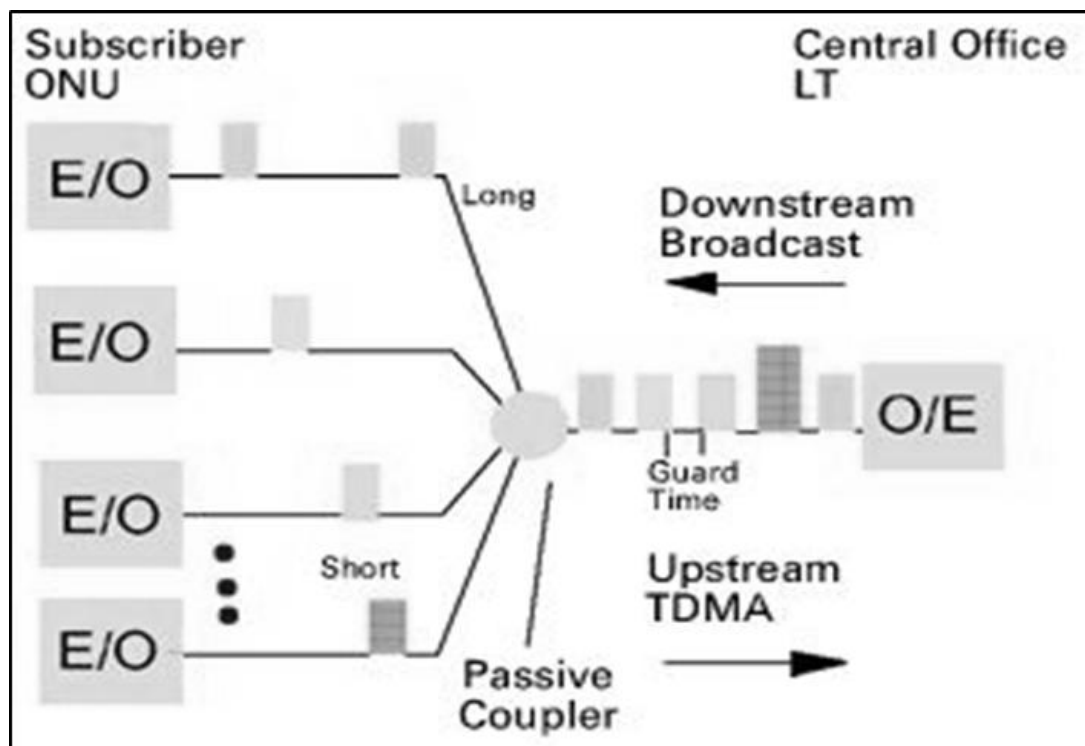
- **TDM**
- **TDMA**

Let us discuss them in detail:

Time Division Multiplexing (TDM) for downstream: It is a technique of transmitting and receiving separate signals over a common signal path. For this, it uses synchronized switches at each end of the transmission line; resultantly, each signal appears on the line only a fraction of time in an alternating pattern.

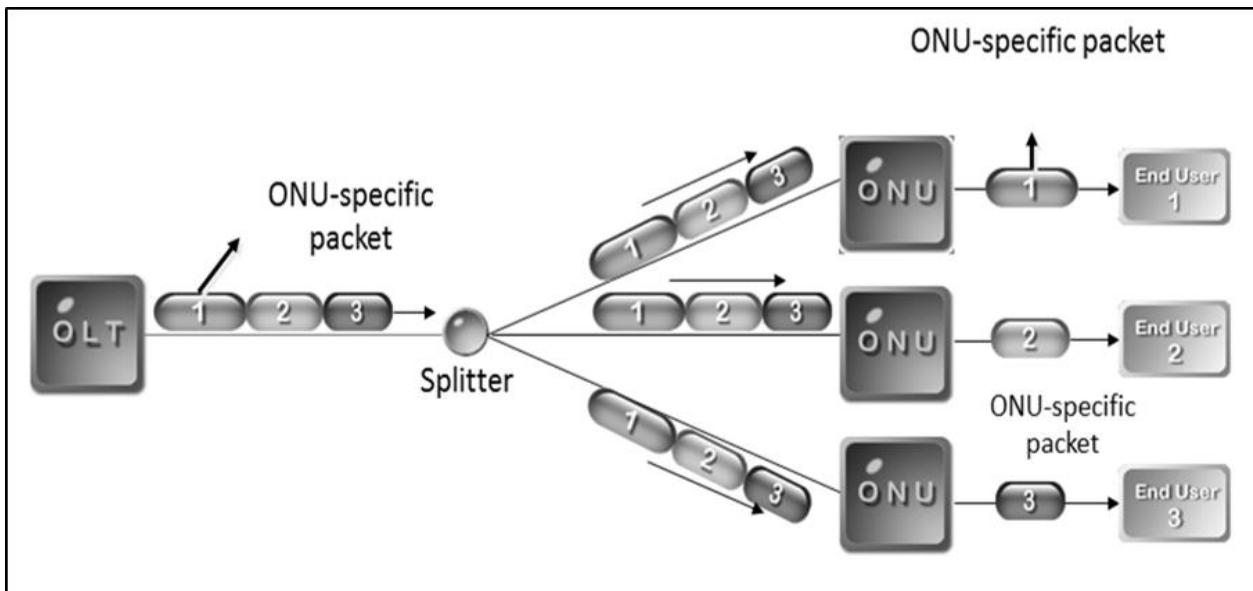


Time Division Multiple Access (TDMA) for upstream: This technique facilitates many users to share the same frequency channel by dividing the signal into different time slots.



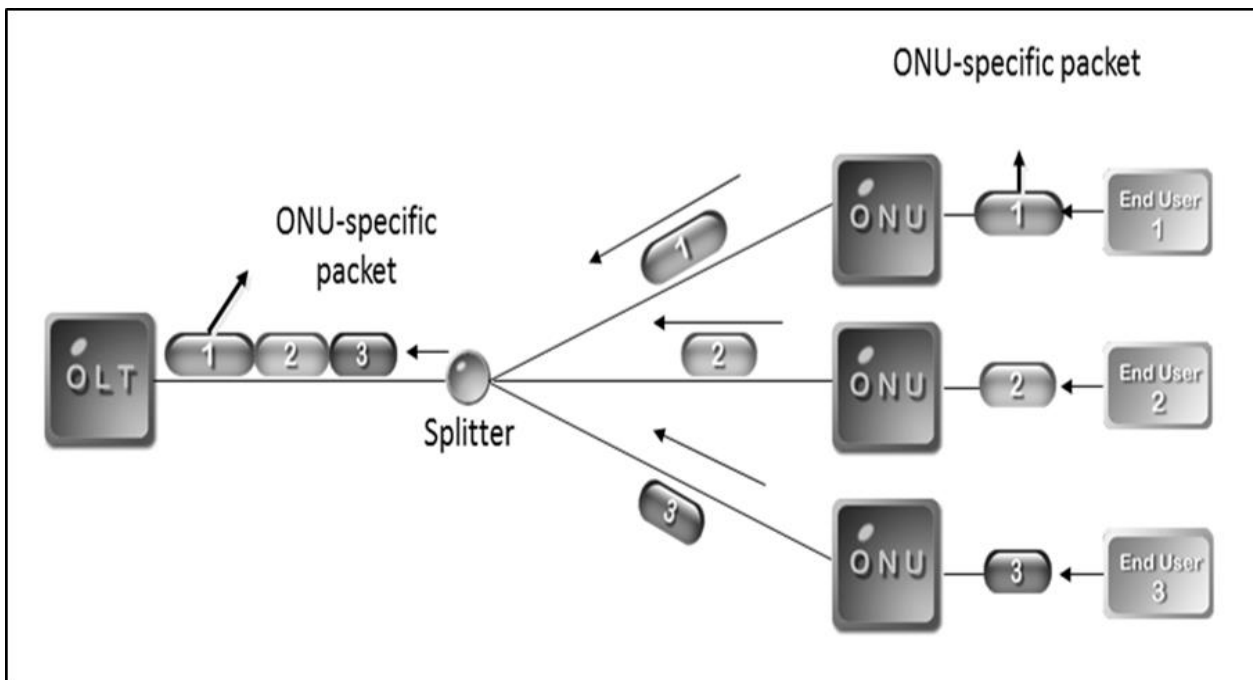
PON: Downstream

Broadcasting mode: Downstream data is broadcasted to all ONUs. But, at the ONU, only the specific packet is processed, and the rest packets are discarded.

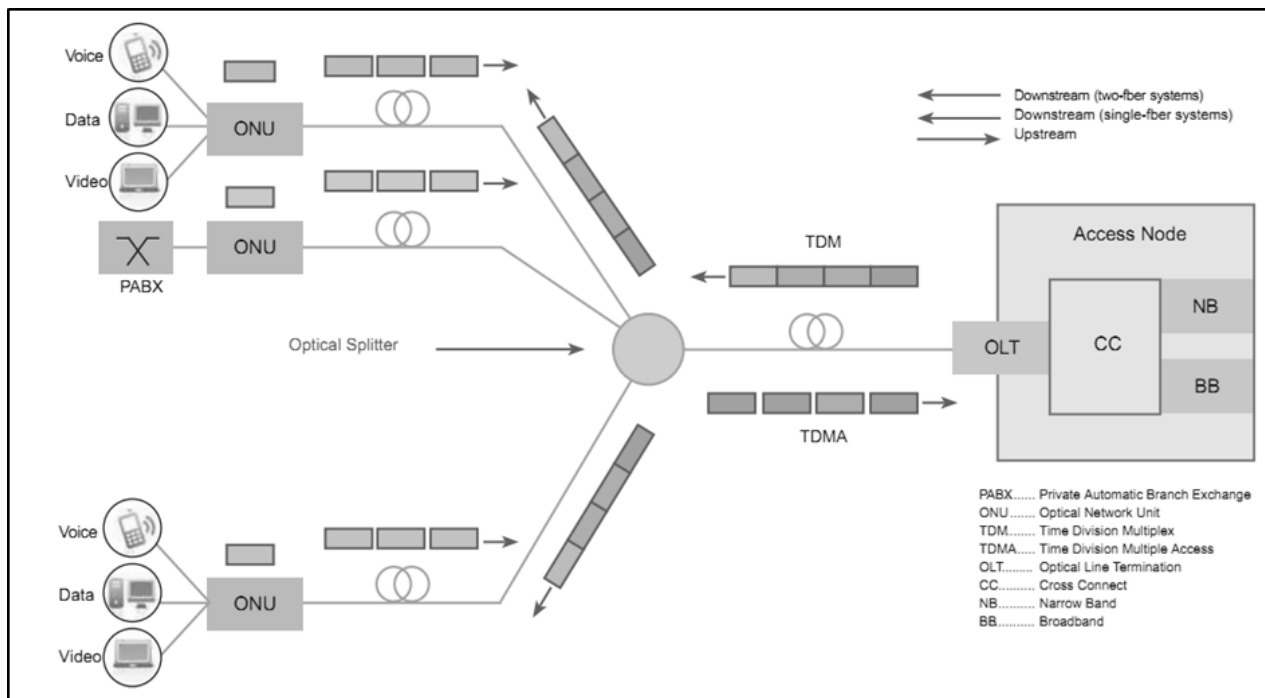


PON: Upstream (TDMA mode)

The following illustration depicts the TDMA mode.



The following illustration shows both the technologies together:



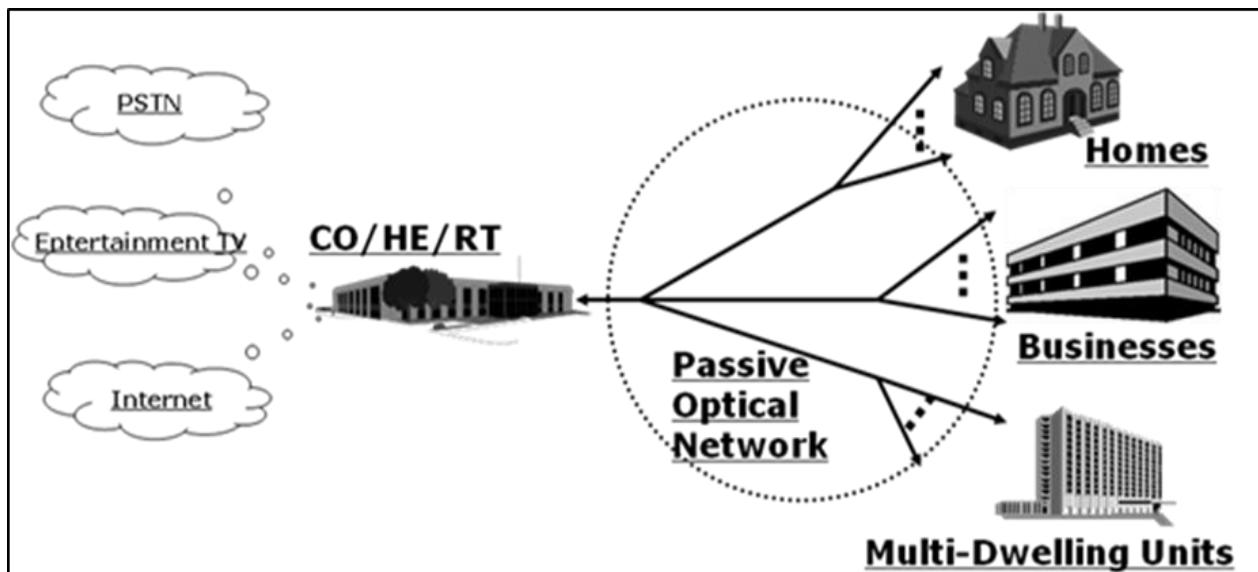
PON Terminologies

Following are the PON terminologies:

- **ODN** (Optical Distribution Network): An ODN realizes the optical transmission from the OLT towards the users and vice versa. It utilizes passive optical components.
- **OLT** (Optical Line Termination): An OLT is the service provider endpoint of a PON and is placed in a CO or head end.
- **ONT/ONU** (Optical Network Termination): An ONT is a device that terminates the PON and presents native service interfaces to the user. An ONT is typically located on the customer's premises.

PON Access Network

Passive Optical Network (PON) is essentially a cost effective optical fiber based access system that provides triple plays (voice, video, & data) services to both the business and the residential customers. Besides, the simple topology shown in the following illustration, PON can work in other topologies. For example – Bus or linear, distributed splitting, etc.



The different types of topology that are used, depends on the customer distribution profile.

An ONT can be connected to PON in any fashion as long as:

- Optical budget from ONT to OLT & vice-versa is met.
- Specification of maximum differential distance between different ONTs is met.
- Fiber length from ONT to OLT is within allowable range.
- Limit of maximum number of ONTs that the PON system can support is not exceeded.

Passive Modules in PON

Following are the Passive modules in the PON system:

- WDM Coupler
- 1 × N Splitter
- Optical fiber and cable
- Connector
- ODF/Cabinet/Subrack

Active Modules in PON

Following are the active modules in the PON system:

In OLT:

- Laser transmitter (1490-nm)
- Laser receivers (1310-nm)
- For CATV application
- Laser amplifier (1550-nm)
- EDFA for amplifying video signal

In ONU:

- X` Power/Battery for ONU
- Laser transmitter (1310-nm)
- Laser receivers (1490-nm)
- Receivers for CATV signal (1550-nm)

In the next chapter, we will understand what Gigabit Passive Optical Networks are.

End of ebook preview

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