FTTH- An Overview

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1.0 Introduction:

Growing demand for high speed internet is the primary driver for the new access technologies which enable experiencing true broadband. Today's, there is an increasing demand for high bandwidth services in market around the world. However, traditional technologies, like Digital Subscriber Line (DSL) and cable modem technologies, commonly used for "broadband access," which have access speeds to the order of a megabit per second, with actual rates strongly dependent on distance from the exchange (central office) and quality of the copper infrastructure, can not fulfill today's customer demand for bandwidth hungry applications such as high-definition TV, high-speed Internet access, video on demand, IPTV, online gaming, distance learning etc.

Amongst various technologies, the access methods based on the optical fiber has been given extra emphasis keeping into long term perspective of the country. It has many advantages over other competing access technologies of which 'Being Future Proof' and providing 'True Converged Network' for high quality multi-play are the salient ones. However, for providing multi-play services (voice, video, data etc.) and other futuristic services fiber in the local loop is must. The subscriber market for multi-play is large and growing and includes both residences and businesses. Businesses need more bandwidth and many of the advanced services that only fiber can deliver. All view Multi- Play as a strong competitive service offering now and into the future and are looking at fiber as the way to deliver.A primary consideration for service providers is to decide whether to deploy an active (point-to-point) or passive (point-to-multipoint) fiber network.

2.0 Fiber To The x (FTTx):

Today, fiber networks come in many varieties, depending on the termination point: building (FTTB), home (FTTH), curb (FTTC) etc. For simplicity, most people have begun to refer to the fiber network as FTTx, in which x stands for the termination point.

As telecommunications providers consider the best method for delivering fiber to their subscribers, they have a variety of FTTx architectures to consider. FTTH, FTTB, and FTTC each have different configurations and characteristics.

2.1 FTTH (Fiber To The Home):

FTTH is now a cost-effective alternative to the traditional copper loop. "Fiber to the Home" is defined as a telecommunications architecture in which a communications path is provided over optical fiber cables extending from an Optical Line Terminal (OLT) unit located in central office (CO) connects to an Optical Network Terminal (ONT) at each premise.

Both OLTs and ONTs are active devices. This communications path is provided for the purpose of carrying telecommunications traffic to one or more subscribers and for one or more services (for example Internet Access, Telephony and/or Video-Television). FTTH consists of a single optical fiber cable from the base station(OLT) to the home(ONT).

The optical/electrical signals are converted and connection to the user's PC via an Ethernet card. FTTH is the final configuration of access networks using optical fiber cable.

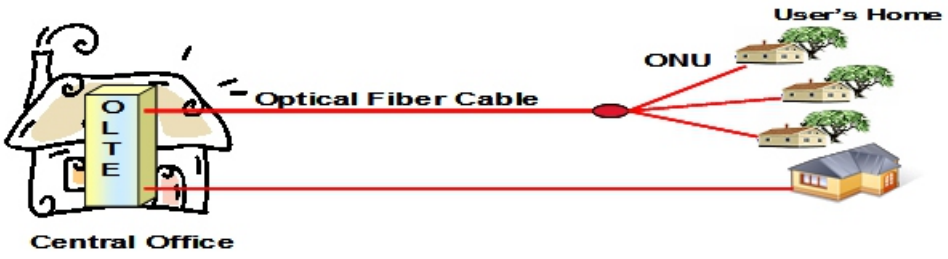


Fig. 1 FTTH Configuration

2.2 FTTB (Fiber To The Building):

"Fiber to the Building" is defined as a telecommunications architecture in which a communications path is provided over optical fiber cables extending from an Optical Line Terminal (OLT) unit located in central office (CO) connects to an Optical Network Unit (ONU at the boundary of the apartment or office or building enclosing the home or business of the subscriber or set of subscribers, but where the optical fiber terminates before reaching the home living space or business office space and where the access path continues to the subscriber over a physical medium other than optical fiber (for example copper loops).

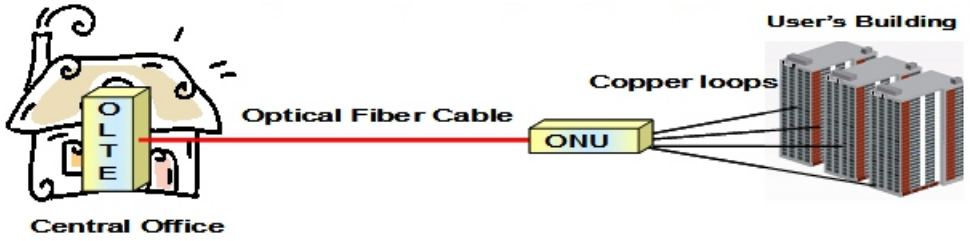


Fig. 2 FTTB Configuration

Optical fiber cable is installed up to the metallic cable installed within the building. A LAN or existing telephone metallic cable is then used to connect to the user.

2.3 FTTC (Fiber To The Curb):

A method of installing optical fiber cable by the curb near the user's home.

An optical communications system is then used between the ONU installed outside (such as near the curb or on Street Cabinet) from the installation center.

Finally, copper cable is used between the ONU and user.

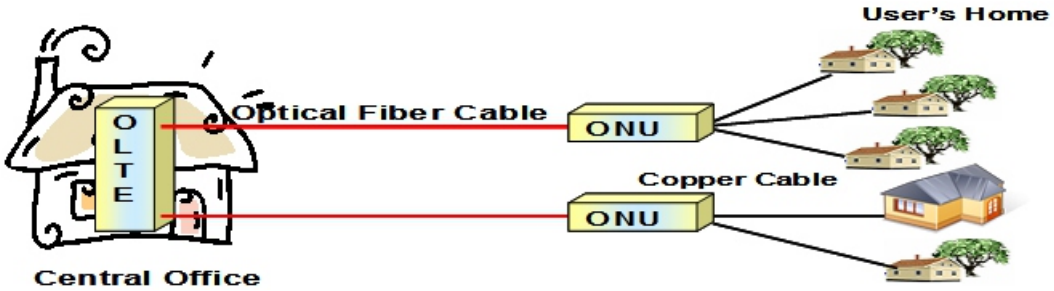


Fig. 2 FTTB Configuration

3.0 Why FTTH?

FTTH is a true multi-service communications access which simultaneously handles several phone calls, TV/video streams, and Internet users in the home/office. There are several advantages of deploying FTTH over other traditional access technologies as given below:

» FTTH provides end-users with a broad range of communications and entertainment services, and faster activation of new services.

» Competition is beginning to offer a "multi-play" (i.e., voice, video, data etc) bundle.

» FTTH provides Service Provider's with the ability to provide "cutting edge" technology and "best-in-class" services.

» Deploying a fiber optic cable to each premise will provide an extraordinary amount of bandwidth for future services.

» FTTH provides carriers with an opportunity to increase the average revenues per user (ARPU), to reduce the capital investment required to deliver multiple services, and to lower the costs of operating networks (fewer outdoor electronics, remote management, ..) will result in less operational expense.

» FTTH provides the community in which it's located with superior communications which enhance the efficiency of local business and thus deliver economic advantage for the community.

» Around the world FTTH is viewed as strategic national infrastructure similar to roads, railways, and telephone networks.(NOFN project in INDIA).

4.0 Technology Options for FTTH Architecture:

When deciding which architecture to select a provider has many things to consider including the existing outside plant, network location, the cost of deploying the network, subscriber density and the return on investment (ROI). At present different technology options are available for FTTH architecture. The network can be installed as an active optical network, or a passive optical network (PON).

4.1 Active Optical Network:

The active optical network implementation is known as the "Active Node" and is simply described as a "point-to-point" solution. Subscribers are provided a dedicated optical cable and the distribution points are handled by active optical equipment. These active architectures have been set up as either "Home Run Fiber" or "Active Star Ethernet".

4.1.1 Home Run Fiber (Point-to-Point) Architecture:

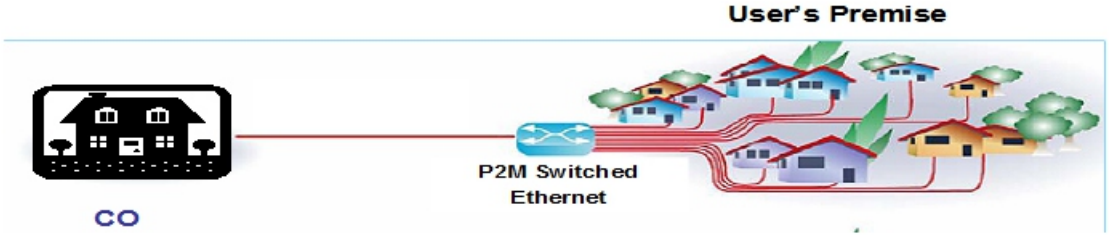
A Home Run Fiber architecture is one in which a dedicated fiber line is connected at the central office (CO) to a piece of equipment called an Optical Line Terminator (OLT). At the end user location, the other side of the dedicated fiber connects to an Optical Network Terminal (ONT). Both OLTs and ONTs are active, or powered, devices, and each is equipped with an optical laser The Home Run fiber solution offers the most bandwidth for an end user and, therefore, also offers the greatest potential for growth.

Over the long term Home Run Fiber is the most flexible architecture; however, it may be less attractive when the physical layer costs are considered. Because a dedicated fiber is deployed to each premise, Home Run Fiber requires the installation of much more fiber than other options, with each fiber running the entire distance between the subscriber and the CO.

Fig. 4 Home Run Fiber (Point-to-Point) architecture

4.1.2 Active Star Ethernet (Point-to-Multi Point) Architecture:

Active Star Ethernet (ASE) architecture is a point-to-Multi-point architecture in which multiple premises share one feeder fiber through a Ethernet switch located between the CO and the served premises.



. 5 Active Star Ethernet (ASE) architecture

With Active Star Ethernet (ASE) architecture, end users still get a dedicated fiber to their location; however, the fiber runs between their location and Ethernet switch.

Like Home Run Fiber, subscribers can be located as far away from the Ethernet switch and each subscriber is provided a dedicated "pipe" that provides full bidirectional bandwidth. Active Star Ethernet reduces the amount of fiber deployed; lowering costs through the sharing of fiber.

4.2 Passive Optical Network (Point-to-Multipoint) Architecture

The key interface points of PON are in the central office equipment, called the OLT (Optical line terminal),and the Customer Premises Equipment (CPE), called ONU(Optical network unit) or ONT (Optical network terminal).

1. OLT: The OLT resides in the Central Office (CO). The OLT system provides aggregation and switching functionality between the core network (various network interfaces) and PON interfaces. The network interface of the OLT is typically connected to the IP network and backbone of the network operator.

Multiple services are provided to the access network through this interface. OLT devices support management functions and manage maximum up to 128 downstream links. In practice, it is common for only 8 to 32 ports to be linked to a single OLT in the central office

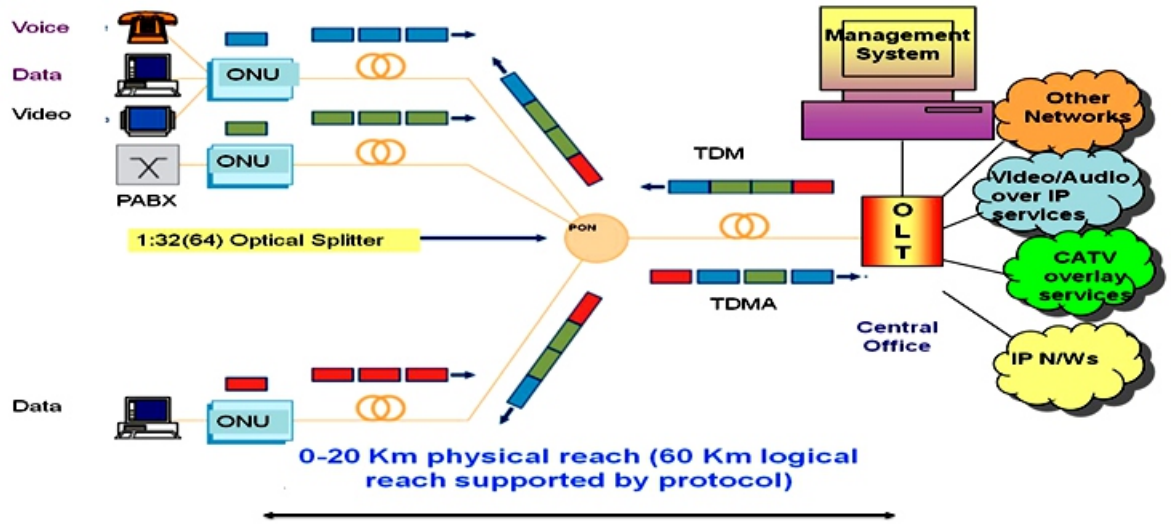


Fig. 6 PON Architecture

2. ONU/ONT: This provides access to the users i.e. an External Plant / Customer Premises equipment providing user interface for many/single customer. The access node installed within user premises for network termination is termed as ONT. Whereas access node installed at other locations i.e. curb/cabinet/building, are known as ONU. The ONU/ONT provide, user interfaces towards the customers and uplink interfaces to uplink local traffic towards OLT.

3. PON: Distributed or single staged passive optical splitters/combiners provides connectivity between OLT & multiple ONU/ONTs through one or two optical fibers. Optical splitters are capable of providing up to 1:64 optical split, on end to end basis. These are available in various options like 1:4, 1:8, 1:16, 1:32 and 1:64.
4. NMS: Management of the complete PON system from OLT.

» One OLT serves multiple ONU/ONTs through PON.

» TDM/TDMA protocol between OLT & ONT.

» Single Fiber/ Dual Fiber to be used for upstream & downstream.

» Provision to support protection for taking care of fiber cuts, card failure etc.

» Maximum Split Ratio of 1:64.

» Typical distance between OLT & ONT can be greater than 15 Km.

» Downstream transmission i.e. from OLT to ONU/ ONT is usually TDM.

» Upstream traffic i.e. from ONU/ONT to OLT is usually TDMA.

» PON system may be symmetrical or asymmetrical.

» PON and fiber infrastructure can also be used for supporting any one way distributive services e.g. video(CATV) at a different wavelength .

PON systems use optical splitter architecture or multiplexing signals with different wavelengths for downstream and upstream.There are two common splitter configurations are being used for PON architecture i.e. centralized and the cascaded approaches.

A. Centralized Splitter Approach:

In Centralized Splitter Approach typically uses a 1x32 splitter in an outside plant enclosure, such as a fiber distribution terminal. In the case of a 1x32 splitter, each device is connected to an OLT in the central office. In this approach, optical splitters are concentrated in a single location from which all customer's optical network terminals (ONTs) at 32 homes are connected as shown in fig. 7.

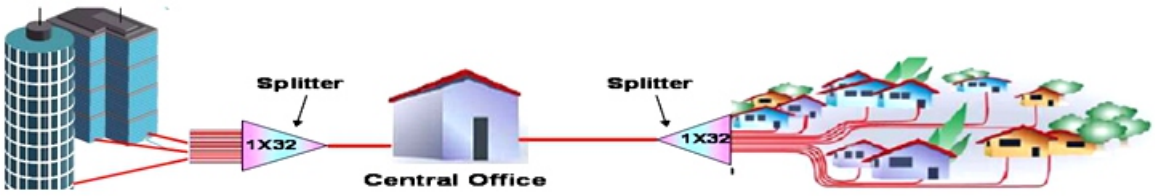


Fig. 7 Centralized Splitter Approach

B. Cascaded Splitter Approach:

A cascaded split configuration results in pushing splitters deeper into the network as shown in fig.8. Passive Optical Networks (PONs) utilize splitter assemblies to increase the number of homes fed from a single fibre.

In a Cascaded PON, there will be more than one splitter location in the pathway from central office to customer. Currently, standard splitter formats range from 1 x 2, 1 x 4, 1 x 8, 1 x 16 and 1 x 32 so a network might use a 1 x 4 splitter leading to a 1 x 8 splitter further downstream in four separate locations. Optimally, there would eventually be 32 fibers reaching the ONTs of 32 homes.

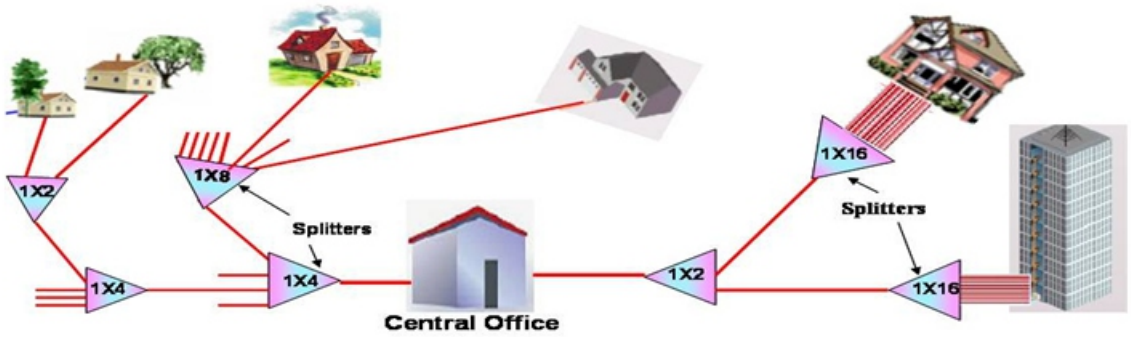


Fig.8 Cascaded Splitter Approach

There are several "flavors" of PON technology, i.e. new access technology named APON (ATM Passive Optical Network), BPON (Broadband Passive Optical Networking), EPON (Ethernet Passive Optical Networking) and GPON (Gigabit Passive Optical Networking) which delivers gigabit-per-second bandwidths while offering the low cost and reliability.

4.2.1 APON:

ATM PON (APON) was standardized by the ITU in 1998 and was the first PON standard developed. It uses ATM principles as the transport method and supports 622 Mbps downstream services and 155 Mbps upstream service shared between 32-64 splits over a maximum distance of 20 km.

4.2.2 BPON:

Shortly after APON, Broadband PON (BPON) followed and is very similar to APON. BPON also uses ATM, but it also boasts superior features for enhanced broadband services like video. BPON has the higher performance numbers then APON pre-splitting maximum of 1.2 Gbps downstream and 622 Mbps upstream.

4.2.3 EPON:

The IEEE standardized Ethernet PON (EPON) in the middle of 2004. It uses Ethernet encapsulation to transport data over the network. EPON operates at rates of 1.25Gbps both downstream and upstream (symmetrical) over a maximum reach of 20 Km. EPON is also called now as Gigabit Ethernet PON (GE-PON).

4.2.4 GPON:

Gigabit PON (GPON) is the next generation of PON's from the line of APON and BPON. The ITU has approved standard G.984x for it. GPON will support both ATM and Ethernet for Layer 2 data encapsulation so is clearly an attractive proposition. GPON supports two methods of encapsulation: the ATM and GPON encapsulation method (GEM).

GEM supports a native transport of voice, video, and data without an added ATM or IP encapsulation layer. GPONs support downstream rates as high as 2.5 Gbits/sec and an upstream rate from 155 Mbits/sec to 2.5 Gbits/sec. BSNL is procuring the GPON that will support downstream rate 2.5Gbps and upstream 1.25 Gbps.

The features of different PON standard

Features	BPON	GPON	EPON
Standard	ITU-T(G-983 Series)	ITU-T (G-984 Series)	IEEE 802.3ah
Down Stream Bandwidth	up to 622 Mbps	up to 2.5 Gbps	up to 1.25 Gbps
Up Stream Bandwidth	up to 155.52 Mbps	up to 2.5 Gbps	up to 1.25 Gbps
Downstream λ	1490 nm & 1550 nm	1490 nm & 1550 nm	1490 nm
Upstream λ	1310 nm	1310 nm	1310 nm
Layer-2 Protocols	ATM	ATM, Ethernet, TDM over GEM	Ethernet
Frame	ATM	GPON Encapsulation Method	Ethernet Frame
Max. Distance (OLT to ONU)	20 km	20 Km(supports logical reach up to 60 Km)	10 and 20 Km.
Split Ratio	1:16, 1:32 and 1:64	1:16, 1:32 and 1:64	1:16 and 1:32
Downstream Security	**AES:** Advanced Encryption Standard - 128 bit key	**AES:** Advanced Encryption Standard (Counter mode)	Not Defined
FEC	None	Yes	Yes
No. of fibers	1 or 2	1 or 2	1
Protection Switching	Support multiple protection configuration	Support multiple protection configuration	None

6.0 Proposed Services on FTTH network of BSNL:

The following services are proposed on the FTTH network:

» Basic internet Access Service controlled and uncontrolled from 256Kbps to 1000Mbps.

» TV over IP Service (MPEG2).

» Video on Demand (VoD)(MPEG4) play like VCR.

» Audio on Demand Service.

» Bandwidth on Demand (User and or service configurable).

» Remote Education.

» Point to Point and Point to Multi Point Video Conferencing, virtual classroom.

» Voice and Video Telephony over IP: Connection under control of centrally located soft switches.

» Interactive Gaming.

» Layer 3 VPN.

» VPN on broadband.

» Dial up VPN Service.

» Virtual Private LAN Service (VPLS).