Name of Course : E1-E2 CFA

Chapter 16

Topic : FTTH(NGPN)

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FTTH (NGPN)

The Department of Telecom (DOT) formulated a comprehensive Broadband policy in the year 2004 and the year 2007 had also been declared as the "Year of Broadband". By 2010, the total Internet users in the country are estimated to be around 40 millions out of which 20 millions are expected to be Broadband users. To meet the Government of India's goal, it is essential to drive Fiber To The Home (FTTH) technology along with other broadband access technologies for providing broadband access. Today, majority of broadband connectivity is offered through Digital Subscriber Line (DSL), Cable Modem and to the limited extent with Wireless technology. FTTH provides enormous bandwidth and long reach offering multi-play services (Data, Voice, Video etc.) on a single fiber. BSNL has planned 2 million customers of FTTH based on Gigabit Optical Passive Network (GPON) and Gigabit Ethernet Passive Optical Network (GEPON) technology upto year 2010-11. The broadband, voice, data & video etc services will run on this network. All these services clubbed into a brand name **"Next Generation Play Networks"**. FTTH is future proof solution for providing add-on services such as Video on demand, Online Gaming, HDTV etc.

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. The stable

and long-term growth of Broadband is, therefore, going to be dependent on robust growth of fiber in the last mile.

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. Optical fiber cables have conventionally been used for long-distance communications. However, with the growing use of the Internet by businesses and general households in recent years, coupled with demands for increased capacity, the need for optical fiber cable for the last mile has increased. A primary consideration for 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 telecommunications operator’s switching equipment 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 to the home. 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.

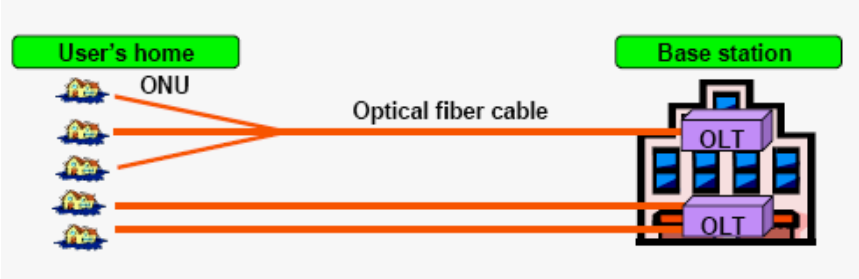

Fig. 1 FTTH Configuration

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 telecommunications operator's switching equipment connects to an Optical Network Unit (ONU) or Remote Terminal (RT) 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).

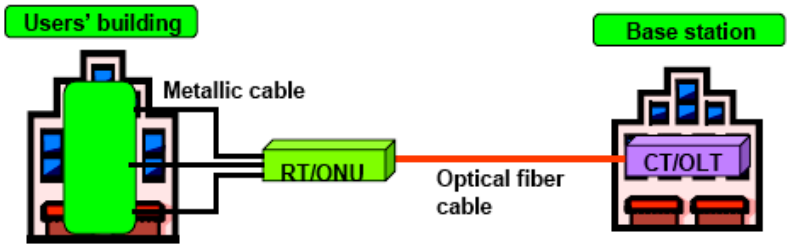

Fig. 2 FTTB Configuration

FTTB regarded as a transitional stage to FTTH. By introducing fiber cables from the fiber termination point to the home living space or business office space FTTB can be converted to full FTTH. Such a conversion is desirable as FTTH provides better capacity and longevity

than FTTB. 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 remote unit (optical signal / electrical conversion unit) installed outside (such as near the curb or on Street Cabinet) from the installation center. Finally, coaxial or other similar cable is used between the remote unit and user.

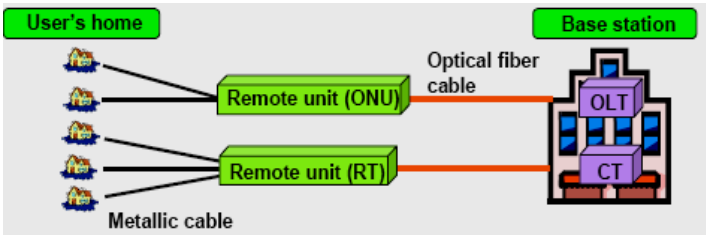

Fig.3 FTTC Configuration

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.

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 setup 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.

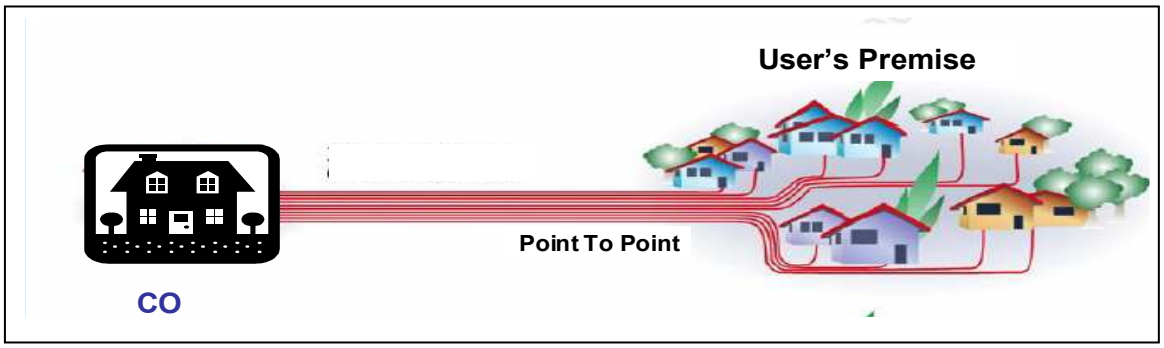

Fig. 4 Home Run Fiber (Point-to-Point) architecture

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 an Ethernet switch located between the CO and the served premises.

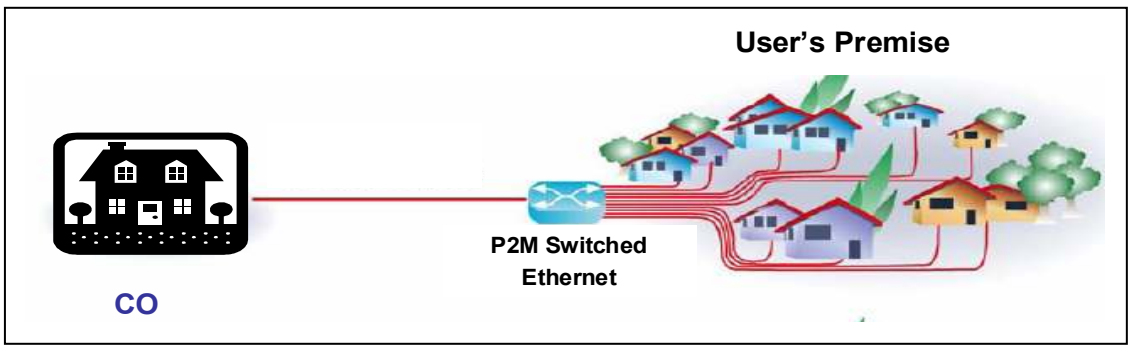

Fig. 5 Active Star Ethernet (ASE) architecture

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 bi-directional 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

A Passive Optical Networks (PON) is based on the premise of a point-to-multipoint architecture. Passive Optical Network is essentially a cost effective optical fiber based access system for providing multi-play (voice, video, data etc) services, being rolled out by BSNL shortly, to both business and residential customers. A Passive Optical networks (PON) use optical fiber and optical power splitters to connect the Optical Line Terminal (OLT) at the local exchange (CO) to the subscriber’s Optical Network Unit (ONU) on his premises. Passive splitters are located downstream from the CO and can split the fiber signal up to 32 or more times over a maximum distance of 10-20 km. This means that the bandwidth is split, or shared, between users as well. The architecture is called passive because all splitters and intermediate equipment located between the CO and the ONT is passive; that is, it has no active electronics and therefore does not need separate power. This approach greatly simplifies network operation & maintenance, and reduces the cost. Another advantage is that much less fiber is required than in **point-to point topologies**.

There are two common splitter configurations are being used for PON architecture i.e. **centralized and the cascaded** approaches as shown in fig. 6.

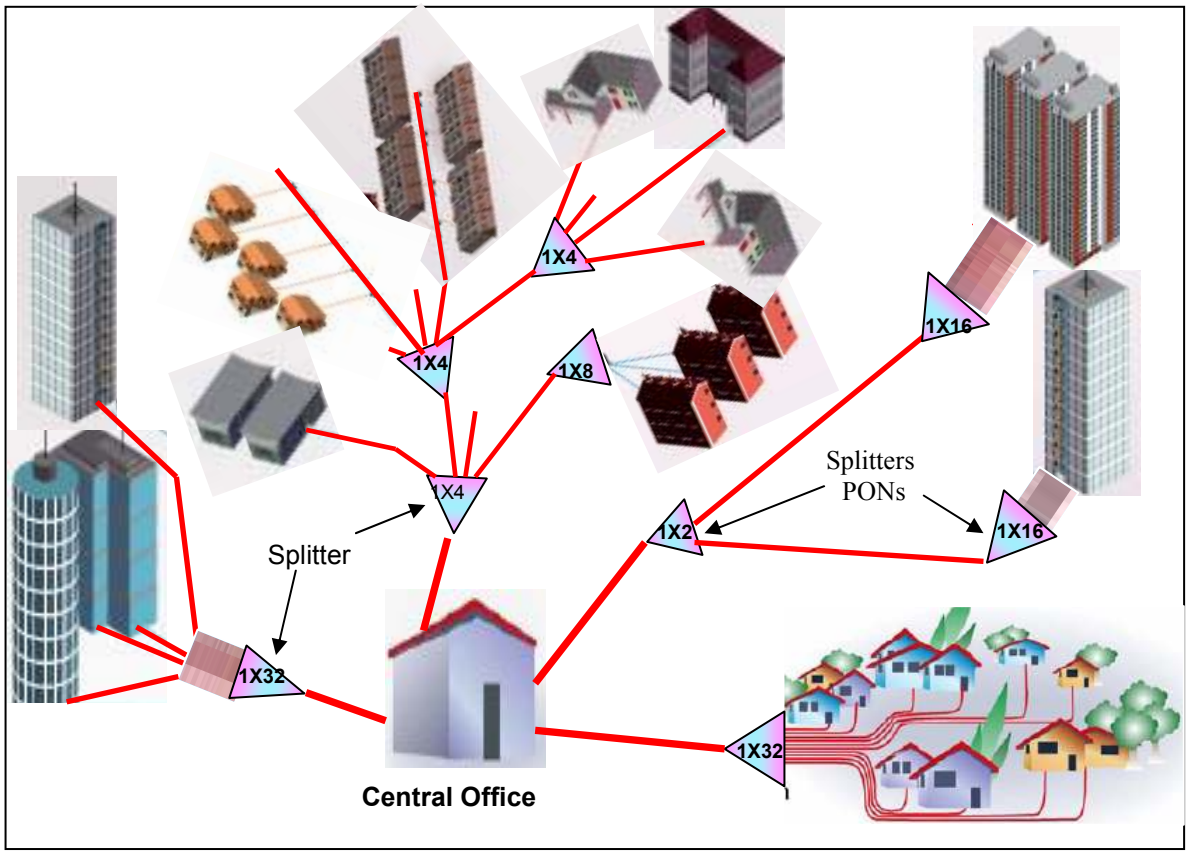

Fig. 6 Centralized and the Cascaded Passive Optical Network architecture

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 customers' optical network terminals (ONTs) at 32 homes are connected.

B. Cascaded Splitter Approach

A cascaded split configuration results in pushing splitters deeper into the network as shown in fig.6. Passive Optical Networks (PONs) utilize splitter assemblies to increase the number of homes fed from a single fiber. 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.

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

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. It supports 2.5 Gbps downstream and 1.25 Gbps upstream.

5.0 User Categories

FTTH / FTTB Networks may deliver services to the following categories of users:

- **Residential** refers to private users in their homes. Residential users may live in **"MDU"** (multi-dwelling units such as apartments/condominiums) or **"SFU"** (single family dwelling units such as stand-alone houses/villas/landed property).
- **Business** refers to large (corporate), medium, and small (Small Business, Small Office Home Office) business users. Businesses may occupy **"MTU"** (multi-tenanted units such as office blocks/towers) or **"STU"** (single-tenanted units such as a stand-alone office building or warehouse).

The features of different PON standard

Features	BPON	GPON	EPON
Responsible Standard body	FSAN & ITU-T SG15 (G-983 Series)	FSAN & ITU-T SG15 (G-984 Series)	IEEE 802.3ah
Bandwidth	Down Stream up to 622 Mbps Up Stream up to 155.52 Mbps	Down Stream up to 2.5 Gbps Up Stream up to 2.5 Gbps	Down Stream up to 1.25 Gbps Up Stream up to 1.25 Gbps
Downstream ג	1490 nm & 1550 nm	1490 nm & 1550 nm	1490 nm
Upstream ג	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

Line Codes	NRZ (Scrambled)	NRZ (Scrambled)	8B/10B
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 PON Architecture:

The key interface points of PON are in the central office equipment, called the OLT for optical line terminal, and the CPE, called ONU for optical network unit (for EPON) and ONT for optical network terminal (for GPON). Regardless of nomenclature, the important difference between OLT and ONT devices is their purpose. 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. On the other hand the ONT (or ONU) devices in the CPE support only their own link to the central office. Consequently, the ONT/ONU devices are much less expensive while the OLTs tend to be more capable and therefore more expensive.

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.

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 (UNI) 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.

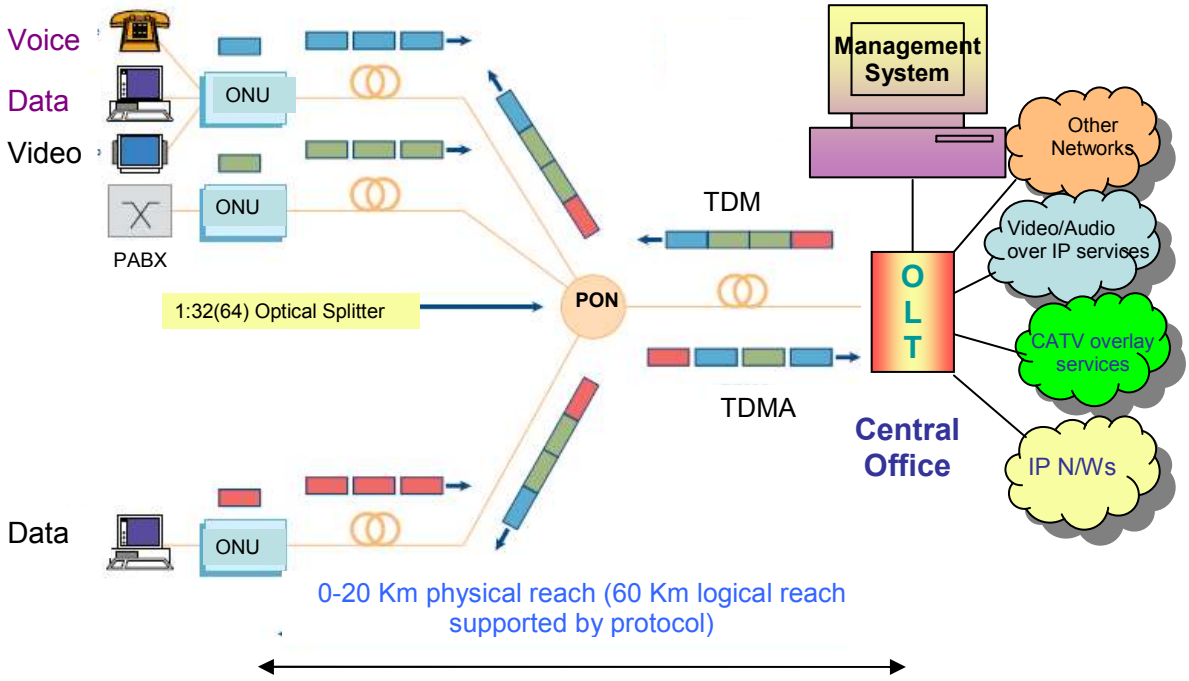

Fig. 7 PON Architecture

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 15Km (with unequal splitting - up-to 35Km)
- 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 at a different wavelength

PON is configured in full duplex mode in a single fiber point to multipoint (P2MP) topology. Subscribers see traffic only from the head end, and not from each other. The OLT (head end) allows only one subscriber at a time to transmit using the Time Division Multiplex Access (TDMA) protocol. PON systems use optical splitter architecture, multiplexing signals with different wavelengths for downstream and upstream.

7.0 EPON & GPON Applications:

- Residential or Business Services
  - High Speed Internet
  - Transparent LAN Service
  - Broadcast Video
  - Multi-Play (Voice, Video, Data etc.)
  - TDM Telephony
  - Video on Demand
  - On –line Gaming
  - IPTV etc
  - Wireless Services
  - Wireless backhaul over PON

8.0 Conclusion:

PON is a leading new technology for broadband access that promises to deliver bandwidth for a new generation of bandwidth-intensive applications such as HDTV, interactive

gaming, distance learning etc. As it uses passive network components, that simplifies and reduces the cost and maintenance challenges associated with active network technologies. Japan, Korea, China, Taiwan and other regions, where PON has already been deployed, it has quickly gained a reputation for high performance, low cost, and exceptional stability.

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