GEPON - Way Forward for Broadband in Railways

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Abstract

Broadband in Railways is used to provide Railnet connectivity to railway users at their residence and remote offices. IP-DSLAM is used as the technology for delivering this service. This article details GE-PON as the future technology for delivering this service for railway users.

1 Introduction

To provide last mile connectivity and extending Boardband services, railways are using IP-DSLAM technology. The technology used in IP-DSLAM are ADSL2, defined by ITU-T G.992.3 and G.992.4 can Support downstream rate of 10 Mbits/sec reliably up to 3,000 m. ADSL2+ (ITU-T G.992.5) supports downstream rate of 24 Mbits/sec for up to 1000 m (or 20 Mbits/sec for up to 1,500 m), and VDSL supports data rates up to 52 Mbits/sec over distances to about 1,200 m, if the loop lengths are longer data transmission will decreases. Hence due to speed-distance limitation the DSLAM Boardband services can be limited to shorter distance.

The better proposition in such case is the use of point-to-point (P2P) optical access network solution with dedicated fibers from Central Office (CO) to each end user. This approach from economic aspects is expensive due to the fact that it requires dedicated fiber deployment and optical transponders. Hence a solution which replaces the dedicated fibers by low-cost passive optical element which additionally minimizes the amount of optical transceivers, terminations. This solution was named as Passive Optical Network (PON). With this technology voice, data and video can be integrated and transmitted to the subscriber premises upto a distance of 20km using single fiber.

2 PON Standard

There are two major specification for PON.

2.1 International Telecommunication Union (ITU-T) - GPON

- ITU-T -G.984 defines Gigabit-capable Passive Optical Networks (GPON).
- 2.488 gigabits per second (Gbit/s) of downstream bandwidth.
- 1.244 Gbit/s of upstream bandwidth.
- GPON Encapsulation Method (GEM) allows very efficient packaging of user traffic with frame segmentation.
- ITU-T-G.987 defines 10G-PON with 10 Gbit/s downstream and 2.5 Gbit/s upstream.
- 10G-PON is Not BackWard Compatible with G-PON.

2.2 Institute of Electrical and Electronics Engineers (IEEE) GEPON

- IEEE Std 802.3ah-2004 defines Gigabit Ethernet Passive Optical Networks (GE-PON).
- P2MP 1.25 Gbit/s Symmetrical Ethernet links over PON (UP and Down Stream).
- IEEE Std 802.3av-2009 defines 10 Gigabit Ethernet Passive Optical Networks (10GE-PON).
- 10GE-PON isBackWard Compatible with EPON.
- It support
  - Asymmetrical - 10 Gbps Downstream and 1.25 Gbps Upstream
  - Symmetrical - 10 Gbps up /Downstream

3 GE-PON Architecture

Figure 1 shows the full GE-PON stack. The Architecture of GE-PON Point to Multi-Point Access network is as shown in Figure 2. It includes AF (block of Adaptation Function), ONU (Optical Network Unit),

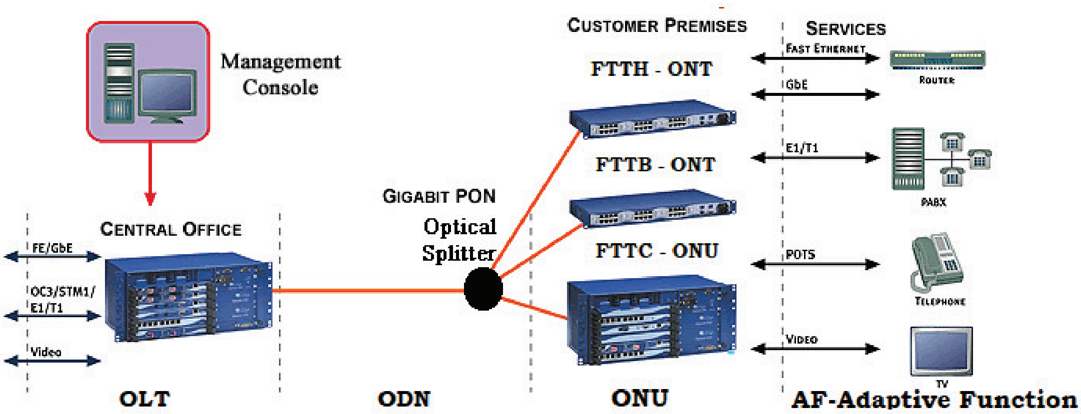

Figure 1: GE-PON Stack

ODN (Optical Distribution Network), OLT (Optical Line Termination), references points and management interface (Q3).

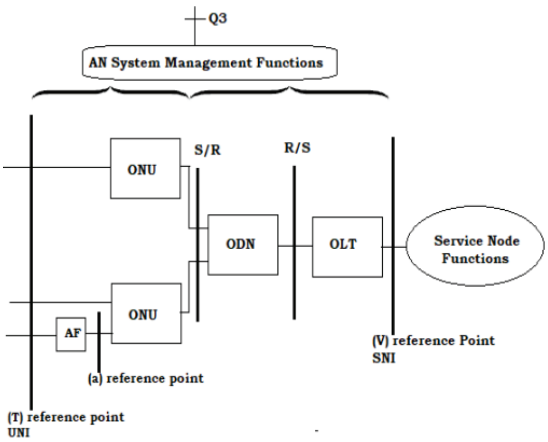

Figure 2: GE-PON Architecture

GE-PON is a very exciting technology, because it allows Ethernet networks to be directly connected via fiber, and it supports point-to-multipoint connectivity. The GE-PON standard supports EFM[1] technologies such as all of the FTTx standards FTTC (Fiber To The Curb/Cabinet), FTTH (FTT Home), FTTB (FTT Building) etc.

3.1 Optical Line Terminal

Located at the Head end /Central Office, the OLT interfaces with the metropolitan network and controls the downstream and upstream transmission. The Downstream is broad cast to each premise and the upstream transmission uses a multiple access protocol, Time division multiple access(TDMA). The OLT manages traffic to ensure bandwidth amount and priority for specified services. The main functionality of the OLT is to adapt the incoming traffic (Voice and Data) from the metropolitan rings into the PON transport layer. The OLT is defined by core shell, common shell and service shell functions. The core shell functions include digital cross connect function, transmission multiplex function, ODN interface function. The common shell is responsible for power supply and Operation and Maintenance (OAM) function and the service shell OLT is able to support two or more different services.

3.2 Optical Distribution Network

ODN refers to outside plant which includes Fibers, Optical Connectors, Optical Patch Cords and Optical Splitters. The ODN consists of an all Passive Network elements hence the equipment doesnt required any power.

3.3 Optical Network Termination & Optical Network Unit

ONT and ONU are basically the same device - however, the ONT is located at the customer premise, and the ONU is located outside the home. These devices are the interface between the customer equipment and the PON. They talk to the OLT via the PON.

3.4 Adaptation Function

AF block is responsible for providing Ethernet, x-DSL transmission over copper to the end user.

[1]Ethernet in the First Mile

4 GE-PON Traffic Flow

In an Ethernet PON the process of transmitting data downstream from the OLT to multiple ONUs is fundamentally different from transmitting data upstream from multiple ONUs to the OLT.

4.1 Downstream Traffic

The data is broadcast in downstream from the OLT to multiple ONUs in variable-length packets of up to 1,518 bytes according to the IEEE 802.3 protocol. Each packet carriers a header that uniquely identifies it as data intended for ONU-1, ONU-2 or ONU-3. In addition some packets may be intended for all of the ONUs (broadcast packets) or a particular group of ONUs (multicast packets). At the splitter the traffic is divided into three separate signals, each carrying all of the ONU-specific packets. When the data reaches the ONU it accepts the packets that are intended for it and discards the packets that are intended for other ONUs. For example, in Fig.3 ONU-1 receives packets 1, 2, and 3, however it only delivers packet 1 to end user 1.

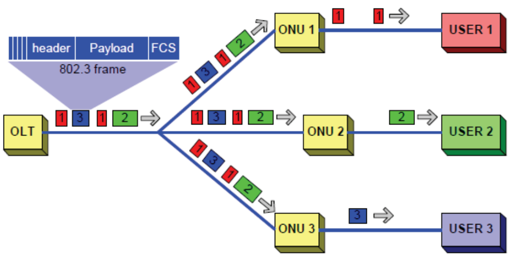

Figure 3: Downstream Traffic

4.2 Upstream Traffic

Upstream traffic is managed by Multi-Point Control Protocol (MPCP), which uses time division multiplexing, in which transmission time slots are dedicated to the ONUs. The time slots are synchronized so that upstream packets from the ONUs do not interfere with each other once the data are coupled onto the common fiber. As shown in Figure 4, For example, ONU-1 transmits packet 1 in the first time slot, ONU-2 transmits packet 2 in a second non-overlapping time slot, and ONU-3 transmits packet 3 in a third non-overlapping time slot.

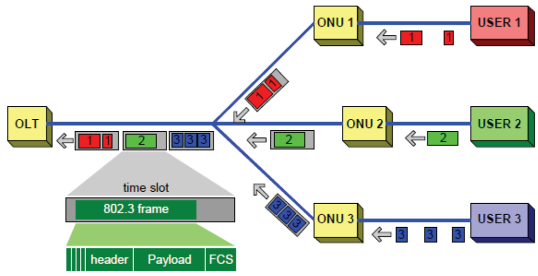

Figure 4: Upstream Traffic

5 EPON Optical System Design

Ethernet PONs can be implemented using either a two-wavelength or three-wavelength design.

5.1 2-Wavelength Ethernet PON

The architecture is as shown in Fig.5 utilise 1510 nm wavelength which carries data, video, and voice for downstream, while a 1310 nm wavelength is used to carry video on demand/channel change requests upstream as well as data and voice. Using a 1.25 Gb/s bi-directional PON the optical loss with this architecture gives the PON a reach of 20 km over 32 splits.

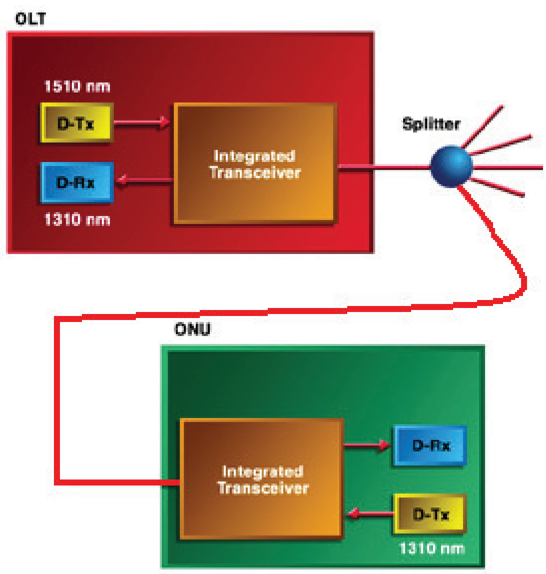

Figure 5: 2-Wavelength Ethernet PON

5.2 3-Wavelength Ethernet PON

The architecture is as shown in Figure 6 utilise 1510 nm and 1310 nm wavelengths are used in the downstream and the upstream directions respectively, while the 1550 nm wavelength is reserved for downstream video. The video is encoded as MPEG2 and is carried over Quadrature Amplitude Modulated (QAM) carriers. Using this setup, the PON has an effective range of 18 km over 32 splits.

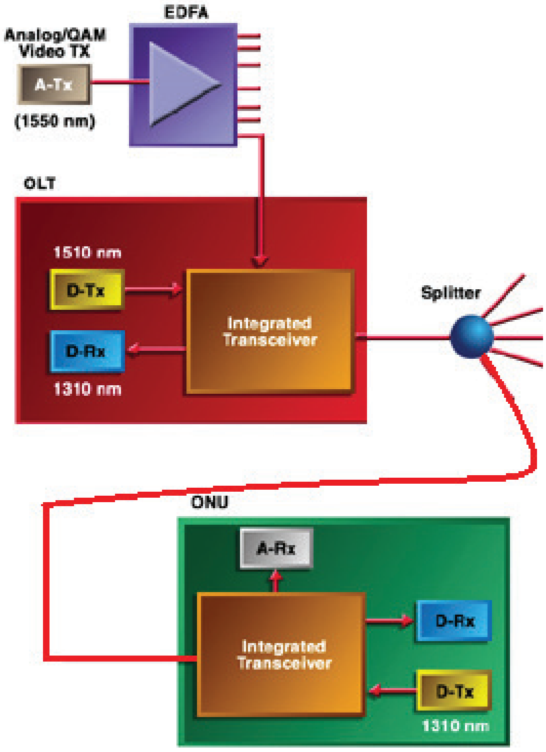

Figure 6: 3-Wavelength Ethernet PON

6 PON Advantages

1. **Reduced Capital Expenditure** 16 -128 customers per fiber which reduces the cost of initial expenditure.

2. **Reduced Operating Expenditure** Passive network, High reliability, reduced power expenses and shorter installation time.

3. **Increased Revenue Opportunities** Multi-service like Data, E1/T1, Voice, and Video can be achieved and integrated.

4. **Scalable** Central Office is Shared Equipment; New customers can be added easily as the network grows.

5. **Security and Interoperability** Security from cyber attacks and interoperability between different vendors are made easy.

6. **Green technology** Since the power consumption is very less than normal legacy active Ethernet and GPON, it is much eco-friendly network.

7 Conclusion

GE-PON, a green technology for making available broad band, is very suitable for replacing DSLAM Network in railways. It offers higher bandwidth and hence is ready for deployment of high bandwidth applications like video telephony, video on demand, Television broadcast etc. This is a requirement of future technologies where voice, video and data is to converge.

The information / views expressed in this paper is of the authors and are based on their experience. Comments / observations may be sent to the author at mohankrishna@gmail.com.

K Mohana Krishna has done his graduation in Electrical & Electronics Engineering from SV University, Tirupati in 2004. He has an experience of 6 years in BSNL. He joined Indian Railways in 2009. He has worked in maintenance and construction organizations over Southern Railways. He is currently working as Instructor in IRISET. He has been instrumental in setting up the VoIP Telephony lab at IRISET.