Passive Optical Network: A Critical Review

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ABSTRACT

The growing popularity of the Internet, Internet Protocol television, Demand of video, Conferencing through video, and online Games are the key factors behind the development of new access method which would meet the bandwidth requirement. The access methods based on the optical fiber are getting more and more attention as they offer the ultimate solution in delivering different services to the customer-provided. Due to the deficit of active units in the light path the Passive Optical Network architecture is simple, money-spinning, and offered bandwidth that is not possible to achieve by other access methods.

1. INTRODUCTION

The PON (Passive Optical Network) is an access network based on Optical Fiber. It provides virtually unlimited bandwidth to the users. A passive Optical network is a single, optical fiber shared by the users that uses a passive optical splitter to divide the signal towards individual users. A passive optical network provides minimal number of optical transceivers [1]. The main advantage of passive optical network is the fiber data-rates can be upgraded as technology improves, initially data rate is 155 Mbps,after few years data rate is 622 Mbps,at present time data rate is 1.25 Gbps, and in future data rate will be 2.5 Gbps and higher. All passive optical network systems are based on a point-to-multipoint physical topology where a single feeder fiber from the local exchange office is shared by a group of subscriber optical terminals. PON is called passive because there is no active element within the access network other than at the central office.

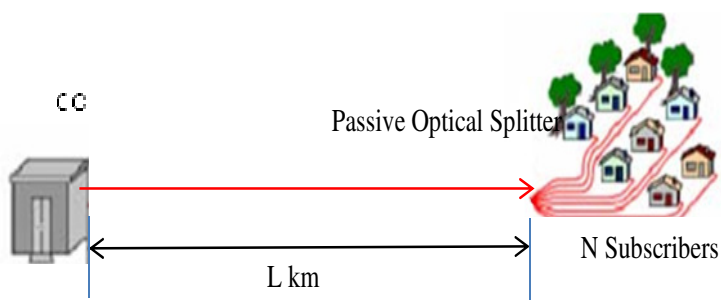

Fig.1 A typical Passive Optical Network

A PON enables to deliver a true triple play offering of voice, video and data to a service provider, IPTV is an important component for data offering [1]. PON are widely used for Fiber to the Home (FTTH) infrastructure. A Passive Optical Network avoids costly optic-electronic conversions. PON (Passive Optical Network) has emerged as a promising technology to replace conventional access network [3].

1. PON Services

PON provides the following services to the users:

Digital Entertainment: Passive Optical Network provides several types of digital entertainment type services. These are describing as:

- IPTV (Internet Protocol Television)
- Video on Demand
- Video Telephony
- Audio on Demand
- Gaming, etc.

Broadband Data services: Passive Optical Network provides various broadband data services. These are describe as:

- Internet access speed is high with bandwidth 256 kbps to 100 Mbps.
- VoIP (Voice over IP) Telephony.

PON Architecture

PON has three elements: (1) Optical Line Terminal (OLT) (2) Passive Optical Splitter and (3) Optical Network Unit (ONU).

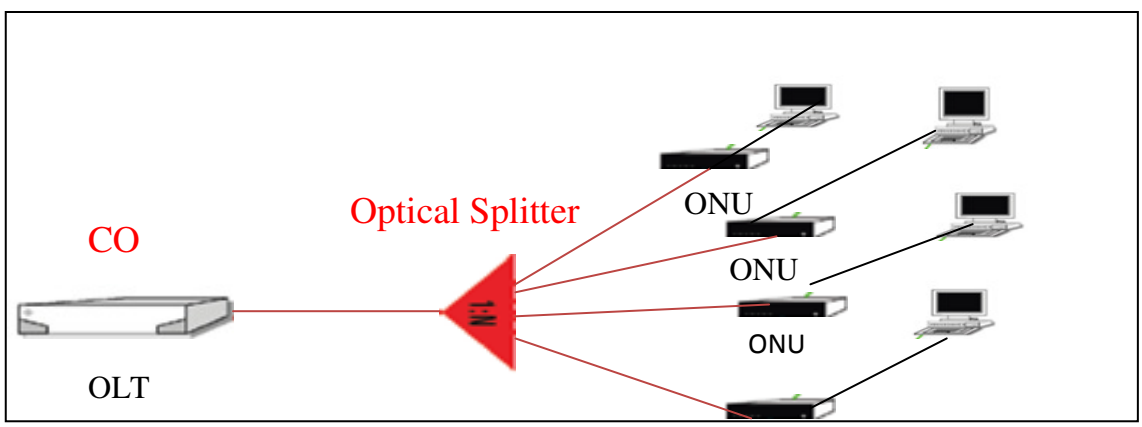

Fig.(2) Basic PON architecture

1. **Optical Line Terminal (OLT):** The Optical Line Terminal is the most important element of the network and is basically situated in the Local Exchange[1]. Optical line terminal is a network element with PON line card, basically it is a network switch. It provides an interface between core network and PON network.

2. **Passive Optical Splitter:** Passive Optical Splitter is a passive device with single input and multiple outputs. It can transmit packets using time division multiplexing (TDM) in the downlink and gather packets using the time division multiplexing access (TDMA) protocol in the uplink. Optical signal travels from input to the outputs, optical signal can also travel from the output to the input[4]. Splitters can be placed anywhere in between CO and user premises. It is used to connect an optical port of OLT with multiple users

3. **Optical Network units (ONUs):** Optical Network units (ONUs) provide as an interface to the network and are deployed at customer-provided. It provides several interfaces for accessing triple play services and in the upper side it connects with the OLT via optical splitter.

2. PON CONFIGURATION

Passive optical networks can exist in three basic configurations (tree, bus and ring), the tree topology is favoured due to smaller variation in the signal power from different end station. Passive optical networks uses different wavelength for downstream and upstream [2]. It uses 1490 nm wavelength for the downstream wavelength & 1310 nm wavelength for the upstream. Signals are inserted or extracted from the fiber using a coarse wavelength division multiplexer (CWDM) filter at the CO and subscriber premises.

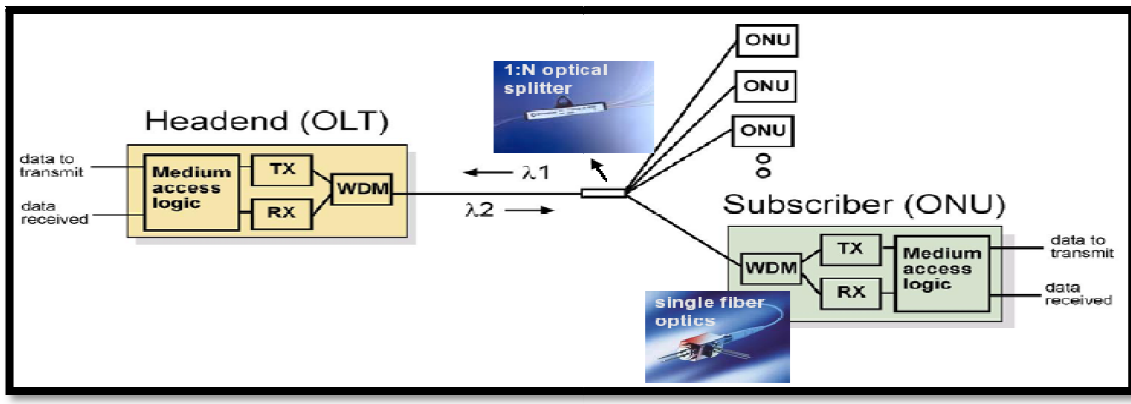

Fig.3 Basic PON Configuration

The communication path from the OLT to the ONU is referred to as downstream and reverse path as upstream. The downstream and upstream signals are carried over the same fiber.

Downstream: In the downstream direction the signal sent by the OLT arrives at the splitter's input and later the same signal reaches every ONU.

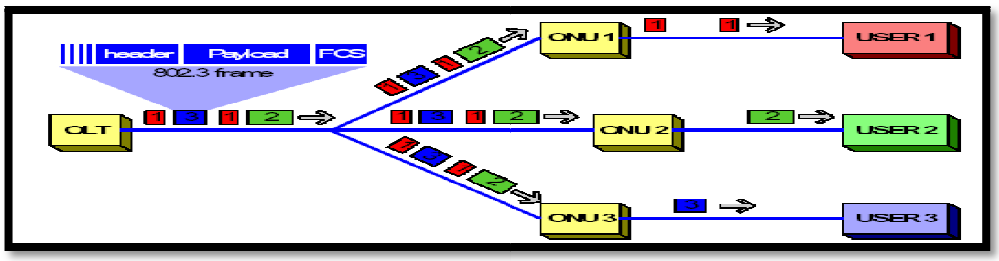

Fig.4 Basic downstream configuration

Upstream: In the upstream direction, from ONU's to the OLT, different users signal arrives at ONUs and these are arrives at splitter's inputs. Although the signals can not reach different ONUs, as they propagates through the splitter they get mixed with each other and the superposition of all signals is received at the OLT [3].

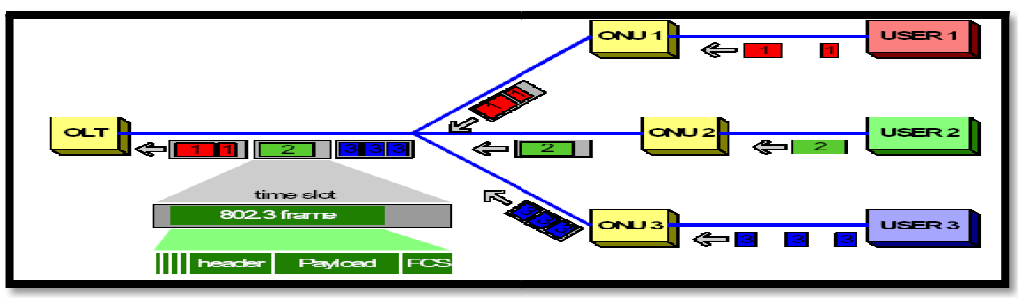

Fig.5 Basic upstream configuration

3. PON STANDARD

There are three basic standards with respect to PONs: (i) BPON (ii) EPON (iii) GPON.

1. BPON: The Broadband passive optical network (BPON) was the first attempt towards a PON standard. It is controlled by the ITU-T and is designated as ITU-T G.983 [5]. It established the general requirements for PON protocols. BPON use Asynchronous Transfer Mode (ATM) as the underlying transport mechanism to carry used data. BPON did not obtain much popularity due to lack of bandwidth and widespread use of Ethernet protocol.

2. EPON: The Ethernet Passive Optical Network (EPON/GE-PON) is governed by IEEE and is nominated as IEEE 802.3ah. EPON is based on Ethernet, unlike other passive optical network technologies which are based on ATM [5]. It provides simple, easy-to-manage connectivity to Ethernet-based IP equipment both at the customer premises and at the central office (CO). It is well suited to carry packetized traffic as well as time-sensitive voice and video traffic. It offers 1.25Gbps high data rate for both upstream and downstream. EPON supports 16 ONUs at a range of 20 km can be connected with a single port of OLT means it has 1:16 split ratio.

3. GPON: The most recent PON standard is the ITU-T G.984 Gigabit Passive Optical Network standard, which offers approx. 2.5 Gbps bandwidth and direct support of both TDM(POTs & E1) and Ethernet traffic at the edge of the network with possible three play voice, data and video services on the same PON [5]. GPON can support ONUs that is located as far as 30 Km from the OLT. GPON offer higher split ratio of which results in an OLT reduction by more than a factor of 2 over EPON.

4. CONCLUSIONS

Bandwidth demand for growth of existing services and introduction of new services will continue to increase day by day. Existing access method will not be able to meet the bandwidth requirement in near future. PON can offer sufficient bandwidth for providing true triple play services of voice, video and data. Among different PON technologies, GPON offers best solution that will address the access bandwidth growth in the foreseeable future.

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