ISSN(Online): 2320-9801
ISSN (Print): 2320-9798

International Journal of Innovative Research in Computer and Communication Engineering

(An ISO 3297: 2007 Certified Organization)

Vol. 3, Issue 4, April 2015

# A Review on Passive Optical Network

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**ABSTRACT:** In this paper, passive optical network and its techniques have been reviewed. Due to the property of high bandwidth and energy saving, Passive optical network can be a better solution for the networks accessed in future. Traffic pattern has evolved to video and image based services from voice and text oriented services in the access networks. For the support of symmetric, high-speed and perfect bandwidths for future video services with high-definition TV quality will require passive optical networks. PON is point to multipoint mechanism and provides an application like data transmission and reception (IP), video and voice (triple play).

**KEYWORDS:** Fiber to the premise (FTTP), Optical access network, Passive optical network (PON).

## I. INTRODUCTION

A PON is a point to multipoint, fiber to the premises network design in which unpowered optical splitters are used to enable a single optical fiber to serve multiple premises typically 32-128 [1]. Several fiber to the premises or fiber to the home networks have been proposed to offer broadband services to the customers [2]. However access networks have three great necessities they must meet high reliability, performances and be cost efficient. Passive optical networks meet the low cost and reliability requirements. Fiber to the home networks has employed passive optical components at the customer premises [3]. Passive optical network significantly decreases the network operation cost by employing passive optical devices along the optical line [4]. Passive optical network is widely known as capable solution for broadband capacity and transmission stability. PON is now widely accepted as optical access network solutions to distribute reasonably high bandwidth to the customers through an optical fiber network infrastructure [5]. Passive Optical Network (PON) is standardized by ITU-T and IEEE, although it is originally created by the Full Service Access Network. PON system can carry various services such as plain old telephony service, voice over IP, data, video and telemetry [6].

Ki-Man Choi et.al [7] proposed an efficient evolution method from a time-division multiplexing passive optical network and demonstrated for a next-generation PON. Each user on the TDM-PON has a dedicated data rate of 40 Mb/s equal to only 1/N of the total downstream data rate of 1.25 GB/s. The proposed evolution scenario does not interfere with both the existing PON infrastructure and the wavelength band. In addition, user-by-user evolution is feasible. Thus, it is possible to provide a smooth evolution from the TDM-PON to the next-generation PON. Lingbin Kong et.al [8] demonstrated a novel dense wavelength division multiplexing passive optical network system which provided bidirectional transmission of simultaneous download, upload and video select cast services using single light source in central office. The experiment results showed that for 10 Gbps DL, 2.5 Gbps VS and 1.25 Gbps UL services over 20 km transmission, the system had good performance with power penalties less than 0.5 dB.

## II. PON STANDARDS

The currently deployed PON systems include ATM PON, Broadband PON, Ethernet PON, Gigabit PON, 10G EPON, and Next-generation PON to provision different data rate. The initial PON specifications are ATM PON is defined by the FSAN committee. APON uses ATM as their signaling protocol in layer 2. In APON downstream transmission is a continuous ATM stream at a bit rate of 155.52Mb/s or 622.08 Mb/s. upstream transmissions are in the

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form of bursts of ATM cells. Broadband PON as defined in ITU-T G.983 series is a further improvement of the APON system [9]. With the purpose of achieving early and cost effective operation of broadband optical access systems, BPON offers many broadband services including video distribution, ATM and Ethernet access. The PON standards are shown as in Fig 1.

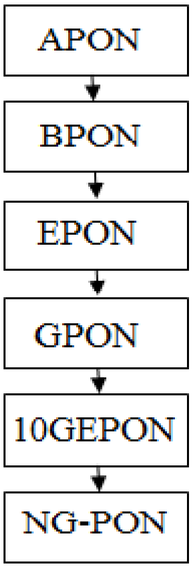


Fig.1. PON Standards

Ethernet passive optical network is a point to multipoint network topology implemented with passive optical splitters along with many advantages such as fine scalability, simplicity and the ability of providing full service access. The EPON standard was considered to better handle packet-based data traffic compared to the APON and BPON standard that was optimized for voice traffic. EPON can provide the symmetric bandwidth capacity of 1.25 Gb/s in both the downstream and upstream directions [10]. GPON is defined by ITU-T G.984 series. GPON supports different bit rate options using the same protocol including a symmetrical data rate of 622 Mb/s in both downstream and upstream, a symmetrical data rate of 1.244Gb per second in both streams, as well as a data rate of 2.488 Gb/s in downstream and a data rate of 1.244Gb/s in upstream. Gigabit passive optical network considers the suggestions of service providers at the same time and supports multi-speed data rates, full services, high efficiency and other advantages [11]. In the future GPON is regarded as one of the best choices for broadband access network. Having completed the mission on GPON, ITU-T/FSAN has since been investigating next-generation PON with higher bandwidth provisioning. Next-generation PON is divided into two phases: NG-PON1 and NG-PON2. NG-PON1 is dependent on PON technologies that are compatible with GPON standards (ITU-T G.984 series).The objective of NG-PON2 is to provision an independent PON system without being controlled by the GPON standards and the currently deployed outside plant.

Table1. BPON, EPON & GPON

| | BPON | EPON | GPON |
|---|---|---|---|
| Standard | ITU G.983 | IEEE 802.3ah | ITU G.984 |
| Downstream Speeds | 622/1244Mbps | 1244Mbps | 1244 or 2488Mbps |
| Upstream Speeds | 155Mbps or 622Mbps | 1244Mbps | 155 to 2488Mbps |
| Downstream Wavelength | 1480-1500 nm | 1500 nm | 1480-1500 nm |

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| | | | |
|---|---|---|---|
| Upstream Wavelength | 1260-1360 nm | 1310 nm | 1260-1360 nm |
| Protocol | ATM | Ethernet | Ethernet and ATM |
| Voice Support | TDM over ATM | TDM over packet | Ethernet over ATM /IP or native TDM |
| Video Support | RF overlay (over 1550nm) or IP video | IP video | RF overlay (over 1550nm) or IP video |
| Number of Splits | 32 | 16 | 64 |
| Distance | >20 Km | <20 Km | <60 Km |

## III. DESIGN OF PASSIVE OPTICAL NETWORK

Passive optical networks are an ultimate broadband access solution for future Internet they bring many advantages such as cost-effectiveness, energy savings, service transparency and signal security over other last/first-mile technologies [12]. A typical design of PON is shown in Fig.2. Commonly PON has a tree topology. The OLT is located at the service provider's central office. The ONU is located near end users. The optical distribution network refers to the collection of fibers and passive optical splitters or couplers that lies between the optical line terminal and the various optical network terminals and optical network units connects them in the Central Office (CO) sequentially. The capacity of the feeder fiber is shared between all optical network units by means of time division multiplexing technology. Each optical network unit has the capacity according to the bandwidth distribution scheme [13].

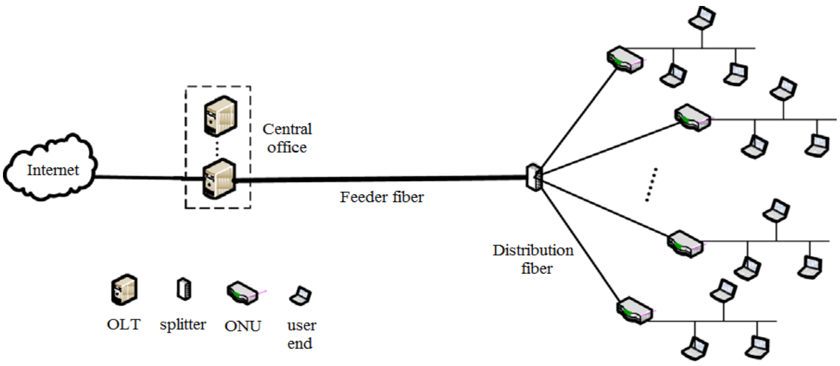


Fig.2. PON architecture

The key interface points of passive optical networks 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). The main difference between optical line terminal and optical network terminal devices is their purpose regardless of their classification. Optical line terminal devices manage maximum up to 128 downstream links and support management functions. Generally, In the Central Office only 8–32 ports to be linked to a single optical line terminal. Therefore the optical network unit devices are much less costly while the optical line terminals tend to be more capable and thus more expensive [14].

## IV. PON TECHNOLOGIES

### (a)TDM- PON

TDM passive optical networks like Gigabit Passive Optical Network and Ethernet Passive Optical Network are now widely accepted as optical access network solutions to distribute reasonably high bandwidth to the customers through an optical fiber network infrastructure [15]. A single wavelength channel shared by all the users attached to a time division multiplexing passive optical network, the average dedicated bandwidth assigned to each user in either direction

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is usually limited to a few percent of the channel capacity i.e., a few tens of Mbps [16]. Due to lower maintenance costs and more reliable operation network operators tend to support the TDM-PON scheme. However, the bandwidth provided by one wavelength is shared by the whole optical network units in the network because the time division multiplexing passive optical network architecture provides only limited scope for improving the bandwidth performance. As compare to TDM, in WDM-PON architecture all the optical network units can transmit data independently since each optical network unit is assigned its own dedicated wavelength [17].

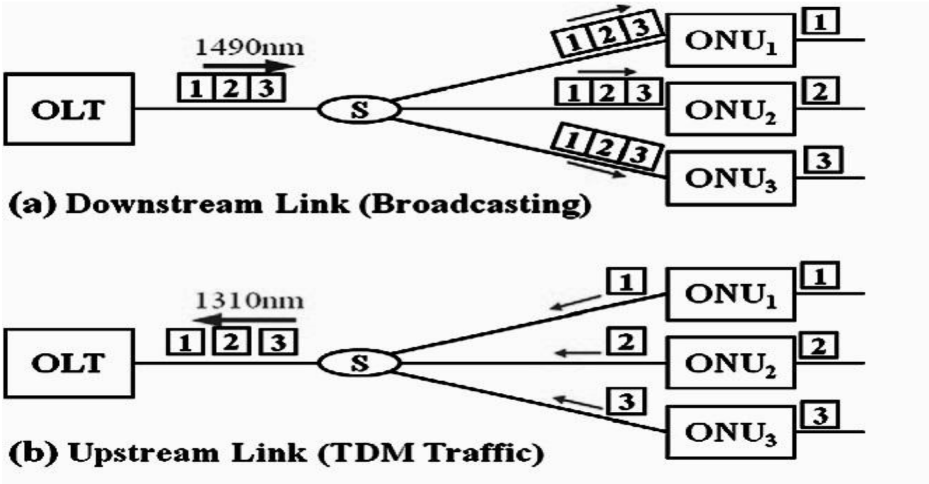


Fig.3. TDM-PON architecture

**(b)WDM-PON**

The wavelength division multiplexed passive optical network is investigated for its high data bandwidth, scalability and enhanced security to support several local subscribers. On the other hand, technologies such as WiFi/WiMAX/3G are becoming popular because they are more flexible and scalable [18].There are many WDM-PON designs proposed. In general, WDM-PONs are deployed as tree topology or bus topology with the characteristic of flexibility and simplicity as shown in Fig.4. In wavelength-division multiplexing passive optical network a dedicated pair of wavelengths is assigned to each optical networking unit; hence, high-bit-rate transmission in both upstream and downstream directions can be easily guaranteed for each optical network unit. WDM PON also provides a direct optical point-to-point link between each optical network unit and the optical line terminal. Hence, there is no need to handle complicated passive optical network over network management and Ethernet mapping [19]. Wavelengh division multiplexing PON design enjoys several advantages over conventional Time division multiplexing PON systems. First, wavelength division multiplexed passive optical network allows each user being dedicated with one or more wavelengths, thus allowing each subscriber to access the full bandwidth accommodated by the wavelengths. Second, wavelength division multiplexed passive optical network typically provide better safety and scalability since each user only receives its own wavelength.

ISSN(Online): 2320-9801
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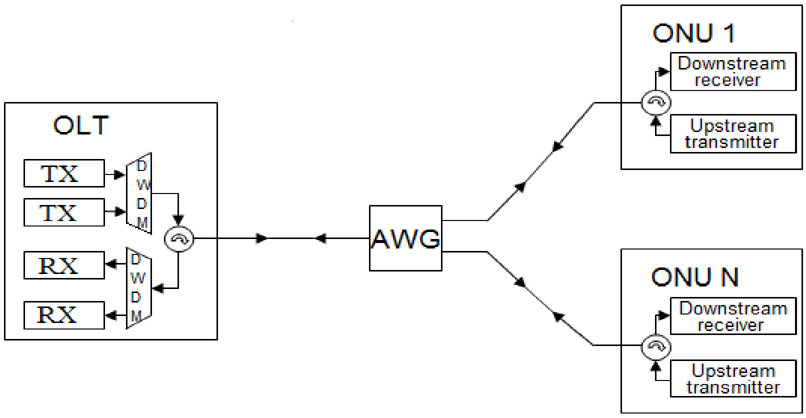


Fig.4. WDM-PON architecture

**(c)OFDM- PON**

Orthogonal frequency division multiplexing PON, as shown in Fig. 5, employs OFDM as the modulation scheme and exploits its superior transmission capability to improve the bandwidth provisioning of optical access networks. In OFDM to carry data traffic uses a large number of closely spaced orthogonal subcarriers. In this conventional modulation scheme is used to modulate each subcarrier at a low symbol rate, thus achieving the sum of the rates provided by all subcarriers compatible to those of predictable single-carrier modulation schemes in the same bandwidth [20]. Since the data rate carried by each subcarrier is low, the duration of each symbol is relatively large. Thus the inter-symbol interference can be efficiently reduced in a wireless multipath channel. Therefore, employing the OFDM modulation scheme in the optical access network can greatly increase the network provisioning data rate and lengthen the network reach. The OFDM-PON is flexible because that the OFDM frames can realize two dimensional resource allocation in both time and frequency domain. However, resource allocation in frequency domain for different ONUs will induce severe fluctuation of received power due to optical interference effect when the optical carriers from different ONUs are mixed in one PD with direct detection.

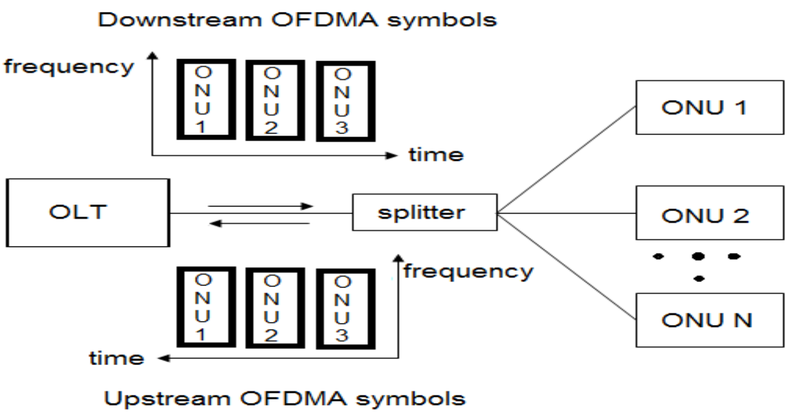


Fig.5. OFDM-PON architecture

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## V. APPLICATIONS OF PASSIVE OPTICAL NETWORKS

In terms of the functionality, Passive optical network categorized into three areas: (a)Broadband Internet application, (b)Triple play with RF video and (c)IP triple play application**.**

**(a)Broadband Internet application:** In Japan fiber to the home started from simple application of IP/Ethernet and it is still leading. Simple indoor ONU provides Broadband access of 100 Mbit/s best effort service. The service is like of ADSL.

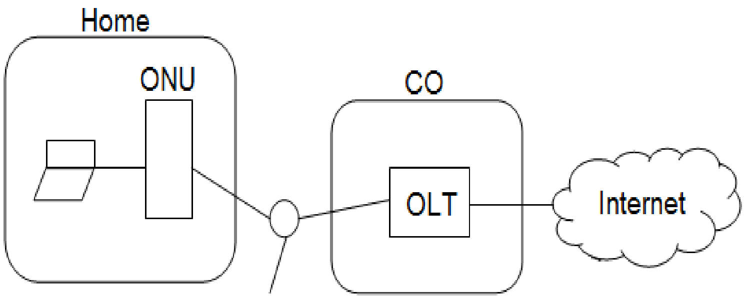


Fig.6. Broadband Internet

**(b) Triple play with RF video:** Using WDM Radio Frequency overlay provides conventional CATV type video service in addition to Broadband Internet as shown in Fig.7. This application is very popular in North America.

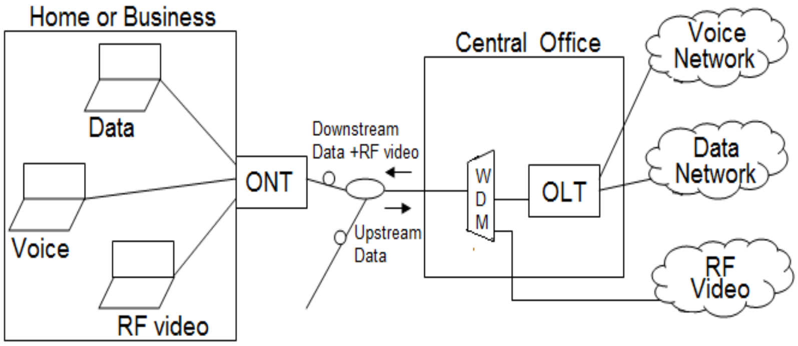


Fig.7. Triple play with RF video

**(c) IP triple play application:** In this Home Gateways are used to separate IP video and provide plain old telephony service (POTS), conversion as shown in Fig.8. Entire network based on IP and Ethernet.

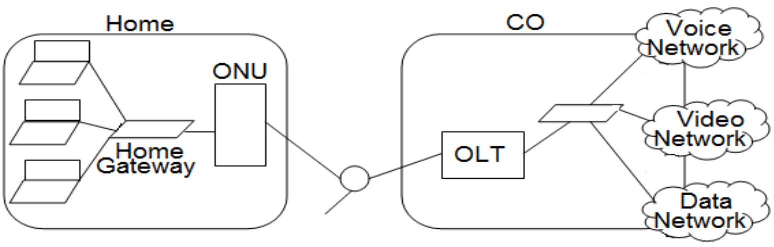


Fig.8. IP triple play application

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## VI. ADVANTAGES OF PON

Very high speed data up to 160Gbit/s to home and businesses is provided through PON [21]. PON cost is low because of fiber and the CO interface that is shared by a great number of users. There is no electronics between CO and customers which makes it cost effective. PON has a constant data rate regardless of reach. Applications like data transmission and reception (IP), video and voice (triple play) are provided by PON.

## VII. CONCLUSION

It is concluded that PON is characterized by extremely high reliability, low cost and high bandwidth. A competent solution for future access networks is provided by PON because of large bandwidth capacity and long transmission distance. Due to its high performance and reliability it is suitable for high data rate PON applications such as broadband and cable TV services, home run services and in optical signal processing**.**The utilization of available wavelength is increased by PON and achieves a smooth upgrade under the premise of without disturbance of original users, business which improve the scalability of network.

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