Abstract - Modern society is becoming increasingly dependent on high-speed communication networks for instant access to information. Triple play, online gaming and real time applications are in demand. In use xDSL can not meet the required demand. Passive optical network technologies (APON/BPON, EPON and GAPON) are the ultimate solution for the present and future. BPON being the mature and pioneer technique can serve our purpose by implementing FTTH. BPON is economical and easily upgradable.

Keyword - Asynchronous Transfer Mode Passive Optical Networks (ATM PON), Optical Line Terminal (OLT), Optical Network Unit(ONU), Optical Splitter

I. INTRODUCTION

Over the past decades, the telecommunications infrastructure has transitioned from a copper-based plant to a fiber-based plant. The transition began with the wide area networks (WANs) that provide connectivity between cities and progressed through the metropolitan area networks (MANs) that provide connectivity between service provider locations within a metropolitan area using optical networking technologies. At the same time, local area networks (LANs) that interconnect nodes within an individual location have seen average bit rates migrate from 10 Mb/s to 1 Gb/s over copper cabling. Although significant bandwidth improvements occurred in the service provider networks (i.e. WANs and MANs), as well as at the subscriber premises (i.e. LANs), the link between the private customer networks and the public service provider networks, also called as access network, did not experience the same level of progress because it still mainly depends on copper wire. The performance of end-users computing equipment has reached gigahertz speeds. The xDSL and cable modem technology developments made marginal improvements in bandwidth capacity but failed to open the bottleneck that exists in access networks which is commonly referred as the “last mile”. Because end users are becoming more sophisticated and rich multimedia and real-time services are becoming more popular due to triple play, the current last-mile capacity is rapidly becoming unacceptable and it is a network bottle neck.

From the service provider perspective, access network links have different revenue dynamics than links in the WAN and MAN. Whereas WAN and MAN links carry the bit streams of many revenue generating customers, access network links carry a single or only a few revenue generating bit streams. Access networks are very sensitive to cost due to lower consumer density and intermittent use. But it is the need of hour to provide high bandwidth services to customer as service providers want to be on top in throat cut competition. Increasing this capacity to support these advanced services is one of the most significant problems facing providers and local carriers today. Fiber-to-the-home (FTTH) is the ultimate level of access, allowing end users to access the backbone networks through the gigabit capacity of a fiber optic cable. Unfortunately current systems have proven too complex and expensive to be commercially viable. To lower the cost and expedite the implementation of FTTH, passive optical network (PON) based solutions have been proposed [1], [2]. PONs are point-to-multipoint fiber optical networks with no active elements in the signal’s path. Reduced equipment costs and the reduced operational costs of PONs will enable carriers to justify FTTH, thus solving the last-mile bottleneck. Cost issues are slowing the deployment of a new physical plant in the access networks. Deploying a passive optical network (PON) between service providers and customer premises can provide a cost efficient and flexible infrastructure that will provide the required bandwidth to customers for many years to come. PON is a network in which a shared fiber medium is created using a passive optical splitter in the physical plant. Sharing the fiber medium means reduced cost in the physical fiber deployment, and using passive components in the physical plant means reduced recurring costs by not maintaining remote facilities with power. These reduced costs make PONs an attractive choice for access networks, which are inherently cost sensitive. It is expected that FTTx connections potential in urban areas in India will be 16.8mn and total revenue would be more than 16 USD bn up to 2017 [3].

PONs are classified into two main networking architectures, namely, ATM-based PON (APON) and Ethernet-based PON (EPON) [1][2] , and a gigabit PON (GAPON) uses the GAPON encapsulation method (GEM) in addition to ATM cells to support Ethernet. The International Telecommunication Union (ITU) has generated standards for APONs: G.983, commercially it is available as broadband PON (BPON) [4], as well as GPONs: G.984 gigabit-capable PON (GPON).

APONs were standardized and developed around 1995 through the work of the Full Services Access Network (FSAN) initiative [5]. The FSAN recommendation (ITU G.983) defines a PON-based optical access network that uses asynchronous transfer mode (ATM) as its layer 2 data link protocol. At that time, ATM was viewed by many as the technology that will dominate the local area network, MAN, and backbone. Since that time, ATM (APONs) has lost favor
and Ethernet has emerged as the front runner technology for transporting data, video, and voice services over a single platform. Since most of the key technologies are borrowed from APON, EPON is very similar to APON in its basic operations. Like APON, EPON uses coarse wavelength division multiplexing (CWDM) and time-division multiplexing (TDM) to provide bi-directional, point-to-point communications over a fiber and maintains frame structure for both downstream and upstream communications. One significant distinction is that EPON uses variable-length IEEE 802.3 frames, whereas in APON, data is transmitted in fixed-length 53-B cells (48-B payload and 5-B overhead). While EPONs have recently been getting more and more attention from both the research community and the telecommunication industry [7], its deployment in access networks is still facing several obstacles and challenges.

### II PON ARCHITECTURE

A PON generally has a physical tree topology, where one optical line terminal (OLT) residing at the central office of the service provider connects to several optical network units (ONUs) in the field. The OLT is connected to the ONUs with a feeder fiber that split using a 1:N optical splitter/combiner to enable the ONUs to share the optical fiber. This is illustrated in Fig. 1. The transmission direction from OLT to ONU is referred to as downstream and operates as a broadcast medium. The transmission direction from the ONUs to the OLT is referred to as upstream. The upstream signals propagate from ONU to OLT but are not reflected back to each ONU, therefore the PON is not a broadcast medium in the upstream direction. The BPON is a multipoint-to-point medium, where the ONUs cannot detect each other’s transmission because the upstream optical signal is not received by the ONUs. However, ONUs share the same fiber, hence, their transmissions can collide, and contention resolution must be performed. To avoid collisions in the upstream direction, time division multiplexing (TDM) or wavelength division multiplexing (WDM) can be used. WDM provides a large amount of bandwidth to each user, but requires that each ONU use a unique wavelength, which presents inventory challenges for service providers that must stock many different ONU types. TDM allows all ONUs to share a single wavelength, thus, reducing the number of transceivers at the OLT and allowing for a single ONU type. First generation PONs use wavelengths to separate the upstream and downstream channels but use TDM to avoid upstream transmission collisions between ONUs. Due to the topology of the PON, MAC protocols that rely on connectivity between all nodes cannot be utilized. A PON allows for connectivity from the OLT to all ONUs in the downstream and from each ONU to the OLT in the upstream (only the OLT has connectivity to all nodes). This connectivity pattern dictates the use of a centralized MAC protocol residing at the OLT. This leads to a polling-based MAC, where the OLT polls ONUs and grants them access to the shared PON medium [8].

The work on APON was started by the full service access network (FSAN) consortium and later standardized by the ITU-T Study Group 15 (SG15). APON (ATM-PON) and BPON (Broadband PON) are different aliases of the TDM-PON architecture based on the ITU-T G.983 series standards. While the name BPON serves its marketing purpose, APON clearly conveys that ATM frames are used for transport in the ITU-T G.983 standards. G-PON stands for gigabit-capable PON and is covered by the ITU-T G.984 series standards [9]. It is the next generation PON technology developed by ITU-T after BPON. Both BPON and G-PON defined line rates as multiples of 8 kHz, the basic SONET/SDH frame repetition rate. As a matter of fact, the OLT distribute the 8-KHz clock timing from OLT to ONUs. This makes it easier to support TDM services on BPON and GAPON [10].

BPON systems were mostly deployed in North America by RBOCs for their FTTP projects. Many ideas covered in the G.983 standards were carried over to the G.984 G-PON standards. The original G.983.1 standard published in 1998 defined 155.52-Mbps and 622.08-Mbps data rates. A newer version of the standard published in 2005 added 1244.16-Mbps downstream transmission rate. BPON vendors can choose to implement symmetric or asymmetric downstream and upstream transmission rates. Table 2.1 shows the possible combinations of downstream and upstream data rates for a BPON system. ITU-T G.983.1 specifies the reference architecture, transceiver characteristics, transport frame structures, and ranging functions in BPON. BPON signals are transported in time slots. Each time slot contains either an ATM cell or a PLOAM (physical layer OAM) cell. PLOAM cells are used to carry physical layer management information such as protocol messages for ranging, churning [11].

<table>
<thead>
<tr>
<th>Table 2.1 APON downstream/upstream bit-rate Combinations</th>
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<tr>
<th></th>
<th>Downstream</th>
<th>Upstream</th>
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<td>1</td>
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<td>155.52 Mbps</td>
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<tr>
<td>2</td>
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<td>155.52 Mbps</td>
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<tr>
<td>3</td>
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<tr>
<td>4</td>
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<tr>
<td>5</td>
<td>1244.16 Mbps</td>
<td>622.08 Mbps</td>
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### III Architectural System Description

Like all passive optical network, the BPON architecture is composed of one OLT, one splitter and 8 ONU (optical network units) modules. The point-to-multipoint connectivity between the OLT and ONU is ensured by the splitter. A single fiber is used to link the OLT to the splitter. From the splitter, each user is connected by its dedicated single fiber. With this configuration, the ONT modules need to be equipped with an appropriate filter according to the wavelength allocated. The fiber and the splitter are not assumed to be lossless. In the upstream, multiple wavelength signals from allocated users systems are multiplexed at the splitter and transmitted on the common shared fiber section. OLT transmit at 1550 nm in the downstream with 0.3 dBm power. In the upstream, the subscribers are allocated the same wavelength based on TDMA (time division multiple access). The extinction ratio is 15 dB and the line width is 10 MHz on off keying. The considered optical fiber has an attenuation of 0.2 dB/km, a 16.75 ps/nm/km of chromatic dispersion and 0.5 ps/nm²/km dispersion slope. The length of cable is varied at 5, 10, 15, 20 km.

### IV Results and Discussion

In order to evaluate the performance of the system a number of simulations have been performed with OptiSystem simulation tool. The initial parameters are those presented in section III. The total distance between the OLT and the ONT is varied as discussed earlier, this includes the distance between the OLT and the splitter and it is assumed that ONU are densely located near to splitter. Figures are snapshots of the spectrum analyzer at one of the outputs of the splitter. These show the impact of cable length on the system performance comparing the minimum bit error rate (min BER). It is clear from eye diagrams that BPON provides low BER up to 20 Km exceptionally at 15 Km.

### V Future Proofing BPON

As the final touches are added to Gigabit Passive Optical Network (GPON) standards and with next-generation GPON (N-GPON) standards already underway, it should be clear to service providers that additional network upgrades are imminent as demand for bandwidth continues will increase. Today’s fiber-to-the-premises (FTTP) architectures, deployed with broadband PON (BPON) technology, are meeting the needs of small business and residential customers, but these should be constructed with easy upgradeability once bandwidth usage demands it. But there will be a logical migration from BPON to GPON architectures in coming years. Here are some reasons in this favour.

1. **Future Ready Fiber Infrastructure**

   When deploying PON architectures, much of the cost is directed toward the infrastructure of fiber deployment and electronics. Network planners should keep in mind that the ultimate goal is to build PONs so the next upgrade is only a matter of replacing the electronics at each end of the network. Adding new services to the existing network should be achieved without having to change or re-deploy any infrastructure between the central office (CO) and the premises.

2. **Enhanced Interoperability**

   GPON is expected to span greater distances, an ongoing issue in FTTP deployments. The GPON standard promises enhanced interoperability, support for legacy services, and physical interconnect conformance and performance. Each of these issues makes it important for service providers to ensure the PON networks they are deploying today will easily and cost effectively scale to GPON and other future standards. The actual components deployed in today’s PON systems – connectors, cables, splitters, etc. – are already GPON capable. These components have the capacity to carry many types of signals, from BPON to GPON. This could hold true for migration to N-GPON as well.

3. **Easy Swapping**

   The first consideration for a migration-ready network is to ensure cross-connect capability – the ability to connect from any splitter port to any customer. Installing centralized splitter architecture from the start will make this a much easier – and less costly – process. Individual drop cables can simply be swapped from BPON to GPON splitter ports for customers desiring the new services.

4. **Co-existence with GPON**

   GPON protocol is in such a designing fashion that it can also carry BPON data without any much change.

### VI Conclusions

BPON is the first PON technology ever deployed. But in term of total cost of service it is still less expensive. BPON is now in use especially in US. Hence instead of discarding BPON we must take care of it for low paying, less bandwidth demanding and intermittent data users and areas. It is easily
upgradable to GPON. Despite of drawbacks as compared to new technologies in pipeline, the BPON installation would within the reach of all. Proper planning can make the transition faster, less expensive and increase customer satisfaction.

ACKNOWLEDGMENT
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