Chapter 4

EPON & GPON

PON (Passive Optical Network)

The Internet revolution started by connecting masses of people over copper lines and through dial-up modems at data rates of a few thousands of bits per second. Propelled by an ever-increasing need to access richer content, access speeds have been constantly growing. While the throughput of dial-up modems has stopped out at about 56Kbps, DSL and cable modem technologies, commonly dubbed "broadband access," have pushed the access speeds to the order of a megabit per second, with actual rates strongly dependent on distance from the central office and quality of the copper infrastructure.

The customer need for more bandwidth at the "last mile" is not stopping at these rates. It is fueled by ever-increasing CPU speeds and disk space at the home and office, increasing resolution of I/O devices such as LCD displays and digital still and video cameras, and increasing wired and wireless LAN speeds, together with bandwidth-hungry applications such as high-definition video, online gaming, and distance learning.

Passive Optical Network (PON) is a new access technology, named as EPON and GPON, which delivers gigabit-per-second bandwidths while offering the low cost and reliability. BSNL has already started mass deployment of EPON and GPON systems, and it is now emerging as the next broadband access technology.

A Passive Optical Network (PON) is a single, shared optical fiber that uses inexpensive optical splitters to divide the single fiber into separate strands feeding individual PON Users in New Generation of Bandwidth-Intensive subscribers. PONs are called "passive" because, other than at the CO and subscriber endpoints, there are no active electronics within the access network. This approach greatly simplifies network operation, maintenance, and cost. Another advantage is that much less fiber is required than in point-to-point topologies.

EPON is based on the Ethernet in the First Mile standard of IEEE while GPON is based on the G.984.x series standard of ITU-T. EPON is also called now as Gigabit Ethernet PON (GE-PON). In further noting EPON and GE-PON references indicate one technology only.

In a standard passive optical network (PON), the Optical Line Terminal (OLT) resides in the central office or head -end. It transmits an optical signal to a splitter, from which the signal is distributed to multiple customers directly or via another splitter. Optical-Network Terminals (ONT) terminates the signal at the customer premises or, in the case of a fiber to the curb architecture, at a remote hub. PON technology allows the service provider to share the fiber cost of running fiber from the CO to the premises among many users—usually up to 32 locations. PON deployments define a maximum distance, typically 20 km, between the OLT and the ONU (ONT). As shown in Figure 1, the fiber run from the CO is brought to a centralized distribution point, and then extends from this fiber to each customer location. The extension of the fiber is done via passive optic splitters at the distribution point, which guides the laser on the fiber to their locations.

PONs do not require any power in the outside plant to power the filters or splitters, thereby lowering the overall operational cost and complexity. And because the single fiber either in a ring or tree technology is shared, this "high-cost" capital deployment of fiber for several kilometers is lower than to deploy individual fibers to each location.

To visualize the lower fiber requirements, it is useful to look at the topologies of point-to point Ethernet and “curb switched” Ethernet along with PON. Figure 1 illustrates all of these options.

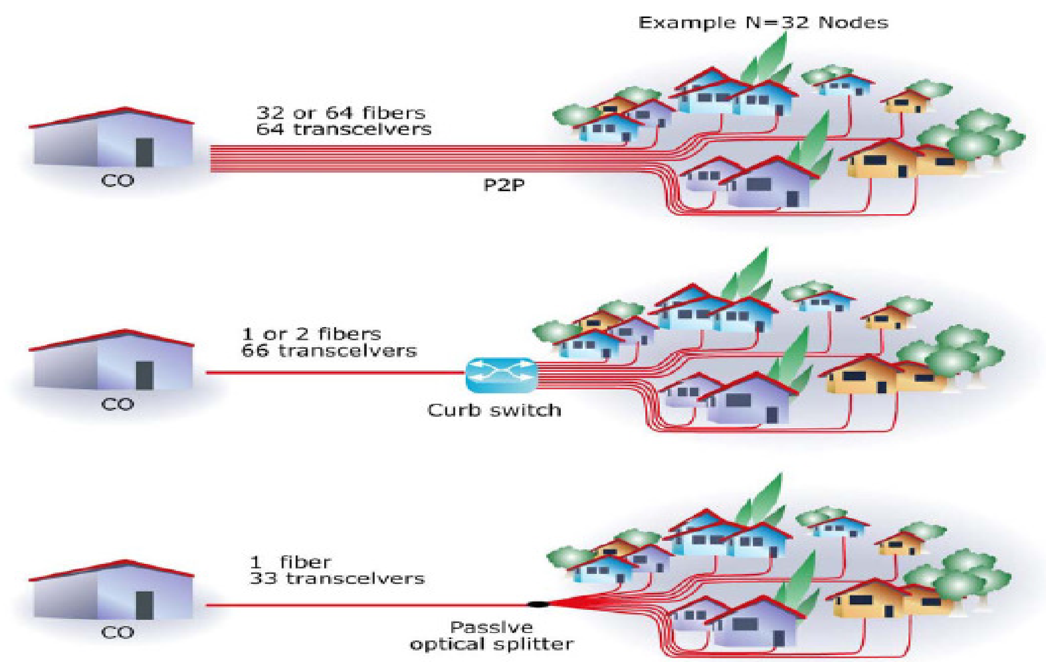

Figure 1: Point to Point Ethernet, Curb-Switched Ethernet, and EPON

Point-to-point fiber might use either N or 2N fibers, and would have 2N optical transceivers. Curb-switched connection uses one trunk fiber and thus would save fiber. But it would use 2N+2 optical transceivers and would require electrical power in the field. PON also uses only one trunk fiber and thus minimizes fibers and space in the CO and it also uses only N+1 optical transceivers. It requires no electrical power in the field. The drop throughput can be up to the line rate on the trunk link. PON can support downstream broadcast such as video.

PON Topologies

As Figure 2 shows, PON is typically deployed as a tree or tree-and-branch topology, using passive 1: N optical splitters.

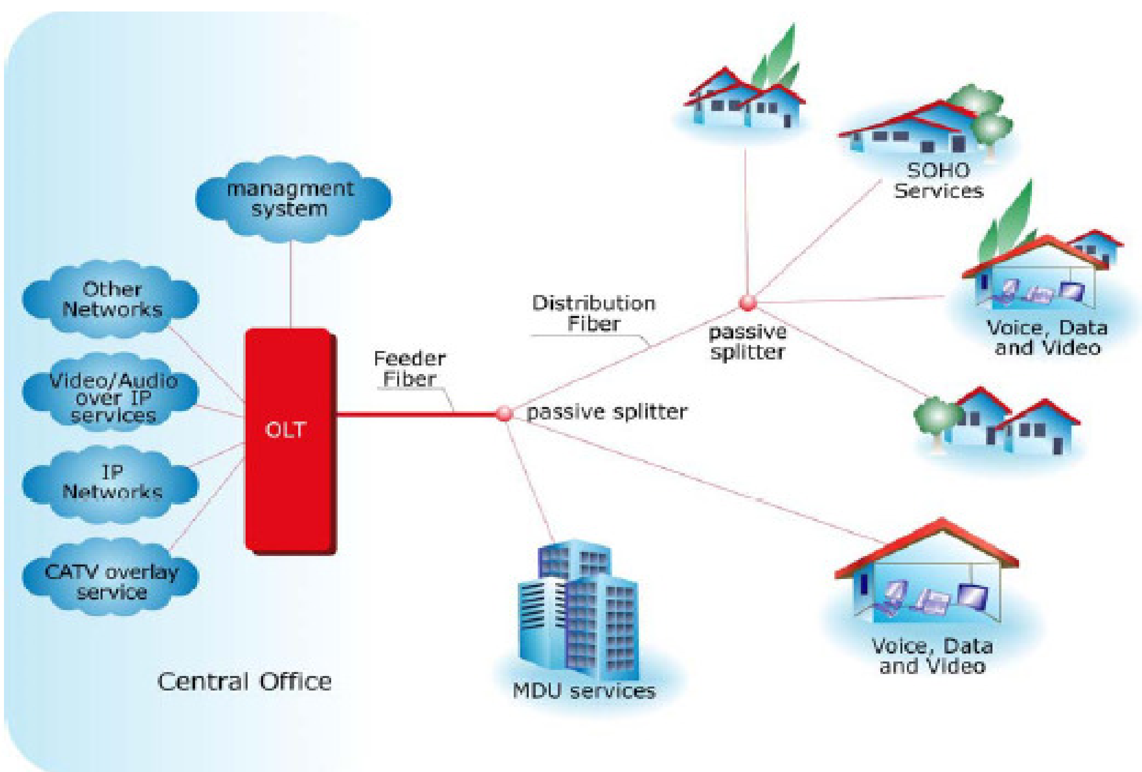

Figure 2: EPON System Architecture

PON Network

A PON network includes an *optical line terminal* (OLT) and an *optical network unit* (ONU), as shown in Figure 2. The OLT resides in the CO (local exchange). The OLT system would typically be an Ethernet switch or Media Converter platform. The network interface of the OLT is typically connected to the IP network and backbone of the network operator. Through this interface, multiple services are provided to the access network. A PON interface will connect the OLT to the subscribers. The ONU resides at or near the customer premise: on the curb outside, in a building, or at the subscriber residence.

PON Systems

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 as such:

- 1490 nm downstream
- 1310 nm upstream

EPON Protocol

To control the P2MP fiber network, EPON uses the Multi-Point Control Protocol (MPCP). MPCP performs bandwidth assignment, bandwidth polling, auto-discovery, and ranging. It is implemented in the MAC Layer, introducing new 64-byte control messages:

- GATE and REPORT are used to assign and request bandwidth
- REGISTER and REGISTER_REQUEST are used to control the auto discovery process

MPCP provides looks for network resource optimization. Ranging is performed to reduce delays, and bandwidth reporting satisfies requirements by ONUs for dynamic bandwidth allocation (DBA).

ONU and OLT Operation

The OLT performs an auto-discovery process, which includes ranging and the assignment of Logical Link IDs. Using timestamps on the downstream GATE MAC Control Message, the ONU synchronizes to the OLT timing. ONU receives the GATE message and transmits REGISTER_REQUEST message within the permitted time period. The OLT adds the ONU to the network by sending a REGISTER message.

EPON Downstream

Downstream, EPON handles the physical broadcast of 802.3 frames. As Figure 3 shows, broadcast frames are extracted by the logical link ID in the preamble, and 64-byte GATE message is sent downstream to assign bandwidth.

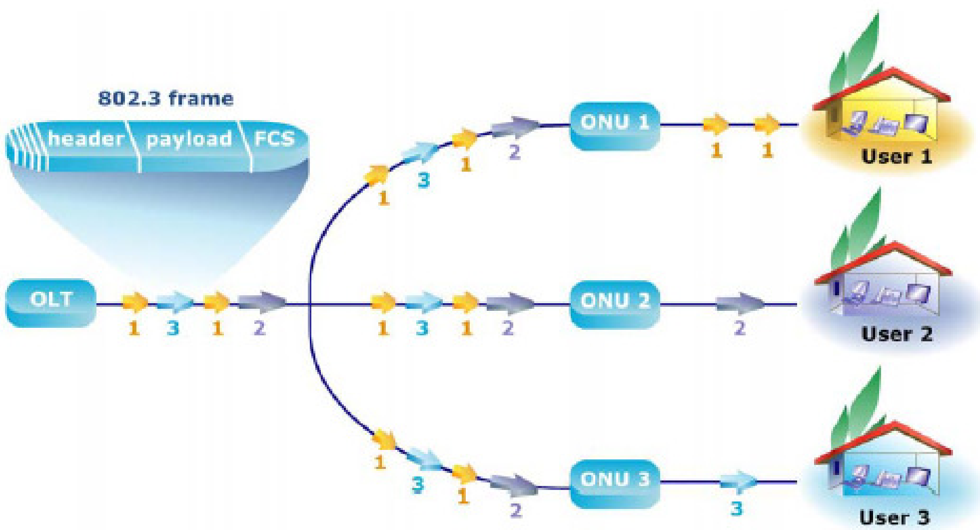

Figure 3: Downstream EPON Operation

EPON Upstream

For upstream control (Figure 4), the MPCP uses time slots containing multiple 802.3 frames. The 64-byte REPORT message sends an Optical Network Unit (ONU) state to the OLT. There are no collisions and no packet fragmentation in this architecture.

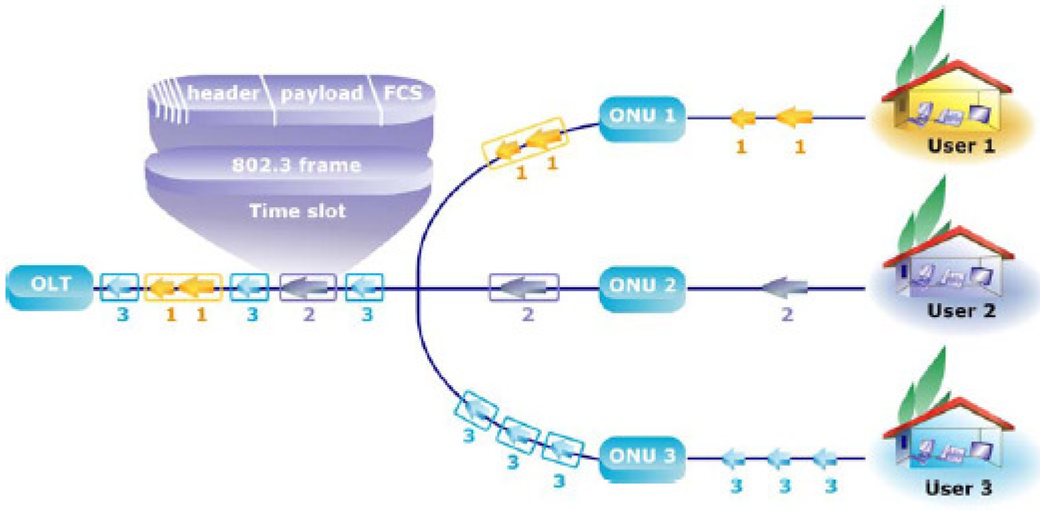

Figure 4: EPON Upstream Control

Equipment design aspects:

1. OLTs

At the central office side OLTs can be placed in a sub rack /chassis though mounted rack type are preferable. OLTs are collocated with the exchange. These equipments work at 48V DC power supply.

2. ONTs

At the customer end the ONTs shall be pizza box type. The power input for ONT is 230V AC type with power back for 4 Hrs.

3. PON Splitters

The Optical power budget is an important consideration in PON design because it determines the number of ONUs (ONTs) that can be supported, as well as the maximum distance between the OLT and ONUs (ONTs). There is a tradeoff between the number of ONUs (ONTs) and the distance limit of the PON because optical losses increase with both split count and fiber length.

Proposed Services on FTTH network

The first and foremost service proposed in the deployment of these PON technologies is to roll out the Next Generation Play Network (NGPN). Today Ethernet is the most popular medium used by the most of the customers in their Local Area Networks (LAN). In addition Ethernet, being the most common and interoperable protocol, is being used extensively in the entire computer – communication products. Hence Ethernet access service such as Ethernet Private Leased Lines (EPL), Ethernet Private LAN service (EP-LAN) shall be few of the popular service in the current days of computer communication. The regular TDM leased lines give away to this Ethernet access service.

Apart from bigger bandwidth requirements, some of the high end customers require carrier class reliability up to their premises. These PON technologies shall be one of the ultimate technologies that deliver both high bandwidth and high reliability. The fibre redundancy up to the customer premises ensures this reliability. Therefore it shall be easier to sign the Service Level Agreements (SLA) with the customers using the PON technologies. These PON technologies shall permit management of the customer premises equipment (Optical Network Terminals – ONTs). End to end provisioning feature on PONs enable the service provider to dynamically manage the customer needs.

The second important service proposed to offer to customers is Next Generation Broadband Service. This PON technology can also be used to deliver Broadband service to the customers in the Technically Non Feasible (TNF) areas. Higher bandwidths for broadband connections can be delivered to the customers as remote as 20 Kms from the Exchange premises with the PON technologies. PON technology allows the service provider to share the fiber cost of running fiber from the CO to the premises among many users—usually up to 32 locations. Since multiple customers use the single fiber infrastructure, the cost of the service roll-out shall be lower than for the fiber provisioning for the individual customer. Thus customers can be offered the broadband service in the entire operational area of BSNL network.

The third service that can be proposed is the voice service (TDM or IP), i.e. extension of PSTN lines to the customers. In GPON, this service can be extended using the 64 Kb/s TDM lines from exchange to customer. Alternately to cover a group of customers, we may use V 5.2 interface to extend the voice service to the customer premises. In case of GE-PON the voice service can be extended to the using Voice over Internet Protocol (VOIP).

From the BSNL network point of view GPON, being the TDM based technology, shall integrate into the existing switching network. While the VOIP feature in the GE-PON provides easy migration path to the Next Generation Network (NGN) of the BSNL. Since TDM switches and the NGN are to coexist for up to 2015 as per the NGN vision plan both GPON and GE-PON are the most suitable PON technologies for BSNL.

The video service (RF or IP), which is one of the triple play services, is the fourth service proposed to be extended to the customer. GE-PON offer 1.25 Gb/s capable Gigabit connectivity up to the customer premises. Both GPON and GE-PON can also roll-out broadcast Cable TV services using the third wavelength at 1550 nm using RF-video.

• GPON:

GPON supports two methods of encapsulation: the ATM and GPON encapsulation method (GEM). The ATM method is an evolution of existing APON standards, and all voice, video, and data traffic is encapsulated at the customer premises for transport back to the CO. With GEM, all traffic is mapped across the GPON network using a variant of SDH generic framing procedure (GFP). GEM supports a native transport of voice, video, and data without an added ATM or IP encapsulation layer. GPONs support downstream rates as high as 2.5 Gbits/sec and upstream rates from 155 Mbits/sec to 2.5 Gbits/sec. BSNL are procuring the GPON that will support downstream rate 2.5Gbps and upstream 1.25 Gbps.

• EPON:

As with standard Gigabit Ethernet, EPON has a nominal bit rate of 1.25 Gbps. It is defined as a single fiber network using Wavelength Division Multiplexing (WDM) operating at a wavelength of 1490 nm downstream and 1310 nm upstream. This leaves the 1550 nm window open for other services, such as analog video or private WDM circuits. EPON Physical media Dependent (PMD) choices will include short reach optics with a range of 10 km and a 1:32 split ratio, and long reach optics with a range of 20 km and a 1:32 split ratio.

Conclusion

PON is a leading new technology that promises quantum leaps in delivered bandwidth for a new generation of bandwidth-intensive applications. While deriving its strength and stability from universally deployed and proven Ethernet technology, it uses passive network components to simplify and to reduce the cost and maintenance challenges associated with active network technologies. EPON is making tremendous gains in Japan, Korea, China, Taiwan while other regions are deploying GPON extensively.

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