Comparing Gigabit PON Technologies
ITU-T G.984 GPON vs. IEEE 802.3ah EPON

Abstract

This White Paper compares GPON versus EPON solutions and demonstrates how GPON provides a compelling business case for access deployment, supporting both Ethernet and TDM services on a single fiber, to a large number of end users covering a broad network reach.

GPON systems enable the service provider to provide 2.5Gbps converged data and voice services for the last mile, in a cost-effective and bandwidth-efficient manner. There is a growing concern that weaknesses in the efficiencies of the Ethernet protocol will create major obstacles to use Ethernet as a transport mechanism for access in the last mile. Specifically, many Ethernet access implementations provide as little as 50% of usable bandwidth to the service provider and may be inadequate to support legacy TDM and Voice. Moreover, EPON supports only ODN (Optical Distribution Network) Classes A and B, while GPON also supports ODN Class C required by service providers all over the world.

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GPON in Brief

In 2001, the FSAN group initiated a effort for standardizing PON networks operating at bit rates above 1 Gbps. Apart from the need to support higher bit rates, the overall protocol had to be opened for reconsideration so that the solution would be most optimal and efficient to support multiple services and operation, administration, maintenance and provisioning (OAM&P) functionality and scalability.
As a result of FSAN efforts, a new solution emerged in the optical access market place – Gigabit PON (GPON), offering unprecedented high bit rate support (up to 2.488 Gbps) while enabling the transport of multiple services, specifically data and TDM, in native formats and with extremely high efficiency.
In January 2003, the GPON standards were ratified by ITU-T and are known as ITU-T Recommendations G.984.1, G.984.2 and G.984.3.

EPON in Brief

Ethernet for subscriber access networks, also referred to as “Ethernet in the First Mile” (EFM), combines a minimal set of extensions to the IEEE 802.3 Media Access Control (MAC) and MAC Control sub-layers with a family of Physical (PHY) layers.
EFM also introduces the concept of Ethernet Passive Optical Networks (EPONs), in which a point to multipoint (P2MP) network topology is implemented with passive optical splitters, and optical fiber PMDs, that support this topology. In addition, a mechanism for network Operations, Administration and Maintenance (OAM) is included to facilitate network operation and troubleshooting.

Number of End Users per PON Tree

The IEEE 803.2ah standard decided to support only two ODN classes: Class A and Class B, where as the ITU-T G.984.2 GPON GPM Specifications also supports the superior Class C. Class C allows PON network to extend beyond a 20 kilometer reach while supporting a large number of end-users, reaching up to 64 ONTs.
The following diagram depicts the benefits in terms of distance and split ratio that service providers gain by using Class C optics.

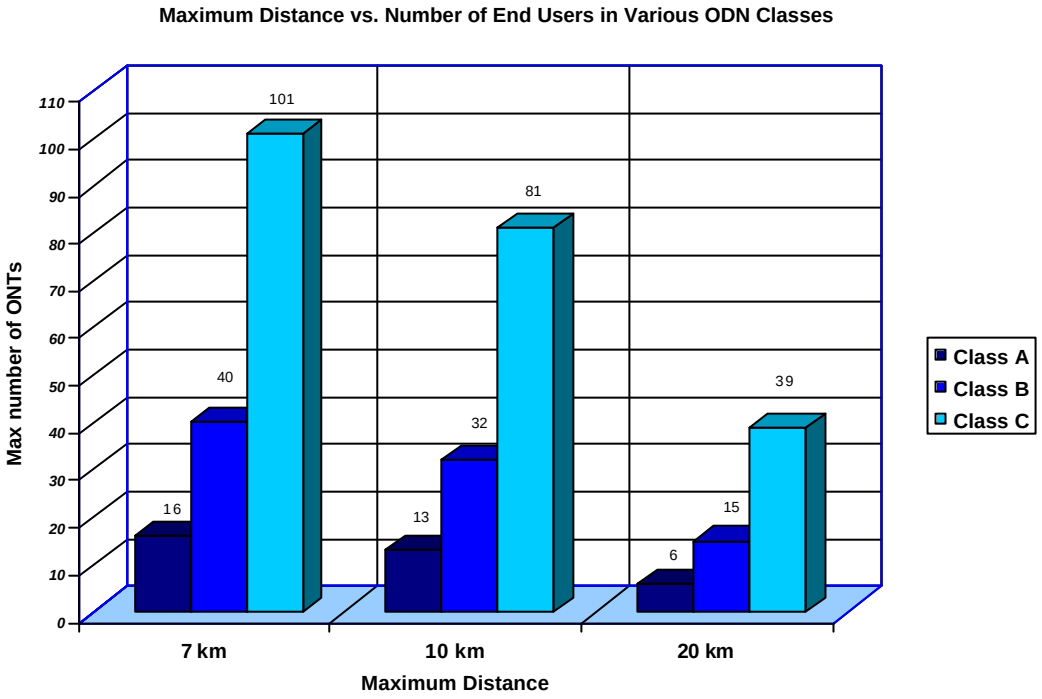

Figure 1: Class C Compared to Class A&B

With GPON Class C Optical components the split ratio is doubled comparing to Class B optics. This translates into direct cost savings, as less fiber and OLT needs to be deployed.

Scalability and Flexibility

IEEE EPON supports only one bit rate, the symmetrical 1.25/1.25 Gbps. The ITU-T G.984.2 GPON GPM Specifications is much more flexible and scalable. In the downstream direction it allows 1.25 and 2.5 Gbps while in the upstream it allows 155, 622 Mbps or 1.25, 2.5 Gbps. As both technologies are targeted for the access market, whether for Fiber-To-The Home or for Fiber-To-The Building/Curb applications, it is well known that one of the characteristics of access traffic is asymmetry between downstream and upstream. Even with the evolving dataapplication, there is no need for 1.25 Gbps in the upstream. While GPON enables the

network provider to configure the rates according to the real needs, this can not be done in EPON.
This would not have been an issue if the cost of the high rate had been negligible. But, unfortunately this is not the case. The need to support 1.25 Gbps in the upstream, requires an expensive DFP laser at the end-station and an expensive APD receiver at the Central Office.

Bandwidth Utilization

A prime factor for a carrier to determine a solution's benefit is to analyze the overall bandwidth that can be sold as services over the system. Let us define the term "revenue bits" as the number of bits that can be extracted from the network and sold as services. Revenue bits are derived from the networks overall bandwidth, minus the overhead of the protocol used to transport traffic over the network.

When comparing EPON vs. GPON systems supporting similar bit rates of 1.25 Gbps, it can be assumed that the system cost will be very similar. The major cost contributing components are the Burst Mode Optics and the Digital MAC ASICs. Regardless of the protocol used, these components will have a similar cost.

Table 1 below illustrates the efficiencies of both EPON and GPON with varying mixtures of voice and data. As shown, the efficiency of the Ethernet systems is poor in comparison to GPON, and yields much fewer revenue bits. EPON systems are characterized by relatively large overheads which causes low efficiency and consequently lower number of revenue bits vs. GPON solutions.

	Overall Efficiency 10% TDM, 90% Data
EPON	49%
GPON	93%

Table 1 – Overall PON Efficiency

The main factors contributing to poor bandwidth utilization of EPON are depicted in the following diagram.

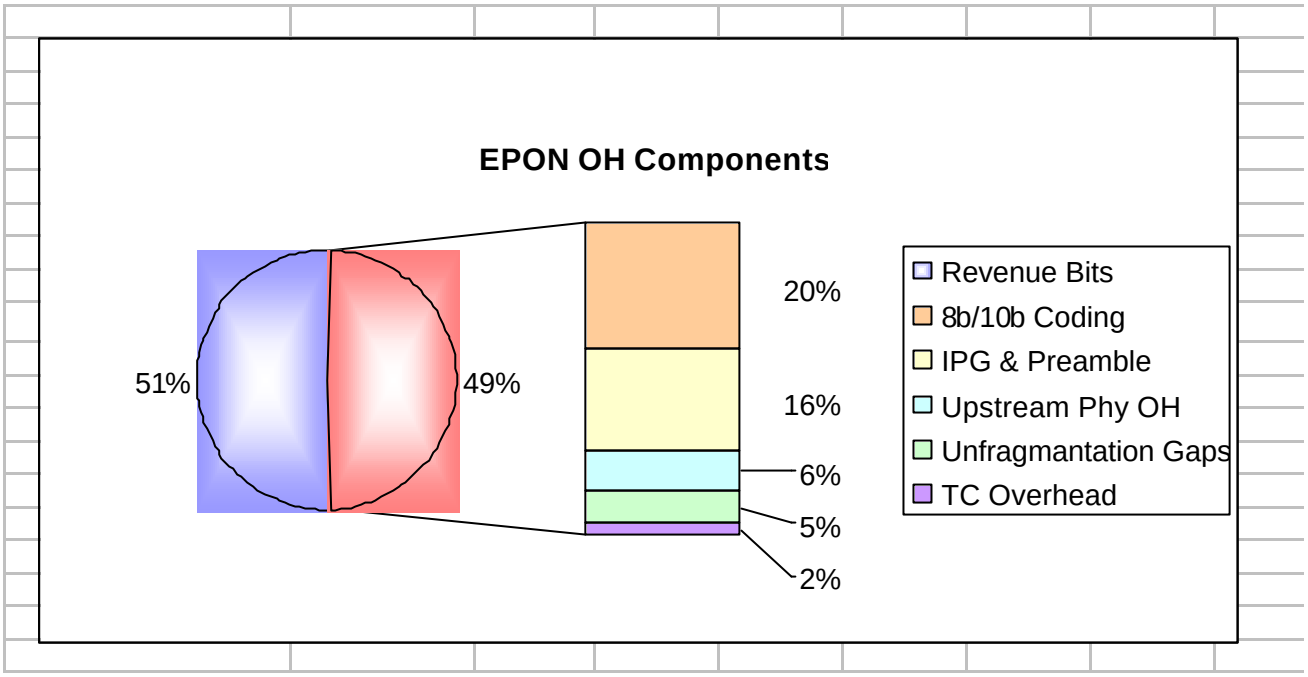

Figure 2: EPON OH (Over Head) Components

Poor Ability to Support Voice/TDM Services

Ethernet is an efficient packet-based data protocol and is not equipped to handle the needs to support synchronous TDM transport (Native TDM). In order to overcome these voice transport deficiencies, various schemes are being implemented but they are rather complex QoS mechanisms. These mechanisms, though well defined in Ethernet standards, are still considered by most incumbent carriers as immature technologies which have yet to be proven to meet the toll-grade quality and reliability required from carrier-class equipment.

TDM emulation over EPON and voice transport dictates the need for additional Hardware/Software to support VoIP schemes. This will add additional costs to the EPON solution.

GPON, on the other hand, supports transport of TDM services (both low rate E1/T1 and high rate STM1/OC3) in their native format and therefore Jitter and delay standards are easily met with no additional cost.

Summary

- Ethernet services will continue to be a promising market in the coming years. The question is not whether Ethernet services will be provided, but how?
- Carriers have a large installed base of TDM/legacy voice services. This install base should be considered as a cash cow, in terms of revenues and profits, for carriers today.
- Carriers are looking for an access solution which supports Ethernet services, yet at the same time, leverages the existing installed base and increase the revenue stream.
- ODN class C brings a major cost reduction for the PON topology by doubling the number of end-users at each PON tree.
- GPON is scalable in rates while EPON is not.
- EPON solutions are extremely inefficient regarding application throughput of the network, consequently reducing revenue bits for carriers to 40% less than with a GPON solution.
- Pure Ethernet solutions lack the ability to support carrier-class TDM/voice service.

Additional Information

This paper was written by Flexlight and BroadLight. Please contact www.flexlightnetworks.com and www.broadlight.com for additional information on the companies and their products.