Innovations in PON Cost Reduction

Abstract

Passive Optical Network (PON) deployments become a reality only when the promised price of a Fiber To The Premise (FTTP) network met the carrier's objectives for a viable business. Since the number one feature for PON is cost, equipment vendors had to aggressively forward price their products to win the carrier's business. This has resulted in pressure to drastically cost reduce the products through design and manufacturing innovations. For a healthy, long-term industry, everyone in the PON food chain must be profitable. Can component technology alone satisfy the costs demand as well as the performance requirements? Are there product architectural improvements or network enhancements that are worth the effort to meet the cost targets? This paper will address the PON and PON component technology that can reduce the cost of the current equipment implementation by up to 50%.

Aspects that this paper will address are the Optical Network Termination (ONT) Bill Of Material (B.O.M.) and the PON itself. Since the optical components have the largest B.O.M. impact, integration of the various optical and PON chip functions as well as some common ONT functions can offer up to a 20% cost reduction to the ONT. The encouragement is that such innovations can be realized within the next two years. Regarding the PON itself, an increase in PON speed, efficiency and split ratio can provide up to 40% overall cost reduction. Although some carriers have already established their Optical Distribution Network (ODN) policy based on previous technology, the largest market opportunity for PON, China, has yet to be established its ODN policy. Such details pertaining to speed and split ratios will influence such carriers for planning their PON ODN and selecting their technology.

PON System Factors

There are three key system factors that affect the total cost of a PON solution:

- PON Split ratio – for Optical Line Terminal (OLT) cost efficiency
- PON Speed – for more subscribers per PON and/or higher speed services per subscriber
- PON Protocol - for efficient use of PON capacity

Although much focus is put on the direct per subscriber cost associated with ONT, figure 1 shows that the OLT is a contributing factor even in split ratios higher than 32. Setting the cost for an OLT at $900 and an ONT at $100, figure 1 shows that going from a 32 to 64 split ratio, an 11% cost reduction for the subscriber cost is realized. This simple calculation of OLT cost ÷ split + ONT cost illustrates how much of an effect the OLT will have on per subscriber costs. Carriers currently looking at PON ought to consider supporting high split ratios provided that the Optical Distribution Network (ODN) distance requirements can be achieved cost effectively.

The PON's speed becomes a significant cost factor as the total sustained rate for subscribers start to approach the maximum capacity of the OLT. To illustrate the effect of PON downstream speed and efficiency on cost, the downstream sustained speed per subscriber in a 10,000 FTTP network will be modeled. The cost of the OLT and ONT equipment will be the same for each PON speed at $900 and $100 respectively. The result of the model is illustrated in figure 2

whereby the subscriber cost difference is significant. The reason is highlighted in figure 3 where the number of OLTs required for each subscriber data rate for each PON speed has a direct bearing on the per subscriber costs. As seen in figure 3, the outline of the number of OLTs tracks the per subscriber costs in figure 2 for each PON speed.

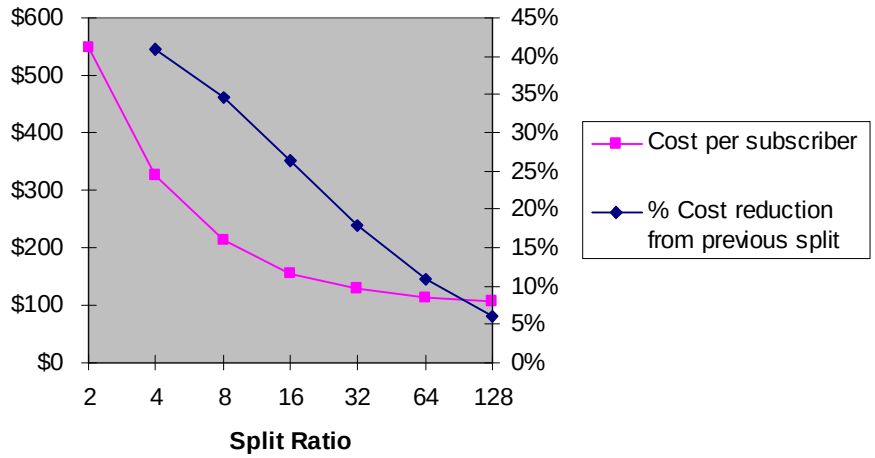

Figure 1 Effect of Split Ratio. OLT = $900, ONT = $100

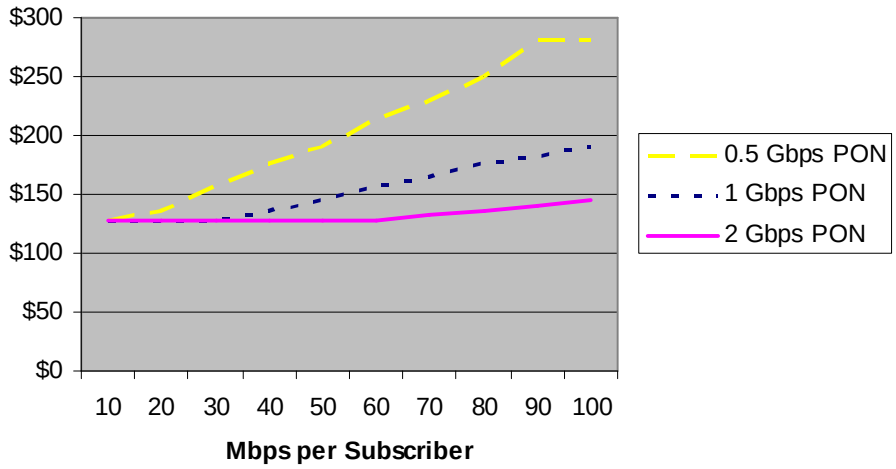

Figure 2 PON Speed Subscriber Cost. OLT = $900, ONT=$100

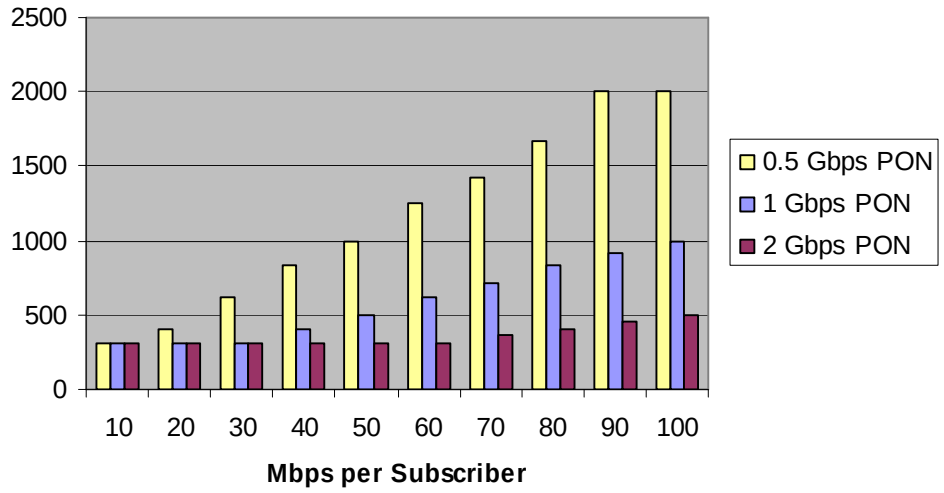

Figure 3 PON Speed OLT Requirements for Sustained Subscriber Rates

Using the same 10,000 home model for a 1Gbps PON and fixing the subscriber downstream data rate at 100 Mbps, the PON's efficiency bearing on cost can be determined. As shown in figure 4, improving the downstream efficiency form 75% to 95% yields a cost savings of $29 (i.e $229 - $200) or 13% per subscriber. Once again, the cost impact is due to the number of OLTs required to service the network of 10,000 homes.

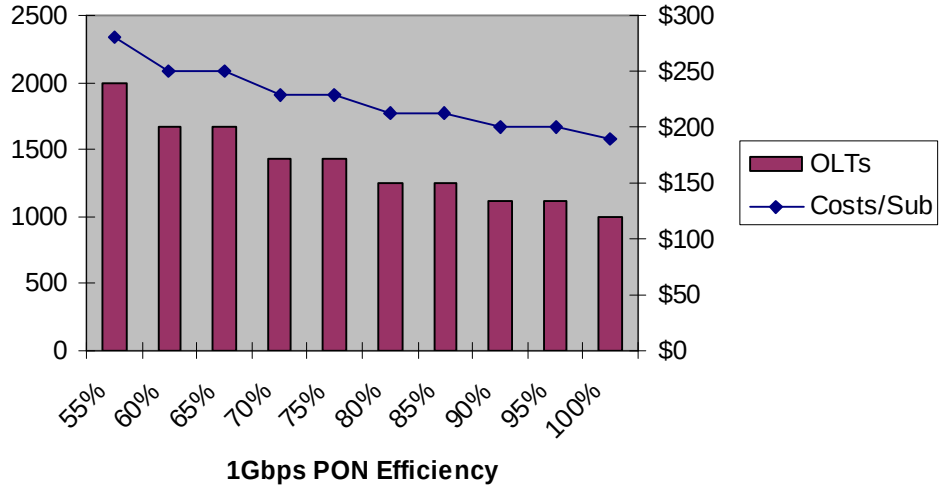

Figure 4 1Gbps PON Efficiency Effect. OLT = $900, ONT = $100. Subscriber rate = 100 Mbps.

Modeling all variations for the effects of PON speed, efficiency and split ratio and putting them on to a single diagram would yield a many axis graph that would be very difficult to interpret. Rather, a simple comparison of BPON, EPON and GPON has been done. As a result of the three factors just considered, it was shown that GPON can be as much as 40% cheaper than EPON for 100 Mbps downstream subscriber service.[1]

[1] GPON Gets Ready for Primetime. Parsons. FTTH Council North America Annual Conference 2005.

ONT Cost Reduction Directions

The best investment in PON cost reduction is done at the ONT whereby a dollar saved per ONT is a dollar saved per subscriber. Two critical factors affecting subscriber costs are volume and the ONT design reflected in the Bill Of Material (BOM). ONT volume going from 100K units to 1M units can reduce ONT costs by 30%. For the ONT BOM, a breakdown of the functional blocks and their relative cost for a GPON ONT is shown in figure 5. As can be seen, the dominant ONT cost is associated with the optical transceiver accounting for up to 30% of the B.O.M. With the availability of auto-tuning burst mode laser drivers, it is now possible to design the optical transceiver module in a flattened approach, directly on the PCB of the ONT. This design approach eliminates several items off the cost of the transceiver module; PCB, controller, non-volatile memory for calibration data (Flash memory, or EPROM), packaging, pins and/or socket connector as well as the test and manufacturing costs of the module. The profit of the transceiver vendor, otherwise known as its margin, is also eliminated. The optical block is now be part of the overall test and manufacturing cost of the ONT. It is estimated that this can contribute 30% cost reduction for the GPON ONT optical interface, providing of approximately 10% on ONT cost.

Flatten design of the ONT optical interface has not been possible so far. But there are new highly-integrated ASICs coming to the market with ability to automatically compensate for a wide range of aging, temperature and other variables of the lasers & diodes. These GPON PHY ASICs are an essential building block for the design of the flat ONT, eliminating the risks associated with discrete designs. With a burst mode laser driver, a continuous limiting amplifier, a built-in controller and all associated support functions such as PRBS generation, temperature meters, current and voltage drivers, as well as voltage and current digitizers, the advanced GPON PHY ASIC adds the ability to self-calibrate the optical interface after producing the ONT and provide a rich set of monitoring and diagnostic capabilities in the field.

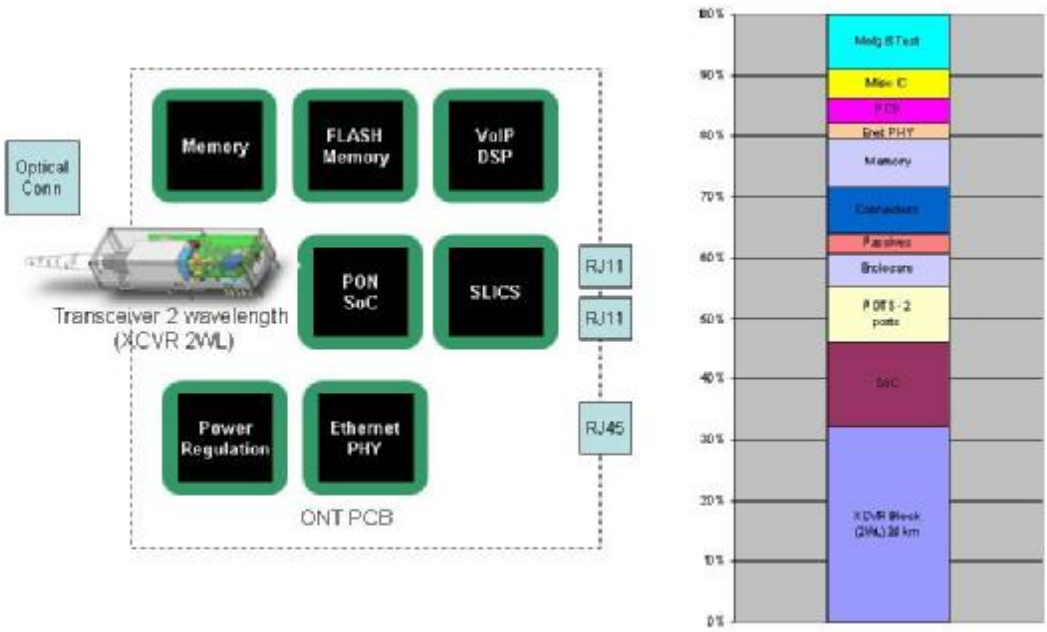

Figure 5 ONT Cost of Functional Blocks

The promise of high volume is an incentive for chip companies to provide further cost reduction through integration of common functional blocks such as memory, physical layer devices (PHY) and interfaces. The ONT SoC is already a highly integrated component made up of high speed mixed signal technology for the optical interface, PON MAC, control processor, packet processor, Ethernet MAC, and others functions. Although memory is common element across all ONTs, the amount is not. Also, the integration of memory does not offer a significant cost savings since memory is quite inexpensive. Integrating it would also limit flexibility. Functions worthy of integration for the high-volume residential market are common interfaces such as voice and data. The common interface configuration is two ports of voice and one port of data per single home. As a result, the integration of the voice digital signal processor (DSP) function can be done with the subscriber line interface circuits (SLICS) left outside the SoC. This integration will provide approximately a 5% costs savings to the ONT B.O.M. Integration of the 10/100/1000 Mbps Ethernet PHY would provide an additional 4% savings yielding a total savings of 9% to the ONT B.O.M. for the subscriber interface integration.

With the integration of common subscriber interfaces as well as the PON PHY, a total ONT B.O.M. cost savings of almost 20% can be achieved. This new optically flattened highly integrated ONT is shown in figure 6.

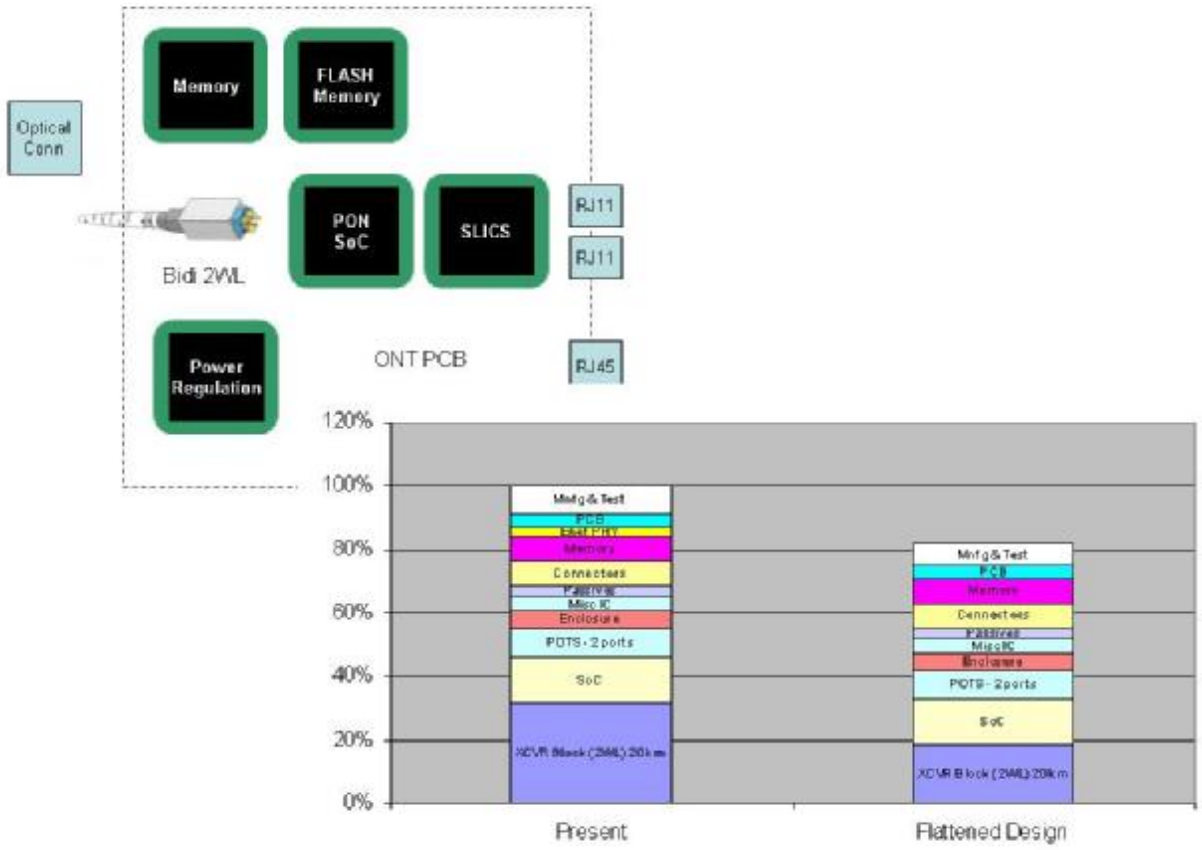

Figure 6 High Integration Flattened ONT

The Next 2 Years

ITU-T G.984 GPON has emerged as the fastest available TDM PON technology offering a highly efficient 2.5 Gbps transport featuring split ratios up to 128 subscribers resulting in significant network cost savings over BPON (~ 500 Mbps downstream) and EPON (~ 1 Gbps downstream). With interoperability initiatives underway and large service providers promising volume deployment, achieving technology advancements for cost reduction is a natural business evolution. This is precisely what has happened with all standards based broadband deployment – namely cablemodem, DSL and WiFi. The first step towards GPON cost reduction has already happened with highly integrated GPON ONT SoC entering the market. Some of the SoC have integrated voice DSPs already. ONT PON PHY chips are now available and flattened optical designs are being evaluated. With further integration of the PON PHY in the SoC, achieving a 20% cost reduction to a typical GPON ONT within the next two years can readily be realized.

Dan Parsons *is Director of Marketing at BroadLight Inc. (www.broadlight.com). He can be reached at dan.parsons@broadlight.com.*