Current and Future Markets for PON, the Evolution to PON 3.0 Technology—2017-2026

September 2017

Current and Future Markets for PON, the Evolution to PON 3.0 Technology—2017-2026

Report Description

CIR believes that we are now on the verge of rapid growth in the PON market brought on by new applications and by growing international demand. Meanwhile, this new "PON revolution" is being enabled by powerful new PON technologies, especially XGS-PON and NG-PON. This report identifies the emerging opportunities for the passive optical network (PON) business over the coming decade. Coverage includes:

An in-depth look at XGS-PON and NG-PON and how their technical and performance advantages will create value for both equipment suppliers and major carriers. The report will also identify how new directions for PON technology will create new opportunities for optical component suppliers.

A discussion of the emerging applications that will provide new business revenues beyond fiber-to-the-home (FTTH) deployments. These include business loops, 5G backhaul and even in-building networks. The report also explores the potential for rebranding PONs as a ubiquitous broadband platform.

Analysis of the PON deployment strategies of leading carriers worldwide and implications of long-term supply chains that they are establishing with major suppliers. The report explores whether the future of the PON equipment business will become concentrated in the hands of a few major suppliers or if there is still room for start-ups.

An assessment of how the latest PON technologies and installations are being designed to fit in with other "big picture" developments in the telecommunications industry. These include the powerful and growing impact of clouds, SDN, and open source equipment—the role of PON software is also discussed.

An examination of the current installed base of PONs using mature technologies such as EPON and GPON. Are there still opportunities to be had in this mature space and what strategies will PON equipment and components suppliers, as well as the carriers themselves, adopt to move to the next-generation PON era.

The report includes ten-year (volume and value) forecasts of PON equipment, fiber utilized and major components (such as splitters), with breakouts by

country/region, type of technology, etc. Ten-year forecasts for each of the 15 leading countries in terms of PON deployment are also included in this report. In addition, the report also includes markets shares by carrier and supplier for the emerging PON types.

This report will make invaluable reading for any product, marketing or business development manager actively involved in the PON space, whether they are from carriers, equipment vendors or component firms. In addition, CIR believes this report will provide considerable guidance to the telecom investment community, which is currently focused on many of the technologies and markets with which this report is concerned.

Provisional Table of Contents

Chapter One: Introduction

1.1 Background to this Report

1.1.1 Prolog

Passive Optical Network (PON) technology has been with us since 1998 when the ITU-T released the recommendation G.983.1, which defined a PON running at 155.52 Mbps upstream and downstream, and was then based on the then-current technology, ATM. The ITU-T updated the recommendation a couple of years later and the line rate increased to 622.08 Mbps with a rebranding as Broadband-PON, or B-PON. There were some successes, but PONs did not really take off until the ITU-T released its G-PON recommendation with line rates of 1.244 Gbps and 2.488 Gbps.

G-PON networks have now been deployed in numerous networks across the globe, and the trends indicate that this will continue for fiber-to-the-home (FTTx) applications. The success of G-PON attracted competition, notably the IEEE's E-PON (also called GE-PON for gigabit Ethernet PON). Essentially, what we had here was the ITU-T pushing the telco way of doing things—with ATM—while the IEEE's standards understandably supported Ethernet, the IEEE's own. Note: the line rate of E-PON had to be increased to support the Ethernet frame, but the data part of E-PON still remained the same as G-PON.

In the current state of play, it seems that G-PON is winning, which might not have been expected given the ubiquity of Ethernet. Much of this has to do with Chinese operators shifting their capital expenditures. Also, G-PON is being used for mobile backhaul and will continue to be so even with the introduction of 5G mobile networks. CIR believes that G-PON will account for three out of five subscriptions worldwide by the end of 2018

1.1.2 PONs Becoming the Technology-of-Choice for Several Markets

Nonetheless, this part of the PON opportunity story has more or less played itself out. In the abstract the PON concept provides a powerful technology to bring the advantages of optical networking to short-to-moderate-haul networks at a reasonable cost. However, the markets for PONs' capabilities are now shifting in ways that are creating opportunities for manufacturers and components/modules makers and standards makers are also responding with more appropriate frameworks for current needs.

PONs are achieving a growing role as the go-to technology for low-cost fiber infrastructure, not just for residential users but for (1) next-generation mobile fronthaul and backhaul at a time when 5G networks are about to take off, (2) as an infrastructure choice for the additional fiber going to small business customers, and (3) PONs are deployed at a fast pace across the globe, especially in Asia. We are also entering the next-generation PON era by moving away from solely TDM-based solutions and embracing multi-wavelength technologies that we find in some of the PON standards of the last few years.

1.1.3 Next-Generation PONs Begin: XGS-PON and NG-PON2

There are a growing number of PON types, some of which are a little obscure. From our current perspective the two most important are XGS and NG-PON2. XGS-PON optics prices are around $100 and GPON ONT optics prices are under $10, however, as stated, typical NG-PON2 ONT optics prices are over $1,000.

In Exhibit 1-1 we list and profile many of the PON types that are currently available or will soon be available. In addition to the PONs shown in the Exhibit there are OFDMA-PONs, RFoG, DP0E, S-PONs WDM-PONs, MW-PONs, FDMA-PONs, TDMA-PONs, etc.

Exhibit E-1: Selected PON Types			
PON	**Same As**	**Upstream Rate**	**Downstream Rate**
A-PON	ATM-PON	155 Mbps	155 Mbps
B-PON	Broadband PON	155 Mbps	622 Mbps
G-PON	2.5G-PON	1.25 Gbps	2.5 Gbps
E-PON	1G-EPON/GE-PON	1.25 Gbps	1.25 Gbps
10G/10G-EPON	10G-EPON	10.3125 Gbps	10.3125 Gbps
10G/1G-EPON	10G-EPON	1.25 Gbps	10.3125 Gbps
10G/10G-EPON	10G-EPON	10.3125 Gbps	10.3125 Gbps
10G/1G-EPON	10G-EPON	1.25 Gbps	10.3125 Gbps
NG-EPON	25G/50G/100G-EPON	25/40/100 Gbps	25/40/100 Gbps
NG-PON2	-	10/40 Gbps	40 Gbps
NG-PON2	-	80 Gbps	80 Gbps
NG-PON3	-	40/100 Gbps	100/250 Gbps
XG-PON1	10G-PON/XG-PON/NG-PON1	2.5 Gbps	10 Gbps
XG-PON2	10G-PON/NG-PON1	10 Gbps	10 Gbps
XGS-PON	-	10 Gbps	10 Gbps

Source: CIR

ITU creates opportunities and challenges with NG-PON2: The ITU introduced XG-PON (also called NG-PON1), which pushed up the line rate to 10 Gbps and a reach of 60 km to 80 km. The IEEE's response to this was 10G-EPON which also had an effective data rate of 10 Gbps but a line rate of 10.3125 Gbps to allow for the Ethernet frame. However, the reach was only 20 km.

The ITU-T's next recommendation pushed the boundary technologically and increased the line rates to 40 Gbps (and 80 Gbps in some cases) with a reach of 40 km. This was the recommendation for NG-PON2 which used a mixture of TDM and WDM techniques, called TWDM. As with all technological leaps forward, NG-PON2 has created cost issues. More specifically, NG-PON2 uses tuneable transceivers at the customer premises ONT and this has pushed the cost of NG-PON2 to unacceptable levels since the cost of the tuneable transceiver components can be as high as $1,000. NG-PON2 combines TDM and WDM transmission, but as the wavelength(s) assigned to each ONT can change, the ONT transceivers must be able to adapt quickly to transmission reconfigurations.

Switching times of 50 ms are possible for this, but many would like the minimum switching speed to be10 ms or 25 ms. These challenges have opened up a new set of opportunities for module makers around low-cost tunables. The seriousness of this challenge should not be underestimated—low-cost tunable components have been a problem in optical communications and have never come to a satisfactory conclusion. The tunable issue is being addresseed by a number of component manufacturers, some in China.

The component manufacturer that can come up with a 10-ms switching tuneable transceiver for NG-PON2 will be inundated with orders. Although tuneable transceivers are widely used in carrier networks, these are too expensive for ONT use and do not meet all of the NG-PON2 performance specifications in any case. CIR believes that a tunable transceiver with symmetrical 10 Gbps won't be available until after 2018.

For now, NG-PON2 equipment, while providing high bandwidth and long reach, is possibly the most expensive of all conventional PON equipment. Even with large orders from Verizon and others, the cost of NG-PON2 remains a problem for many carriers and service providers.

XGS-PON offers a temporary solution: Given all this, a lot of service providers around the world are not interested in waiting for NG-PON2 and are attracted to XGS-PON instead. XGS-PON really fulfills the immediate need for a low-cost PON replacement for G-PON, and is the result of a lot of lobbying by many companies and organizations.

The XGS-PON recommendation has now been adopted by numerous operators and carriers worldwide and offers line rates of 10 Gbps and a reach of 20 km—which is a "same-cost" replacement for G-PON at a much higher line rate. Mobile operators are also considering XGS-PON for the 5G backhaul standard as a massive number of small cells are required. With XGS-PON, around 128 small cells can be served using a single PON, or if long reach is required, NG-PON2 can fulfil this need.

In fact, at 10 Gbps and 20 km XGS-PON can address a large number of sizeable markets. However, in CIR's view, it still looks like an interim standard. The line rates seem extremely low now as we are currently entering the era of 100 Gbps to 250 Gbps

line rates, using mostly the same fiber optic cables as we did in the late 1990s. Nonetheless, we can also expect further advances in PON technology to emerge quite rapidly. With NG-PON3 from the ITU-T and NG-EPON from the IEEE, the 100 Gbps to 250 Gbps line rates are expected to be reached. This will push the use of PONs into loop markets where PONs have never been considered previously.

1.1.4 New PONs will Create a Positive Impact on the Optical Cable Market

The ITU-T recommendations, from A-PON and B-PON all the way to NG-PON2 and XGS-PON share the same fiber cable infrastructure at the same time. The same can also be said for the IEEE Ethernet over PON standards, E-PON and 10G-EPON. An example of this is shown in Exhibit 1-2 in the context of mobile backhaul.

Exhibit 1-2: NG-PON2, G-PON, XGS-PON and TV RF Sharing the Same Fiber Infrastructure
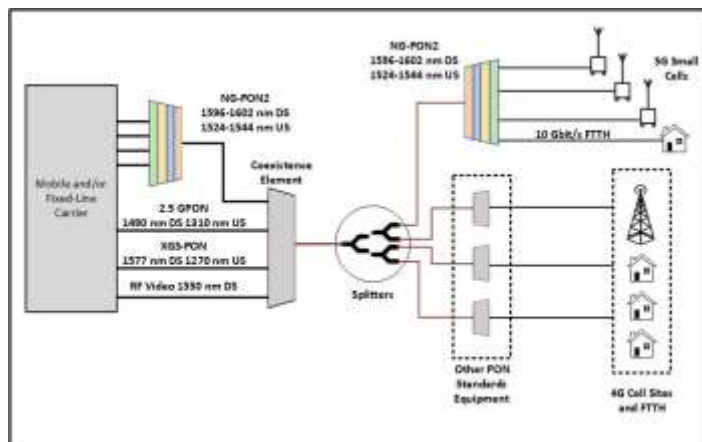
Source: CIR

This is bad news for the fiber cable industry, even if it is good news for operators. In the past it was often stated that fiber cable could provide almost infinite bandwidth, but in reality, the practicalities of deployment, architecture and performance constraints of OLTs/ONUs does lead to some restrictions. Fiber cable does support tens of terabits per second over short distances, but capacity drops off as the length of cable increases. Amplifiers could be used but are inconsistent with the PON business model, amplifier and repeater technology is too expensive and not suitable for PONs.

Nonetheless, due to technology improvements the effective transmission capacity of fiber has increased tenfold every four years for the past three decades. And there are signs that the optical cable industry can expect some kind of revenue stream from the shift to

higher performance PONs. For example, CIR expects demand to grow for better performance fiber, such as ITU-T Recommendation G.652.D as it has less loss in the PON wavelength band.

Meanwhile, PON technology and reach is approaching the performance of some Active Optical Networks that use regeneration of wavelengths in the line. The reach of some of the PONs is around 100 km and some PONs can service 128 customers over a single line. Whilst this does not match the capacity of carrier networks using SDH/SONET or OTN, the advances made in PON technology is now quite rapid as a raft of new ideas are productized.

1.2 Objective and Scope of this Report

The objective of this report is to determine where the business opportunities are that are expected to arrive with the latest wave of interest and deployments of PON technology. We are also especially interested in this report in who will make money out of this trend.

- While the report examines each PON type listed in Section 1.1, it takes an especially in-depth look at XGS-PON and NG-PON2 and how their technical and performance advantages will create value for both equipment suppliers and major carriers. The report will also identify how new directions for PON technology will create new opportunities for optical component suppliers.

- This analysis will be based on a discussion of the emerging applications that will provide new business revenues beyond fiber-to-the-anywhere (FTTx) deployments. These include 5G backhaul, remote monitoring and telemetry and triple- and quad-play applications. As part of this analysis, we consider the PON deployment strategies of leading carriers worldwide and implications of the long-term supply chains that they are establishing with major suppliers. The report explores whether the future of the PON equipment business will become concentrated in the hands of a few major suppliers or whether there is still room for start-ups.

- We include a ten-year (volume and value) forecast of PON equipment, fiber utilized and major components (such as splitters), with breakouts by country/region, type of technology, etc. Ten-year forecasts for each of the 15 leading countries in terms of PON deployment are also included in this report. In addition, the report also includes markets shares for some of the key sectors are also included.

1.3 Methodology Used in this Report

The methodology used to compile this report is similar to that used in other reports published by CIR. That is to say, it is based in part on telephone interviews with a variety of players in this space ranging from key suppliers and users to relevant industry journalists. We have also conducted "live" interviews at major trade shows, mainly in the U.S.

To the primary information mentioned above we have added data that was collected by CIR from third-party sources such as corporate websites, financials and presentations, as well as reputable trade and technical publications, including papers delivered at conferences.

The forecasting methodology is explained in more detail in the chapters that include the forecasts themselves. Here, we note that the framework for the methodology is similar to that used in other CIR reports. This is essentially to determine a baseline addressable market and then establish a relationship between that and the time series being established in the forecast.

1.4 Plan of this Report

In Chapter Two, the emerging and current PON technologies are analyzed and their capabilities are presented. Also, standards development is examined mainly from the ITU-T and the IEEE. The emerging PON technology standards are also outlined as well as projected capabilities. A consideration is taken of the costs of implementing some standards and the opportunities for PON component makers.

In Chapter Three, focus is on the many applications possible with PONs, including FTTx and 4G and 5G backhaul deployment. Other applications, such as business loop applications, long reach PONs and use of PONs as an integrated broadband platform.

In Chapter Four, the worldwide deployment of PONs is examined, covering up to 15 leading countries in North and South America, Europe and Asia Pacific regions. The impact on small cities is also examined.

Chapter Five focusses on forecasts and provides ten-year forecasts for the PON market, including the components and software. Forecasts of the PON market by country and region are also provided.

The final chapter, Chapter Six, looks at the major suppliers of PON equipment and components and their strategies for more business.