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Review

# The next generation of passive optical networks: A review

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ABSTRACT

Passive Optical Networks (PONs) have become a popular fiber access network solution because of its service transparency, cost effectiveness, energy savings, and higher security over other access networks. PON utilizes passive low-power components which removes the need for power-feeding in the fiber distribution network. This paper presents three different generations of PON that are based on the Ethernet PON and Gigabit PON standards. This article showcases the first generation of PON in terms of physical and data link layers and forms the basis for discussion about the different approaches being pursued for the next generation stage 1 PON (NG-PON1). Additionally, the main objective of this study is to review the technologies proposed for the next generation stage 2 PON (NG-PON2); highlighting the important contributions and limitations of the corresponding technologies. Hybrid approaches that combine multiple technologies are introduced as a solution to eliminate major limitations and to improve overall system-wise performance. However, NG-PON2 is still suffering from a number of challenges include cost, reach, capacity and power consumption are discussed at the end of this paper. Another purpose of this paper is to identify potential remedies that can be investigated in the future to improve the performance of the NG-PON2.



**Contents**



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## 1. Introduction

Passive Optical Networks (PONs) are a series of promising broadband access network technologies that offer enormous advantages when deployed in fiber to the home (FTTH) scenarios. The advantages include a point to multi-point architecture, high quality triple play service capabilities for data, voice and video, high speed internet access, and other services in a cost-effective manner (Ragheb and Fathallah, 2012).

Over the past decade several PON architectures have been developed by the International Telecommunications Union (ITU) and the Institute of Electrical and Electronic Engineers (IEEE). The four main PON variations developed by the ITU and IEEE can be categorized into two groups. The first kind of architecture is based on Asynchronous Transfer Mode (ATM) and includes ATM PON (APON), Broadband PON (BPON) and Gigabit PON (GPON) and the second group consists of Ethernet PON (EPON). EPON and GPON are the most popular PON variations found in use today. A conventional PON architecture is presented in Fig. 1 (Ragheb and Fathallah, 2012). In the figure, it can be seen that the PON architecture consists of an Optical Line Terminal (OLT), Optical Distribution Network (ODN), and Optical Network Units (ONU). The OLT is placed at the Central Office (CO) and connected to the splitters by fiber. The optical splitters connect to customer premises making PON a point to multi-point architecture (P2MP) (Ragheb and Fathallah, 2012).

The EPON and the GPON standards have the same general principle in terms of framework and applications but their operation is different due to the implementation of the physical and data link layers (Olmos et al., 2011). EPON is defined by IEEE 802.3 and it is widely deployed in Asia whilst GPON is deployed in a number of other regions. GPON's requirements were defined by the Full Service Access Network (FSAN) group that was ratified as ITU-T G.984 and is implemented in North America, Europe, Middle East, and Australasia (Van Veen et al., 2011; Skubic et al., 2009).

In this paper the advancement of PON technology is classified into three generations: the first generation (deployed PON), next generation stage 1 (NG-PON1), and next generation stage 2 (NG-PON2). The evolution of the PON architectures and their corresponding capacity features are shown in Fig. 2.

The first generation of PON is based on Time Division Multiple Access (TDMA) and provides an EPON downstream rate of 1 Gbps and a GPON downstream rate of 2.4 Gbps. The NG-PON1 increases the data rate up to 10 Gbps for both standards (Biswas and Adak, 2011). There are two main scenarios to achieve an upgrade that are the upgrade from deployed EPON to XG-EPON and from deployed GPON to XG-GPON. An upgrade from deployed GPON to XG-EPON

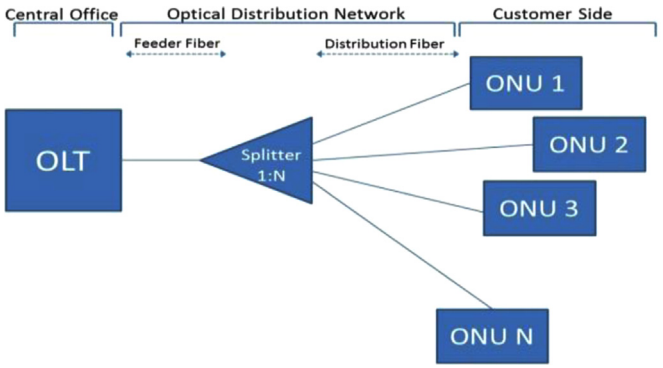


**Fig. 1.** PON architecture.

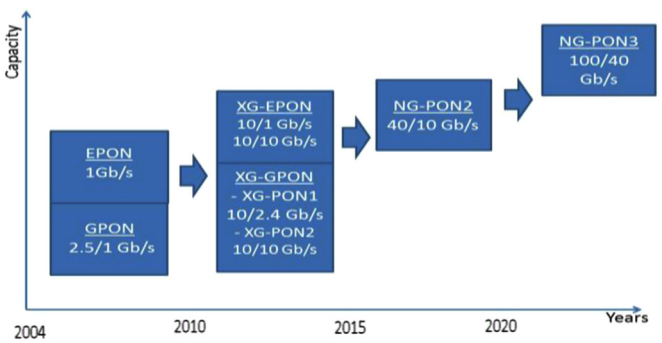


**Fig. 2.** PON generations.