Ethernet Passive Optical Networks

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INTRODUCTION

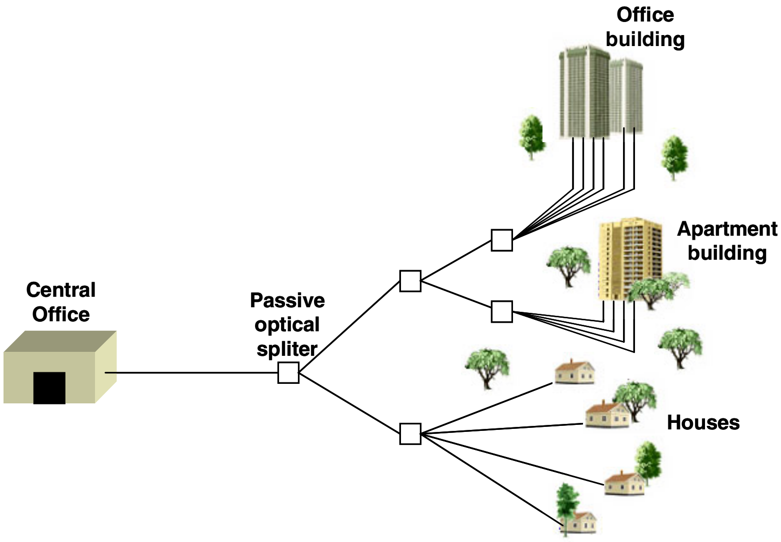
Recently, Ethernet Passive Optical Networks (EPONs) have received a great deal of interest as a promising cost-effective solution for next-generation high-speed access networks. This is confirmed by the formation of several *fora* and working groups that contribute to their development; namely, the EPON Forum (http://www.ieeecommunities.org/epon), the Ethernet in the First Mile Alliance (http://www.efmalliance.org), and the IEEE 802.3ah working group (http://www.ieee802.org/3/efm), which is responsible for the standardization process. EPONs are a simple, inexpensive, and scalable solution for high-speed residential access, capable of delivering voice, high-speed data, and multimedia services to end users (Kramer, Mukherjee &Maislos, 2003; Kramer & Pesavento, 2002; Lorenz, Rodrigues & Freire, 2004; Pesavento, 2003; McGarry, Maier & Reisslein, 2004). An EPON combines the transport of IEEE 802.3 Ethernet frames over a low-cost and broadband point-to-multipoint passive optical fiber infrastructure connecting the Optical Line Terminal (OLT) located at the central office to Optical Network Units (ONUs), usually located at the subscriber premises. In the downstream direction, the EPON behaves as a broadcast and select shared medium, with Ethernet frames transmitted by the OLT reaching every ONU. In the upstream direction, Ethernet frames transmitted by each ONU will only reach the OLT, but an arbitration mechanism is required to avoid collisions.

This article provides an overview of EPONs and focuses on the following issues: EPON architecture; Multi-Point Control Protocol (MPCP); quality of service (QoS); and operations, administration, and maintenance (OAM) capability of EPONs.

EPON ARCHITECTURE

EPONs, which represent the convergence of low-cost and widely used Ethernet equipment and low-cost point-to-multipoint fiber infrastructure, seem to be the best candidate for the next-generation access network (Kramer & Pesavento, 2002; Pesavento, 2003). In order to create a cost-effective shared fiber infrastructure, EPONs use passive optical splitters in the outside plant instead of active electronics, and, therefore, besides the end terminating equipment, no intermediate component in the network requires electrical power. Due to its passive nature, optical power budget is an important issue in EPON design, because it determines how many ONUs can be supported, as well as the maximum distance between the OLT and ONUs. In fact, there is a tradeoff between the number of ONUs and the distance limit of the EPON, because optical losses increase with both split count and fiber length. EPONs can be deployed to reach distances up to around 20 km with a 1:16 split ratio, which sufficiently covers the local access network (Pesavento, 2003). Figure 1 shows a possible deployment scenario for EPONs (Kramer, Banerjee, Singhal, Mukherjee, Dixit & Ye, 2004).

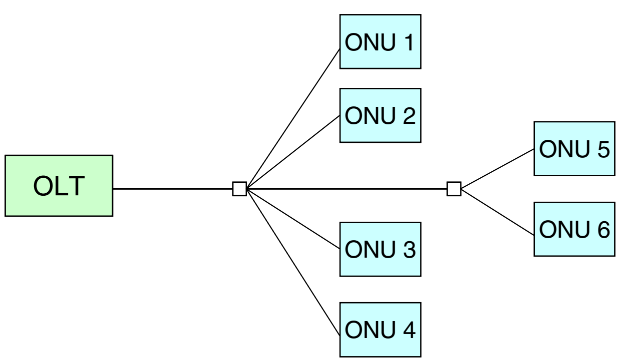
Figure 1. Schematic representation of a possible deployment scenario for EPONs



Although several topologies are possible (i.e., tree, ring, and bus) (Kramer, Mukherjee & Maislos, 2003; Kramer, Mukherjee & Pesavento, 2001; Pesavento, 2003), the most common EPON topology is a 1:N tree or a 1:N tree-and-branch network, which cascades 1:N splitters, as shown in Figure 2. The preference for this topology is due to its flexibility in adapting to a growing subscriber base and increasing bandwidth demands (Pesavento, 2003).

EPONs cannot be considered either a shared medium or a full-duplex point-to-point network, but a combination of both depending on the transmission direction (Pesavento, 2003). In the downstream direction, an EPON behaves as a shared medium (physical broadcast network), with Ethernet frames transmitted from the OLT to every ONU. In the upstream direction, due to the directional properties of passive couplers, which act as passive splitters for downstream, Ethernet frames from any ONU will only reach the OLT and not any other ONU. In the upstream direction, the logical behavior of an EPON is similar to a point-to-point network, but unlike in a true point-to-point network, collisions may occur among frames transmitted from different ONUs. Therefore, in the upstream direction, there is the requirement both to share the trunk fiber and to arbitrate ONU transmissions to avoid collisions by means of a Multi-Point Control Protocol (MPCP) in the Medium Access Control (MAC) layer. An overview of this protocol will be presented in the next section.

Figure 2. Schematic representation of a tree-and-branch topology for EPONs



EPONs use point-to-point emulation to meet the compliance requirements of 802.1D bridging, which provides for ONU to ONU forwarding. For this function, a 2-byte Logical Link Identifier (LLID) is used in the preamble of Ethernet frames. This 2-byte tag uses 1-bit as a mode indicator (point-to-point or broadcast mode), and the remaining 15-bits as the ONU ID. An ONU transmits frames using its own assigned LLID and receives and filters frames according to the LLID. An emulation sublayer below the Ethernet MAC demultiplexes a packet based on its LLID and strips the LLID prior to sending the frame to the MAC entity. Therefore, the LLID exists only within the EPON network. When transmitting, an LLID corresponding to the local MAC entity is added. Based on the LLID, an ONU will reject frames not intended for it. For example, a given ONU will reject

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Aleksey Charapkoand Ching-Hua Chuan (2015). *International Journal of Multimedia Data Engineering and Management (pp. 1-18).*
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