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Abstract

A medium access control (MAC) layer protocol for passive optical networks (PONs) based on orthogonal frequency division multiple access (OFDMA) is proposed in this paper. The protocol is able to exploit statistical multiplexing to offer an efficient bandwidth control with greater flexibility and granularity to the bandwidth allocation, hence, providing high performance measured in terms of throughput, delay and jitter. The main recommendations of the proposed MAC are described in accordance to the physical layer features of the architecture named Bandwidth Scalable OFDMA PON (BS-OFDMA PON). Simulation results show that the proposed architecture based on tree topology is able to provide triple-play services to 32 optical network units (ONUs) and transmission rates above 33 Gb/s per wavelength.

Index Terms

Passive optical network, medium access control, orthogonal frequency division multiple access, bandwidth scalable.

I. Introduction

Services such as digital video, mobile traffic back-haul, cloud and data center interchanges require an efficient bandwidth control with significant scalability to the next-generation passive optical networks (PONs) [1]. Therefore, the adoption of technologies based on advanced multiplexing techniques such as orthogonal frequency division multiplexing (OFDM) [2], [3], subcarrier multiplexing (SCM) [4]–[6] and wavelength division multiplexing (WDM) [5], [7]–[9] is mandatory. These techniques significantly reduce the per-bit delivery cost and offer high capacity to the aforementioned optical networks, even in single wavelength systems. Furthermore, cost-effective PONs that support the Quality of Service (QoS) requirements of future applications should quickly and dynamically adapt to the new architectures and protocols [6].

Orthogonal frequency division multiple access (OFDMA) has emerged as a promising resource sharing mechanism for next generation networks. Power consumption and computational complexity are constraints that can be reduced if a multi-band OFDMA technique is adopted in PONs [10]. However, even in optical access techniques composed by multiple lower rate sub-bands, a bandwidth control should be implemented. Technologies described by some authors such as the use of centralized light source [4], [5], the re-modulation of the downlink optical carrier [5], [11] and the redistribution of the optical carrier [6] were gathered to be used in the PON proposed in [12]. This architecture named Bandwidth Scalable OFDMA PON (BS-OFDMA PON) was experimentally demonstrated in [13]–[15]. The BS-OFDMA PON provides a bandwidth management by using OFDM/OFDMA techniques in order to increase the granularity of the bandwidth allocation. Moreover, this architecture improves the system spectral efficiency by rejecting the guard band between optical network unit (ONU) sub-bands and by reducing the guard band between the optical carrier and the signal bandwidth.

The 10 Gigabit Ethernet PON (10G EPON) [16], [17] and the 10 Gigabit-Capable PON (XGPON) [18] standards, widely used in recent years, specify medium access control (MAC) protocols based on time division multiple access (TDMA). More recently, in order to increases the data rate beyond 10

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