A WDM-PON System Providing Quadruple Play Service with Converged Optical and Wireless Access

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Abstract *We demonstrate a WDM-PON structure providing quadruple play service integrating optical and wireless access based on hybrid modulation formats. Downstream signals are re-modulated for upstream transmission enabling source-free ONUs.*

Introduction

Passive optical network (PON) providing triple play service with video, voice and data delivery has become an attractive solution to the increasing bandwidth driven by the emerging multimedia applications [1]. Due to the recent advances in wireless communication and strong desire of flexible wireless-data access, convergence of optical and wireless technologies for quadruple play (voice, data, video and mobility) is promising to provide broadband and ubiquitous access in an integrated platform with cost-effective configuration [2].

In this paper, we propose and demonstrate a novel wavelength-division multiplexing (WDM)-PON system to deliver downstream video, voice, data and radio-over-fiber (RoF) based wireless access signals simultaneously. For the first time to the best of our knowledge, we realize the quadruple play service (QPS) with a single wavelength by sub-carrier modulations at different bias conditions of the modulators, combined with amplitude modulations. Upstream data are re-modulated on the downstream optical signals, which eliminate light sources in the optical network units (ONUs). For wireless access, RoF technology minimizes the cost of the distributed ONUs and shift the system complexity and expensive devices to the optical line terminal (OLT) [3]. Transmitting the four kinds of service in dedicated physical channels can provide guaranteed individual bandwidth, and avoid complicated scheduling algorithm among different services.

Principle and architecture

Figure 1 shows the proposed WDM-PON architecture providing QPS including RoF based wireless access, voice, data and broadcast video service with source-free ONUs. In the OLT, for each WDM channel, the output of a continuous wave (CW) laser is split into two paths. One part is launched into a Mach-Zehnder modulator (MZM) which is biased at its null point. The MZM is driven by an electrical sub-carrier multiplexed (SCM) signal, which is produced by mixing an alternating current (AC)-coupled bipolar data with a radio frequency (RF) carrier, to generate an optical carrier suppressed-differential phase-shift keying (OCS-DPSK) signal. The other part of the CW carrier is modulated by a dual-drive MZM (DDMZM). As each arm of the DDMZM is a phase modulator, an optical double-sideband (DSB) sub-carrier DPSK signal is obtained by driving one arm of the DDMZM using a mixed signal of bipolar data with an RF clock signal. The two sidebands without the central tone in spectrum can be also considered as an OCS-DPSK signal. In the other arm of the DDMZM, the optical phase of the light carrier is modulated by an electrical baseband signal. After interference with the central carrier of the DSB sub-carrier DPSK signal, the phase shift transfers to amplitude variation, resulting in an amplitude-shift keying (ASK) baseband signal. Therefore if RF clock signals of different frequencies are applied to the MZM and DDMZM, respectively, one can obtain an optical signal carrying three different streams of data, including two in OCS-DPSK format and one in ASK format. The MZM and DDMZM can be integrated into one chip to form a dual-parallel MZM, in order to further shrink the transmitter size. The optical signals from different channel are coupled into one fiber through an arrayed waveguide grating (AWG). An interleaver with a proper channel spacing is used to separate the OCS-DPSK components with lower repetition rate from the input signals for each WDM channel. Broadcast video data are subsequently superimposed through ASK modulation to generate OCS-DPSK/ASK signal format. Note that the extinction ratio (ER) of the ASK modulation should be low enough to maintain the phase information of the OCS-DPSK signal. The OCS-DPSK/ASK signal is combined again with the OCS-DPSK signals at higher RF frequency and the baseband signals, thus optical signals in hybrid modulation formats are obtained to carry four independent services, which are then pre-amplified and delivered downstream.

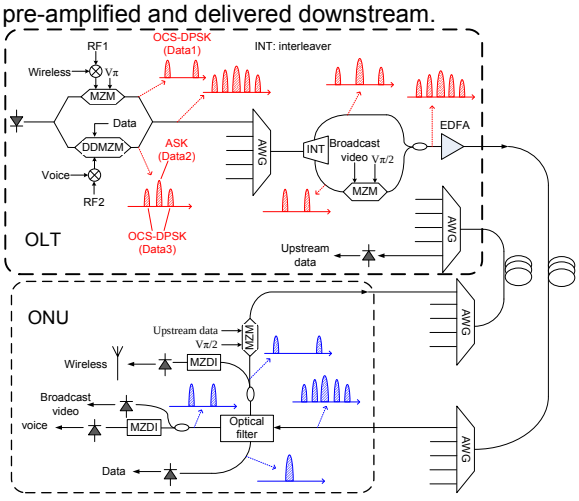

Figure 1: The proposed WDM-PON providing QPS.

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At the ONU side, the received optical signal is filtered and separated to three components at different RF