Simultaneous Transmission of Three Services in A WDM-PON System with Wireless Access for Multicast Data

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Abstract: We propose and experimentally demonstrate a wavelength division multiplexed-passive optical network (WDM-PON) architecture supporting point-to-point, broadcast, and multicast services based on hybrid modulation format. Wireless access for multicast data is provided using optical-carrier-suppression (OCS) technology.

1. Introduction

Wavelength division multiplexed-passive optical network (WDM-PON) has been regarded as a promising access technology for its advantages of high capacity, large coverage range, upgradeablity, and cost-effective configuration [1]. In access networks, point-to-point (p-t-p) data, multicast and broadcast services may co-exist. In addition, with the deployment and application of 3G networks, an increasing number of 3G users subscribe high-speed wireless services, and these services are desired to be selectively delivered to subscribers per requests on the WDM-PON infrastructure to lower the Capex. Thus it is attractive to achieve simultaneous transmission of p-t-p, broadcast and multicast services in a WDM-PON system with certain wireless access capability. However, in previous demonstrations [1-5], only broadcast or multicast service was transmitted in company with p-t-p data.

In this paper, for the first time to the best of our knowledge, we realize simultaneous transmission of p-t-p, multicast and broadcast services, and provide wireless access for multicast service in a WDM-PON architecture. In our scheme, p-t-p and broadcast data are modulated on the optical carrier using orthogonal modulation format, and multicast data is carried on the first-order sub-carriers with optical carrier suppression (OCS) modulation. For each WDM channel, selective delivery of the multicast data is achieved by simply turning on/off an electrical switch in the optical line terminal (OLT), which is programmable and suitable for practical applications.

2. Principle

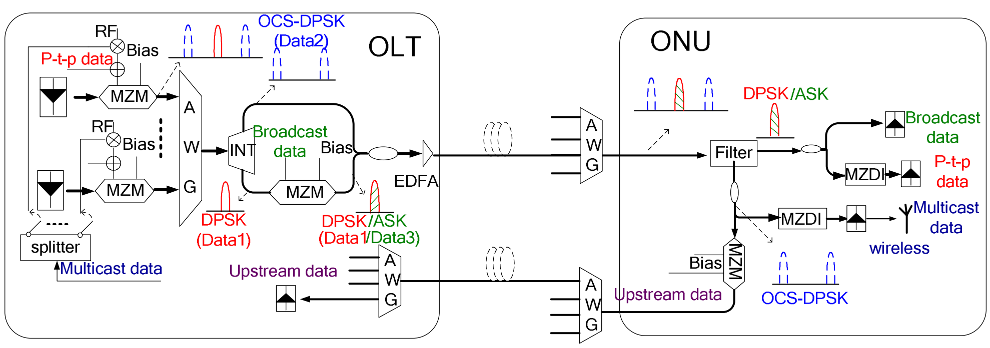

Fig. 1: Schematic diagram of the proposed WDM-PON system.

Fig. 1 depicts the schematic diagram of the proposed WDM-PON system. In the OLT, at the output of each Mach-Zenhder modulator (MZM), the multicast data is modulated on the first-order sub-carriers in an optical carrier suppression- differential phase shift keying (OCS-DPSK) format, while the p-t-p data is modulated on optical carrier in a differential phase shift keying (DPSK) format. The optical signals from different channels are coupled through an arrayed waveguide grating (AWG). An interleaver is used to separate the baseband DPSK signal from the input signal for each WDM channel. Broadcast service is subsequently superimposed on the p-t-p data through amplitude shift-keying (ASK) modulation to realize DPSK/ASK orthogonal modulation format. The DPSK/ASK signal is combined again with the OCS-DPSK signal using an optical coupler. The multicast service can be simply switched on/off by controlling electrical switches in the OLT, which realizes selective delivery function.

After transmission over fiber, at each optical network unit (ONU), an optical filter is employed to separate the baseband DPSK/ASK and the OCS-DPSK signals. The DPSK/ASK signal is split into two parts. One is directly detected by a low-speed photo detector (PD), to receive the broadcast data; while the other part is demodulated by a DPSK receiver, to recover the p-t-p data. For users who subscribe the multicast service, the OCS-DPSK signal is converted to an OCS-ASK signal after a Mach-Zehnder delay interferometer (MZDI), and a wireless signal with double repetition of the radio-frequency (RF) clock can be obtained after detection by a high-speed PD. Part of the

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OCS-DPSK signal is tapped as an optical carrier for upstream ASK data re-modulation.

3. Experiment and results

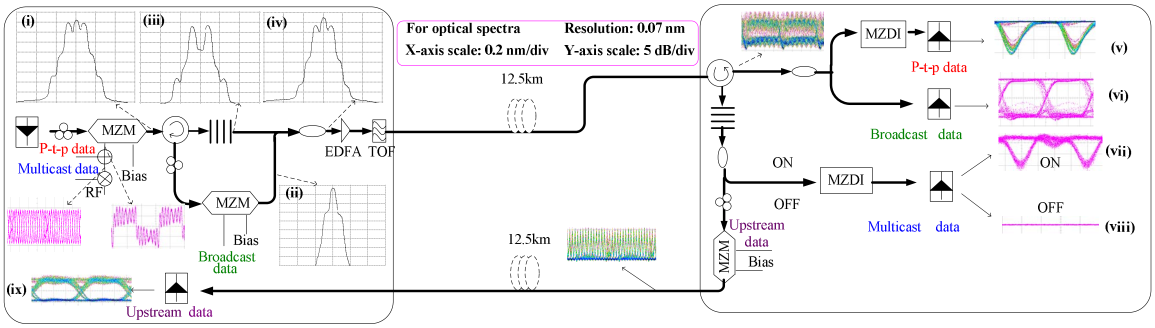

Fig. 2 : Experimental setup and results.

We perform an experiment to verify the feasibility of the proposed scheme with its setup shown in Fig. 2, where the four types of data, i.e., p-t-p, broadcast, multicast and upstream data are 1.25-Gbit/s pseudo-random bit sequence (PRBS) streams obtained from the rear-panel output ports of the pulse pattern generator (PPG) (ANRITSE MP1763C). Due to the PPG setting limitation, the word lengths of the four data signal are set to 2^7-1 when they are obtained from the divide-by-8 ports in the rear panel. In the OLT, a CW light from a tunable laser at 1551.06 nm is fed into a single-drive MZM, which generates a baseband DPSK signal and a 20-GHz OCS-DPSK signal (inset (i) of Fig. 2). The baseband DPSK signal is reflected by a fiber Bragg grating (FBG) with a 3-dB bandwidth of 0.106 nm and a reflection ratio of 90%, which is re-modulated by the broadcast data to obtain DPSK/ASK format (inset (ii) of Fig. 2). Then the passing OCS-DPSK signal (inset (iii) of Fig. 2) is combined with the generated DPSK/ASK signal through an optical coupler. The output of the coupler is amplified by an erbium-doped fibre amplifier (EDFA) and a tunable optical filter is utilized to suppress amplified spontaneous emission (ASE) noise.

After transmission over 12.5-km standard single-mode fiber (SMF), in the ONU, the optical signal is separated by a second FBG with the same performance. The reflected baseband DPSK/ASK signal is split into two parts, which are received by an 8-GHz DPSK receiver and a 2.5-GHz PD, to recover the p-t-p data and the broadcast data (insets (v) and (vi) of Fig. 2), respectively. When the ONU makes a request for the multicast service, the electrical switch in the OLT is turned on and the eye diagram of the multicast data in the ONU shows wide opening (inset (vii) of Fig. 2). If the ONU does not subscribe the multicast service, the electrical switch is turned off and the eye is completely closed (inset (viii) of Fig. 2). Part of the OCS-DPSK signal is tapped for re-modulation of the upstream data. After 12.5-km SMF transmission, the upstream data is detected by a 2.5-GHz PD in the OLT and the electrical eye diagram is shown in inset (ix) of Fig. 2. The BER measurement results in Fig. 3 show less than 1-dB power penalties for all the four types of data.

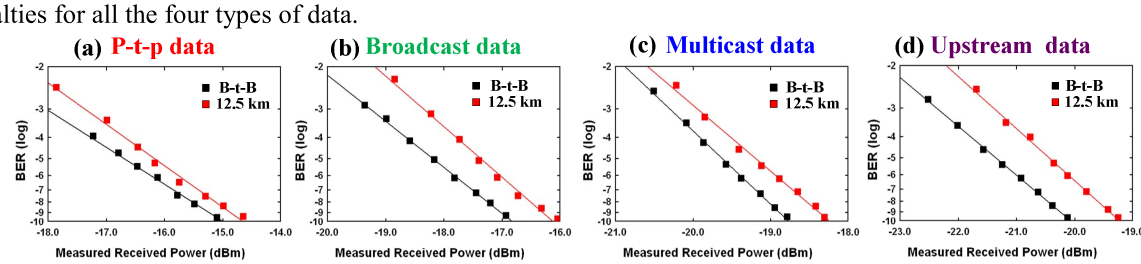

Fig. 3: BER curves for (a) p-t-p data, (b) broadcast data, (c) multicast data, and (d) upstream data.

4. Conclusion

We have proposed a WDM-PON simultaneously delivering three types of services (p-t-p, multicast, broadcast) with converged optical and wireless access. The feasibility of the technique was experimentally demonstrated with the power penalties less than 1 dB. This work was supported by the 863 High-Tech program (2009AA01Z257).

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