A Selective-broadcast Overlay Scheme for WDM-PON Using NRZ/DPSK Orthogonal Modulation Technique

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Abstract: A novel scheme to overlay the DPSK broadcast signal onto the NRZ point-to-point signal in a WDM-PON is proposed. Selective broadcast is realized by adjusting the extinction ratio of the NRZ signals on individual wavelengths.

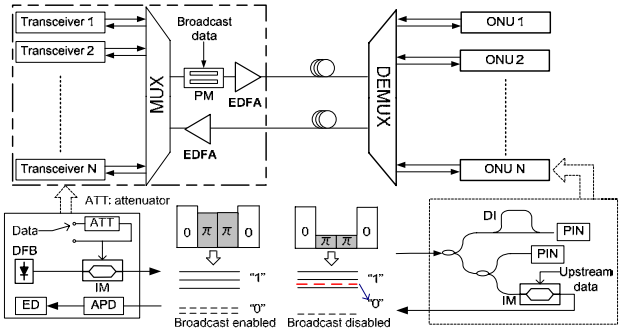
Keywords: wavelength division multiplexing, passive optical networks, orthogonal modulation, broadcast, multicast

1. Introduction

To realize more flexible network functions in wavelength division multiplexing passive optical networks (WDM-PONs), broadcast overlay has been proposed to deliver downstream high-bandwidth video or data service to subscribers [1-3]. The previously proposed approaches include bandwidth sharing with the point-to-point data [1] or using additional light sources, which required complicated timing control [2]. Moreover, all optical network units (ONUs) would receive the broadcast signal. In [3], a WDM-PON architecture with selective-broadcast overlay was proposed, in which all or only a subset of the ONUs on the network could receive the broadcast services, and the flexible control is performed at the optical line terminal (OLT). The selective-broadcast feature was realized by switching the point-to-point signal format between non-return-to-zero (NRZ) and inverse-return-to-zero (IRZ) on each wavelength channel, while the broadcast signal, in differential phase-shift keying (DPSK) format, was superimposed onto the multiplexed point-to-point signal. To further reduce the cost and simplify the control, in this paper, NRZ, instead of the uncommonly-used IRZ format, is employed as the format for the point-to-point data in both broadcast-enabled and disabled cases. By simply adjusting the extinction ratio (ER) of the NRZ point-to-point signal, the downstream DPSK broadcast signal can be flexibly transmitted or interrupted on every individual wavelength channel in a WDM-PON.

2. WDM-PON Architecture using NRZ/DPSK Signals to Support Selective Broadcast Overlay

Fig. 1 depicts the WDM-PON architecture with the proposed selective-broadcast overlay. At the OLT, each individual point-to-point transceiver generates the downstream NRZ signals and receives the upstream re-modulated signal from its respective designated ONU. By properly adjusting the input amplitude of the point-to-point electrical data signal via an electrical attenuator, optical NRZ signals with different extinction ratios (ER) can be generated, via the optical intensity modulator (IM). All of



the downstream point-to-point signals on different wavelength channels are multiplexed before being fed into an optical phase modulator (PM) for superimposing the common DPSK broadcast data onto them. If the ER of the NRZ point-to-point signal is low enough (2~4 dB), the superimposed DPSK broadcast signal can be demodulated correctly at the selected destined ONU. On the contrary, if the ER of the NRZ signal is high (>5 dB), the superimposed DPSK broadcast signal will suffer from excessive intensity fluctuation induced by the NRZ signal and thus can no longer be correctly detected at the destined ONU. In this way, by controlling the ER of the NRZ point-to-point signal on individual wavelength channels at the OLT, only those selected ONUs can receive the broadcast signal properly and thus selective-broadcast overlay is achieved. In both cases, the point-to-point NRZ signal on each wavelength channel can still be successfully received by its respective destined ONU. The simple control of selective broadcast is centralized at the OLT. At each ONU, a portion of the received signal power is tapped off for downstream data reception. The NRZ point-to-to-point data is detected via direct detection; while the DPSK broadcast data is demodulated via a delay-interferometer (DI) before direct detection. The rest of the received power is re-modulated with the upstream data, via an intensity modulator, given the limited ER of the downstream NRZ signal (<8 dB). No light source is needed at the ONU.

Fig. 1. WDM-PON architecture with the proposed selective-broadcast overlay scheme

3. Experimental Results

We have experimentally demonstrated the proposed scheme with an experimental setup similar to Fig. 1. At the OLT, a light source at 1546.8 nm was first NRZ modulated by a 10-Gb/s 2^{31}-1 pseudo-random binary sequence (PRBS) as the downstream point-to-point signal. Here, we

used an ER of 3.5 dB for the broadcast-enabled mode and an ER of 6.5 dB for broadcast-disabled mode. These two modes are activated by switching between these two ER values, via the two electrical path, one of which contains a fixed-value electrical attenuator, at the input of the optical modulator. After passing through the array waveguide grating (AWG), the signal was further modulated by the decorrelated 10-Gb/s PRBS data via a phase modulator, to superimpose the DPSK broadcast signal. The point-to-point signal and broadcast signal were bit synchronized by using a common clock signal. The downstream signal was then amplified to around 6.5 dBm before being coupled into a piece of 20-km dispersion-shifted fiber to emulate the dispersion compensated transmission between the OLT and the remote node. At the ONU, the optical signal power was 3-dB split for detection of DPSK broadcast data and NRZ point-to-point data, respectively.

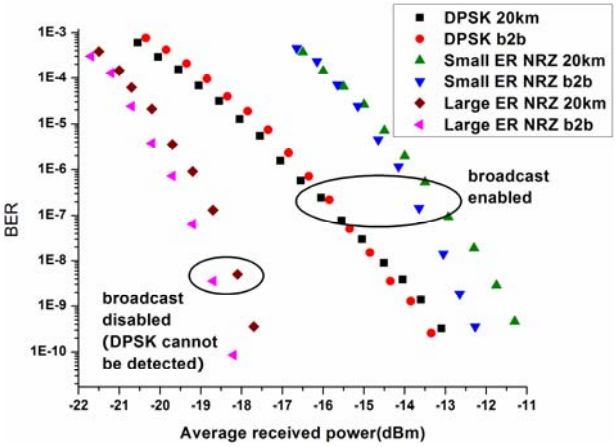


Fig. 2. BER measurements of downstream NRZ point-to-point and DPSK broadcast signals under broadcast

Fig. 2 depicts the BER of the measured downstream signals. When selective broadcast was enabled, both DPSK and NRZ signals could achieve error-free detection. We observed some phase to amplitude conversion after the AWG at the remote node, as shown in Fig. 3 (a), due to the imperfect frequency response of the AWG. With bit synchronization, the influence on the NRZ performance was minimized and around 1-dB power penalty was measured for the NRZ point-to-point signal after transmission. The DPSK broadcast signal had negligible penalty after 20-km transmission. When the selective broadcast was disabled by using high ER on the NRZ signal, the point-to-point NRZ signal was properly detected; while the superimposed DPSK signal (as shown in Fig. 3(d)) could not be properly demodulated at the ONU and thus no BER measurement could be performed. In the experiment the downstream signals had around 2-dB system margin.

4. Summary

We have proposed and demonstrated a selective-broadcast overlay scheme on WDM-PON, with NRZ point-to-point and DPSK broadcast signals, using orthogonal modulation technique. Selective broadcast was simply realized by adjusting the ER of the NRZ point-to-point signal. A 10-Gb/s experiment showed the effectiveness of the proposed scheme. The project was supported by a research grant from HKRGC.

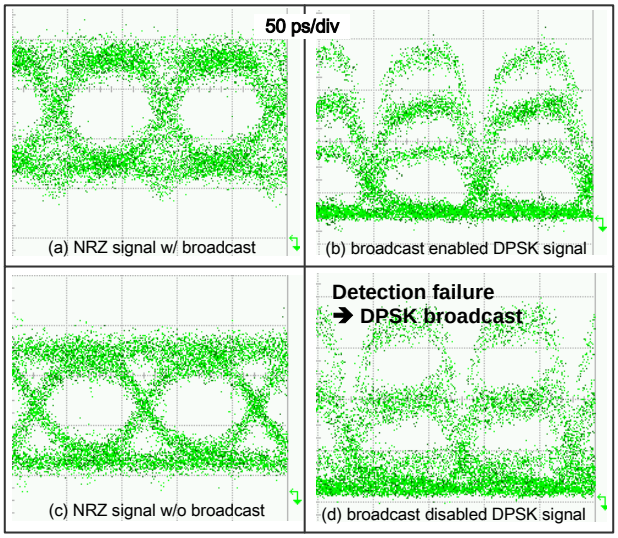


Fig. 3. Eye diagrams of downstream NRZ and demodulated DPSK signals after 20-km transmission.

5. References

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