All-Optical Multicast Switch based on Raman-Assisted
Four-Wave Mixing in Dispersion-shifted Fiber

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Abstract: We demonstrate a 3x6 all-optical multicast switch employing with wavelength control capability to select the multicast channels at 10 Gb/s using Raman-assisted FWM in dispersion-shifted fiber. All the output channels comply with the 100 GHz (i.e. 0.8nm) spaced ITU grid.

1. Introduction

Optical multicast is an important and exciting research area [1] because many future broadband applications such as Video Conferencing (VC) and High Definition (HD) Internet TV can be realized without the need for O-E-O conversion at the lower layers. Optical multicast on data plane was proposed and demonstrated using various techniques [2-6]. However, all proposed schemes can only be used for fixed multicast in the data plane without the possibility of changing multicast group member with control information from control plane.

In an Internet Protocol (IP) network such as Internet with multicast switches, group membership protocol and multicast routing protocol are used to support IP multicasting across the IP network. This allows the switch to send data only to the hosts that belong to the group. To map the control information of these protocols to Data plane lightpath connections, optical multicast switches need to be reconfigurable based on the control plane information. However, no controllable optical multipath switch has been demonstrated up to now.

In this paper we propose a scheme of using Raman-assisted FWM for its high conversion efficiency and wide bandwidth of operation to demonstrate an all-optical multicast switch. A 3x6 multicast switch (6 multicast channels) was demonstrated experimentally with the capability to select the multicast channels based on 3 wavelength controls.

2. Results and discussion

Figure 1a shows the proposed 3x6 multicast switch. It consists of three 1x2 multicast switches which are the basic building block of the switch. The 1x2 switch can be easily implemented through the use of FWM to generate two copies of the same signal. However, the scaling up of the switch is limited by the low FWM efficiency. This problem has been solved through the use of Raman-Assisted FWM in a DSF fiber and a 3x6 switch has been implemented. The 3 wavelengths controls (Enable, C0 and C1) are used to select the multicast channels to provide support for multicast protocols such as the Internet group membership protocol (IGMP) which is widely used in today’s IP multicast network. Table 1 shows the Input/Output (I/O) table of the switch.

Figure 1b shows the experimental setup. The 10 Gb/s non-return-to-zero (NRZ) data signal at 1552.2 nm (λ4) was generated by external modulation of a tunable laser with the power of 5.13 dBm. The wavelength (and power) of the CW pumps generated by DFB lasers are 1549.8 nm (λ2, 4.25 dBm), 1553 nm (λ3, 2.63 dBm) and 1555.4 nm (λ5, 0.36 dBm) respectively. The measurements are taken at port 1 of the circulator C1 (CIR1). The wavelength separation between data signal and the CW pumps are multiples of 0.8 nm which is the recommended wavelength grid specified by the ITU-T recommendations. This will ensure that all newly generated wavelengths comply with the ITU grid. The data signal and the pumps were combined with a Wavelength Division Multiplexer (WDM1) after passing through polarization controllers PC2, PC3, PC4 and PC5 respectively. The combined signals were then launched into a 10-km DSF (zero dispersion wavelength is 1538 nm) through a circulator (CIR1). The Raman pump at 1455 nm is coupled into the DSF through another circulator (CIR2) in the counter-propagating direction. The Raman pump power at the input of the DSF is 1.4 W which is used to compensate the low FWM efficiency and provide the conversion efficiency required for newly generated channels. The newly generated signals were obtained from the output ports of WDM2.

Figure 2a, b and c show the output spectrum of the channels for 3 cases: (a) all 3 pumps are present (b) Enable and C0 pumps are present (c) Enable and C1 pumps are present. The results agree with what is given in table 1 and also demonstrate how multicast group are selected. In all cases the power of all multicast channels which have been generated respectively through the use of Raman-assisted FWM was larger than -20 dBm.

We also investigate the performance of the multicast system in the case (c), by measuring the BER performance of 10 Gb/s signals in 6 channels, which have been generated respectively through the use of
Raman-assisted FWM, as shown in figure 3. We noted that the output signal performances of 6 channel are similar. The power penalty is −2.0 dB at BER of 10⁻⁶.

3. Conclusion

We proposed and demonstrated experimentally a 3x6 optical multicast switch employing Raman-assisted FWM in DSF with wavelength control capability to select the multicast channels. All 6 channels were obtained with an average power penalty of less than 2 dB at BER of 10⁻⁶. The inherent high speed nature of FWM should allow it to operate at bit rates higher than 10Gb/s demonstrated here. The results also indicated that wide bandwidth of operation for Raman should allow multiple switches to operate in a DSF over a C band simultaneously.

4. References


(a)

(b)

Figure 1(a). The 2x6 switch (b) The experimental setup

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Table 1. Input/output table of the switch where 0 = a wavelength is present; 1 = no wavelength is present and x = don’t care

Figure 2. Output Spectrum of (a) all 3 pumps present (b) C0 and C1 and Enable pumps present (c) C1 and Enable pumps present

Figure 3. BER versus the received power for the outputs of 6 channels 10 Gb/s wavelength converted signal.