400 Gbit/s, 4 Gigapackets/s multiwavelength optical packet router based on superstructure fibre Bragg gratings

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Abstract

We present a multi-wavelength (40 WDM x 10 Gbit/s) optical packet router capable of processing 4 Gigapackets/s based on header recognition using 16-bit, 20 Gbit/s superstructured fibre Bragg gratings. The approach is readily scalable to longer address codes and is transparent with respect to packet data rate.

Introduction

There is an increasing need for future optical networks that have a reconfigurable optical layer to provide a high-bandwidth flexible core. Optical packet switching is one such reconfigurable transport technology that is well matched to the bursty nature of IP traffic, enabling efficient utilisation of the available fibre bandwidth.

In this paper we demonstrate a 400Gbit/s multiwavelength optical add-drop packet switch network node based on all-optical header recognition and generation using phase-coded superstructured fibre Bragg gratings (SSFBGs) [1], and switching using fast electro-optic switches. The parallel routing look-up table is implemented all optically, using an array of SSFBGs. All-optical header processing is completed in 1.6ns, allowing packet processing rates of up to 4 Gigapackets/s (4 Gpps) within the node. SSFBG technology allows for far longer address lengths than currently possible using planar lightwave circuit based pattern generation and recognition elements [2], and represents a far less expensive approach. Our routing approach is fully compatible with existing DWDM technologies and networks and, since both header and payload are on the same wavelength, it is spectrally more efficient than techniques that place header and payload on separate wavelengths [3].

Experimental Results

The schematic of our multi-wavelength packet transmitter is shown in Fig. 1. The packet transmitter generates optically coded header pulses that are attached in front of the data payload to create labelled packets on each of 40 optical wavelengths. The 20ps header pulses are generated by external modulation of CW laser sources using an electro absorption modulator (EAM) driven with a 10 GHz sinusoid. These pulses are then optically encoded by reflection from an SSFBG to generate the required header waveforms. The SSFBGs used within this experiment allow the generation of 16-bit, 20 Gbit/s quaternary phase coded pulse sequences [4]. These codes have distinct well defined autocorrelation properties, and mutually low cross correlation properties allowing for at least 16 distinct headers for the given code length per wavelength. As previously mentioned phase coded grating encoders/decoders offer several advantages as they are readily scaled to

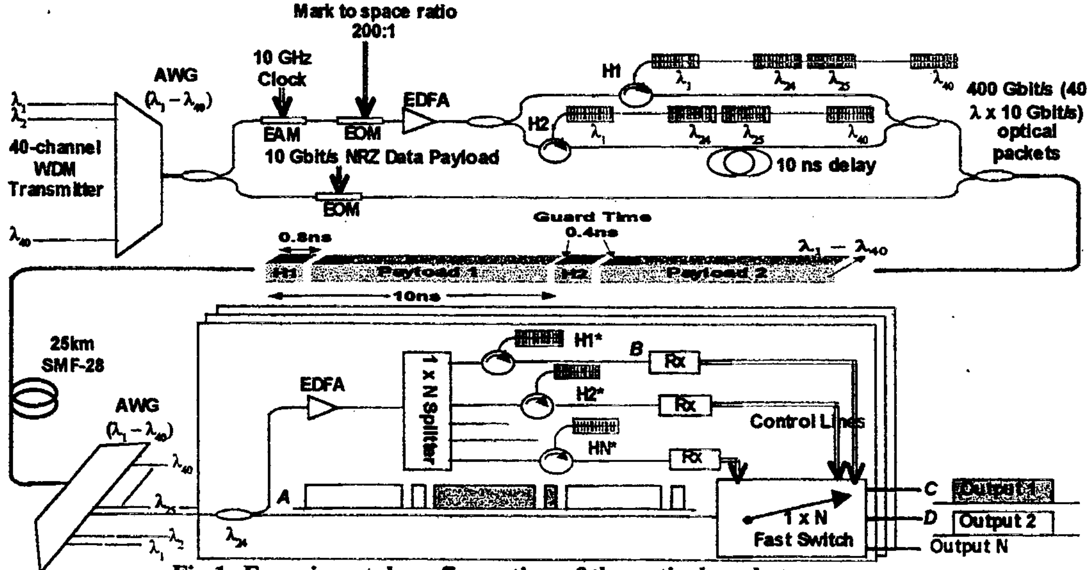

Fig 1: Experimental configuration of the optical packet router

long code sequences (255-bit OCDMA codes previously demonstrated in the laboratory [5]), and are low cost, compact and integrate easily with other fiberised network components. The packet structure at each wavelength is shown inset in Fig. 1 (and Fig.3A) and consists of the coded header followed by the data payload. The packets are 10 ns long corresponding to a packet rate of 100 Mpps. The optically coded header has a duration of 800 ps, and is separated from the payload by 800ps guard bands. The header thus occupies 16% of the total packet time in this implementation. The packet switching is transparent to the bit-rate and the modulation format of the data payload. In this experiment 10 Gbit/s (PRBS 2^7-1) NRZ data is used as the payload. In our current experiment we used two distinct coded header pulses at each wavelength to reduce the complexity of the set up. These header pulses were modulated with a 2^7-1 pseudorandom bit pattern before encoding in order to produce randomly labelled packets whose header code can either be H1, H2 or no header.

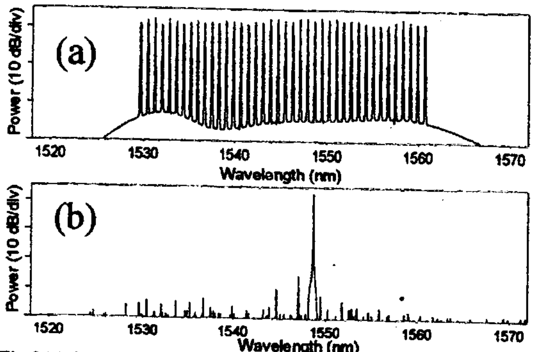

Fig 2(a) Spectrum incident to the AWG, (b) spectrum of a dropped wavelength channel.

Fig. 2(a) shows the optical spectrum of 40 WDM optical packet channels upon entering the add/drop node. The dropped wavelength channel has an extinction ratio of ~ 30 dB after wavelength demultiplexing using the AWG, as shown in Fig 2(b).

Optical header recognition is performed independently for each wavelength channel in order to control the switching of the data. Part of the incoming packet stream is sent to the header-decoder that consists of an array of fibre gratings H1*-Hn* whose codes are matched to the coding gratings in the transmitter. For example, header recognition is carried out by reflecting the packets off decoding grating H1* which results in a strong correlation peak H1:H1* arising from header H1, some residual background from the cross-correlation between header H2 and the decoding grating H1*, and a contribution from the reflected data payloads (see scope trace Fig.3B). Threshold detection can then be used to determine header recognition and this can then be used to activate an electro-optic switch and to route a particular packet to a particular node output. (See Figs. 3 C and D).

The quality of the header recognition is characterised by measuring the bit error rate (BER) of the header recognition process. Error free performance is obtained for all of the measured channels, even in the instance that all 40 channels are transmitting simultaneously (see Fig. 3b).

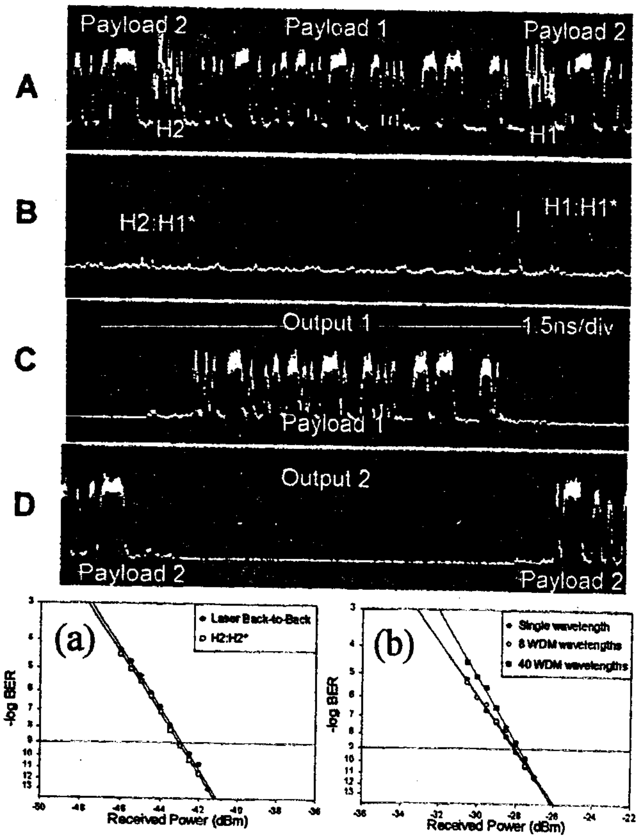

Fig 3 A; Packet structure at a particular wavelength showing two headers and the associated packets. B: Corresponding decode signal. C&D dropped packets at ports 1 and 2 respectively. (a) Header recognition in the absence of attached payloads and WDM MUX:DEMUX. (b) Packet recognition for the full system.

Conclusions

We have experimentally demonstrated a multi-wavelength packet add/drop node capable of high packet processing capacity (>4Gpps) and aggregate data capacity (currently 0.4 TBit/s but readily upgradable to the multi-TBit/s level).

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