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SELF-ROUTING EDGE-TO-EDGE OPTICAL PACKET SWITCHED NETWORK BASED ON SUPERSTRUCTURED FIBRE BRAGG GRATINGS

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Abstract *A simple self-routing edge-to-edge optical packet switched network based on all-optical recognition of a 20 Gchip/s cascaded header using fibre Bragg gratings is presented. Self-routing of optical packets through two network switching nodes is demonstrated.*

Introduction

Optical packet switched networks provide a high bandwidth, flexible core that is well suited to the bursty nature of IP traffic whilst providing the QoS required for voice and high-definition video [1, 2]. Several ultrahigh bandwidth optical packet switches based on parallel all-optical header recognition have recently been demonstrated [3, 4]. Here we demonstrate a self-routed optical packet switched network architecture that moves the routing intelligence to the edge of the network, simplifying the processing that is required within the optical core.

Our proposed self-routed optically packet switched network is based on a slotted mesh topology, consisting of a number of optical packet switching nodes (OPSN) as illustrated in fig. 1. This system is based on an optical packet, created at the source edge of the network, consisting of an optically coded header followed by a data payload. The optical header describes the route for each packet from the source edge to the destination edge of the network. The packet header is made up of a number of unique optically coded waveforms, one for each OPSN in the network path, to produce a cascaded header. The cascaded header is used at each OPSN in the network to determine the routing of the data packets through the network. At each OPSN only the part of the header that controls the switching for that particular node is correctly decoded. The decoded signal is then used to control the switching of the packet through the switch to the desired output. Superstructured fibre Bragg gratings (SSFBG) are used to carry out the encoding and decoding of the optical header pulses. Fig.1 shows the routing and switching decisions made for a single packet entering the mesh network at $OPSN_1$ and being routed to its destination at $OPSN_5$.

Self-routing of optical packets in a two node optically packet switched mesh network consisting of two 1x2 OPSNs is demonstrated and error free decoding of a four code cascaded header is shown.

Experimental Demonstration

The two node self-routing demonstration uses an edge source node that generates a series of packets that have three different destinations. The optical packets consist of a cascaded header containing two optically coded pulses (one specific to a particular switching decision for each node in the system) followed by a data payload. Here we generate three distinct cascaded headers denoted $Q_{1,1}Q_{2,1}$, $Q_{1,2}Q_{2,2}$ and $Q_{1,1}Q_{2,2}$ as shown in fig. 2.

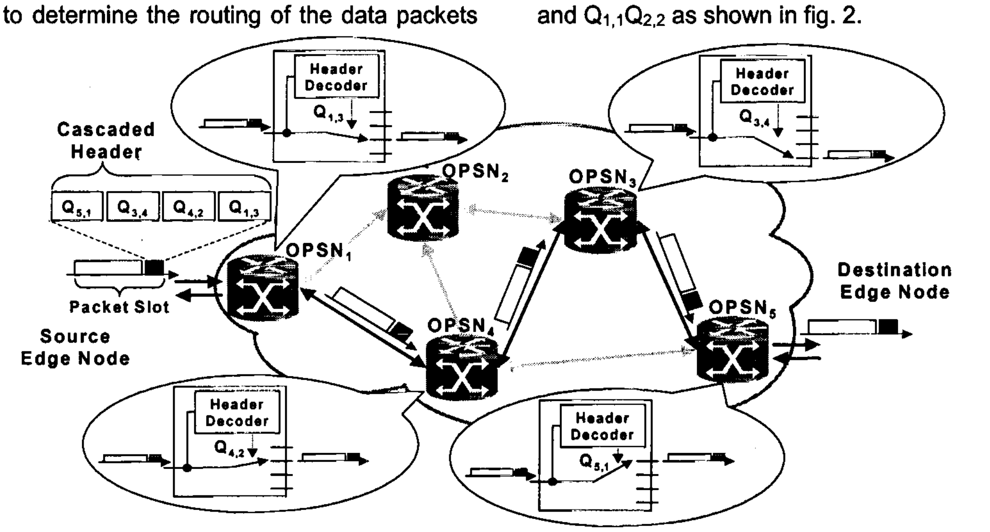

Fig. 1. Self-routing optically packet switched mesh network architecture. The packet structure and self-routing principle is illustrated. Matched filtering of the cascaded header using an array of decoder gratings allows self-routing of the packet at each node.

The cascaded header is optically encoded by reflecting 20 ps duration optical pulses off a cascaded SSFBG. The SSFBGs used within this experiment contain the coding information within their spatial refractive index profile that allows the generation of 16-Chip, 20 GChip/s quaternary phase coded pulse sequences. The two optically coded pulses and their guard bands occupy 20% of the 25 ns packet. The packet switching is transparent to the bit-rate and format of the data payload employed. In this experiment it was convenient to use 10 Gbit/s (PRBS 2^{31}-1) NRZ data as the payload.

The packets are sent to the first packet switching node ($OPSN_1$) where they are switched to either output $O_{1,1}$ or $O_{1,2}$ of this switch depending on the first code ($Q_{1,1}$ or $Q_{1,2}$ respectively) in the packet header. Packets exiting output $O_{1,1}$ of the first switch are sent on to the second $OPSN_2$ whilst packets exiting output $O_{1,2}$ are measured. The second switching node similarly directs the incoming packets according to the second code ($Q_{2,1}$ or $Q_{2,2}$) in the packet header. The operation of the optical packet switching nodes is shown in fig. 2. Part of the incoming packet stream is tapped off in an optical coupler and is sent the header decoder the remaining signal is sent to the optical switch, which controls the packet routing. The tapped optical signal is split between the parallel array of header decoders whose codes ($Q_{n,1}$* & $Q_{n,2}$*) correspond to the switch outputs ($O_{n,1}$ & $O_{n,2}$). The decoding process is based on matched filtering carried out using SSFBGs that have the complementary header code encoded in their spatial profile. When the incident optical header pulse code corresponds to that of the decoder (ie. $Q_{n,1}$:$Q_{n,1}$*) then the reflected signal has a distinct autocorrelation peak otherwise only a low-level cross-correlation signal is reflected. The auto-correlation signal from decoder ($Q_{n,1}$* or $Q_{n,2}$*) is used to control the 1x2 lithium niobate switch so that the packet is routed to output $O_{n,1}$ or $O_{n,2}$ respectively. Fig. 2 shows the packets at the outputs of the two OPSNs indicating that the correct packet routing has occurred.

To further demonstrate the potential of the cascaded header for self-routing we constructed a packet with a cascaded header containing four unique codes as shown in fig. 1. This header is capable of routing a packet through four core switches in a network. Fig. 3 shows BER measurements on the header decoding process indicating that error free operation is obtained for all four codes with a 3 dB penalty observed over back-to-back measurements.

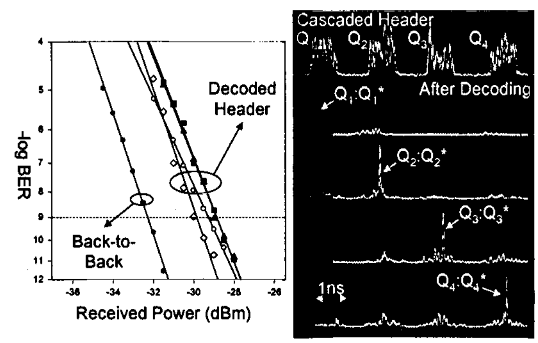

Fig. 3. (Right) The cascaded header before and after the decoding operation on each of the four codes. (Left) BER for each of the four codes in the cascaded header after the decoding operation.

Conclusion

The operation of a self-routing optically packet switched mesh network has been demonstrated. This optical packet switching architecture forms the basis for creating larger switches and is commensurate with existing WDM technology.

References

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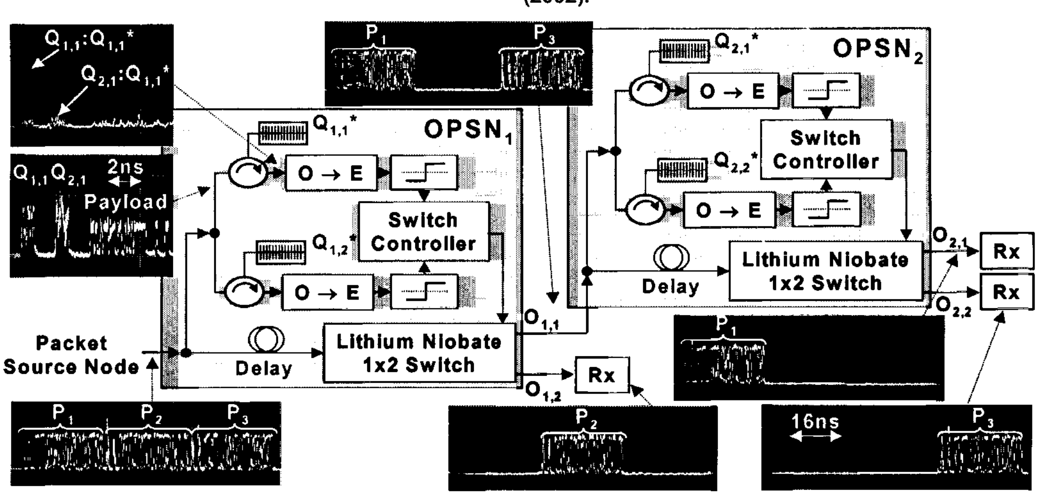

Fig. 2. Self-routing optical packet switching experimental setup. The packet routes and associated outputs are shown. The packets P1, P2 and P3 were labelled with optically coded cascaded headers denoted $Q_{1,1}Q_{2,1}$, $Q_{1,2}Q_{2,2}$ and $Q_{1,1}Q_{2,2}$ respectively.