

Fig. 2 – The injection module is an SOA based switching node with a feedback FDL. It is comprised of couplers (ellipses), filters (λ), p-i-n photodetectors (O/E), control electronics, and SOAs.

The module routes the wavelength-parallel Data Vortex packets described in [7] where the header and the payload are encoded on separate dedicated wavelengths and are transmitted as one unit in a single time-slot. When a packet is received, the *frame* signal, denoting the existence of a packet, is extracted using a wavelength filter, detected, and driven into the control electronics, implemented as a Xilinx complex programmable logic device (CPLD). The CPLD uses the frame signal from the received packet and from the delayed packet, along with an externally received control signal to dynamically decide, on a packet-by-packet basis, where to route each packet. Four SOA gates, driven by the CPLD, control the four possible input-output paths and allow the module to handle two packets (one from the input and one from the FDL) simultaneously.

Experimental results

Two experiments are performed to verify the correct functionality of the injection module. In the first experiment, a stream of optical packets, each 38 ns long, is driven into the input port of the module while the control signal is intermittently switched. The waveforms in fig. 3 indicate that packets are delayed and are only injected when the control signal indicates that injection is allowed (i.e. when it is low).

Fig. 3 – The waveforms shown are (top down): input frame optical signal, input payload, input control signal, and output payload (after a latency of 38 ns). Four packets, annotated P1 through P4, are injected into the module and only proceed to the output when the control signal is low.

In the second experiment, the signal integrity of the packets routed through the module is verified. Bit error rate (BER) measurements are taken on one wavelength (1552.3nm) to measure the power penalty caused by a hop through the module. The measured power penalty is smaller than 0.2 dB (fig. 4).

Then, a 120 Gb/s wavelength-parallel payload (12×10 Gb/s) is routed through the module. The payload wavelengths span over 17nm (1543.1nm to 1560.4nm) with a minimum spacing of 0.8nm. After 3 loop passes a BER better than 10^{-9} is achieved on all wavelengths. Under typical Data Vortex operating conditions, the probability that a packet will need to traverse the loop more than 3 times before entering the OPS system is less than 10^{-6} [1],[8]. Eye diagrams after 3 loop passes are shown in fig. 4.

Fig. 4 – BER curves for the module after 1 hop (\bullet ,dashed), and back-to-back (\blacktriangle ,solid) indicate a power penalty < 0.2dB. Eye diagrams at 10 Gb/s ($\lambda=1554.4nm$) for back-to-back (bottom left) and after 3 loop passes (top right).

Conclusions

We have demonstrated a dynamic injection control module which is essential to the operation of optical packet switching fabrics. The module design is detailed and experiments verifying the functionality and the signal integrity are reported. Future work will include inter-operability testing with a Data Vortex switching fabric and priority mechanisms that control packet dropping.

References

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