All-optical header processing using an injection-locked Fabry-Pérot laser diode

L. Y. Chan, P. K. A. Wai, and L. F. K. Lui
Photonics Research Centre and Department of Electronic and Information Engineering,
The Hong Kong Polytechnic University, Hong Kong, China
Tel.: +852 2766 6231; Fax: +852 2362 6412; Email: emwai@polyu.edu.hk

Hwa-yaw Tam and M. S. Demokan
Photonics Research Centre and Department of Electrical Engineering, The Hong Kong Polytechnic University, Hong Kong, China

Abstract: Simultaneous all-optical header processing and control packet switching are demonstrated using a multi-wavelength mutual injection-locked Fabry-Pérot laser diode. The data rates of the header and payload are 2.5 Gb/s and 10 Gb/s respectively.

1. Introduction
All-optical packet switching is one of the key enabling technologies for future broadband networks. We demonstrated simultaneous all-optical processing of the data packet headers and switching of the control packets for data packets with data rate of the payload at 10 Gb/s and header at 2.5 Gb/s using multi-wavelength mutual injection-locking in a Fabry-Pérot laser diode (FP-LD). The header processing is achieved using a special 2-level control packet by which the outcome of the optical processing of one bit in the data packet header will switch ON or OFF the entire control packet. The switched control packet output can then be used to switch the data packets. The proposed all-optical header processing scheme can be used to implement a recently proposed self-routing address format for all-optical packet-switched networks with arbitrary topologies [1].

2. Operating principles and experimental results
We utilize the multi-mode injection locking property and the bi-stable characteristic of injection-locking in an injection-locked FP-LD for all-optical header processing and switching of the control packet. Figure 1 shows the input-output power characteristic of a continuous wave (cw) signal injected into a FP-LD under one-mode and two-mode injection. The solid lines show the power hysteresis of single-mode injection locking with a cw signal injected at 1547.02 nm with +0.1 nm wavelength detune from the closest FP mode. The dashed line in Fig. 1 shows the measured hysteresis of the same injected signal when a second signal at 1554.60 nm with zero detune from another FP mode is injected into the FP-LD at a power of −10 dBm. Figure 1 shows that the injection-locking threshold at the wavelength of an injected signal decreases in the presence of a second signal injected at a different wavelength.

Figure 2 illustrates the proposed scheme for the all-optical header processing and control packet switching using a FP-LD. The proposed scheme requires a special 2-level control packet at wavelength (λc) that has a trigger at power Pt and a long trailer at power P1 where Pt > P1. The powers of the control packet trigger Pth and trailer P1 are chosen to be P2th ≤ Pth ≤ P2a and P3th ≤ P1 < P2a respectively, where P1th and P2th are the injection-locking thresholds at λc in the absence and presence of the header signal at λh. P3th is the power at which the FP-LD returns to the unlocked state from the locked state (see Fig. 1).

Figure 3a shows the experimental setup. Figures 3b, 3c, and 3d show the input 10 Gb/s NRZ data packets, the synchronized input control packet, and the switched output of the control packets respectively. The output of the entire control packet is switched ON and OFF depending whether the trigger of the control packet coincides with a ‘1’ in the data header. Thus the operation principle of the proposed all-optical header processing scheme is demonstrated. The proposed scheme can be used to perform all-optical packet switching with all-optical header processing by injecting the output of the proposed header processor into the all-optical switch demonstrated in [2].

4. Conclusion
We have demonstrated all-optical header processing and switching of the control packet by using a dual-wavelength injection-locked FP-LD with a specially designed two-level control packet. The header processing speed is demonstrated at 2.5 Gb/s while the payload data rate is at 10 Gb/s. A single bit in the header of the data packet determines whether the control packet will be switched ON or OFF at the output of the FP-LD.
5. References

Fig. 2 Schematics showing: (a) the proposed format of the control packet; (b) output of the control packets with and without injection-locking by the triggering header; and (c) all-optical switching of the control packets with all-optical header processing.

Fig. 3 (a) Experimental setup, and temporal profiles for (b) input data packets (packet 1 and packet 2); (c) input control packet with a 400 ps header with a repetition rate of 155 MHz; and (d) switched control packets at the output of the FP-LD. Packet 1 is switched ON while packet 2 is switched OFF. Note: TL – tunable laser, PC – polarization controller, MOD – modulator, COUP – intensity coupler, CIR – circulator, FP-LD – Fabry-Pérot laser diode, BPF – variable bandpass filter, and PD – photodiode.