All-optical label swapping techniques for data packets beyond 160 Gb/s

All-Optical Label Swapping Techniques for Data Packets Beyond 160 Gb/s

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Abstract: We present two paradigms to realize all-optical packet switches, and report experimental results showing the routing operation of the 160 Gb/s packets and beyond. Photonic integrated sub-systems required to implement the packet switch are reviewed.

1. Introduction

All-optical packet switching (AOPS) has been proposed as a technology to solve the bottleneck between the fibre bandwidth and the electronic router capacity by exploiting high speed and parallel operation of all-optical signal processing. Moreover, photonic integration of the optical packet switch potentially allows for a reduction of volume, power consumption and costs. In all-optical packet switches the optical packets are routed based on the address information that is encoded by the attached labels. The optical packet is stored (delayed) in the optical domain for the time required to the label processor to process the address and provide a routing signal for routing all-optically the stored packet. To exploit the benefit of photonic technology to miniaturize and decrease the power consumptions of the system, photonic integration of the all-optical packet switch depends on the capability to integrate the label processor and the optical delay related to the latency of the label processing. This imposes stringent constraints on the latency time of the label processor. Therefore, high speed operation of the label processor (< 100 ps) is a must to allow photonic integration of the packet switch system. Moreover, scalability of the label processor with the number of labels (or the number of label bits) is crucial too.

Our research focuses on the realization of an AOPS that is scalable and suitable for photonic integration. We present two AOPS techniques that utilize all-optical signal processing to implement the label processor and the label rewriter. The two techniques are based on two different paradigms. One is based on wavelength routing switching [1] and the other one on space routing switching [2]. Both techniques employ scalable and asynchronous label processor and label rewriter capable to process optical in-band labeling addresses [1]. We report for both technique experimental results showing the routing operation of the 160 Gb/s packets based on the processed in-band address information, and all-optical label erasing and new label insertion operation. In the presentation, we will discuss and compare both techniques in term of devices and bit-rate scalability, latency, power consumption, power penalty performance and cascadability as key parameters for the realization of an all-optical packet switching node. Moreover, photonic integrated sub-systems required to implement the packet switch will be presented.

2. AOPS based on wavelength routing switch

The first AOPS technique is based on wavelength routing switching [1]. To perform the label swapping and routing of the packet, we utilize four all-optical functions as shown in figure 1a. The input packet is firstly processed by the label extractor/eraser (LE), which consists of fiber Bragg gratings (FBG) centered at the labels wavelengths. An integrated version of the LE was presented in [3]. While the labels are reflected by the FBGs, the packet payload can pass through the LE before to enter the wavelength converter. The continuous wave (CW) routing signal that is needed for wavelength conversion (WC) is provided by the label processor. The optical power of the extracted labels is used to drive the label processor. The label processor receives also as input 2^N CW bias signals at different wavelengths $\lambda_1 \ldots \lambda_{2^N}$. The label processor operates on the fly and is described in [1]. For each input labels combination, the label processor provides a routing signal according to the input labels. The CW-signal at distinct wavelength has a time duration equal to the packet and represents the routing signal to which the payload will be converted. Note that the processing is performed entirely in the optical domain. Moreover, as no synchronization is required in the scheme, the system can handle packets with variable lengths. The wavelength of the routing signal represents the central wavelength at which the 160 Gb/s data payload will be converted by means of WC [4]. An integrated version of the WC was presented in [5]. Simultaneously, the label rewriter, which is based on the same operation principle of the label processor, provides the new labels, which have a time duration equal to the packet duration. Moreover, the wavelengths of the new labels are selected so that they are in-band with the bandwidth of the converted payload. The new labels are attached to the wavelength converted payload. The packet with the new

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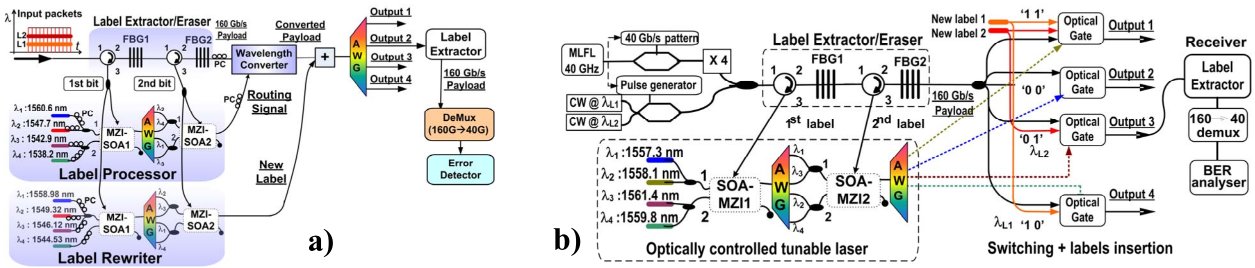

Figure 1. All-optical packet switch based on a) wavelength routing switch; b) space routing switch.

labels is routed by means of an AWG to distinct output ports of the packet switch, according to the central wavelength of the converted payload as shown in Figure 2a.

3. AOPS based on space routing switch

The schematic of the AOPS is shown in figure 1b [2]. The AOPS consists of a label extractor/eraser, an optically controlled tunable laser (OCTL), and optical gates for payload switching and label rewriting. The input packets are firstly processed by the LE. The data payload passes through the label extractor/eraser and is broadcasted into the optical gates. The two labels are reflected by the FBGs and fed into the label processor via optical circulators. The labels optically control the output wavelength of the OCTL [2]. The OCTL output acts as a control signal for one of the SOA-MZI based optical gates. These optical gates have two functions. Firstly, they route the packet payload according to the routing table. Secondly, they rewrite the new labels. The operation of the gate guarantees that the payload and the new label have the same duration at the gate output. Integration of the optical gates is presented in [6]. Figure 2b shows the switched packets at the four outputs of the optical packet switch. It is worth to note that since the label processor and label rewriter operate ‘on the fly’, the time delay required to store the payload is very short. This may allow photonic integration of the whole packet switch system.

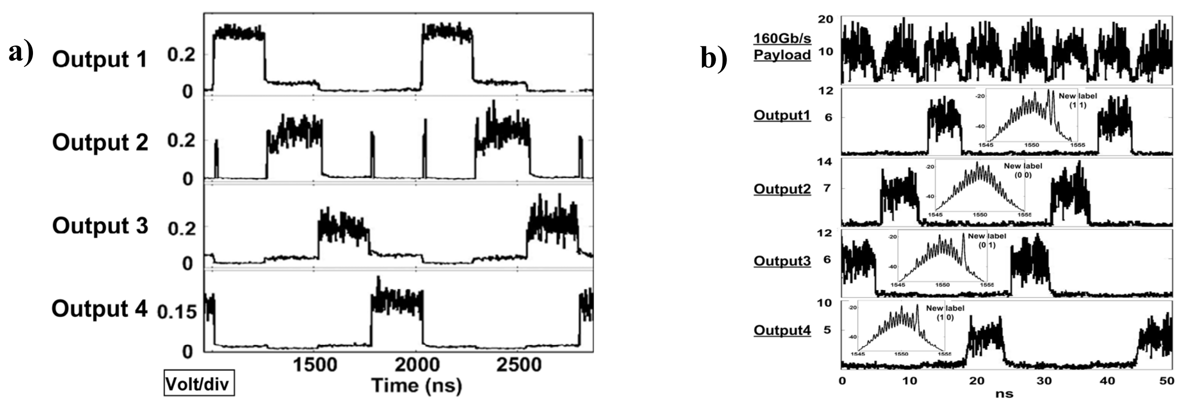

Figure 2. Switched packets at the four output ports of the AOPS for a) the wavelength routing switch; b) the space routing switch.

4. Conclusions

We discuss two paradigms for realizing AOPS operating at 160 Gb/s and beyond, and compare them in term of scalability, latency, power consumption, power penalty performance and cascadability. Moreover, photonic integrated sub-systems required to implement the packet switch will be presented.

5. References

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