Packet-by-packet contention resolution in an optical-label switching system with 2R regeneration

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Abstract: We demonstrate packet-by-packet contention resolution in wavelength, time and space domains in an optical-label switching system using tunable wavelength conversion, arrayed-waveguide grating router and fiber delay-line, and with 2R regeneration.

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1. Introduction

Electronic routers rely on random access memory (RAM) to resolve contentions. Without a practical optical RAM, all-optical packet-switching routers can exploit contention resolution in wavelength, time and space domains. Previous network simulations [1] and experiments [2] show excellent performance in optical-label switching systems. We further demonstrate packet-by-packet contention resolution with 2R regeneration.

2. Experiment Description

Optical-label switching with sub-carrier label has been reported [3], and will not be covered here. Fig. 1 shows the experiment setup. (m,n) in represents wavelength n on input fiber m. Likewise, (m,n) out represents wavelength n on output fiber m. Two packet streams arrive at (1,1) in and (2,1) in, aligning to a fixed-sized time slot T (T=819 ns), with the former arriving 50 ns earlier than the latter. Three scenarios demonstrate wavelength, time and space domain contention resolutions respectively. In each scenario contentious and non-contentious time slots alternate to show packet-by-packet operation. For all scenarios, at 0T packet P1 with label L1 (L1 means that the destination is any wavelength on output fiber 1, denoted by (1,*)) arrives at (1,1) in and obtains its preferred path (1,1) out. After 50 ns, P1’ with L1 arrives at (2,1) in. The controller finds (1,1) out occupied, thus contention happens. The controller resolves the contention either in wavelength domain by converting the packet to another wavelength on the same output fiber (1,2) out or in time domain by sending the packet to a fiber delay-line (4,1) out, or in space domain by sending the packet to a deflecting route (3,1) out. For all scenarios, at 1T, P2 with L2 (destination (2,*)) arrives at (1,1) in and gets its preferred path (2,1) out. 50 ns later, P2’ with L1 arrives at (2,1) in and gets its preferred path (1,1) out without contention. For the wavelength and space domain scenarios packet patterns repeat from here. For the time domain scenario, at 2T the packet previously sent to the delay-line comes back at (4,1) in and goes to (1,1) out while P3 with L2 arrives at (1,1) in and goes to (2,1) out, P3’ with L3 arrives at (2,1) in and goes to (3,1) out. Then the packet pattern repeats.

To be concise, only the results from the wavelength domain contention resolution are presented. Fig. 1 shows the input and output packet streams. Fig. 2(a) shows the traces at output ports, proving the successful operation. Comparing the bottom trace to the top one, the extinction ratio is improved, and the logic inversion due to cross-gain modulation is reversed. Fig. 2(b) shows the BER measurement and eye-
diagrams. Negative power penalty is achieved by 2R regeneration from cross-phase modulation in the fixed wavelength conversion.

![Setup diagram](image)

**Fig. 1** Setup and the scenario of wavelength domain contention resolution. SCM Tx=Sub-carrier Transmitter; LE=Label Extractor; BMR=Burst-mode Receiver; TLD=Tunable Laser Diode; SOA=Semiconductor Optical Amplifier; AWGR=Arrayed Waveguide Grating Router; MZI WC=Mach-Zehnder Interferometer Wavelength Converter

![Eye-diagram](image)

**Fig. 2** Results for wavelength-domain contention resolution. (a) Traces at output ports. (b) BER and eye-diagrams.

### 3. Conclusion

We demonstrate contention resolution in wavelength, time and space domains using optical-label switching. Experimental results show successful packet-by-packet forwarding with contention resolution and 2R regeneration with improved extinction ratio.

