

280Gb/s Hybrid Optical Switching Demonstration combining Circuit and Multi-Wavelength Packet

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Abstract—In this paper, we design a novel hybrid optical network architecture combining both MW-OPS and OCS, and experimentally demonstrate its feasibility in a 280-Gbps network testbed.

Index Terms—Hybrid Optical Network, Optical Packet Switching

I. INTRODUCTION

Due to the emergence of various applications, multi-level network services such as DiffServ is expected to be required in a future Internet. In order to provide such services, a hybrid approach combining optical burst and circuit switches has been researched [1]. To fully utilize the ultra-broad bandwidth as well as fine granularity of optical packet switching, implementation of multi-wavelength optical packet switching (MW-OPS) is attractive. We have recently proposed a novel hybrid optical network architecture combining both MW-OPS and OCS [2]. MW-OPS is one class of OPS architectures capable of reducing the number of optical devices by switching a wavelength-multiplexed optical packet with a single wideband optical switch. Each packet consists of a header encoded into one particular wavelength and a payload encoded into possibly multiple other wavelengths [3]. In this paper, we discuss design and implementation of its node architecture.

II. DESIGN OF THE HYBRID SWITCHING NODE

Fig. 1 shows the diagram of the NxN switching node architecture. As shown on left top of the figure, one particular wavelength $\lambda_0$, multiple wavelength channels between $\lambda_1$ and $\lambda_W$, and rest of the wavelengths are assigned for label, optical circuits, and multi-wavelength optical packet switches respectively. A tunable long-wavelength bandpass filter (LBPF) extracts wavelengths for optical packets.

The coupler (1) splits an incoming signal towards the FBG (2) and the MEMS. The FBG (2) divides the wavelengths into those for a label and all others. The OE converter (3) converts the signal containing a label and the controller operates the label generator and optical switches in the contention resolution components in accordance with its output port. The tunable LBPF (4) extracts wavelengths only for MW-OPS and the newly generated label is merged at the FBG (5). Optical packets are switched at MW-OPS SW based on broadcast and selection. The other signal split at the FBG (1) is demultiplexed and switched by the MEMS. The MEMS and the tunable LBPF are controlled via path setup signalling means such as RSVP-TE in the GMPLS protocol suite. We assume that the control plane is constructed using an out-of-band network such as Ethernet. Coupler (6) merges both signals into an output port.

III. EXPERIMENTAL SETUP

In order to verify the feasibility of this design, we implemented a 1x2 hybrid switching node based on the static border model as a first step and demonstrate hybrid switching of 240 Gbps MW-OPS and 40 Gbps OCS.

Fig. 2 depicts an overview of our experimental configuration. This system mainly consists of two components: a signal generator and a 1x2 switching component. In the signal generator, a light source generates eight wavelengths. One of the wavelengths is modulated to a 25Mb/s NRZ signal ("111" or "101") by the PLZT switch as labels. The other seven wavelengths are modulated to 40Gb/s PRBS signal by the LN modulator. One of the seven wavelengths is statically dedicated for a lambda path and the other six wavelengths are used as MW-payloads. In order to remove bit correlations among the six, each wavelength is transmitted into fiber delay lines of differing lengths. The AO modulator cuts the incoming multiplexed signal to 300 ns envelopes. These three signals are merged at the couplers of the signal generator as an optical signal containing both a lambda path and MW-packets.

The 1x2 switching node consists of three components: a label processing unit, an OCS unit, and an MW-OPS unit. The incoming signal is divided into OCS signal and MW-OPS signal by the first FBG. This experiment is limited to
only one lambda path and therefore exploits FBGs instead of tunable LBPFs. The second FBG divides the incoming signal into a label signal and an MW-payload signal. The PD converts the label signal and sends it to the FPGA; the FPGA operates PLZT switches in accordance with the label. New labels modulated by the PLZT switch in the label processing unit are merged with the MW-payload signal into an MW-packet signal at the third FBG. In an MW-OPS SW, the packet signal is switched based on broadcast-and-selection. We omitted contention resolution components in this experiment as we have confirmed their functionalities in [2]. The other signal from the first FBG is separated at the demultiplexer, each wavelength of lambda paths is switched by the MEMS, and the multiplexer combines the wavelengths. Both signals for MW-OPS and OCS are merged at the coupler in front of the oscilloscope.

Packets with labels “111” and “101” are switched into port 1 and 2 with new labels “100” and “110”, respectively. The lambda path is switched into port 1.

IV. EXPERIMENTAL RESULTS

Fig. 3 shows waveform and spectrum results at each point (a) to (h) as shown in Fig. 2. Point (a) shows the waveform and the spectrum of the incoming signal. The upper waveform depicts labels by zooming in the lower waveform. Point (b) is the waveform from the transparent port of the FBG. The wavelength for OCS is eliminated correctly. Point (c), which depicts the signal state from the reflection port of the second FBG, shows that the six wavelengths for an MW-payload are suppressed. To eliminate noise, we introduce an optical bandpass filter in front of the PD. Points (g) and (h) show packets with labels “100” and packets with labels “110” are correctly switched into output port 1 and 2 respectively as well as the signal of the lambda path is seen only at point (g).

Fig. 4 shows the results of BER and eye diagrams. We obtain sufficient eye-opening for all channels with power penalty of approximately 2dB. Therefore, we have confirmed that error-free transmission can be achieved in this switching node.

V. CONCLUSIONS

This paper designed and implemented a novel hybrid switching node for the optical network architecture combining both multi-wavelength packet and circuit switching in order to provide QoS and high bandwidth utilization. The result showed that error-free transmission is possible in this switching node. We will exploit a tunable LBPF and support dynamic control for MEMS and tunable LBPFs.

REFERENCES