Optical Label Switching

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Abstract—In this technical report, we provide a brief review on our research efforts on optical label switching (OLS). Specifically, our studies tried to achieve efficient and transparent forwarding of ultra-high speed optical packets by using a shim layer that employs optical labels. In an OLS network, the high speed payloads stay in the optical layer for switching and forwarding, while the control of payload switching and forwarding are done by attaching a short and low-speed optical label on each OLS packet. To realize high-performance OLS systems, we designed label encoding schemes, considered how to realize efficient label swapping, incorporated optical regeneration for improving payload transmission distance, and studied the cascadability of the developed OLS routers.

Index Terms—Optical label switching (OLS), Optical packet switching, Field trials.

I. INTRODUCTION

PTICAL packet switching has been considered as a promising technology that can utilizes the numerous bandwidth resources in the optical layer wisely to adapt to the highly dynamic traffic demands in today's Internet [1-5]. Among the proposed optical packet switching architectures, optical label switching (OLS) is an interesting one, since it can provide scalability in label-based routing where the highcapacity all-optical switching occurs directly in the optical layer. Therefore, OLS can combine the advantages of both electrical and optical processing to realize highly-efficient optical packet switching. Specifically, the optical packets consists of the labels for control information and the payloads for data transmission. The low-speed labels are extracted and swapped every hop for dynamic switching configuration while the high-speed payloads would not be converted to the electrical format for ensuring high-speed data transmission and energyefficiency. In this report, we first describe our efforts to design the label encoding and swapping subsystems in Section II. Then, Section III discusses the network-level experimental demonstrations to explore the features of our OLS routers. Next, the cascadability of the OLS routers are presented in Section IV. Finally, Section V summarizes the report.

II. LABEL ENCODING AND SWAPPING SUBSYSTEMS

Note that, when receiving an OLS packet, each OLS router will extract its optical label, search the routing table based on the label's content, make the forwarding decision, and configure its switching fabric to deliver the high-speed payload to the desired output. Hence, both the architecture and performance of the OLS router depends heavily on the methods for encoding, extracting and swapping the optical labels. Our research first compare a few label encoding techniques in [6], and determined that the subcarrier multiplexing (SCM) based technique has a few irreplaceable advantages, *e.g.*, simple system architecture, loose timing constraint and high spectrum efficiency. Then, we designed a few novel schemes to achieve high-performance SCM-based optical label swapping [7, 8].

III. NETWORK-LEVEL DEMONSTRATIONS

The designs of OLS routers and network systems can never be verified without network-level experimental demonstrations. Therefore, we have considered numerous networking scenarios to demonstrate the performance of our proposals from many perspectives. First of all, we confirmed that the proposed OLS routers can realize packet-by-packet contention resolution [9, 10], which is a very important feature of optical packet switching. Next, we added in the support of multicast in the OLS routers [11–13]. Eventually, we loaded upper-layer applications in the OLS systems and conducted experiments to verify that they can support legacy IP networks well [14].

IV. CASCADABILITY OF OLS ROUTERS

Similar as other packet switching systems, the cascadability of OLS routers directly affects the scalability of OLS networks. In our research, we first conducted experiments to investigated how many hops an OLS router can support without incorporating any optical regenerators [15]. However, we discovered that the cascadability of OLS routers got restricted below 12 hops in such cases. Hence, we added optical regeneration in the OLS routers [16, 17], and found that the cascadability of OLS routers was improved to over 1000 hops [18–20].

V. CONCLUSION

For the topic of optical label switching, we designed the label encoding and swapping subsystems, conducted network-level experimental demonstrations to explore the features of our OLS routers, and confirmed the cascadability of the OLS routers with experiments. We have published 21 conference papers and 9 journal papers for the topic. Students and researchers who interested in our work in this area are encouraged to check the full versions of the papers on http://www.zuqingzhu.info.

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