Demonstration of Optical TTL Based Selective-3R in OLS Network Testbed with Label Rewriting and Fiber Transmission

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Abstract: We propose and experimetnally demonstrate an optical-TTL-based selective-3R regeneration scheme in an OLS testbed with fiber transmission. This scheme cognitively employs 3R when necessary. The experiment achieves burst mode clock recovery and error free operation.

Keywords: **TTL-based Selective-3R, Burst-mode Clock Recovery**

Introduction

Optical-label-switching (OLS) is a promising technology to enable the aggregation and integration of high data rate optical networking. In order to extend the reach of the optical signal in OLS router, we employed optical 3R regeneration (re-amplification, re-shaping and re-timing) without repeated high-speed O/E/O conversions. Meanwhile, it is not always necessary to apply 3R regeneration for all the packets of every hop and every channel; moreover, 3R has a much more sophisticated structure than its 1R or 2R counterparts [1]. This paper proposes and demonstrates the time-to-live (TTL)-based optical selective-3R in OLS routers. This scheme employs 3R to the necessary packets. The switch controller selectively sends the packets that need 3R regeneration to the 3R port in the loop-back path according to the optical TTL values in the label, while other packets directly pass through without 3R regeneration. This experiment demonstrates the proposed selective-3R scheme in a 10 Gb/s 3-node OLS network testbed with error free operation.

Experimental Setup

Fig. 1 shows the experimental setup. At OLS Node-1, the subcarrier-multiplexed transmitter (SCM Tx) first modulates 155 Mb/s labels and 10 Gb/s return-to-zero (RZ) payloads separately in optical domain and comibnes the labels and payloads into OLS packets [2]. This improved SCM method greatly suppressed the label-payload crosstalk. The OLS packets travel to Node-2 via a 40 km large effective area fiber (LEAF) transmission. Meanwhile, 50% power of the RZ payload emulating the local-addition packet is inserted directly at Node 2. Fig. 2 shows the packet sequence and schematic logic of the experiment. Node-1 generates pacekts P1 and P2, while the packets P1' and P2' inserts locally at Node 2. The pakcets have different lengths: P1 and P1' have the packet length of 8192 bits while P2 and P2' have the pacekt length of 5120 bits. Label extractor LE at Node-2 receives the optical labels for P1 and P2, and the burst mode receiver BMRX converts the label to electrical domain and forwards the label contents to the switch controller for routing decisions [3]. P2 emulates a locally dropped packet from the main traffic and P1' is destined for the ouput port other than Node-3. P1 and P2' are destined for Node-3 and the label rewriting module (LR) generates and attaches new labels for them [2].

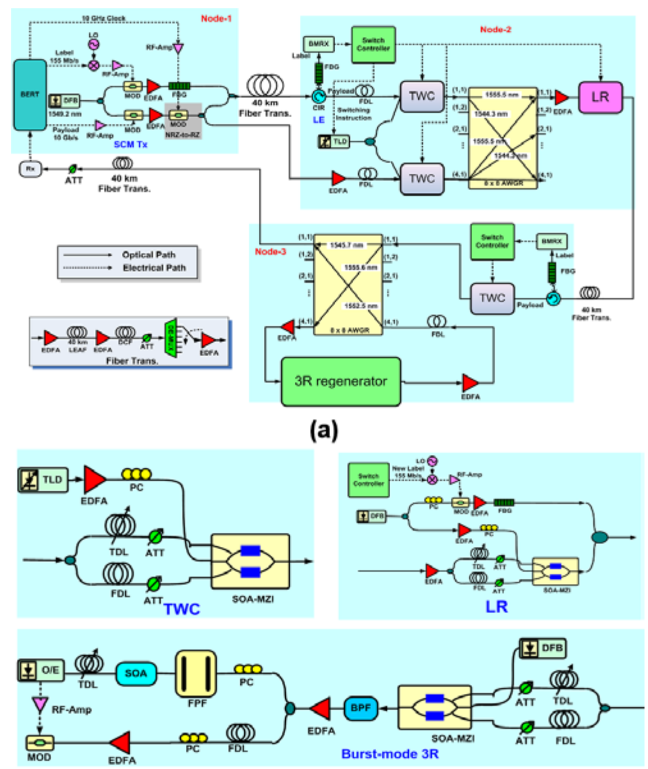

Fig. 1 (a) Experimental Setup. (b) subsections of the experimental setup. ATT: optical attenuator; BPF: band pass filter; CIR: circulator; DFB: DFB laser diode; EDFA: Erbium-doped fiber amplifier; FBG: Fiber Bragg Grating; FPF: Fabry-Perot Filter; SOA: semiconductor optical amplifier; TDL: tunable delay line; FDL: fixed delay line; ParBERT: Parallel Bit-Error-Rate Tester; Rx: receiver; TWC: tunable wavelength converter; SOA-MZI: semiconductor optical amplifier based Mach-Zehnder Interferometer; LR: label rewriter; PC: polarization controller; Fiber Trans. : large effective area fiber LEAF transmission; AWGR: arrayed waveguide grating router.

The switching fabric, composed of the tunable wavelength converters (TWC's) and the AWGR, conducts routing for P1, P2, P1', and P2' according to the instructions of the switch controller. The output of the tunable laser (TLD) is split and fed into two TWC's to synchronize the local addition of P2' to the transmitted packets P1 so as to achieve the packet sequence in Fig.2. In the new label attached to P1 at the output of Node 2, the TTL decreases by a unit value (1) and reaches the threshold for selective-3R at Node-3. Meanwhile, the TTL values of P2' indicates that this packet does not need selective-3R at Node-3 because they are locally added at Node-2. When P1 and P2' reach Node-3 after another 40 km LEAF fiber transmission, the switching controller directs P1 to the 3R loop while P2' gets pass through without 3R. In this sence, the router at Node 3 successfully achieves selective 3R regeneration on packet P1. The 3R regenerator consists of a 2R regeneratior with a Semiconductor Optical Amplifier based Mach-Zehnder interferometer (SOA-MZI)[4], and retiming module with synchronization modulation[5]. The all-optical clock recovery is performed by a Fabry-Perot filter (FPF) and a semiconductor optical amplifier (SOA)[5, 6]. The FPF has a periodic comb-like spectrum that can extracts the clock components from the signals. The free spectrum range of the FPF is 10 GHz, while the finesse is 100. The subsequent SOA works in saturation region and provides a uniform clock output.

Experimental Results

Fig. 2 shows the packet sequences and the recovered clock signal from 3R regenerator. At Node 2, the local packet P2' is added into the main passthrough traffic while the packet P2 is dropped at the local port, therefore, Node 2 performs the local add/drop multiplexing. The clock recovery module acheives fast and burst mode operation. The 20-80% rise time of the clock envelope is approximately 1 ns. We delay the payload data stream 1.3 ns in the 3R regenerator to gaurantee the reasonable modulation synchronization. After 3R, P1 is combined with P2' at the output of Node-3 and propagates through 40 km fiber before the destination.

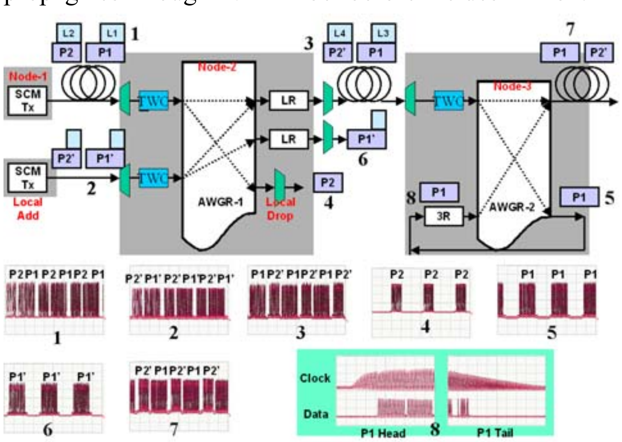

Fig. 2. Logical schematic and packet sequences, all-optical burst mode clock recovery performance.

The payload BER evaluation utilizes PRBS pattern length of 2^{23}-1. Fig. 3 shows the BER curves and the eye-diagrams. All BER curves indicate the error free operation for all the packets at each node, and all the BERs achieve below 10^{-11} at an average receiver power –8 dBm. The burst-mode 3R regeneration achieves 2.5 dB negative penalty for P1 at 10^{-10} BER relative to that at Node-3 input. The eye diagram shows the smaller timing jitter and cleaner space and mark levels after 3R regeneration.

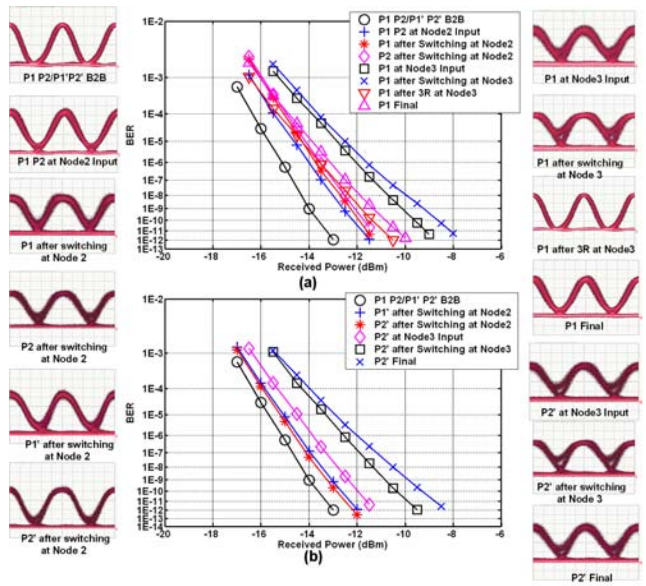

Fig. 3 (a) BER curves of P1 and P2 at each node; (b) BER curves of P1' and P2' at each node; eye diagrams of P1, P2, P1' and P2' at important nodes.

Summary

We proposed and demonstrated the optical TTL based selective 3R regeneration in an OLS network. In order to emulate the realistic network, we include label rewriting and fiber transmission. The experiment achieves error free operation with variable length packets. The burst-mode 3R regeneration achieved 2.5 dB negative power penalty at 10^{-10} BER.

References

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