Scalability Study of a Prototype 640Gbit/s/port Optical Packet Switch for Network Applications

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Abstract *We investigate the scalability of a prototype 640Gbit/s/port optical packet switched system. Based on the expected new component parameters by extensive simulations a scalability of 8 nodes is demonstrated for the worst case scenario.*

Introduction

Optical packet switching (OPS) is considered as a near future technology for optical networks[1-3]. In 2005, the National Institute of Information and Communications Technology (NICT) developed a 160 Gbit/s/port optical time division multiplexed (OTDM)-based OPS prototype[2]. Dense WDM (DWDM) technology was introduced into OPS systems[3] to increase the bandwidth of optical packets and to interface with current systems as opposed to OTDM based ones.

Previously, NICT has improved each function of an OPS prototype. Polarization-independent plomb lanthanum zirconate titanate (PLZT) switches were used to achieve 1.28 Tbit/s optical packet switching[4]. Burst-mode transmitter/receivers (Tx/Rx) and 10Gb-Ethernet optical-packet converters were developed as interfaces between IP and OPS networks and demonstrated a field trial of 160 Gbit/s optical packet switching with multiple optical label processors and burst-mode EDFAs[3].

In[5] a 640 (64λ × 10) Gbit/s DWDM-based OPS prototype was presented. In case of an OPS network several nodes are connected in series. In lack of several nodes the only solution for scalability investigation was the simulation. This paper addresses the issue mentioned before i.e., we investigated by extensive simulations the scalability of the OPS node presented in[5]. The key components of the node, are the burst mode EDFA, PLZT switches and the burst mode receiver. Since both the EDFA and PLZT switches used in[5], have been upgraded and it is expected to have much better performance[6-7] We also investigated the scalability using parameters of these new devices.

Simulation setup

The basic setup of the simulations can be seen in figure 1. The aim of the investigation was the scalability of the payload, therefore we do not consider the label distortion. Firstly, we measured the key parameters of the experimental system for use as simulation inputs. These were the wavelength and power dependence of the EDFA gain and noise figure, the wavelength dependency of the crosstalk and insertion loss of the switch and receiver parameters. The number of wavelength-channels were 64, and the bit rate of each channel is 10 Gbit/s. All the simulations were carried out using OptiSystem 7.0 (64-bit) simulation tool[8]. Due to time and memory constraint instead of the 25 packets used in the real experiment the simulations used only 4 packets. For realistic results the same switch ports and buffering (fiber delay lines) were used as in real experiment. To validate the results we compared the obtained spectra, eye diagrams and BER curves and found a very good match between the simulation and experiment results, considering only one node. The results can be seen in figure 2. The right-hand side are the experimental results published in[5] the left-hand side are simulation results. The power penalty between the two methods was less than one dB in the worst case. This is attributed to imperfect modeling of the burst mode receiver.

In case of PLZT switches, we investigated the influence of crosstalk and insertion loss improvement. In case of multiple nodes, the signal from the output port 1 is fed back to the input port of the OPS system as shown in figure 1. In this specific buffer scenario, the most distorted packets are the second and the third packets. In the label switch component, the last

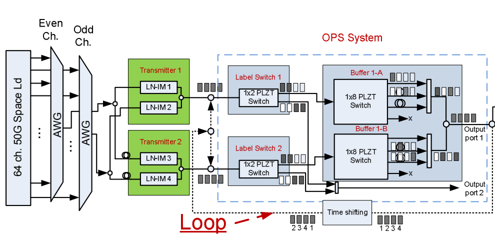

Fig. 1: Schematic of the OPS node

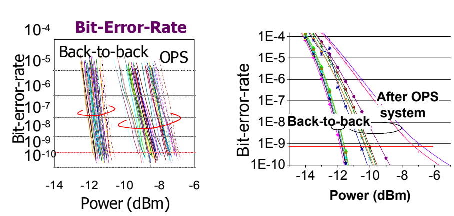

Fig. 2: Experimental and simulation results

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two packets are always dropped thus we made a time shifting to have the worst packets distortion accumulation. In the following figures on the X axis the channel number is plotted (Ch 1 is 191.94 THz; Ch 64 is 195.09 THz, with channel spacing 50 Ghz) on the Y axis the BER value of each channel at +5 dBm receiver input power i.e. the BER floor.

Burst mode EDFA investigation

The original EDFA (O. EDFA) has a gain tilt of 0 to 3 dB at the entire band depending from the input power. In case of several EDFAs in chain this can cause serious performance degradation. In simulation we assume that after each hop the gain tilt is compensated using gain flattening filters. The F. EDFA means the new released flat EDFA[7]. The results , in figure 3, show that the gain flatness does not have high influence at the overall system performance when compensated at each hop.

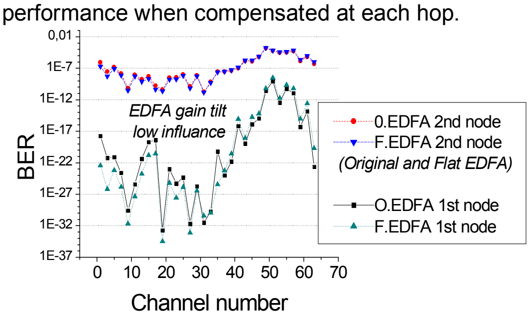

Fig. 3: EDFA performance

PLZT switch insertion loss and crosstalk

The previous PLZT switches were also prototypes with relatively high insertion loss of 15-20 dB and worse crosstalk parameter varying between 18dB and 50dB depending from the wavelength and polarization. We expect that the new PLZT switches will have around 7 dB insertion loss and better crosstalk[6]. In figure 4 the influence of the insertion loss is depicted. Normal means the original parameters, -5 and -10 means 5 and 10 dB improvement on the insertion loss. It is noted that in this case the wavelength dependency of the switches has not improved, however it is expected that this will also improve. As shown in figure 4, the impact of the insertion loss is greater than EDFA gain tilt, however, despite an improvement of 10 dB the scalability is just two nodes.

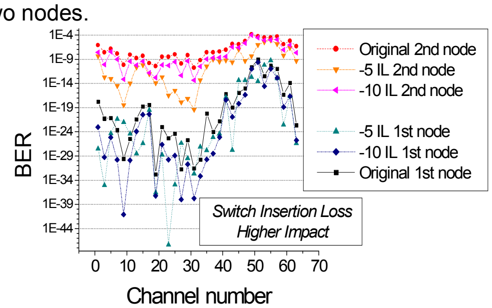

Fig. 4: The influence of the switch insertion loss

In case of PLZT switch crosstalk the results are shown in figure 5. As it was expected, the switch crosstalk has the highest impact onto the system overall performance. In figure 5, a 20 dB crosstalk improvement is considered which is expected considering the PLZT prototype crosstalk range 18 to 50 dB. As it is to be seen, the signal quality is still adequate using forward error correction (FEC) schemes (BER < 10^{-5}) for up to 4 nodes.

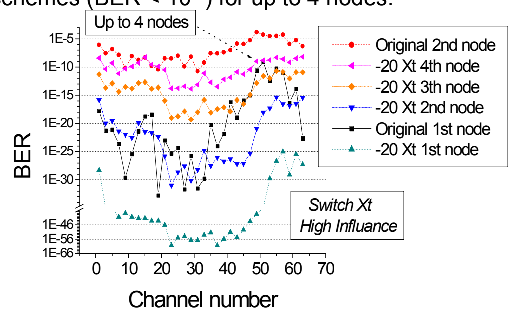

Fig. 5: The influence of the switch crosstalk

Expected system performance

To find out the expected scalability of the proposed OPS node, we performed simulations with all the improved components i.e. flat EDFA, 10 dB insertion loss and 20 dB crosstalk improvement of the switches. As shown in figure 6, after 8 nodes the signal quality is still adequate (BER < 10^{-5}). In this case the main constraint is the imperfect power equalisation of the packets in the buffer. It is noted that the wavelength dependency of the switch has not been changed however it is expected that this would provide further improvement.

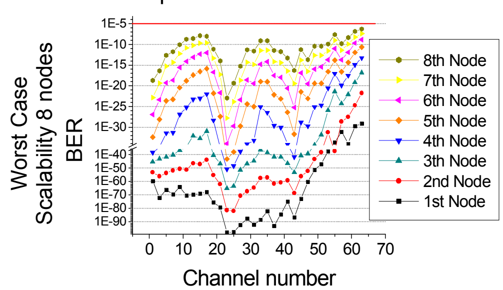

Fig. 6: Expected system performance

Conclusions

In this paper, we investigated the influence to the scalability of a prototype OPS node with improved EDFA and switch parameters. It is demonstrated that the system is scalable up to 8 nodes.

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