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A Study on Optimized Assignment of Dispersion Compensation Capability for Dynamic Optical Paths

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Abstract

For dynamic optical paths over all-optical networks requiring dispersion compensation control, this paper proposes a new node architecture where compensation devices are shared as well as an extension to GMPLS to advertise compensation capability information for optimized assignment of compensation devices.

1 Introduction

The authors proposed extensions to GMPLS (Generalized Multi-Protocol Label Switching) to offer dynamic control of chromatic dispersion compensation for dynamically established optical paths, and called it GMPLS-Plus (Photonic layer usability support) [1]. GMPLS-Plus extends the three protocols of GMPLS [2], namely LMP, OSPF-TE [3], and RSVP-TE, to automatically discover link chromatic dispersion, to exchange it between nodes for selection of the best route for optical paths taking into account chromatic dispersion, and to optimize compensation upon path establishment. GMPLS-Plus defines additional objects and procedures in the Control Plane to perform these tasks, while electronic pre-distortion [4] with a wide compensation range is to be used to compensate for dispersion in the Data Plane.

In the future, dynamic establishment and release of optical paths over all-optical networks will become common with the aid of tunable electronic pre-compensator. Then it will be necessary for them to support a wide range of compensation capability. For example, Fig. 1 illustrates dispersion ranges of dynamic optical paths between randomly chosen source/destination pairs over the NSF network topology shown in Fig. 2. In this example, 2/3 of links are assumed to have 3 times higher chromatic dispersion than other links and each link can support up to 20 wavelengths. A dynamic optical path may be established over a minimum length route (MinLength) or a minimum dispersion route (MinDispersion) if the same wavelength is available on each link through the route. Traffic demands for optical paths were 20 erl over the whole network.

Fig. 1 tells us that strong compensation capability is required at each node to fully compensate for dispersion that may be accumulated over an optical path destined to an arbitrary node. Yet such strong capability is necessary for a small percentage of all paths, e.g., about 5 % of all paths will require compensation capability stronger than twice the average dispersion when each link supports 4 wavelengths. This percentage will be larger if available wavelengths become fewer or traffic demands grow.

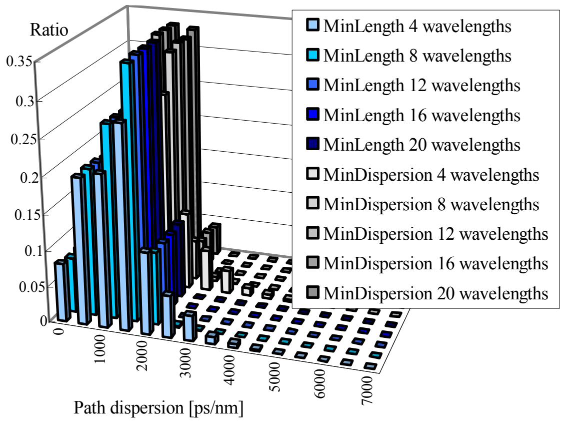
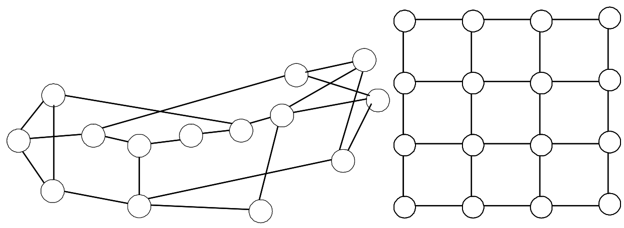


Fig. 1 Path dispersion range over the NSF network



(a) NSF network (b) lattice network
Fig. 2 Network Models

Considering that there are many compensation technologies and device cost may differ corresponding to different compensation capability, we arrived at a new optical node architecture where compensation devices, such as electronic pre-compensator, with different capability are shared by dynamic optical paths so that assignment of compensation capability will be optimized. In the following, we propose the new architecture as well as an extension of GMPLS, in which each node's compensation capability is advertised for optimized assignment of compensation devices upon route selection.

2 New optical node architecture with shared compensation devices

We propose a new optical node architecture shown in Fig. 3, where compensation devices with different capability are shared by dynamic optical paths. In this

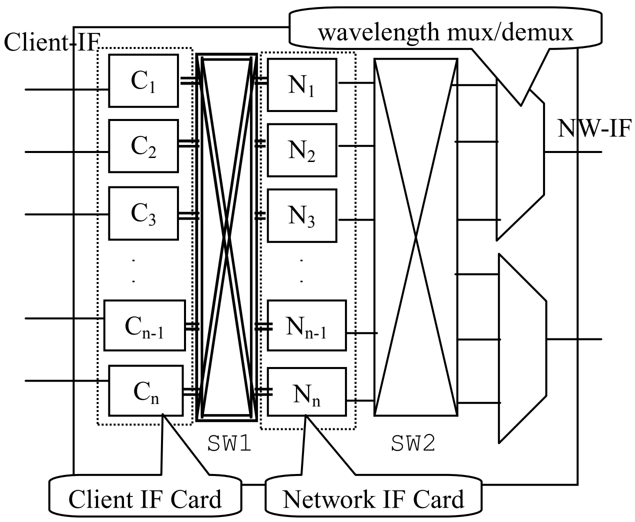


Fig. 3 New optical node architecture

architecture, signals from clients are received by Client IF Cards (C_1, C_2, … C_n), switched by switch "SW1" to any of Network IF Cards (N_1, N_2, … N_n), and again switched by switch "SW2" to any network interfaces through wavelength mux/demux. Network IF Cards are equipped with tunable lasers and compensation devices to accommodate an arbitrary wavelength and a wide range of path dispersion. This architecture allows any client accommodated by the node to use a compensation device with appropriate capability for an optical path upon its establishment. Thus compensation devices with different capability can be shared by optical paths based upon compensation requirements of optical paths.

3 Advertisement of compensation capability information and its effects on routing performance

To achieve optimized assignment of compensation devices with different capability upon path establishment, up-to-date availability of compensation devices at a path's ingress node as well as at its egress node shall be obtained by the route selection process. Thus we propose to advertise each node's compensation capability information by an extension to OSPF-TE for GMPLS.

Compensation capability information may consist of the number of available compensation devices and their compensation ranges. Its advertisement will take some abstracted form of such information because it should not depend on a particular compensation technology.

To evaluate effects of advertisement of compensation capability on routing performance, we performed simulation on the two network models, NSF network and lattice network, shown in Fig. 1. In the simulation, each node is assumed to have the same number of two types of compensation devices, Type_A and Type_B. Type_A devices could compensate for dispersion exceeding the threshold, i.e., 75% over the average path dispersion, while Type_B device could not.

Fig. 4 summarizes simulation results comparing compensation capability-aware (Optimized) routing and unaware (Conventional) routing over the NSF network and the lattice network with varied wavelengths, with respect to failure ratio due to inappropriate assignment of Type_B devices to high dispersion paths. Optimized routing assigned Type_A devices prioritized over Type_B devices to paths exceeding the threshold, whereas Conventional routing assigned compensation devices based upon availability. Fig. 4 shows Optimized routing resulted in fewer failures, which demonstrates effects of advertisement of compensation capability.

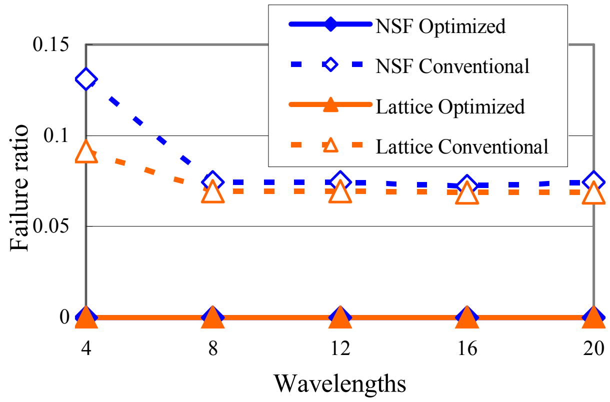


Fig. 4 Comparison of compensation device assignment

4 Conclusion

For optimized assignment of compensation devices such as electronic pre-compensator with different capability at optical nodes, we proposed a new optical node architecture where compensation devices can be shared by dynamic optical paths, as well as an extension to GMPLS to advertise each node's compensation capability. It was confirmed that compensation device assignment based upon advertised capability information would result in better routing performance by simulation.

Acknowledgement

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