The Effect of Wavelength Advertisement on the Performance of an Optical Routing Protocol

Bilal Khan* Dardo D. Kleiner† David Talmage* Abdella Battou∘
Center for Computational Science, Naval Research Laboratory, Washington D.C.
http://www.nrl.navy.mil/ccs/project/public/DC/web/

***Abstract*— This paper investigates the efficiency of wavelength selection in an optical network when it is conducted without knowledge of wavelength utilization, and compares it to the case when switches exchange wavelength availability through a routing protocol such as OSPF. We describe a series of experiments to determine the effect of wavelength advertisement on connection blocking probability in heterogeneous networks consisting of both wavelength converter and non-converter switches. Based on these experiments, we describe some consequences of advertising wavelength availability, and quantify when it is advantageous to advertise wavelength availability within the routing protocol.**

I. Introduction

All-optical switches are the future technology for transport backbones in next-generation networks. Scalability issues are very important and intimately tied to the problem of wavelength assignment. The majority of integrated DWDM in switching technologies offer up to 32 wavelengths per fiber. However, it is still not feasible to optically parse packet headers, thus, the control and data planes are decoupled and circuit switching is utilized.

A user requests the establishment of a call, an optical path or trail, via a signaling protocol such as OIF User Network Interface (UNI), RSVP, or CR-LDP. Upon receiving the request, the optical switch selects the outgoing port and a wavelength/interface and forwards the signaling packet to the next adjacent switch towards the specified destination. For networks without wavelength converters, the initial wavelength path is selected by the first switch. If at any point along the route the required wavelength becomes unavailable the call is blocked. Even when wavelength availability is advertised and wavelength conversion possible, blocking can occur because information propagation is not instantaneous.

This paper investigates the efficiency of wavelength selection (in terms of blocking probability) when done without any knowledge of wavelength availability, and compares it to the case where switches exchange this information through a suitably augmented routing protocol (e.g. OSPF-TE using opaque LSA).

Early IETF drafts by Chaudhuri et al. [3] and Basak et al. [1] specified optical network characteristics that should maintained in the switch routing database, classifying it in two categories: (i) *information advertised* using OSPF, e.g. the total number of active channels, preemptable channels, risk groups, etc., and (ii) *information kept locally*, e.g. available link capacity, association between fibers and wavelengths, etc. Later proposals [5], [6] made use of the Opaque OSPF LSAs [4] to implement advertisement of such characteristics.

At present, two routing protocols OSPF-TE and IS-IS-TE have been extended in the IETF to handle optical networks under the Generalized Multiprotocol Label Switching architecture (GMPLS RFCs 3471 and 3473). Since the two routing protocols are both link state protocols, we will only consider OSPF-TE in this paper.

Wang et al. [6] argued that the optical OSPF-TE protocol *should* advertise both the available wavelengths per fiber and the total available bandwidth. The rationale for the approach of Wang et al. is that in a network where a significant fraction of the switches are not wavelength-conversion capable, the probability of selecting a feasible source route decreases dramatically because wavelength continuity constraints at the transit switches render most of these routes infeasible.

On the other hand, RFC 3630 by Katz et al. postulates that an optical adaptation of the OSPF protocol should not advertise wavelength availability in link state advertisements since available wavelengths change frequently, and so presumably any performance increase would not be proportionate to the costs of increased control traffic. In this RFC, the problem of wavelength assignment is postponed to when the lightpaths are being signaled/provisioned.

In this paper, we seek to quantify the tradeoff between wave-

* Advanced Engineering & Sciences, ITT Industries., Alexandria VA
† Computer Integration & Programming Solutions, Corp., MD
∘ Lambda Optical Systems, Reston VA.

REFERENCES

[1] D. Basak, D. Awduche, J. Drake, and Y. Rekhter. Multi-Protocol Lambda Switching: Issues in Combining MPLS Traffic Engineering Control with Optical Corssconnects. Internet Draft, January, 2000.

[2] G. B. Brahim, B. Khan, A. Battou, M. Guizani, and G. Chaudhry. TRON: The Toolkit for Routing in Optical Networks. Proceedings of IEEE Globecom 2001, San Antonio, Texas USA; November, 2001.

[3] S. Chaudhuri, G. Hjalmtysson, and J. Yates. Control of Lightpaths in an Optical Network. Internet Draft, February, 2000.

[4] R. Coltun. The OSPF Opaque LSA Option. Request for Comments No. 2370, July, 1998.

[5] K. Kompella, Y. Rekhter, D. Awduche, J. L. G. Hjalmtysson, S. Okamoto, D. Basak, G. Bernstein, J. Drake, N. Margalit, and E. Stern. Extensions to IS-IS/OSPF and RSVP in support of MPL(ambda)S. Internet Draft, October, 1999.

[6] G. Wang, D. Fdyk, V. Sharma, K. Owens, G. Ash, M. Krishnaswamy, Y. Cao, M. Girish, H. Ruck, S. Bernstein, P. Nquyen, S. Ahluwalia, L. Wang, A. Doria, and H. Hummel. Extensions to OSPF/IS-IS for Optical Routing. Internet Draft, March, 2000.

[7] B. M. Waxman. Routing of multipoint connections. *IEEE Journal on Selected Areas in Communications*, 6:1617 – 1622, 1988.