Network Management Information for Light-Path Assessment

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Abstract —
In this work, we consider assessing wavelength availability using partial management information for dynamically setting up a light-path across administrative domains. We cast the light-path assessment as a decision problem, define and analyze the performance as the probability of an erroneous decision. We show that the performance is related to the blocking probability, and a good performance may be achieved using local and aggregated information.

I. Background and Motivation

Dynamically assessing the wavelength availability on a given route is important to on-demand provisioning of light paths in wavelength-routed optical networks. The assessment is done based on available state information that corresponds to "which wavelengths are used at which parts of a network without wavelength converters"; and "the number of available wavelengths at wavelength converters".

Providing state information is a functionality of network management. Ideally, minimal information should be used for light-path control. This is especially important for future IP-WDM networks with hundreds of wavelengths available at each link, where the amount of complete state information can be overwhelming (e.g. $> 100,000$ states). Updating a lager number of states due to dynamic connections and flows may result in undesirably large amount of management traffic.

Using minimal management information is also a requirement of multi-vendor network services. A light path may trespass multiple administrative domains (sub-networks) run by different service providers. A service provider may prefer to exchange only minimal information with others. Then an open question is how much information would be needed for assessing wavelength availability.

II. Partial Information and Performance

We consider a simple setting where two wavelength converters are located at the boundaries of a one-dimensional subnet and there are L subnets on a given path. Each subnet has H hops and F usable wavelengths. The partial information consists of local and aggregated information. The local information corresponds to the number of available wavelengths at wavelength converters. This information is readily available, and therefore of practical interest. The aggregated information [1] is on network load characterized by the probability p of wavelength occupancy at each link, plus the information on network topology (H) and resource (F). The local and aggregated information is incomplete in determining network states, resulting in possibly erroneous wavelength assessments. A question is whether it is possible to use "minimal" management information at the cost of a small number of incorrect decisions.

We define the performance of an assessment as the probability of error which occurs when the assessment differs from the ground truth (in terms of availability/unavailability of wavelengths on a given path). The value of the probability measures a deviation from the optimal performance (zero error) when the complete information is available, and thus quantifies the (in)sufficiency of the management information.

We adopt a simple model in [2] to evaluate the error probability, where wavelength usage is assumed independent at different hops within a subnet and among wavelengths. Given the local and the aggregated information, the Bayes decision rule leads to the best assessment, and the Bayes error (P_e) as the best performance attainable. In particular, the Bayes error P_{eb} made at each subnet satisfies

$$P_{eb} \leq 2P_b(1 - P_b), \tag{1}$$

where P_b is the blocking probability of the subnet, and $P_b = [1 - (1 - p)^H]^F$. When the number of wavelength F is large and the number of subnets L is moderate, the Bayes error of the assessment made about the light path satisfies

$$P_e \leq 2LP_b(1 - P_b). \tag{2}$$

When $F \gg \frac{1}{(1-p)^H}$ (a large number of wavelengths or a moderate load),

$$P_e \leq 2L[1 - (1 - p)^H]^F. \tag{3}$$

When $F \ll \frac{1}{(1-p)^H}$ (heavy load),

$$P_e \leq 2L(1 - p)^{FH}. \tag{4}$$

These results suggest that (a) the assessment error is in the order of the blocking probability when it is small, and (b) the local and aggregated information may indeed result in only a small number of assessment errors under large network resource- and a certain load-conditions.

References

[1] R. Guerun, "QoS Routing in Networks with Inaccurate Information: Theory and Algorithms," *IEEE/ACM Trans. Networking*,Vol. 7, No. 3, June 1999

[2] R. Barry, "Models of Blocking Probability in All-Optical Networks with and without Wavelength Changers," IEEE J. Selected Areas. Comm., Vol. 14, No. 5, June 1996

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