Performance Evaluation of two new GMPLS Lightpath Setup Proposals over an Unidirectional OADM Ring Implemented on a Testbed

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Abstract *Provisioning of bidirectional optical connections over unidirectional DWDM rings using a GMPLS control plane has not been deeply considered. This paper presents and compares the performance of two new experimental proposals over EMPIRICO project testbed.*

Introduction

In the basic GMPLS architecture [1], bidirectional optical connections are established using a single set of Path/Request and Resv/Mapping messages, but this mechanism does not work over unidirectional rings. On the other hand, in the basic MPLS architecture, LSPs are unidirectional, so in order to establish a bidirectional optical connection, two unidirectional LSPs in opposite directions must be established independently. This approach has many disadvantages, being the most important that it does not work in an IP/MPLS network environment where high-speed IP/MPLS routers request dynamically uni or bidirectional connections to the optical network.

The objective of this paper is to present and compare the performance of two new experimental proposals of GMPLS bidirectional lightpath provisioning over an unidirectional ring implemented on EMPIRICO project testbed[1], called Whiting and Salmon.

Testbed network model overview

EMPIRICO testbed is based on an ASON network constituted by a metropolitan DWDM ring with three dynamically configurable all-optical OADM, allowing the establishment of real-time, dynamic, end-to-end connections handled by a GMPLS control plane.

The transport plane is composed by an unidirectional ring with three all-optical OADM. Each fiber is capable of handling up to 8 wavelengths spaced 100 GHz, and each link has a distance of 35Km. EMPIRICO testbed uses fully tunable laser sources (C-Band) without wavelength converters, so wavelength-continuity constraint must be guaranteed.

GMPLS bidirectional lightpath setup: Whiting

The Whiting proposal (figure 1) is based on a downstream reservation, in which wavelength resources are reserved along the downstream path to the destination on a hop-by-hop basis along the selected route. The signalling protocol is based on GMPLS extensions to RSVP-TE [2]. When a new connection request arrives to the source OCC, it determines the route towards de destination and initiates an RSVP Path message with session 1 containing a Generalized Label Request Object. This explicit path follows the same direction that the ring. Finally, other relevant objects like the label set are included in order to guarantee the wavelength-continuity constraint. If the requested connection is bidirectional, a void UPSTREAM label object is also included. Then the Path message is sent along the selected route. The UPSTREAM label object is ignored in all the intermediate nodes.

When the Path message reaches the destination, it processes it and generates automatically a new Path message with session 2 that is sent to the source node along the ring direction, that is, the new path is not traveling in the reverse direction back towards the source. In order to maintain a synchronization for handling RSVP messages, the destination node must relate the PSB from session 1 and the PSB from session 2, e.g. when a Resv message of session 2 is received, automatically a Resv message of session 1 is propagated. Note that the source node cannot establish the optical connection until a Resv message of session 1 is received, so it results in long setup times, increasing the time that network resources are over-reserved due to Label Set.

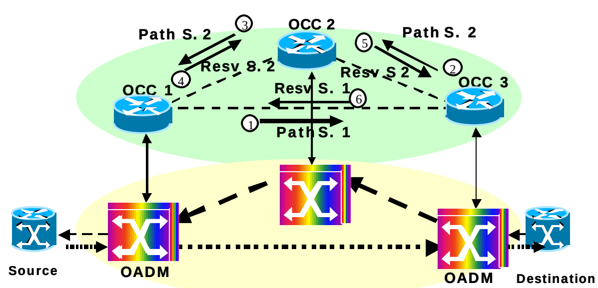

Figure 1 . Whiting proposal

GMPLS bidirectional lightpath setup: Salmon

The Salmon proposal (figure 2) is also based on a downstream reservation. When a new connection request arrives to the source OCC, it initiates an RSVP Path message with session 1 containing a Generalized Label Request Object and other relevant objects as specified in the previous section. The strict path to the destination follows the same direction of

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the ring. Then the Path message is sent along the explicit route. No UPSTREAM label object is included in the Path message. If the requested connection is bidirectional, the source node generates automatically a new Path with session 2, including all the relevant objects and a void UPSTREAM label object. In this case, the strict path to the destination OCC follows the opposite direction to the ring.

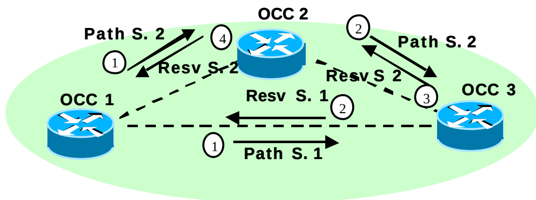

Figure 2. Salmon proposal

The Salmon approach also requires a synchronization of both sessions, but in this case this is performed in the source node. Note that contention for labels may occur between two paths travelling in opposite directions. This contention occurs when both sides allocate the same resources at effectively the same time. To resolve the contention we have adopted a policy in which the session with the higher session identifier will win the contention, and the connection that loses the contention is blocked. It might lead to increasing the blocking probability, but on the other hand the network resources are over-reserved for a shorter period of time than in the Whiting approach. A node receiving a Path message knows if the requested connection is in the ring direction or opposite to it if the Path message includes the UPSTREAM label object.

Performance evaluation

In order to evaluate the above proposals over the EMPIRICO testbed, we assume that all the lightpath requests are bidirectional. The connection requests arrive according to a Poisson process, and the connection holding time is exponentially modeled with a mean of 1 sec. The traffic is uniformly distributed among all node pairs and 500 connection requests have been performed. Each data point is obtained over a simulation of 500 connection requests.

Figure 3 a) plots the obtained blocking probability vs. load for Whiting and Salmon proposals. We have evaluated the salmon approach with no label contention policy (Salmon NO_LCP) and with the higher session identifier policy (Salmon SID_LCP). As shown, the salmon case exhibits, for both options, an upgraded behavior respect to the Whiting proposal. The blocking improvement of the Salmon proposal is respectively about 22 and 15 percent when using and not the session identifier policy with respect to the Whiting proposal when total offered load is fixed at 5 Er. For lower loads, this rate increases significantly reaching up to 50 and 35 percent respectively for both salmon policies. It can be inferred that the setup delay is more important to the label contention policies in order to reduce the blocking probability.

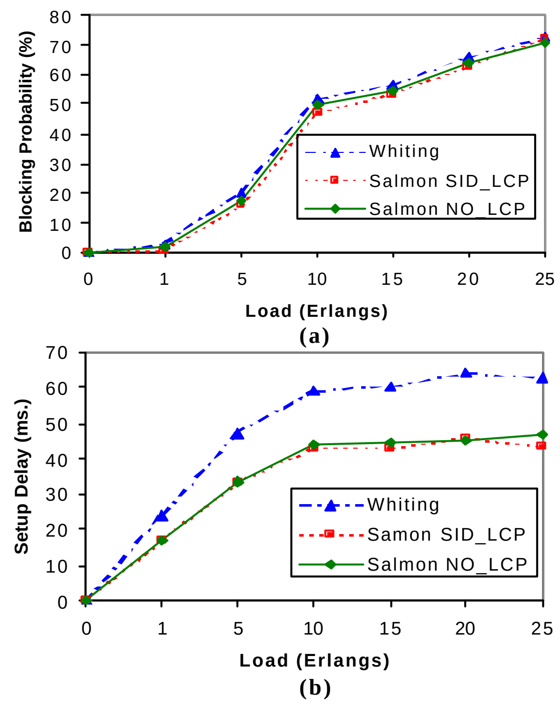

Figure 3 a) Blocking probability and b) setup delay

It has to be noticed that when the network is highly loaded, the improvement for the Salmon proposal is not significant since the connection requests arrive closer causing that the successful connections do not depend so relatively of shorter setup delays.

Figure 3 b) shows the setup delay vs. load. Obviously, salmon proposal presents lower delays than the Whiting proposal. As shown, the connection setup delay increases as load increases due to the fact that each OCC has to support more sessions, and moreover, as a soft-state protocol, RSVP-TE requires to be periodically refreshed causing the increase of the processing delay. Finally, as the load continues to increase, the connection setup delays tend to remain constant due to the number of hops that a connection can span is fixed and consequently the propagation delay is also fixed.

Conclusions

The performance evaluation of the Salmon proposal is always better than the Whiting proposal, even when no label contention policy is applied, achieving an improvement of the blocking probability up to 50%.

References

1 ITU-T G.8080, *Architecture for the Automatically Switched Optical Network (ASON)*, November 2001.
2 L. Berger et al, *GMPLS RSVP-TE*, IETF RFC 3473, January 2003.