Lambda Sharing Demonstration via Traffic-Driven Lambda-on-Demand

Yukio Tsukishima(1), Akira Hirano(1), Naohide Nagatsu(1), Wataru Imajuku(1), Masahiko Jinno(1),
Yoshinori Hibino(1), Yoshihiro Takigawa(1), Kazuo Hagimoto(1), Xi Wang(2), Luc Renambot(2), Byungil Jeong(2),
Jason Leigh(2), Tom DeFanti(2), Alan Verlo(2)
1: NTT Network Innovation Laboratories, NTT Corporation, 1-1 Hikari-no-oka 239-0847 Japan
E-mail: tsukishima.yukio@lab.ntt.co.jp
2: Electronic Visualization Laboratory, University of Illinois at Chicago USA, E-mail: xiwang@uic.edu

Abstract *This paper proposes GMPLS-capable Lambda-on-Demand to adjust the number of load-balanced end-to-end lambdas according to the traffic volume while successfully sharing lambda resources to connect between any two of three nodes for the first time.*

Introduction

The development of high-performance networks comprising Photonic Cross-Connects (PXCs) with Generalized Multi-Protocol Label Switching (GMPLS) capability [1, 2] has driven the increase in the number of high-end wide-area-network (WAN) applications [3]. Such applications target parallel computing to ensure unlimited scalability. Inevitably there will be a need for load-balanced parallel lambdas to carry their traffic. The number of lambdas should be optimized to as few as possible. Therefore, these lambdas should be configured dynamically depending on the widely fluctuating demands from such applications [4-6].

In addition, lambda resource sharing should be implemented to maximize the network resource usage. We anticipate that such a function could yield cost-effective network implementation by minimizing the network resources to be installed.

In this paper, we present the Lambda-on-Demand functionality using a shared lambda to connect any two of three PXCs comprising a triangular network topology in an OSPF-enabled IP-over-photonic network achieved using novel control servers.

Lambda-on-Demand scheme

Figure 1 illustrates the network configuration for this study. Gigabit Ethernet link (GbE) #1 traverses Router #1, PXC #1, PXC #3, and Router #3. GbE #2 connects Router #1 to Router #3 via PXC #1-#3. On the other hand, GbE #3 and GbE #4 are connected by Router #2 and Router #3 via PXC #2 and PXC #3. Tester #1 and Tester #2 generate and send packets to Tester #3. GbE #2 and GbE #4 share lambda resources between PXC #2 and PXC #3. The traffic volume per second fluctuates between 200 Mbps and 1.6 Gbps. As shown in Fig. 1, we developed and installed three Lambda-on-Demand-capable control servers supporting SNMP, Telnet, GMPLS, and a proprietary protocol to collaborate with the other control servers.

Figure 2 shows an example of a messaging diagram among control servers and PXCs to establish or delete GbE #2 to increase or decrease the total link capacity between Router #1 and Router #3.

When we run Lambda-on-Demand between Router #1 and Router #3 and set up GbE #1, we initiate Control server #1 (see the initial step). At that time, both Control server #1 and Control server #3 independently select an available Link Aggregation Group (LAG) number. In addition, the control servers exchange information pertaining to the selected LAG number. Next, the interworked control servers check and select the available interfaces to terminate GbE #1. On the other hand, Control server #1 sets up GbE #1 via GMPLS in collaboration with Control server #3 and the PXCs. The control servers also activate the selected interfaces and eventually add the selected interfaces into the LAG via Telnet. Subsequently, Control server #1 monitors the traffic on GbE #1 via SNMP every 8 seconds.

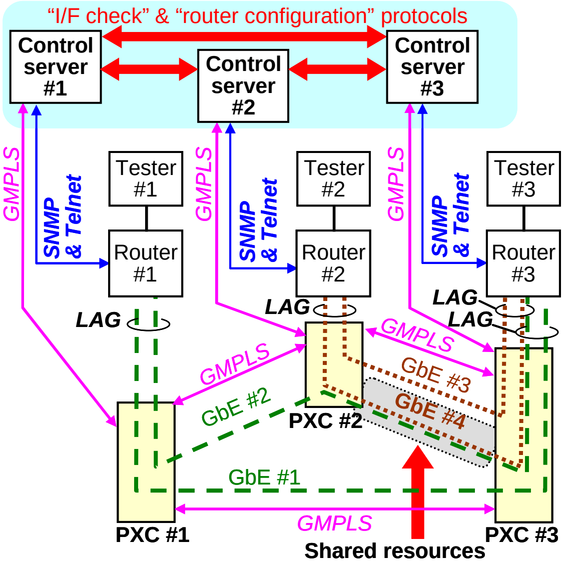


Fig. 1. Network Configuration

When the traffic volume per second on GbE #1 exceeds 800 Mbps, the interworked control servers check and select the available interfaces that belong in the selected LAG (see the increase step). Next, Control server #1 establishes GbE #2 to connect the selected interfaces via GMPLS. Furthermore, the interworked control servers activate the interfaces and add the selected interfaces into the LAG via Telnet. The packets streaming on GbE #1 and GbE

#2 are distributed to the GbE links using Link Aggregation, based on the round-robin algorithm.

When the traffic volume per second on GbE #1 and that on GbE #2 are below 300 Mbps, the interworked control servers release the interfaces from the LAG and deactivate the interfaces at the edges of GbE #2 via Telnet (see the decrease step). Finally, Control server #1 deletes GbE #2 via GMPLS.

The messaging to adjust the number of load-balanced parallel lambdas between Router #2 and Router #3 is similar to the above messaging.

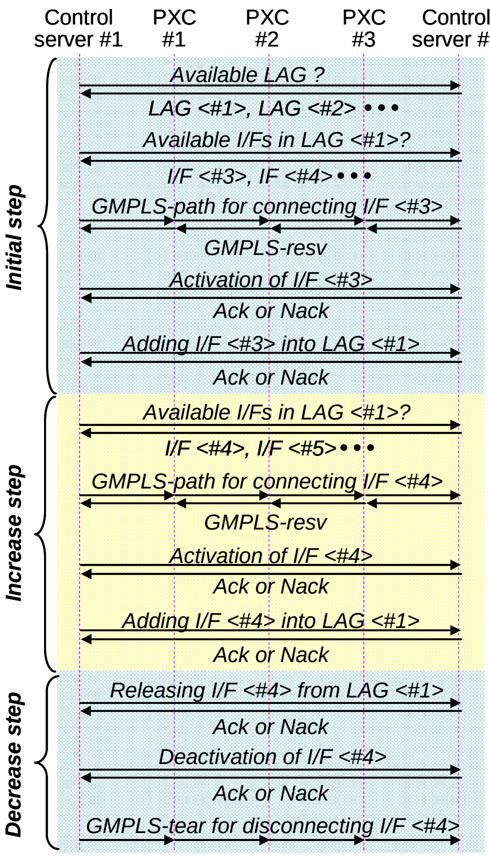
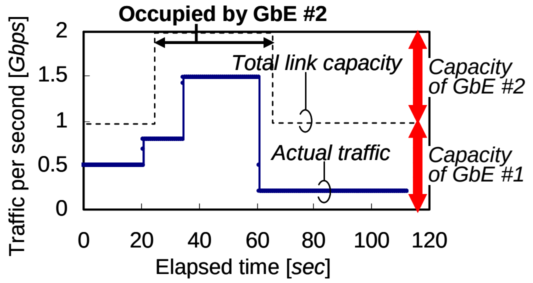


Fig. 2. Messaging diagram

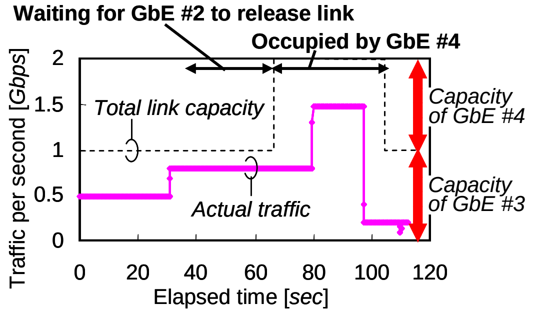
Lambda sharing between GbE #2 and GbE #4

Figure 3 shows an example of the experimental results when adjusting the number of load-balanced parallel lambdas (total link capacity) in response to the actual traffic volume in the lambdas as a function of the elapsed time. Figure 3(a) shows the total link capacity and the actual traffic between Router #1 and Router #3. Figure 3(b) shows the total link capacity and the actual traffic between Routers #2-#3.

After the actual traffic volume between Router #1 and Router #3 increases to 800 Mbps, Control server #1 sets up GbE #2 at the elapsed time of approximately 28 seconds. Therefore, the total link capacity increases to 2 Gbps, and the actual traffic reaches 1.6 Gbps at its peak. On the other hand, after the actual traffic volume between Router #2 and Router #3 reaches 800 Mbps, Control server #2 attempts to add GbE #4 at the elapsed time of approximately 38 seconds. However, it does not execute GbE #4 provisioning because of the lack of lambda resources between PXC #2 and PXC #3. At this time, Control server #2 waits for the emergence of lambda resources between PXC #2 and PXC #3. After the actual traffic between Router #1 and Router #3 decreases to 200 Mbps, Control server #1 deletes GbE #2 at the elapsed time of approximately 68 seconds. Shortly thereafter, Control server #2 sets up GbE #4. After the actual traffic between Router #2 and Router #3 decreases to 200 Mbps, Control server #2 deletes GbE #4 at the elapsed time of approximately 110 seconds.



(a) Measured results between router #2 & #3



(b) Measured results between router #2 & #3

Fig. 3. Actual traffic and total link capacity when lambda resources are shared by GbE #2 & #4

As expected, the lambda resources are shared by GbE #2 and GbE #4, between 28 seconds and 110 seconds, according to the traffic volume on GbE #1-#4. Moreover, sharing is performed without IP routing disruption and packet loss as shown in Fig. 3(a).

Conclusions

This paper proposed a traffic-driven Lambda-on-Demand protocol that shares lambda resources successfully for the first time. The protocol provides control and management through the interworking of the proprietary resource managing protocol, GMPLS, SNMP, Telnet, and Link Aggregation.

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