Performance Evaluation of Efficient Group Design Using Hierarchical MPLS

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Summary

Recnetly, the demands of QoS(Quality of Service) and the traffic in network is increased. So, H-MPLS(Hierarchical MPLS) network research what guarantees the scalability is in progress. But, the H-MPLS has a problem of increasing of groups and the links of these group's nodes. It happens a problem that is increasing of H-MPLS setup cost. In this paper, we setup the H-MPLS groups. We use NS simulator in order to analyze the performance and traffic transfer times of each H-MPLS groups. In conclusion, we can find out the elevation of the traffic performance, by increasing a amount of links.

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Key words:

H-MPLS, MPLS, Hierarchical - MPLS

1. Introduction

Over the years, applications and services using network telecommunication have developed to boast not only significant progress in their quality but also a wide variety in their types. Accordingly, the Internet network required to be more complicated and to have larger bandwidth so that it can deal with increased data usage of those applications and services. To meet the requirement through easier network management and more effective use of network resources, the Internet Engineering Task Force (IETF) suggested MultiProtocol Label Switching (MPLS) [1][2].

However, MPLS generated many problems when the size of the network is extended since the network raised extra processing weight for monitoring the status of the entire network on Edge Label switch Routers (LERs, the routers located at the very end of MPLS network) [3][4].

To disperse the weight concentration on LER, researches on the concept of Hierarchical MPLS (H-MPLS) has been emerged [5]. Different from MPLS where there is one large network, H-MPLS introduced hierarchical structure among a higher-level network that has more than one core network and varing number of lower-level networks that have MPLS edges. In MPLS, each LER has to reconfigure the entire network when there is even a slight change in network topology such as addition of a new router or internal router breakdown [1][4]. As a result, when the network is getting larger, the heavier loads on LER becomes problematic in MPLS.

However, change in network topology in H-MPLS is processed through different levels so that the parts of network other then the affected one can continue the ordinary operation. It is possible to significantly lower the delay and manage the bandwidth more effectively in H-MPLS since the reconfiguration of the network is processed within the affected group [5]. Thus, H-MPLS guarantees higher reliability and more effective resource management through maintaining the entire network's stability and load-balance.

While H-MPLS is very effective way to manage the network, the number of links has to be raised significantly when there is increase in the number of hierarchical levels of core and edge MPLS networks and the number of LER that connects those different levels. In reality, the users have to face the high cost of configuration and installation fee of H-MPLS.

Therefore, this paper focus on the number of LER between different levels of core and edge network of H-MPLS and its effect on network performance. Also, it is our interest to find the optimal ratio of LER links between hierarchical levels of the network that can yield the most effective network configuration. In our simulation using one core network and two edge network hierarchy, we changed the number of LER links connecting different levels of the network and sent packets so that we can compare and analyze the difference in the network performance resulting from the change.

The paper consists of five sections including this introductory section. In the second section, MPLS and H-MPLS is explained briefly as theoretical background. The third section is about the effective configuration of network groups using H-MPLS. We will develop a network model using H-MPLS in the section. The fourth section is about performance analysis. In this section, we actually performed an experiment of our NS-2 model through the simulator and analyze the result. Finally, we conclude our research in the fifth section.

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2. Theoretical Background

2.1 MPLS(Multiprotocol Label Switching)

MPLS is the next generation network protocol that improved the performance and extensibility of core network through high-speed packet transmission of label-based layer-2(L2) switching. Figure 1 illustrates the basic configuration of MPLS.

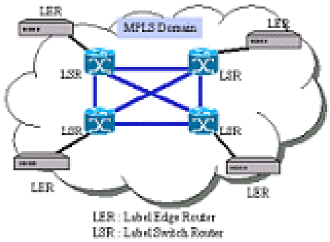

Fig. 1 The basic configuration of MPLS

Figure 1 shows the layout of each configuration.
o LER(Label Edge Router): It labels the IP packets coming from the outside of MPL network and removes the label from packets going outside of the network.
o LSR(Label Switch Router): It is a router that configures MPLS network. Based on specific table generated from the network's information, it refers the packet's label, performs switching, and changes the label if needed (POP functionality)

Through Label Distribution Protocol(LDP), each router received specific label for every route. Label Swithching Path (LSP) enables hi-speed routing through transmitting labeled packets between each LSR and LER. This process results in effective use of network resources.

However, increasing needs for larger bandwidth of the recent high-quality services require the extension of MPLS. The problem here is that even adding or subtracting routers generates significant traffic within the entire network for reconfiguration. Also, it gets more and more complicated for Edge Label switch Router (LER) to monitor the structure and status of the network. This overload of LER leads to overload and performance degradation of network facilities and the entire network.

The MPLS's vulnerability to the network extension leads to the development of Hierarchical - MultiProtocol Label Switching.

2.2 H-MPLS(Hierarchical MPLS)

H-MPLS sets up the hierarchy among routers in the network so that the packets used for monitoring the status of the network is minimized and the change in one hierarchical level does not affect the other levels.

Figure 2 is the simplified illustration of the structural difference between MPLS and H-MPLS.

MPLS edge and core networks that hierarchically divided within H-MPLS exchange data through LER links that connects different levels of each networks. If the network is divided into larger numbers of hierarchical levels of edges and core networks, each LER's processing load will be decreased, and thus the performance of the entire network will be significantly enhanced. However, in doing so, the number of LERs that connects edge and core network and the numbers of links that connects those LERs are increased as well.

As illustrated in Figure 2, MPLS does not have any links that connects LERs except LER connected to the external network. In comparison, H-MPLS has many LER routers connecting edge and core network (A, a, B, b, C, c, D, d in Figure 2) and the links between those routers. These relatively large number of links and LER routers raises the cost of network implementation. Also, it becomes wasteful to have that many idle links when there is less amount of data exchange in the entire network.

To analyze the optimal form of link configuration that brings the least resource waste and the best network performance for H-MPLS network, we changed the number of links that connects the hierarchical levels during our experiment. The goal is to estimate the ratio of links that generates the most efficiency and verify the estimation with results from the experiments.

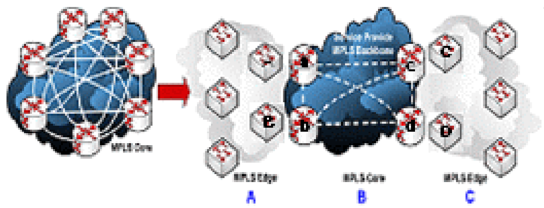

Fig. 2 structural Difference between MPLS and H-MPLS Network

3. The effective Configuration of Network Groups using H-MPLS

Similar to MPLS, H-MPLS consists of close links between LSR routers that operate within given edge or core network and LER routers that connects the entire network to the external one or connects one hierarchical level to others. When there are more LER and links, it is less required for labeled IP packets to detour the route.

However, large numbers of LERs and links raise obvious limitation in the actual network implementation. While we can increase links by adding a few lines in simulation, that doesn't apply in reality. One more link can require many related facilities, and added facilities means more monetary investment.

As the size of the entire network is getting larger, it is inevitable to have more links connecting LERs between different hierarchical levels of network. Then the challenge here is to find optimal network configuration that minimize the performance degradation of the network under certain number of LSRs and LERs. More specifically, the research question here is as follows. How many LERs should be linked to edge network when there is given number of routers in core network?

4. Performance Evaluation

As shown in Figure 3, our H-MPLS model has 25 MPLS nodes. It is full-mesh type network with two edge network in both sides and one core network in the center. Nodes with E (E1, E5, E6, E10...) means LER, and nodes with only numbers means LSR. Connections to the external network or between different hierarchical levels need to get through LERs. The three hierarchical levels of the network are connected with link a and link b. The purpose of the experiment is to observe the change of the data flow in accordance to the change in the number of the LER nodes (E1, E5...) and the number of links. To simulate the commercial MPLS networks more precisely, the bandwidth and delay time of links connecting each node varies slightly. The difference in bandwidth and delay time range from 5 to 30 and from 1 to 20 respectively. The originations of data packets are the five points (from S1 to S5). All data packets communication uses UDP protocol. Constant Bit Rate (CBR) algorism, which continually transmit the packets for given time, is used to send the packets (200 bytes for each.)

Table 1 shows time for sending the packet in the origination, time for discontinue the transmission, and the destination of the packets.

Table 1: The scenario Table

origin	***start time(sec)***	***end time(sec)***	***Destination***
S1	6.0	10.0	D1
S2	11.0	15.0	D2
S3	16.0	20.0	D3
S4	21.0	25.0	D4
S5	26.0	30.0	D5

The time, destination, and scenario of the packet transmission is as follows. Since both edge network and core network have 5 by 5 nodes configuration, the maximum number of LERs is assumed to be five. When there are five links from origination to destination, we check the time required for packets to arrive at the destination. The performance of network when there are five LERs and links is analyzed through the mean value of the results. Then, the performance of network when there are four LERs and links is analyzed in the similar way after extracting a link between edge and core network. The experiments continues for the network with three, two, and one LER and link.

The results of the experiments are shown in Figure

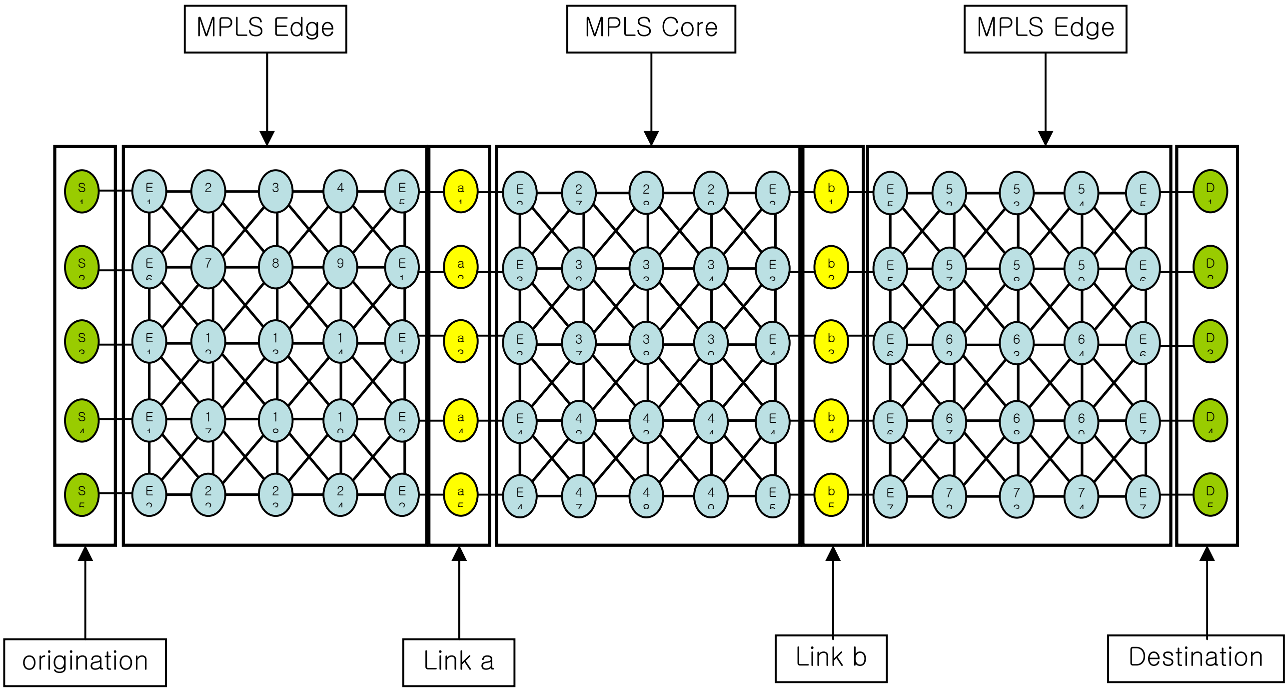

Fig. 1 H-MPLS Model using 1 core & 3 Edge networks

4. When there were five links, the mean arrival time of packets was 0.119 seconds. When there was only one link, the there was 0.029 seconds increase in mean arrival time of packets

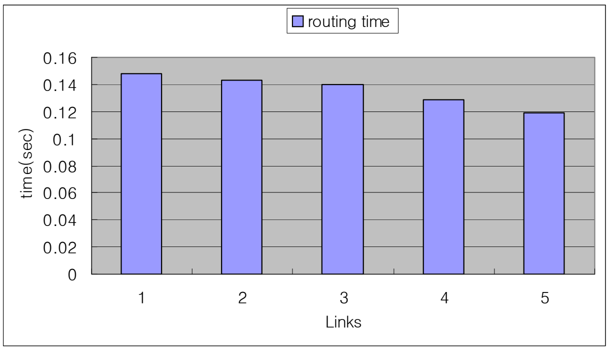

Fig. 4 Proposed beam former.

In the experiment of five LERs and five links, the mean arrival time of packets was 0.119. When there were four LERs and four links, the time was 0.129, which means 8 percents delay time increase. When there were three, two and one LER and link, the time was 0.140 (17 percents delay time increase), 0.143 (20 percents), and 0.148 (24 percents) respectively. Note that delay times were around 20 percent until there were three links, while delay time was significantly decreased from four links within the network.

5. Conclusion

The paper analyzed the effect of links between hierarchical levels of network on the speed of data transmission through changing the numbers of LERs and links that connects edge and core network. The result from the H-MPLS model with relatively small (five by five nodes) three hierarchical levels of network implies that at least 80 percent of links and LERs are required to minimize the delay time and guarantee smooth data transmission.

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