Performance Analysis about the Failure Restoration Scheme Using a Multi-path in Hierarchical MPLS Networks

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Summary

Various technologies about multi-path calculation for extensibility and failure restoration have been suggested as an increasing demand for QoS in MPLS networks. However, the MPLS networks have problems in extensibility for network traffic, failure restoration that waste usage of resources and much delay. Thus, we propose to H-MPLS networks recover failure in networks fast and support efficient methods for network management using a LSP multiple routing algorithm. We also organize expanded networks with a hierarchical MPLS network and apply various failure restoration methodologies to it. We demonstrate, analyze it by the NS simulator and propose improving ideas.

Key words:
H-MPLS, MPLS, multi-path routing, LSP, Failure Restoration

1. Introduction

The functionality that for operate Internet networks more efficiently is required by the policy of telecommunication operators and the Internet traffic growth. Furthermore, many researches have been presented for traffic engineering in these days. A LSP calculation function might become a key technology to distribute the traffic to a substitute path or a multi-path to guarantee the limitation of bandwidth or solve burst problem in network links. It is a MPLS technology that improves overall network performance using maximum network resources and provides easy network management technology. As a LER becomes overloaded to monitor all network states and manage them while the network size is increasing; however, H-MPLS (Hierarchical-Multi Protocol Label Switching) technology is necessary to manage networks efficiently. There are the Pre-assigned and On-demand models to protect or to restore network failure. They are known to have problems such as packet loss and network resource dissipation.

Thus, in this paper, we propose fast and credible restoration from network failure using a LSP multi-path calculation algorithm and H-MPLS networks are supporting efficient network management. We compare conventional restoration methods in the MPLS networks. We also compare the most efficient methodologies of the MPLS and the H-MPLS networks using the NS simulator with various restoration methods when MPLS networks are expanded. And we analyze result from it.

This paper is organized as follows: First, in chapter 2, we describe necessity of multi-path algorithm and problems of restoration in conventional MPLS networks. Then, in chapter 3, We propose the most efficient H-MPLS topology and restoration methods from the failure when extending MPLS networks. Next, in the chapter 4, we analyze the results from the simulation and performance and in the finally, the chapter 5, there are our conclusion.

2. Related works and problem definition

In this chapter, we are going to suggest the background of this paper to issue problems in the conventional MPLS networks and multiple path routing algorithms.

The network operators prefer a minimum delayed path using broad bandwidth links since link metrics make an important effect on efficient network management and performance in the networks [1].

The explicit path calculation method, a CSPF (Constrained-based Shortest Path First) as an improved SPF algorithm, currently used in MPLS networks finds a SPF path using network resource information after eliminating the limitation of a LSP. These single path methods such as CSPF, WSP (Widest Shortest Path) [2] and SWP (Shortest Widest Path) [3] cannot distribute their traffic to another substitute path when the burst traffic happened. The methodologies to minimize the latency simultaneously maximize available bandwidth using multi-paths are suggested, but still known as NP-complete

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problems [4]. The researches about many experienced methods have polynomial time complexity rather than finding an optimized path by solving NP-complete problems have been preceded [5, 6]. The method to solve the problem by transforming code metric except one of multiple metrics to limited integer values and to change the delay or jitter values to a single formulation of bandwidth using WFQ (Weighted Fair Queuing) exist [7]. WKS (Widest-K-Shortest) and SKW (Shortest-K-Widest) were proposed to optimizemetrics (bandwidth, hop) to distribute network traffic by calculating the multiple paths when the failure occurred in the MPLS networks. The SKW method developed from the SWP calculates minimum available bandwidth and selects path of less hop counts among the same bandwidth path. It obtains K numbers of paths from it [8].

Failure protection and restoration technologies in Hierarchical MPLS networks are required to distribute a centralized role of the LER for efficient network management as the MPLS networks are expanded [9].

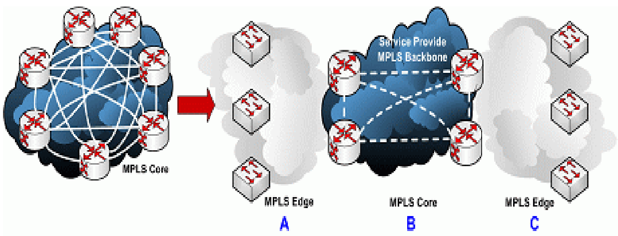
Thus, a multiple path routing algorithm for the fast restoration from the failure, and the H-MPLS network technology should be combined as the network size is growing. To compensate these problems, multi-path pre-assigned method has been used by applying the SKW, the LSP multi-path calculation algorithm in the H-MPLS networks. The SKW can recover fast the path from the failure by calculating a substitute path pro-actively in a routing table using a multiple path algorithm to optimize bandwidth and hops.

3. Proposed idea for H-MPLS restoration method from failure

A PE router's role and complexity are increased to analyze all network structures and to monitor states and traffic in the overall networks is overflowed when a new node is added or removed from the MPLS networks. Therefore the PE router's performance is degraded due to its centralized functionalities, and network extensibility also is limited. The H-MPLS Network model can be used to solve this extensibility matter of the MPLS networks. The H-MPLS (Hierarchical MPLS) can efficiently manage networks by reducing necessity of duplicating the packets at a LRE and signaling overhead. And the H-MPLS can quickly and simply reorganize all networks by executing the group works without reconfiguration of all networks whenever network topology is changed by adding or removing the nodes.

For this, the MPLS networks adopt multiple path algorithms for restoration from the failure and make the H-MPLS networks by organizing several MPLS networks.

Restoration methods are categorized into pre-assigned restoration and on-demand restoration which are setting up a route for path recovery before failure or after failure respectively. The pre-assigned method can save the time to restore the path from the failure, but the pre-assigned method dissipates the resource because it prepares a substitute path without failure occurrence. On the other hand, the on-demand method can set up the optimized new path from the failure comparing to the pre-assigned restoration. However, it has shortcomings to make a lot of time to setup the restoration path. Currently supported methods, Single-path Pre-assigned and Single-path On-demand, cannot distribute network traffic to other substitute paths when failure happens. In this paper, we analyze the performance through the simulation of conventional method applied by pre-assigned restoration with the SKW multiple path algorithm when traffic burst occurs. We propose the most efficient method when MPLS networks are expanded.



(a) MPLS (b) H-MPLS

Fig. 1 H-MPLS network architecture

Fig. 1 shows H-MPLS network architecture. (a) is only one MPLS network topology and (b) is the topology composed of three MPLS networks. In MPLS networks(Figure 1 (a)), many packets can be lost because long latency and broad bandwidth are necessary to consider overall networks when node or link errors are occurred. On the other hand, H-MPLS networks (Figure 1 (b))can improve performance by reducing the load of a PE router managing each three groups, MPLS Edge(A), MPLS Core(B), MPLS Edge(C), individually. In addition, it reduces restoration time and delay and manages bandwidth efficiently since it restores partly within the each groups, A, B, C, at the failure.

The proposed H-MPLS restoration method is multi-path pre-assigned one that uses a pro-active calculated multi-path in each group with the SKW algorithm to support more credible traffic engineering. Thus, it can guarantee a high performance by reducing the time and resource consumption for fast and confident restoration since it can keep the information of overall network states in each group.

4. Performance appraisal

We use a NS-2(network simulator) to evaluate performance of the proposed mechanism. We build a 7×7 mesh network model as <Figure 2> for MPLS networks and a 4×4 mesh network model as <Figure 3> for H-MPLS networks to evaluate performance of the each network. Each MPLS network model has bandwidth range 10Mb~40Mb as shown in <Table 1> and an average is 14.1Mb. Range of latency is 1~20ms and an average is 8.4ms. We configure each node with different values of link latency and bandwidth to get more credible results from the simulation because bandwidth and latency of the nodes are different in commercial MPLS networks.

Table 1: Latency and bandwidth range among the MPLS nodes

Item	*Range*	Average
Bandwidth	10Mb~40Mb	141.Mb
Latency time	1-20ms	8.4ms

We calculated the arrival time of packets at the destination through the substitute path when randomly selected 4 nodes are failed in MPLS and H-MPLS networks respectively. We compared difference of average restoration time by calculating average arrival time at 4 random nodes. We used three restoration methods, single-path pre-assigned, single-path on-demand and multi-path pre-assigned.

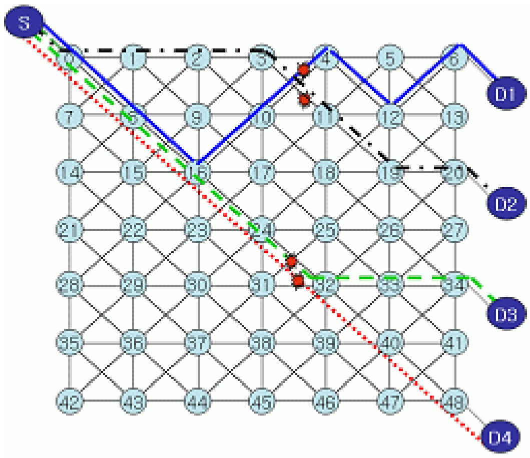


Fig. 2 Model of MPLS network

The result of simulation is shown in < Figure 4>. MPLS networks and H-MPLS networks showed the best restoration time in the failure when a multi- path rerouting method is used. Single-path on-demand method showed longer restoration time than multi-path pre-assigned and single-path pre-assigned restoration methods. All restoration methods in H-MPLS networks showed better results than MPLS networks. Multi-path pre-assigned and single-path on-demand methods showed the stable restoration time at the failed link respectively, but single-path pre-assigned methods had shown the unstable average restoration time without consistency during restoration according to error links.

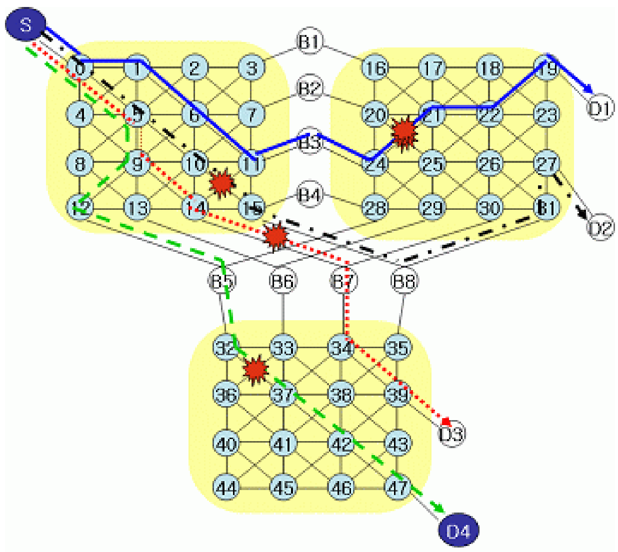


Fig. 3 Model of H-MPLS network

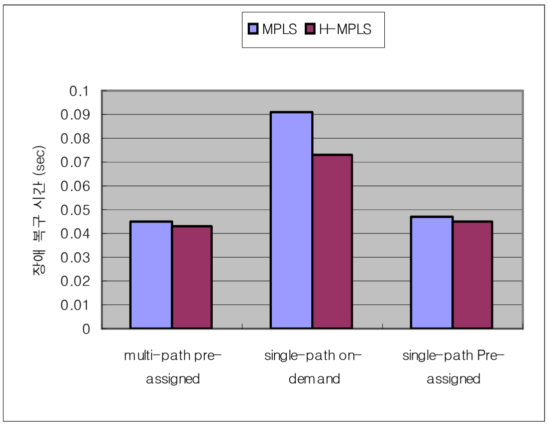


Fig. 4 Restoration time in the link failure

5. Conclusion

In this paper, we propose H-MPLS networks with the SKW algorithm that is a multi-path algorithm recover quickly in the link failure. Compared with a conventional method and a multi-path pre-assigned method in MPLS and H-MPLS networks, we make sure that the multi-path pre-assigned method makes better performance in the H-MPLS and contributes improvement in an overall network performance. Efficient network management technologies should be processed by analyzing performance differences according to the number of LERs between a MPLS core and a MPLS edge in designated H-MPLS networks as a further research issue.

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