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Achieving Robust and Stable Data Transmission on MPLS-TP Based Network using Ring Protection

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ABSTRACT

Objective – Multi-Protocol Label Switching (MPLS) is a technique to achieve efficient, and error free data transmission. MPLS has a vast amount of applications and can be implemented in high-speed data transfer medium such as the optical networks. Multi-Protocol Label Switch-Transport Profile (MPLS-TP) is an improvement of MPLS and it is a core for the service of reliable packet-switched transport networks. Despite having such advantages, network failure may still occur on MPLS-TP, therefore, it needs a method to ensure that the performance of the network is not compromised.
Methodology/Technique – The failures in the network include the link fails to connect to each network element, the network element fails to transfer the data to the destination, or the quality drops below the standard. In order to overcome the quality drops due to failure on the main link, the ring protection method is implemented on MPLS-TP based network, and its performance is analysed.
Findings – The result is, the ring protection is able to maintain the quality of the network after the main link fails, the parameters are: the throughput utilization is 100%, frame loss ratio is 0%, jitter is 0.015 ms, maximum latency is 0.218 ms, and the recovery time is less than 50 ms.
Novelty – The ring protection method is able to maintain the quality of the MPLS-TP based network when the data packets are switched to the ring protection network due to failure on the main ring network

Type of Paper: Empirical

Keywords: MPLS-TP, ring protection, Quality of Service, data transmission, RCC 2544 Testing

1. Introduction

Multi-Protocol Label Switching (MPLS) means labeling the data packet, allowing the router to forward the packet based from its label and establish a mapping (label-to-label) independently. The label has more advantages than IP address such as it has no format and does not use any control protocol, thus, more flexible than IP address [1][2].

Multi-Protocol Label Switch-Transport Profile (MPLS-TP) is an improvement of MPLS that is used to create Packet Transport Network (PTN) as defined by ITU-T, and its goals is to shift from Synchronous Optical

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NETwork (SONET) or Synchronous Digital Hierarchy (SDH) to a packet-switched transport networks that is able to achieve efficient, robust, and error free data transmission. MPLS has a lot of features and can be implemented on the optical networks [1][2].

Dae-Ub et al. [3] have discussed the mechanisms for the protection on switching technology of MPLS-TP to reduce the recovery time and they focused on the OAM (Operations, Administration and Maintenance) mechanisms. Dae-Ub et al. [4] have presented a protection management model on MPLS-TP over OTN (Optical Transport Network) that minimizes the total amount of network resource. Wenjun et al. [5] have proposed a method of ring protection to reduce the amount of packet loss. Jeong-dong et al. [6] have discussed a linear protection switching mechanism on a mesh-based MPLS-TP network and it is compatible to other types of network topologies. Chang-Gyu et al. [7] have presented a finding that the rapidly developing computer networking technology, the Software Defined Networking (SDN), can be used to manage MPLS-TP by using Transport-SDN (T-SDN) controller. Shicheng et al. [8] proposed a protection mechanism in Passive Optical Network (PON) to achieve high availability.

Based on the above previous research, it can be concluded that MPLS-TP is a widely researched topic and there is still problem exists in MPLS-TP, therefore, this research tackles the problem in MPLS-TP by implementing the ring protection method on MPLS-TP based network and then analyzing the ring protection performance to achieve a robust and stable data transmission. There are four Quality of Service (QoS) parameters that are tested in this research, namely throughput utilization, jitter, latency, and recovery time. These parameters are used to determine that the quality of the ring protection is not lower than the quality of the main network.

The rest of this paper is organized as follows: in Section 2 the implementation of ring protection method on MPLS-TP based network is presented, in Section 3 the RFC 2544 testing method that is used to validate the result is described, in Section 4 the result and analysis are discussed, and in Section 5 the conclusion of this paper is presented.

2. Methodology

2.1 Ring Protection on MPLS-TP Based Network

This section presents the two ring topologies that are used in this research, the main ring topology can be seen in Figure 1.

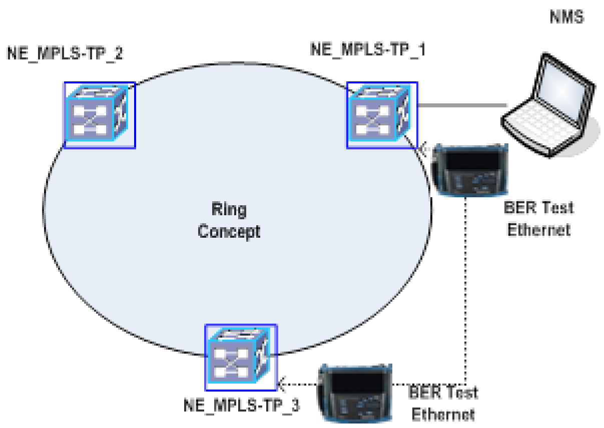

Figure 1. Main Ring Topology

The main ring topology that is used in this research consists of three network elements that support MPLS-TP technologies and an NMS-installed laptop to monitor the parameters. The second topology is the ring protection topology, it is shown in Figure 2.

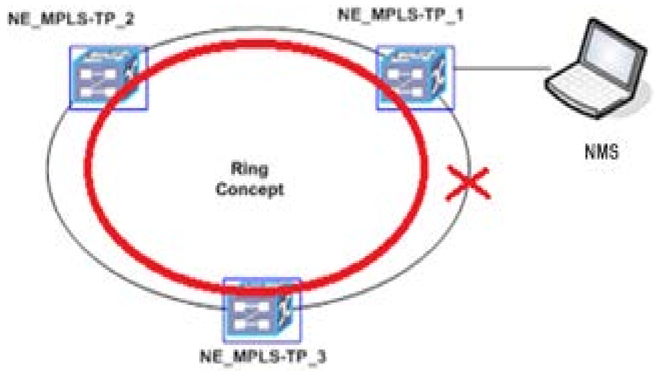

Figure 2. Ring Protection Topology

It can be seen in Figure 2 that the ring protection is presented as a red ring. The ring protection is set to work only when the main ring fails to work. The scenario is the main link between NE_MPLS-TP_1 and NE_MPLS-TP_3 is disabled manually (as shown with red x marks), then the packets will travel on the ring protection network automatically. The NMS is used to measure the QoS on the ring protection network. The next step is, the main ring is enabled once more and the packets switched back to the main ring. The recovery time, which is the time needed for the packets to revert back to the main ring, is measured during this step.

2.2 RFC 2544 Testing

For validating the performance of the MPLS-TP network element, the RFC 2544 Testing of Ethernet Services is used in this research. The RFC 2544 is a standard developed by the Internet international standardization body, the Internet Engineering Task Force (IETF), which contains the necessary testing methods to measure the quality of an Ethernet network. The following parameters are tested to benchmark the network element [9]:

- Throughput
- Latency
- Jitter
- Frame Loss

RFC 2544 test has seven frame lengths for the testing process, there are: 64 bytes, 128 bytes, 256 bytes, 512 bytes, 1024 bytes, 1280 bytes and 1518 bytes. The purpose of the seventh set the frame lengths is to ensure the tested Ethernet network can support all kinds of services, such as VoIP and video streaming.
In [10], the QoS standards for throughput, jitter, and latency have been determined as follows:

Table 1. Standard for Throughput

Category	Throughput
Very Good	75% - 100 %
Good	50% - 75 %
Moderate	25% - 50 %
Bad	< 25%

Table 2. Standard for Jitter

Category	Jitter
Very Good	0 ms
Good	0 – 75 ms

Moderate	75 – 125 ms
Bad	125 – 225 ms

Table 3. Standard for Latency

Category	Latency
Very Good	$t_{end\ to\ end} < 150$ ms
Good	$150 \leq t_{end\ to\ end} \leq 300$ ms
Moderate	$300 < t_{end\ to\ end} \leq 450$ ms
Bad	$t_{end\ to\ end} > 450$ ms

Meanwhile, according to the ITU-T standard, the G 803.2, on Ethernet ring protection switching, it is mentioned that the standard recovery time is less than 50 ms.

3. Results and Analysis

The first testing process performed on the main ring network as shown in Figure 1, it has been mentioned in Section 3 that the testing process refers to the RFC 2544 standard, and there are seven tested frame lengths: 64 bytes, 128 bytes, 256 bytes, 512 bytes, 1024 bytes, 1280 bytes and 1518 bytes. The parameters that are obtained on the testing process are the utilization of the throughput, frame loss ratio, jitter, and latency, and the results are shown in Table. 4 to Table 8.

Table 4. Throughput on the Main Ring Network_1

Frame Length (Byte)	Plan Link		MPLS-TP_1		MPLS-TP_2	
	Throughput (Mbps)	Utilization (%)	Throughput (Mbps)	Utilization (%)	Throughput (Mbps)	Utilization (%)
64	240	100.00%	240.00	100.00%	240.00	100.00%
128	240	100.00%	240.00	100.00%	240.00	100.00%
256	240	100.00%	240.00	100.00%	240.00	100.00%
512	240	100.00%	240.00	100.00%	240.00	100.00%
1024	240	100.00%	240.00	100.00%	240.00	100.00%
1280	240	100.00%	240.00	100.00%	240.00	100.00%
1518	240	100.00%	240.00	100.00%	240.00	100.00%

Table 5. Throughput on the Main Ring Network _2

Frame Length (Byte)	Plan Link		MPLS-TP_3	
	Throughput (Mbps)	Utilization (%)	Throughput (Mbps)	Utilization (%)
64	240	100.00%	240.00	100.00%
128	240	100.00%	240.00	100.00%
256	240	100.00%	240.00	100.00%
512	240	100.00%	240.00	100.00%
1024	240	100.00%	240.00	100.00%
1280	240	100.00%	240.00	100.00%
1518	240	100.00%	240.00	100.00%

Table 6. Frame Loss Ratio

Frame Length (Byte)	Plan Link		MPLS-TP_1, MPLS_2, and MPLS_3		Frame Loss Ratio
	Throughput (Mbps)	Utilization (%)	Throughput (Mbps)	Utilization (%)	
64	240	100.00%	240.00	100.00%	0.00%
128	240	100.00%	240.00	100.00%	0.00%
256	240	100.00%	240.00	100.00%	0.00%
512	240	100.00%	240.00	100.00%	0.00%
1024	240	100.00%	240.00	100.00%	0.00%
1280	240	100.00%	240.00	100.00%	0.00%
1518	240	100.00%	240.00	100.00%	0.00%

Table 7. Jitter on the Main Ring Network

Maximum (ms)	Minimum (ms)	Current (ms)	Average (ms)	Estimate (ms)	Category
0.015	0.015	0.015	0.015	0.015	0 – 75 ms (Good)

Table 8. Latency on the Main Ring Network

Frame Length (Byte)	Latency (ms)	Category
64	0.0078	< 150 ms (Very Good)
128	0.0088	< 150 ms (Very Good)
256	0.0105	< 150 ms (Very Good)
512	0.0128	< 150 ms (Very Good)
1024	0.0173	< 150 ms (Very Good)
1280	0.0199	< 150 ms (Very Good)
1518	0.0218	< 150 ms (Very Good)

From the above result, in which the data flowing on the main ring network, it is shown in Table 4 and Table 5 that the throughput utilization reached 100% for all MPLS-TP element, consequently, the loss is 0% (as seen in Table 6). Therefore, it can be concluded that the achieved throughput is in accordance with the expected throughput, and there is no loss in the data transmission. Table 7 shows that the value of jitter is 0.15 ms, it is in accordance with the standard at [10], and it is categorized as Good (0-75 ms). The latest parameter is latency, it can be seen in Table 8 that the latency value varies according to the frame length, with the minimum latency is 0.0078 ms and the maximum latency is 0.0218 ms, according to [10], the value of this latency meet category Very Good (less than 150 ms).

In the last testing process, the performance of the ring protection method to maintain the quality of the MPLS-TP is evaluated. The design of ring protection on MPLS-TP can be seen in Figure 2.
The results of measurements of the throughput, loss, jitter, and latency on the ring protection network can be seen in Table 9 to Table 13, in addition to these parameters, the recovery time, the time needed to revert back to the main ring network, also being tested, the result can be seen in Table 14.

Table 9. Throughput on the Protection Ring Network _1

Frame Length (Byte)	Plan Link		MPLS-TP_1		MPLS-TP_2	
	Throughput (Mbps)	Utilization (%)	Throughput (Mbps)	Utilization (%)	Throughput (Mbps)	Utilization (%)
64	240	100.00%	240.00	100.00%	240.00	100.00%
128	240	100.00%	240.00	100.00%	240.00	100.00%
256	240	100.00%	240.00	100.00%	240.00	100.00%
512	240	100.00%	240.00	100.00%	240.00	100.00%
1024	240	100.00%	240.00	100.00%	240.00	100.00%
1280	240	100.00%	240.00	100.00%	240.00	100.00%
1518	240	100.00%	240.00	100.00%	240.00	100.00%

Table 10. Throughput on the Protection Ring Network _2

Frame Length (Byte)	Plan Link		MPLS-TP_3	
	Throughput (Mbps)	Utilization (%)	Throughput (Mbps)	Utilization (%)
64	240	100.00%	240.00	100.00%
128	240	100.00%	240.00	100.00%
256	240	100.00%	240.00	100.00%
512	240	100.00%	240.00	100.00%
1024	240	100.00%	240.00	100.00%
1280	240	100.00%	240.00	100.00%
1518	240	100.00%	240.00	100.00%

Table 11. Loss on the Protection Ring Network

Frame Length (Byte)	Plan Link		MPLS-TP_1, MPLS_2, and MPLS_3		Frame Loss Ratio
	Throughput (Mbps)	Utilization (%)	Throughput (Mbps)	Utilization (%)	
64	240	100.00%	240.00	100.00%	0.00%
128	240	100.00%	240.00	100.00%	0.00%
256	240	100.00%	240.00	100.00%	0.00%
512	240	100.00%	240.00	100.00%	0.00%
1024	240	100.00%	240.00	100.00%	0.00%
1280	240	100.00%	240.00	100.00%	0.00%
1518	240	100.00%	240.00	100.00%	0.00%

Table 12. Jitter on the Protection Ring Network

Maximum (ms)	Minimum (ms)	Current (ms)	Average (ms)	Estimate (ms)	Category
0.015	0.015	0.015	0.015	0.015	0 – 75 ms (Good)

Table 13. Latency on the Protection Ring Network

Frame Length (Byte)	Latency (ms)	Category
64	0.0076	< 150 ms (Very Good)
128	0.0083	< 150 ms (Very Good)
256	0.0103	< 150 ms (Very Good)
512	0.0126	< 150 ms (Very Good)
1024	0.0171	< 150 ms (Very Good)
1280	0.0190	< 150 ms (Very Good)
1518	0.0215	< 150 ms (Very Good)

Table 14. Recovery Time

Frame Length (Byte)	Recovery Time (ms)	Category
64	48.111	≤ 50 ms (In accordance with the standard)
128	48.341	≤ 50 ms (In accordance with the standard)
256	48.445	≤ 50 ms (In accordance with the standard)
512	48.785	≤ 50 ms (In accordance with the standard)
1024	49.103	≤ 50 ms (In accordance with the standard)
1280	49.411	≤ 50 ms (In accordance with the standard)
1518	49.588	≤ 50 ms (In accordance with the standard)

In the last testing process, where the data packets are routed from the main ring network into the ring protection network due to the failure on the main ring network, it can be seen in Table 9 to Table 12 that the value of throughput, loss ratio, and jitter on the ring protection network are equal to the value on the main ring network, moreover, Table 13 shows that the latency on the ring protection network does not have a significant difference to latency on the main ring network, therefore, it can be concluded that the protection ring network is capable of maintaining network performance even though the main ring network is currently unavailable. In addition, Table 14 shows that the recovery time, the duration to switch back from the ring protection network to the main ring network is in accordance with the standard ITU-T G803.2, all the values are less than 50 ms.

4. Conclusion

To conclude from the above results, the ring protection method is able to maintain the quality of the MPLS-TP based network when the data packets are switched to the ring protection network due to failure on the main ring network. The value of the QoS parameters of the ring protection network, such as throughput, loss, and jitter are similar to the main ring network, the throughput utilization is 100%, the frame loss ratio is 0%, jitter is 0.015 ms. The latency on the ring protection is a little different than the latency on the main ring, however, both are still categorized as Very Good (less than 150 ms). The last parameter that is measured is the recovery time, which is the time needed to switch back to the main ring network, the recovery time for each frame length is different, ranging from 48.111 ms to 49.588 ms, however, it is still in accordance with the standard that must be below 50 ms.

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