Measurement of OSPF-MPLS-TE-FRR Line Transitions and Data Losses

M. Oğul, N. Akçam, N. Erkan

Abstract— **In this paper, when using Open Shortest Path First (OSPF) and Multi Protocol Lable Switching-Traffic Engineering (MPLS-TE) in Internet Protocol (IP) packet switching networks recover time was tested and compared and during that time amount of data lost in case of the link overload and failure. For the accuracy of measurements, two different traffic generators were used and the differences were compared. One of them is Simena device and the other one is a Hping3 program working with Linux platforms. Line transitions and data losses were measured seperately with Simena and Hping3, calculations were performed and results were compared.**

Index Terms— **Multi Protocol Lable Switching (MPLS), Traffic Engineering (TE), Fast Reroute (FRR), Open Shortest Path First (OSPF)**

I. Introduction

NOWADAYS, continuity of IP (Internet Protocol) networks, used to transport a variety of data on the same physical environments, detection of alternative ways at the time of issue and minimizing data loss have become critical.

In traditional routing protocols, because of the long duration of making alternative solution at the time of issue, during this time, as a serious loss of data and also reputation has been experienced, this problem has been reduced significantly thanks to MPLS (Multi-Protocol Lable Switching) technology. In addition, the transmission of critical data without discarding in the line traffic resulting with different reasons at networks carrying critical data and normal data simultaneously, has gained importance.

Indispensability of TCP / IP results from its flexible configuration, based on packet switching technology[1-3]. As many applications only can run on circuit-switched systems in the past, today is run over IP. In contrast to the bus that packets will be sent in circuit switching, is determined in advance, there is no such a necessity in packet switching. Today, of course, there are circuit-switched configurations, however, packet-switched networks and the Internet, the largest of them are so developing that almost all types of communication take place via the Internet, a packet-switched configuration.

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II. Previous Works

OSPF routing protocol are the most important of the IGP (Interior Gateway Protocol) protocols [4]. Although it mostly compares with the RIP (Routing Information Protocol) protocol in terms of their technology used, that is far superior protocol than RIP protocol. As RIP determines routing tables with the logic of the distance vector, OSPF determines routing tables according to the link mode algorithm.

QoS (Quality of Services) on IP networks, simply, can be defined as sorting according to certain criteria of IP packets and discriminating to the parsed IP packets. On IP networks, there are two different QoS mechanisms as IntServ and DiffServ. In today's IP networks, in case of not being used any QoS mechanism, “best-effort” treated accordingly to the packages. All the received packages in 'Best-effort' are treated as a single cluster regardless of the traffic characteristics. Each received package is tried to be sent without decomposition of data type [5-6]. Each traffic type in IntServ is edited the necessary resource allocation from end to end along the bus until reaching the target before receiving to the IP network. In DiffServ, instead of the resource allocation from end to end for each traffic type, classification is made between types of traffic. These types of traffic are processed by providing the necessary resource in each node (hop / router).

MPLS is a quite new mechanism for package transmission than the IP that has the label switching. When the configuration of the OSI (Open System Interconnection) layer is considered, MPLS label is located between layer 2 and layer 3. Packages are transmitted by using the label information which is smaller than IP. Label information depending on the use, may also be appropriate for some criteria such as QoS and source IP as well as the target IP. MPLS is used for not only IP packets, but also transmission of the other protocol packets, running in layer 3 [7,8].

TE (Traffic Engineering) that comes with MPLS is probably one of reasons about the most used of MPLS. It can be said that TE is a transaction, controlling the effective use of resources and increasing of network performance when sending the data traffic across the network [9]. In environments that classic routing algorithms are used with TE, the observed two questions will be gotten over. One of them is the risk of using the buses, defined as the shortest bus, although they are not more available than the longest buses. The other one, as a result of the use of the shortest bus, is the blockage of the buses and despite of continuing of the blockage, non-using of available alternative buses.

One of the key points is also using of RSVP (Resource Reservation Protocol) signaling [10] in the MPLS-TE. RSVP signaling is also used in this study.

In addition, when carrying the data from high-capacity lines, in the issues of link or node, in order to minimize the risk of cuts, either one-to-one link back-up must be kept or MPLS-TE stand-by tunnels must be formed. Keeping a backup of high-capacity circuits are highly cost solution. Instead, forming of MPLS-TE tunnel backups would be much cheaper and flexible solution. Link Protection with MPLS-TE is called as FRR [11]. There are two types as Link Protection (LP) and Node Protection (NP) of FRR.

III. The Test Network

The experiments presented in this article were conducted on a real-life research test network is shown in Fig.1. The network was built in laboratory and consisted of three Cisco 12000 Series director (GSR) [12], two Cisco 3560 Series Ethernet key, two traffic generator (Simena), two testPC. We used Hping3 utility program in testPC's. The routers are made with a variety of chassis sizes and types. Technical properties of GSR 12000 routers series is given in Table I.

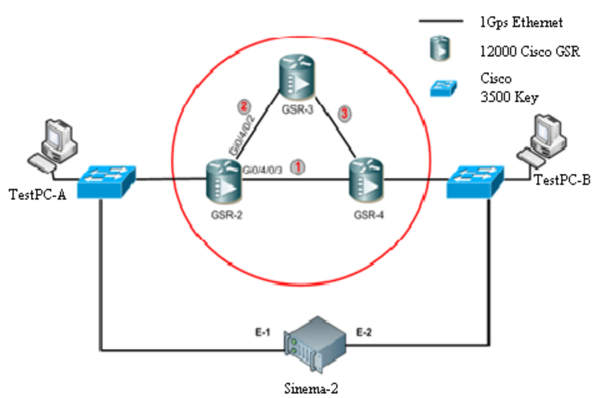

Fig.1. Experimental service setup (Network Topology)

TABLE I
Technical properties of GSR 12000 routers series

CİSCO 1200 family	CİSCO 12004	CİSCO 12008	CİSCO 12012
Bandwidth	5 Gbps	10-40 Gbps	15 to 60 Gbps
Configurable Chassis Slots	4	8	12
Configurable Switch Fabric Slots	1	5	5
Maximum Line Card Support	3	7	11
OC-3/STM-1 Ports[1]	12	28	44
OC-12/STM-4 Ports[1]	3	7	11
Redundancy Options	GRP, Line Card, Power	GRP, Line Card, Power, Fans, Fabric	GRP, Line Card, Power, Fans, Fabric

For the accuracy of measurements, two different traffic generators were used and the differences were compared. One of them is Simena device and the other one is a Hping3 program working with Linux platforms.

IV. Measurement And Calculation

IV.1. Measurement of OSPF+MPLS-TE-FRR Line Transitions and Data Losses

In each of 3 router in Fig.1., OSPF is used as routing protocol. Besides, MPLS-TE and FRR spesifications of routers were activated in order to minimize the datalosses during interruption and quick package switching. Through MPLS-TE-FRR, alternative tunnel definition is performed for the (1) numbered way of the topology in Fig.1., and it traffic's routing directly to backup tunnel was provided in case of an interuption in this way. In definitions of primary tunnel and backup tunnel, Label Switched Path **(**LSP) way was cleared by giving IP's of each of routers on LSP. During tests, because of the importance of configuration on GSR2, MPLS and OSPF configurations are given below. Line transitions and losses were measured seperately with Simena and Hping3, calculations were performed and results were compared.

```
→ explicit-path name explicit_tunnel-te24 → Way definition for TE tunnel
!Primary link
index 10 next-address strict ipv4 unicast 1.1.1.3
index 20 next-address strict ipv4 unicast 10.200.100.12
!
→ explicit-path name explicit_tunnel-te234 → Way definition for backup TE Tunnel
index 10 next-address strict ipv4 unicast 2.2.2.2
index 20 next-address strict ipv4 unicast 3.3.3.3
!
→ interface tunnel-te24          → TE Tunnel from GSR2 to GSR4
ipv4 unnumbered Loopback0
autoroute announce
→ destination 10.200.100.12      → GSR4's loopback IP
→ fast-reroute                   → If TE24 is down, FRR will be active
path-option 1 explicit name explicit_tunnel-te24
!
→ interface tunnel-te234         → Backup TE Tunnel from XJSR2 to GSR4
ipv4 unnumbered Loopback0
destination 10.200.100.12
path-option 1 explicit name explicit_tunnel-te234
!
router ospf 1
log adjacency changes
router-id 150.1.2.2
area 0
mpls traffic-eng                 → MPLS TE tunnels will be used in OSPF
interface Loopback0
!
interface GigabitEthernet0/4/0/0
passive enable
dead-interval 4
hello-interval 1
!
interface GigabitEthernet0/4/0/1
dead-interval 4
hello-interval 1
!
interface GigabitEthernet0/4/0/2
network point-to-point
passive disable
dead-interval 4
hello-interval 1
!
```

interface GigabitEthernet0/4/0/3
network broadcast
passive disable
dead-interval 4
hello-interval 1
!
mpls traffic-eng router-id Loopback0
mpls traffic-eng multicast-intact
!
→ rsvp → *It leads TE and FRR labels to be delivered.*
interface GigabitEthernet0/4/0/2
!
interface GigabitEthernet0/4/0/3
!
→ mpls traffic-eng → *Interfaces which are MPLS TE will be active*
interface GigabitEthernet0/4/0/2
!
interface GigabitEthernet0/4/0/3
→ backup-path tunnel-te 234 → *If Gİ0/4/0/3 interface is interrupted, the traffic will be routed to TE234 tunnel*

In configuration of GSR2 Router, two TE tunnels, named “tunnel-te 24” and “tunnel-te 234”, were created, because there were two alternative ways from GSR2 to GSR4. The start point of both of two tunnels was determinated as GSR2 and endpoint was determinated as GSR4. The interfaces of these additional new tunnels must be inside of OSPF, because tunnels were added as new interfaces. In MPLS configuration; the interfaces, which will be made TE, was detected and transition tunnel information (backup-patlı tunnel-te 234) was entered, in case of an interruption in primary used one of these interfaces. According to this; GSR2 router will use GiO/4/0/3 interface and naturally "tunnel-te24" tunnel, already related with this interface, for packages to TestPC-B. When any information of interruption on this interface is delivered to the router, router will use the tunnel-te234 because router sees interface an tunnelinterface as “down”. It will do it by using FRR method. So, quickly routing can be performed in miliseconds, in case of any interruption. Line transition time is guarantied as under 50 ms on MPLS-TE-FRR used area [10-11].

A. *QSPF+MPLS-TE-FRR Transition Time Measurements and Calculations with Hping3 Program.*

In Fig.1. topology, while using of OSPF+MPLS+TE+FRR between routers; whereas 1Gbps speeded (1) numbered way was primary way of the traffic from TestPC-A to TestPC-B, traffic’s transition time to alternative ways (2) and (3) were calculated with Hping3 program by interrupting (1) numbered way. In Fig.2., two results of OSPF+MPLS+TE+FRR measurements is shown and calculations with results in Table II.

The second measurement in Fig.2. was completed in 9,061 second. According to this; 2000/9,06sn=~247 packages was sent per second and 1 of them was lost. According to 247 packages is sent per second, 1 package is sent in l/247=~0,00404 sn=4,04ms. All of the test results and calculated transition times are shown in Table II. According to these results, MPLS-TE-FRR's average transition time was calculated as 4,5ms. Besides, all of the calculated transition times are shown in Figure 3.

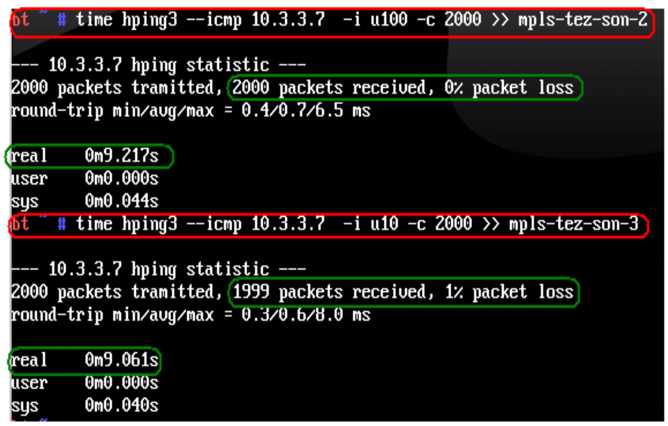

Fig.2. Hping3 OSPF +MPLS +TE+FRR transition test results screen

As seen in Table II; because of package sending rareness of measurements with Hping3, sampling interval is wide. Naturally, package loss cannot be detected and transition time is calculated as 0 in some tests, because of sensitive tests performing.

TABLE II
OSPF-MPLS-TE-FRR MEASUREMENT AND CALCULATING RESULTS WITH HPING3

Hping3 OSPF-MPLS-TE-FRR	Test1	Test2	Test3	Test4	Test5	Test6	Test7	Test8	Test9	Test10
Transmitted Packet Number	2000	2000	2000	2000	2000	2000	2000	2000	2000	2000
Received Packet Number	1999	2000	1999	1999	1999	1999	1999	1999	2000	1999
Loss Packet	1	0	1	1	1	1	1	1	0	1
Transmit Time (sn)	8,091	9,217	9,061	9,82	9,08	9,127	9,076	9,147	9,362	9,582
Transmitted Packet / 1 sn	247,1	216,9	220,7	203,6	220,2	219,1	220,3	218,6	213,6	208,7
Transit Time ~ (ms)	4,04	0	4,53	4,91	4,54	4,56	4,53	4,57	0	4,79

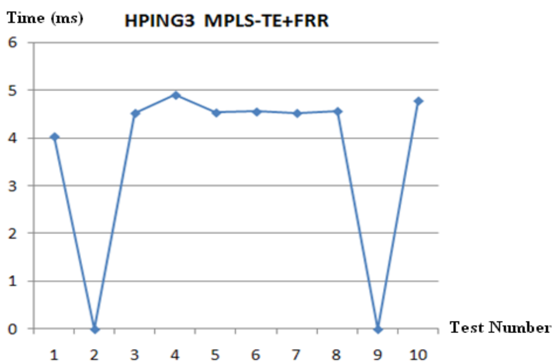

Fig.3. Hping3 OSPF +MPLS +TE+FRR calculated transit time

B. OSPF+MPLS-TE-FRR Transition Time Measurements and Calculations with Simena.

By using hand interface of Simena-2 machine which seems in Fig.1., TCP packages were sent to Simena's E2 interface through GSR2 and after the start of sending, packages losses were measured with Simena by interrupting of 1 numbered line. Transition times were calculated by using these results;

In Test-1, 2.000.000 TCP packages were sent by hand interface with l00.000 pps speed and 1.977.799 packages were received from E2 interface. During transition, 201 packages were lost. According to 100.000 packages sending per second, sending time for 201 packages is 201/100.000=0,00201s=2,01ms. In Table III, measurement results for different packages numbers and speeds and transition times calculated from these results, are shown. Besides, all of the calculated transition times are shown in Fig. 4. sampling interval is closer than done with Hping3, because packages can be sent by Simena with different speeds and between 100.000 and 10.000.000 per second. So, the measurements and calculations are more sensitive.

TABLE III
OSPF-MPLS-TE-FRR MEASUREMENT AND CALCULATING RESULTS WITH SIMENA

Simena OSPF-MPLS-TE-FRR	Test-1	Test-2	Test-3	Test-4	Test-5	Test-6	Test-7	Test-8	Test-9	Test-10
Transmitted Packet(x1000)	2.000	2.000	6.000	6.000	10.000	10.000	1.000	1.000	100	100
Received Packet	1.999.799	1.999.800	5.999.400	5.999.425	9.999.040	9.998.546	999.899	999.920	99.985	99.990
Loss Packet	201	200	600	575	960	1.454	101	80	15	10
Packet Transmit Velocity (pps)	100.000	100.000	300.000	300.000	500.000	500.000	50.000	50.000	5.000	5.000
%Packet Loss	0,01	0,01	0.01	0.009	0.0090	0.014	0.01	0.0080	0.015	0.01
Transit Time (ms)	2,01	2	2	1,916	1,92	2,908	2,02	1,6	3	2
Packet Size (byte) (TCP)	120	120	120	120	120	120	120	120	120	120

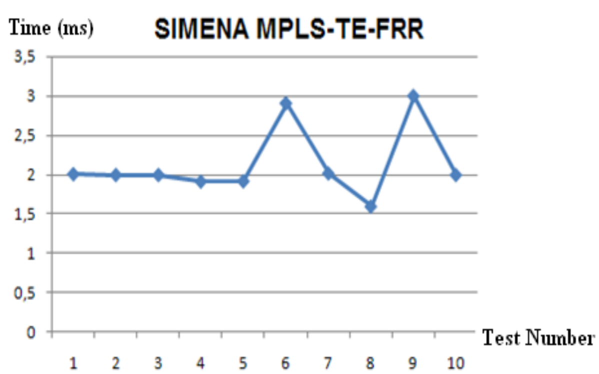

Fig.4. Simena OSPF-MPLS-TE-FRR calculated transit time

Package losses are not so much, because MPLS-TE-FRR transitions take very little time. So difference between Simena transmission and receiving interfaces, which is shown in Fig.5., are little as indistinguishable.

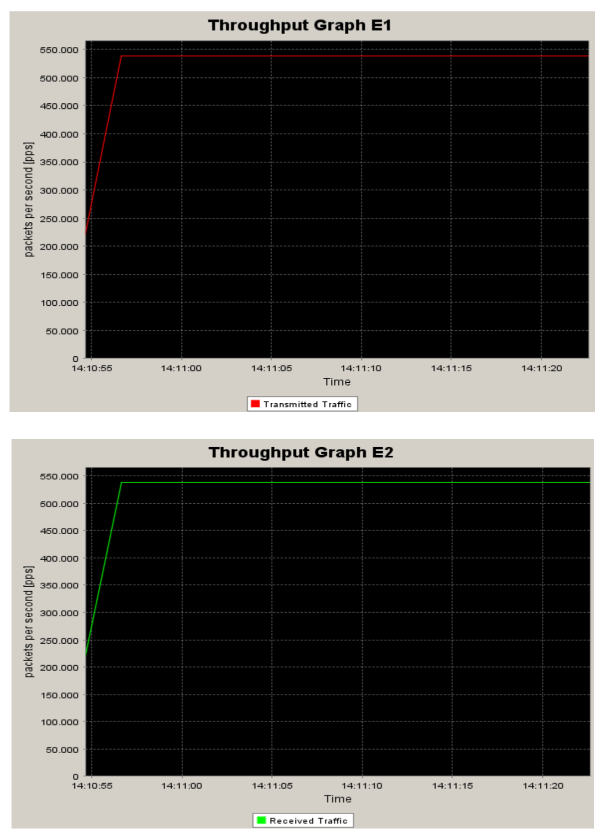

Fig.5. Transmission and recieving screens during Simena OSPF-MPLS-TE-FRR transition

IV.2. Comparing Transition Times of OSPF and OSPF+MPLS-TE-FRR

In measurements and calculations with Hping3 and Simena, both of two results are seen as close to each other. But measurement results of Simena are thought as more sensitive, because more packages can be sent in less time with Simena. In Fig.6., OSPF [13] and OSPF-MPLS-TE-FRR's calculated transition times were compared.

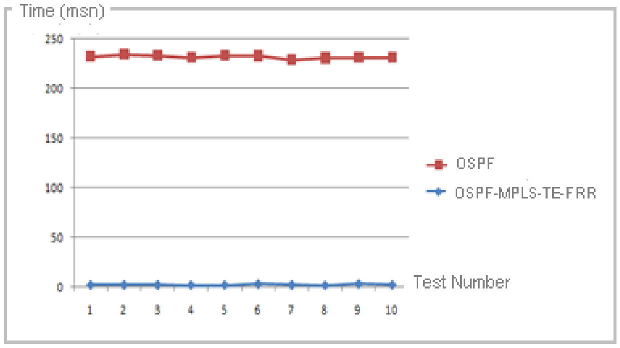

Fig.6. Comparative results of OSPF and OSPF-MPLS-TE-FRR's transition time

V. CONCLUSION

In this study, "data losses and transition time to backup line in line interruptions of OSPF, which is the most common used routing protocol," and "data losses and transition time to backup line when MPLS-TE-FRR technology is used" were compared. Also, protections of critical data were evaluated, in case of a capacity overflow in line without any interruption.

Protection of critical data was transition time to backup line is circa 220msn, when just OSPF protocol was used and there was an interruption in line. But it is 2ms in MPLS-TE-FRR and this is interesting. MPLS-TE-FRR technology guaranties the transition time under 50ms [14]. The reason of longer time in OSPF is the rerunning of Dijkstra algorithm and finding the alternative ways. Extending of line transmission time leads data losses, and naturally costumers' dissatisfaction and low quality service. Besides, one of the most common problems in shared areas is the line forcement to carry over its capacity. In this case, manufacturers generally junk the last coming packages as default evaluated, in case of a capacity overflow in line without any interruption.

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REFERENCES

[1] L. Parziale, D.T. Brit, C. Davis, J. Forrester, W. Liu, C. Matthews, N. Rosselot, TCP/IP Tutorial and Technical Overview Eight Edition // IBM, USA, 2006.

[2] J. Doyle, "Routing TCP/IP Volume I", Cisco Press, USA, 1998, pp.9-357.

[3] M. G. Naugle, Illustrated TCP/IP, John Wiley & Sons, USA, 1998, pp.62-64.

[4] K. Mishra and A. Sahoo, S-OSPF: A Traffic Engineering Solution for OSPF based Best Effort Networks, IEEE GLOBECOM 2007 proceedings, 2007, pp.1845–1849.

[5] C. Hattingh and T. Szigeti, End-to-End QoS Network Design: Quality of Service in LANs, WANs, and VPNs, CiscoPress, USA, 2004, pp.44.

[6] M. Tanvir, A. M. Said, Decreasing packet loss for QoS sensitive IP traffic in DiffServ enabled network using MPLS-TE, Information Technology (ITSim), 2010 International Symposium 15-17 June 2010, Vol.2, pp.789-793.

[7] T. Barabas, D. Ionescu, S. Veres, PIM-SSM within DiffServ-aware MPLS traffic engineering, 6th IEEE International Symposium on Applied Computational Intelligence and Informatics, Timişoara, Romania, May 19–21, 2011, pp.263–268.

[8] D. Awduche, MPLS and traffic engineering in IP networks, IEEE Communications Magazine, No.12 (37). 1999, pp.42–47.

[9] D. Awduche, J. Malcolm, J. Agogbua, M. O'Dell, J. McManus, Requirements for Traffic Engineering Over MPLS, RFC 2702, 1999.

[10] R. Braden, Ed., L. Zhang, S. Berson, et al., Resource ReSerVation Protocol (RSVP), RFC 2205 ,Version 1, 1997.

[11] L.D. Ghein, MPLS fundamentals: forwarding labeled packets, Cisco Press, USA, 2007.

[12] N. Akçam, M. Ogul, Optimizing Data Transport by Using MPLS-TE-FRR and QoS., International Journal on Communications Antenna and Propagation ,Vol. 2, N. 5, October 2012, pp.283-289.

[13] N. Akçam, M. Ogul, "Measurement of OSPF line transitions and data losses", Energy Education Science and Technology Part A: Energy Science and Research 2012 Volume (issues) 29(2), pp.979-988

[14] Liotine, M., "Mission-critical network planning", Artech House Inc., USA, 100, 2003.

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