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Opnet Analyze for FTP and Video Networktraffic using IP over MPLS Protocol

MPLS provide an efficient forwarding mechanism, scalability with an important role in switching and routing of packets through the next step in networking evolution, in order to meet the most complex service demands for these users. In this paper we analyze the performance impact of FTP and Video traffic for mpls network and conventional IP network, using Opnet Modeller for simulations. The simulation results are analyzed, showing that MPLS based solution provide a better performance for the traffic over the network.

Keywords*: MPLS, IP, Opnet, FTP, Video.*

1. Introduction

In recent years, Internet had an upward trend with an evolution for development of new applications for all around the word customers. These new applications required an increase in bandwidth guaranteed over the networks, with new services that are developed and deployed. Exponentially increasing number of users has led to another challenge about transport of data packets over the network backbone to provide different classes of service and diverse requirements for network users. Multi-Protocol Label Switching (MPLS) was introduced in the late 1990s. In its original RFC 3031 [1] the fundamental concept was to switch packets based on looking up a label in the packet header.

From that concept MPLS has evolved into a successful and flexible networking technology that offers a robust set of services and transport functionalities which are controlled by a common control plane. MPLS is an Internet engineering task force (IETF), specified framework that provides for the efficient designation, routing, forwarding and switching of traffic flows through the network [2]. As in RFC 3031 [1], MPLS stands for "Multiprotocol Label Switching”, multiprotocol because its techniques are applicable to any network layer protocol.

One of the basic principles of MPLS is that packets are switched instead of routed. When a packet enters the service provider network from a customer, it is unlabeled IP. The router at the edge of the service provider network accepts the incoming unlabeled packet and applies a label [3]. The newly labeled packet follows an LSP through the service provider network and is label-switched, not forwarded. When the packet leaves the MPLS-enabled service provider network, the label is removed and it again becomes an unlabeled IP packet [4].

A particularly aspect of MPLS is that it efficiently supports origination connection control through explicit label switched paths. MPLS is an advanced forwarding scheme that performs on these functions:

- Specifies mechanisms to manage traffic flows between different network components, hardware or different applications.
- MPLS provides tunneling of packets from an ingress point to an egress point, so the VPN applications that leverage this capability can be created easily.
- Remains independent of the layer2 and layer 3 protocols.
- The transport functionality provides options for traffic engineering, guaranteed QoS, fast protection and restoration.
- MPLS routing increase performance because it replace traditional routing at a much higher switching speed.

Because the MPLS headers are not part of the network layer packet or the data link layer frame, MPLS is to a large extent independent of both layers. Among other things, this property means it is possible to build MPLS switches that can forward both IP packets and ATM cells, depending on what shows up. This feature is where the "multiprotocol" in the name MPLS came from.

By using MPLS with IP, we can extend the possibilities of what we can transport over the network. Adding labels to the packets enables the carry of other protocols than just IP over an MPLS enabled Layer 3 IP backbone, similarly to what was previously possible only with Frame Relay or ATM Layer 2 networks. MPLS can transport IPV4, Ethernet, high-level data link control (HDLC), PPP and other Layer 2 technologies [5].

2. Related work

In [6], a comparative analysis of MPLS over IP networks is presented, where MPLS have a better performance comparing IP network. Analyze of IP, MPLS and ATM based on network core is presented in [7], with better results for ATM and MPLS in term of delay and response time to exposed data. QoS over MPLS, when using traffic engineering is presented in [8], studying the effect of using traffic trunks to separate TCP and UDP flows. The QoS performance study, in terms of Packet Delay Variation (PDV) over DiffServ with or without MPLS TE in IPv4/IPv6 networks is presented in [9], where usage of IPv6 performs better than IPv4.

3. Protocols concept

For MPLS, data transmission occurs on label switched paths (LSPs). LSPs are the path trough the MPLS network, or a part of this path, that packet takes from the source to the destination. These labels are established before starting data transmission, or after detection of a particularly flow of data. Data switching at a high speed will occur in the network, because labels with a fixed length are entered at the beginning of the packet, causing the hardware equipment to switch packets very fast between links [2]. MPLS is the latest step in the evolution of technology switching/routing for Internet, using a solution that integrates IP routing control, as well as switch-level data link (level 2 of the OSI model). The basic idea for MPLS is to add short fixed length labels to IP packets that can be used by the forwarding engines in the network to simplify packet forwarding.

MPLS protocol mechanism includes devices that can be categorized into label edge routers (LERs) and label switched routers (LSRs). LERs are divided in ingress LER, which receive a packet that is not labelled, insert a label and send it to a data link to the MPLS network, after establishing LSPs. The egress LER, receives labelled packets, remove the label, and send them on a data link. The LERs have a very important role in adding and removing of labels, as traffic enters or exits an MPLS network [10]. An LSR is a high speed router device in the core of MPLS network that participate in the establishment of LSPs using the appropriate label signaling protocol at a high speed switching of the data traffic based on the established paths [2].

LSRs can do three operations: pop – removing the labels from the top of label stack before switching the packet out; push – if the received packet is already labeled, LSR pushes one or more labels onto the label stack and switches the packet out; swap – if a labeled packet is received, the top label of the stack is swapped with a new label, and the packet will be switched on the outgoing link [11].

The forward equivalence class (FEC) represents a group of packets that share the same requirements to be transported, all packets in the same FEC will be treated the same when routing to the destination. FECs are based on service requirements for a given set of packets or for an address prefix. In MPLS, traffic trunk is an aggregation of traffic flows with the same class, which are placed inside an LSP [12]. Traffic trunks can be established statically or dynamically between two nodes in an MPLS domain, where all packets that share the traffic trunk will have the same label.

4. Simulated network topology

In this paper, we used Opnet Simulator, a real time simulator specifically designed for network design and analysis, to compare these protocols, when considering a hypothetical network model. The core of the network consists of a number of routers, with two types of traffic: FTP and Video on client sides with two corresponding servers on the other side. Figure 1 shows the MPLS network model, with the elements:

- 2 LERs (Ingress R1 and Egress R4).
- 4 LSRs (R2, R3, R5 and R6).
- 2 stations and 2 servers (FTP and Video).
- 2 Switches (S1 and S2).

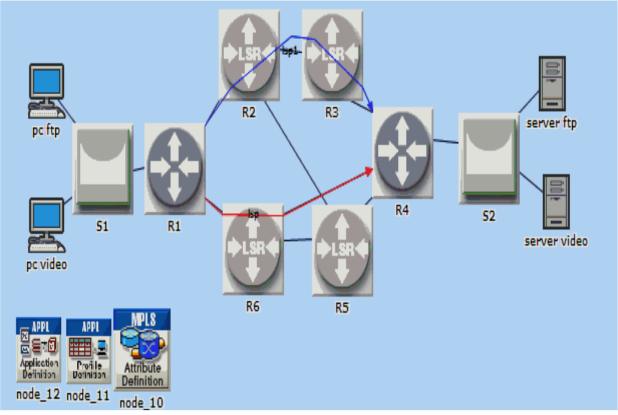

Figure 1. MPLS network model

We used DS3 (44.736 Mbps) to connect switches and routers, and DS1 (1.544 Mbps) to connect stations and servers to the switches. For the IP conventional model, MPLS routers where replaced with normal IP routers, which doesn't support MPLS technology. We have one Application Definition (Node_12), where are defined parameters for FTP application (high load with exponential distribution for packet arrival and best effort type of service) and parameters for Video application (VCR Quality Video with 30 frames/sec arrival rate).

The Profile Definition (Node_11) is use to create users profiles to be specified in different nodes on the network. We have two profiles, one for FTP and one for Video application, which the operation mode set to simultaneous- they can start all at the same time.

In the MPLS Attribute Definition, we have configured two FECs, one for FTP traffic flow and another one for Video traffic that can be treated as a traffic aggregate in the MPLS domain. Here are also configured traffic trunks, one for each FECs defined. Traffic trunks capture traffic characteristics such as peak rate, average rate, and average burst size. On ingress LSR router R1, two static LSPs are created for the MPLS simulation as in Table 1 and Table 2, LSP1 (blue color), R1→R2→R3→R4 and LSP (red color), R1→R6→R4. The LSPs are created independently, specifying different paths that are based on user defined policies.

Table1. Path details for LSP1 (blue color)

Node Name	Interface in	Label in	Interface out	Label out	Label operation
R1	All	Not used	2	16	Push
R2	0	16	1	16	Swap
R3	0	16	1	Not used	Pop

Table2. Path details for LSP (red color)

Node Name	Interface in	Label in	Interface out	Label out	Label operation
R1	All	Not used	4	16	Push
R6	0	16	2	Not used	Pop

5. Simulation result

The simulation time is set for twenty minutes of FTP and Video data transfer between computers and servers in both MPLS and conventional IP scenario. The average bytes per second forwarded to all FTP applications by the transport layers in the network is shown in Figure 2:

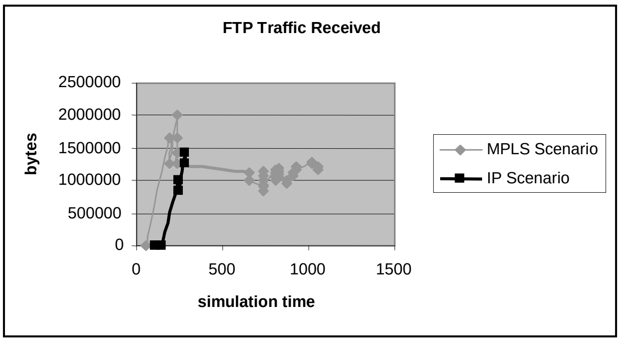

Figure 2. FTP traffic receive

As we can see, for IP scenario, (black color), congestion occurs in the network with a heavy packet dropped and FTP traffic receive stop after first couple minutes of simulation. In Figure 3 we have delay (in seconds) of packets received by the TCP layers in the complete network, for all connections.

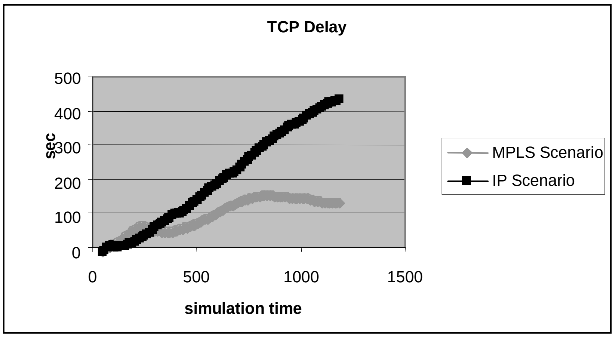

Figure 3. TCP network delay

It is measured from the time an application data packet is sent from the source TCP layer to the time it is completely received by the TCP layer in the destination node. TCP performance is degraded for FTP and Video traffic loads, where delay for IP scenario is increasing till the end of simulation comparing with MPLS scenario, where TCP delay is less than 100 second.

If we increase the file size for FTP transfers to 5000000 bytes and reduce the inter-request time to an exponential growth of 120 seconds, which represent the amount of time between file transfers, the results shown that MPLS scenario has better results than IP scenario, where time got higher values at the end of simulation, as in Figure 4:

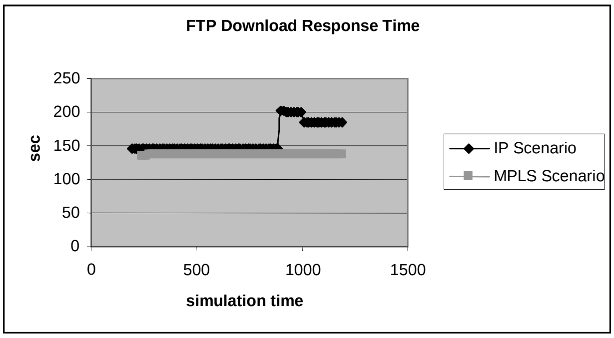

Figure 4. FTP downloads time

By isolating traffic flows in MPLS scenario using LSPs between R1 and R4, the IP traffic receive for video data transfer that video server receive is pointed in Figure 5. Even if we increase the UDP source rate (pc video in our case), the MPLS scenario will have a better results video data transfer over the network.

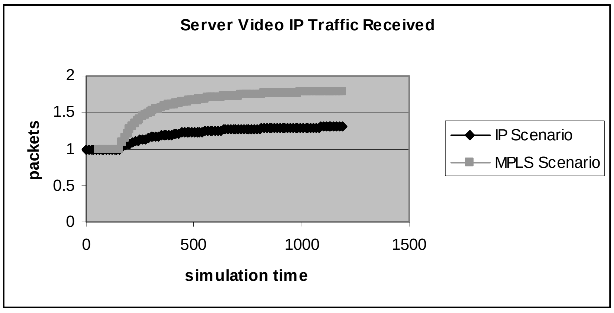

Figure 5. IP traffic receive by the video server

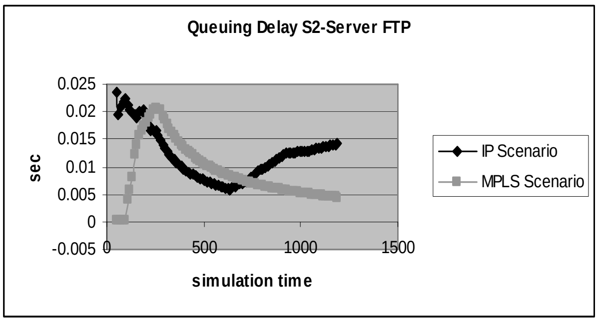

Figure 6. Queuing delay between S2 an server FTP

The queuing delay between switch S2 and server FTP is presented in Figure 6. This statistic represents instantaneous measurements of packet waiting times in the transmitter channel's queue. Measurements were taken from the time a packet enters the transmitter channel queue to the time the last bit of the packet is transmitted. The use of LSPs in MPLS scenario offer an lower delay comparing with standard IP scenario where is a less control over the specific paths that packets traverse the network, paths that are typically subject to delay and packet loss. The utilization of the link between Video Server and switch S2 is shown in Figure 7, where, for IP scenario, the percentage of the consumption to date indicates almost full usage for this link.

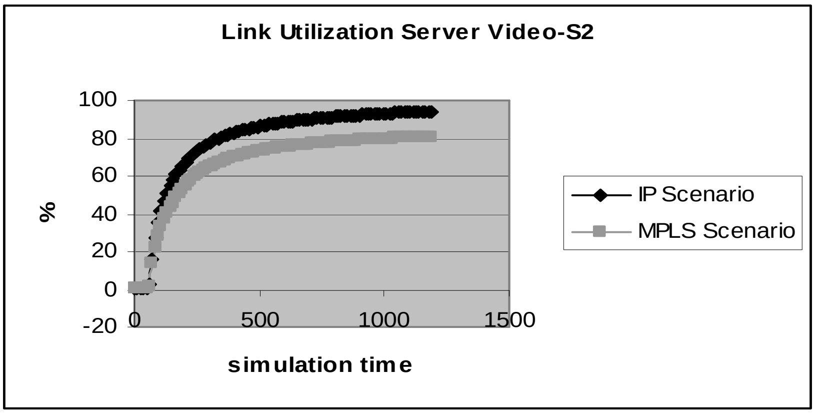

Figure 7. Link utilization between Server video and S2

This statistic represents instantaneous measurements of packet waiting times in the transmitter channel's queue. Measurements were taken from the time a packet enters the transmitter channel queue to the time the last bit of the packet is transmitted. The use of LSPs in MPLS scenario offer an lower delay comparing with standard IP scenario where is a less control over the specific paths that packets traverse the network, paths that are typically subject to delay and packet loss.

6. Conclusions and future work

Using simulation analysis, our scenarios have demonstrated that MPLS provide a considerable advantage for traffic engineering when compared with traditional IP networks. The performance metrics obtained from simulation shows that MPLS protocol makes it a better choice in a real time application, like video conferencing, where traditional IP networks encounter high packet loss and more delays which are unacceptable for this kind of applications.

MPLS seems to perform better than IP when traffic is mixed along the network, due to separation of the data and video traffic into virtual links (different LSPs) with a defined bandwidth (different trunks). Some of the reasons to use MPLS instead traditional IP are: it has the ability to control the traffic routed in the network, congestion preventions, and prioritization for different services, improving the cost and performance requirements for the large enterprise core. MPLS was designed for running on any technology level (not just a structure over ATM) thus facilitating migration to new generation based Internet infrastructure fiber optic SONET / WDM and IP / WDM.

As future work we will concentrate on simulations with more realistic topologies and optimization accuracy, to improve and demonstrate the benefits of MPLS over the World Wide Web networks.

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