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Performance Comparison of MPLS TE Networks with Traditional Networks

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ABSTRACT

The tremendous growth and requirements for service quality, tenability, and efficiency have made traffic engineering an essential consideration in the design and operation of large public Internet backbone networks. Traffic engineering is the aspect of Internet network engineering that deals with the problem of operation analysis and operation optimization of functional IP networks. The principal target of internet traffic engineering is to direct the packets of IP traffic through a given system in an efficient and speedy manner conceivable. This paper explores the role of signaling protocols for traffic engineering in MPLS and provides a comparative analysis of non-MPLS and MPLS networks for substantial traffic situations. The simulation of the proposed solution has been performed in OPNET environment and the simulation results prove enhanced network performance of MPLS.

Keywords: *MPLS, RSVP, Traffic Engineering*

I. INTRODUCTION

The Cyber World has witnessed an immense development over the last years. What commenced as an experiment has matured into the ecumenical network that we identify today. Immensely colossal numbers of users subscribe to online multimedia accommodations like video streaming. Real-time communication services such as Facebook, Google Hangouts, WhatsApp Video calling and chat service, Skype are superseding customary telephones for long distance calls crosswise over urban regions in numerous nations. MultiProtocol Label Switching (MPLS) was conceived to convince the Internet and IP backbones from best effort information systems to business-class convey mediums fit for dealing with conventional multimedia system services. Internet service providers(ISP) have utilized correlative specialized instruments which include Network architecture, Traffic engineering to react to the challenge of internet growth.

MPLS networks offer Quality of Service(QoS) guarantees without requiring a dedicated link unlike other transport services like frame relay and Asynchronous Transfer Mode Switching(ATM). The accessibility of Traffic engineering services to the MPLS has aided it to extend to vital mass related to service provider mindset and ensuing MPLS deployments.

The necessity for traffic engineering in current networks to must accomplish the ideal resource usage is very well discussed in the technology of MPLS Traffic Engineering(TE) [1]. The traffic engineered passages or tunnels give an expedient for mapping traffic flow onto accessible resources of network in a way that obviates the over utilization of subsets of systems administration assets while others subsets are under-used. The constructs and mechanics fundamental to traffic engineering are discussed, together with discovery of tunnel path using Link State Protocols and tunnel path signaling using Resource Reservation Protocol(RSVP).

In this paper, comparative examination of MPLS empowered activity designed and non-MPLS system is discussed and it is demonstrated that MPLS has enhanced system execution for multimedia applications in substantial rush hour gridlock Environments. Section 2 is centered around the hypothetical ideas driving IP protocol and MPLS traffic engineering. The simulation instance introduced in segment 3 has exhibited the capacity of MPLS in establishing traffic engineering in comparison to conventional IP routing. Section 4 comprises of simulation outcomes while section 5 has results and conclusion is given in section 6.

II. COMPARATIVE ANALYSIS OF MPLS AND NON-MPLS NETWORK

When comparing the MPLS and non-MPLS network, it is important to understand the differences in the way MPLS and IP routing forward data across a network.

2.1. Traditional IP routing

IP Routing is a hypernym for the arrangement of conventions that decide the way that information follows with a specific end goal to traverse numerous systems from its source to its destination [2]. Information is directed from its source to destination through a progression of routers, and over different networked systems. The IP Routing conventions empower routers to develop a forwarding table that relates destination address with next hop addresses. Various protocols responsible for this are IS-IS (Intermediate System Intermediate System), BGP (Border Gateway Protocol), RIP (Routing Information Protocol), OSPF (Open Shortest Path First).

For an IP packet to reach its destination, it is forwarded by the intermediate routers based on the packet's next hop address using their own forwarding table [3]. At each intermediate stage, the packet header is enough information to forward the packet to the next hop. The Internet, for the intention of routing, is divided into Autonomous Systems (AS); which is a conglomeration of routers that are under the control of one organization that use a common protocol for interchanging routing information. All the incoming data packets on several ingress interfaces of a similar node that are headed for a similar destination are always incorporated across a common path. The aggravated impact of concentrating extensive information streams over small number of links frequently gives rise to traffic bottlenecks. Indeed, even notwithstanding congested connections, conventional routing protocols will keep on forwarding data over these same paths until the point when packets are dropped. In order to fit exceptionally interactive application streams with less delay and packet loss limits, there is a reasonable need to employ the available network system assets more productively. The primary issue with regular IP Routing conventions is that they don't consider capacity constraints and traffic qualities while packet steering decisions are made. As a result, few portions of a system can wind up noticeably congested while other fragments of network along optional paths are underutilized. Despite congested connections, the packet will still be forwarded along the congested links by the conventional routing protocols which leads to packet drop. This decisive limitation is overcome by a process known as traffic engineering and MPLS [4] provides these potentialities.

2.2. MPLS

Due to its 'multiprotocol design' where it uses a straightforward label exchanging mechanism besides allowing for Quality of Service(QoS) features by employing Traffic Engineering [5], MPLS (Multiprotocol Label switching) technology is growing as the protocol of the future. MPLS is a popular layer 2.5 networking technology that uses labels attached to packets to forward them through the network. MPLS labels are publicized between the routers in order to develop label-to-label mapping. The IP packets are appended with this label so that the routing decisions are made by taking a gander at label without using the destination based IP address. Therefore, in MPLS, packets are sent on employing label switching instead of IP switching [6]. MPLS builds a label switched path(LSP) that solely consists of label switched routers(LSR). After setting up the LSP, the packets course through this path and the entire traffic becomes flow. RSVP or Label distribution protocol(LDP) are used to build the path [7]. An LSP commences at the border of an MPLS space where the principal LSR maps the approaching traffic into forward equivalence classes (FECs). FECs are characterized with adaptability by an arrangement of qualities, for example, a destination IP address or QoS parameters. Packets having the same FEC characterization are provided with the same label and forwarded to the next LSR grounded on that label. No other header information is sought by the LSR while forwarding the packet through LSP. The label is detached at the last LSR of the MPLS domain and packet is then routed as simple IP packet. If an LSP is set up in view of limitations indicated by the system administrator or using system administration algorithm that is independent of the conventional IP routing protocol, it is said to be "explicitly routed". When an algorithm used is LDP, the routing turns out to be constraint based routing over LDP or CRLDP. LDP furnishes LSRs with the various capacities like peer detection, session maintenance, advertisements for label mappings in FECs and notifications. Advertisements incorporate "solicitations" to set up a LSP, which proliferate forward, and label "mappings" which spread back through the system. For CR-LDP, an LSP is accomplished when a progression of label requests traverses from the ingress label switched router to the egress LSR, if all the restraints are satisfied by the requested path then the labels are assigned and mapped by a set of messages which disseminate backwards from the egress LSR to the ingress one [8]. The capability of MPLS to bear explicit routes, function over any media framework and to have the capacity to gather insights with respect to LSPs, it is appropriate to give traffic engineering capacities [9]. you submit your final version, after your paper has been accepted, prepare it in two-column format, including figures and tables.

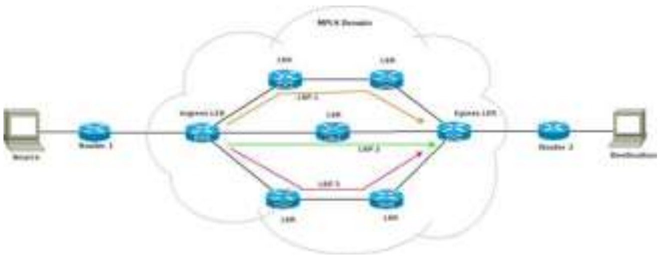

Fig. 1. Simple MPLS network.

2.3. Traffic engineering with MPLS

Traffic Engineering is that component of network engineering which addresses the consequence pertaining to performance rating and optimization of IP networks [9] [10]. The term traffic engineering is broadly utilized as part of the voice communications over telephone. TE aims that the traffic is estimated and investigated. At that point a statistical model is applied to the movement of traffic in order to arrive at a prediction and make estimations. On the off chance that the foreseen movement design does not coordinate well with the network resources the network executive rebuilds the activity design. Such choices can be made to accomplish a more ideal utilization of their own assets or to diminish costs by choosing a less expensive transit carrier. MPLS TE is an answer for IP steering issue as MPLS TE gives proficient spreading all through the system, maintaining a strategic distance from underutilized and over-utilized links [11]. It additionally considers the configured(static) data transfer capacity of connections(bandwidth). It considers link properties (like delay, jitter) and adjusts naturally to changing data transfer capacity and connection qualities. Moreover, traffic is bounded to source based routing in traffic engineered networks as opposed to destination based routing in conventional IP routes.

MPLS TE considers a Traffic Engineered plot where the ingress router of an LSP can figure out the most beneficial path through the framework towards the egress router of the LSP. The ingress router can perform such a task in case it has the network topology. Besides, the head end router needs to know whatever is left of the bandwidth limit on each one of the associations of a framework. At last, one needs to equip the MPLS on the router with the goal that we can build up LSP end to end. The existence of source based routing is attributed to the use of label switching mechanism to forward packets instead of IP directing. MPLS maintains a label forwarding information base(LFIB) to swap an incoming label with the corresponding outgoing one with forwarding being performed in data plane. After all the LSRs agree over a specific label to be used over an LSP, it is the responsibility of the ingress LSR to influence the routing of the packet labelled.

III. SIMULATION MODEL

The simulation of all experiments in this paper has been performed on OPNET. OPNET is a real-time system outlined predominantly for the plan and examination of network system models [12]. OPNET Modeler gives a thorough advancement condition supporting the demonstrating of correspondence networks and disseminated frameworks. Both conduct and execution of displayed frameworks can be dissected by performing discrete event simulations [13]. The simulation has been produced to underline the effect of MPLS over the customary IP system. PPP_adv workstations were utilized for simulating both the conventional IP system and MPLS empowered TE network. The source workstations were configured only for Video.

Fig. 2. IP network without traffic engineering.

Fig. 3. MPLS Network with Traffic Engineering.

In establishing the desired network, the devices and links that have been employed are as:

IP workstations featuring model name in the object palette as ppp_wkstn_adv, IP routers featuring model name in the object palette as CS_7206, Links establishing connection between routers have model name ppp_OC3, Routers are linked to workstations using ppp_DS3 link, Application configuration, profile configuration and MPLS configuration.

The entire simulation is split up into two scenarios: Scenario 1(Conventional IP network on IPv4) and Scenario 2. (MPLS network on IPv4 and TE-RSVP).

The simulation was accomplished in two phases, holding the basic scenario same for both the simulations and varying the configurations only. In both the scenarios we utilized IPv4. We make two sources to send out packets to two destinations, as shown in above simulation scenarios. In fig 2 Source1 sends packet to destination2 via primary LSP, in case the traffic exceeds the limit of the link bandwidth the traffic is rerouted via backup LSP which acts as primary LSP for the traffic going from source2 to destination1. In both the scenarios, the link from node 7 to node 16 is failed at 300 secs and recovered at 450 sec. Meanwhile a recovery path can be defined in TE enabled networks while traditional IP networks have to dynamically choose the alternate path for the traffic using the routing table entries. The network system was effectively kept running for 1-hour simulation while the elapsed recreation time was 4.40 minutes on an average.

IV. SIMULATION RESULTS

4.1. IP network without Traffic Engineering:

Simulation outcomes evidently depict that without traffic engineering an IP network renders only the best effort service. The traffic from source1 to destination2 employs the shortest path (2_12_9_10_6) to forward traffic and the traffic from source2 uses the shortest path (2_12_8_7_16) to forward traffic to destination1 which results in the congestion on the shortest paths. The traffic from source1 to destination2 exceeds the capacity of the shortest path while the longer path (2_12_9_1_3_4_10_13_11_14_15_16) remains underutilized thereby causing congestion on the shortest path which leads to packet drop. The packet drop is attributed to the presence of limited resources in the network incapable of satisfying all the traffic demands.

When the link between node 7 and node 16 is failed, node 7 is required to establish a new path to reach destination2 at node16. To accomplish this, the router tries every possible alternate path using routing table from node7 to node16 without considering the relative distances. From the newly traversed paths, router using OSPF chooses the shortest path as a reroute for directing the traffic from source2 to destination1.

4.2. MPLS Network with Traffic Engineering

MPLS Traffic Engineering utilizes RSVP [14] which is responsible for flagging the path to the traffic engineered tunnel yet it additionally is necessitated to carry the MPLS label so the packets can be label switched along the way of the TE tunnel [15]. The message on the path contains a label request object. Egress router on reception of this object sets a label to the TE tunnel which is then advertised to the upstream router in a Label object of RESV message. This Label becomes an incoming Label in the LFIB of the last router. The label that an upstream router gets from the egress router is set as the outgoing Label in the LFIB for this Traffic Engineered tunnel LSP. The label from the global label table is assigned by the router to this TE tunnel LSP and pushed on a label object in the RESV message of an upstream router. The same label turns out to be the incoming Label in the LFIB of this LSP. It proceeds like this until the RESV message achieves the head end router of the TE tunnel LSP. The way that the Label is promoted from the last router to the head router, hop by hop in the wake of request by the head end router demonstrates that TE tunnels utilize downstream-on-demand (DoD) Label distribution.

In our scenario (fig. 3), two dynamic TE tunnels are defined for the traffic between two sources and their respective destinations, each of the tunnel acting as a backup for the other in case of traffic overload. Additionally, a recovery LSP is manually defined.

On failing the link between node 7 and node 16 as has been done in the non- MPLS network, unlike the traditional IP network in which the router begins calculating the new shortest path. The router here directs the traffic along the already defined recovery LSP saving the unnecessary overhead. Establishing TE tunnels for the traffic flow doesn’t take into cognizance the shortest available path, it can opt even for the longest path of the network to reach the destination.

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V. RESULT ANALYSIS

The network was simulated to study the effects of jitter, throughput and delay on the video traffic originating from two different sources on an IPv4 network employing OSPF. The simulation results are briefed below.

Conventions given in table below are to be noted to study the graphs.

TABLE I: CONVENTION USED IN GRAPHS

Line Color	Represents
Red Line	MPLS TE (IPv4)
Blue Line	IP without TE(IPv4)

5.1. JITTER

If the transmission time of various packets directed from source to destination is fluctuating, progressive faults in the real time data traffic are observed. This fluctuation in the transmission time is referred to as jitter. It is also defined as the variation in packet arrival time. Analysis of the graphs Fig. 4 and Fig. 5 demonstrates the variation in the jitter in the start of the simulation, credited to the begin and setting up of different conventions and diverse messages for instatement and production of ARP tables, steering data and so forth. This phase is termed as the transient phase of the network. Additionally, both the figures demonstrate a decent contrast in the jitter between MPLS with TE and IPv4 network. As the traffic in both the networks even out, the jitter in the MPLS with TE enabled network is observed to be less compared to conventional IP network. Since MPLS is a connection oriented switching technology unlike IPv4 which follows connectionless paradigm and Traffic Engineering in MPLS underlines employing the underutilized links which evidently brings down the jitter in IPv4 networks, therefore, are promising to meet the increasing needs of real time traffic in future.

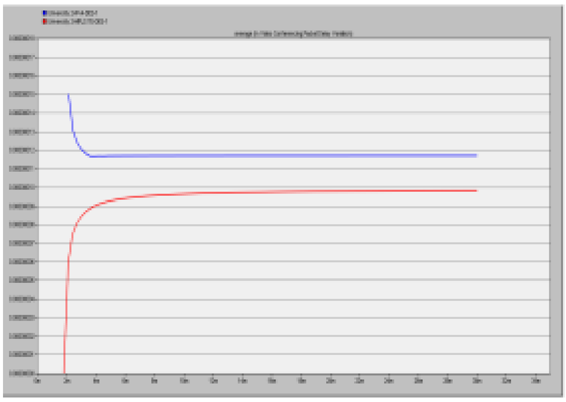
Fig. 4. Jitter for destination1.

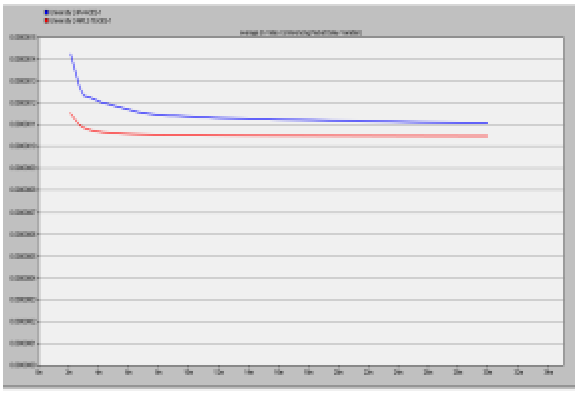
Fig.5. Jitter for destination2.

5.2. QUEUING DELAY

It is one of the significant design and performance representative of operational networks. The delay in a network determines the time it takes for a bit of data to move from one endpoint(source) to another(destination). Depending upon the placement of the communicating nodes, delay may somewhat vary. Due to delays at the

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starting node, intermediary node, or the call receiver serving node many queues can line up. As a result of incrementing congestion in the network queuing delays get raised up causing the overflow in the queue buffer which leads to the loss of packets. A reliable software should keep a proper check on this loss and perform thorough resends accordingly. If packet resend is required, the overall delay is at the least doubled over; the other round-trip time is contributed for a resend request and reply. The value of queuing delay for a cross country network is usually 30ms. In the simulation, it was observed that minimum queuing delay was for MPLS-TE network Fig. 6. This is attributed to the fact that MPLS performs a label check only on incoming packets while disregarding the fundamental IP header for making routing and forwarding decisions, plus the potentialities of traffic engineering to cut down congestion hot spots and ameliorate resource usage in the network through heedful management of traffic distribution inside the network.

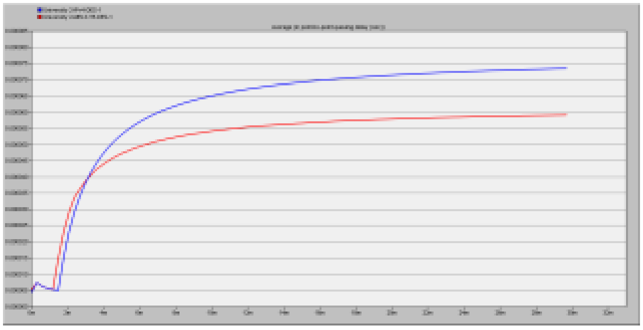

Fig. 6. Queuing Delay

5.3. DELAY WHEN TRAFFIC IS REROUTED USING TE TECHNIQUE

The point to point delay fig.7 in MPLS-TE network is observed to be less compared to the conventional IP network. The reason being the fast automatic switching of the traffic flow to the reroute defined beforehand unlike IP routing where a time consuming procedure of finding all the available paths is performed at router by consulting the routing table and a shortest path is crowned as reroute. Critical traffic can undergo delays due to the time lag between detecting a link failure and establishing a new LSP, making the usage of pre-configured path(reroute) in MPLS-TE network a possibility. Hence, two paths exist between two endpoints at a time with the reroute utilizing diverse paths existing between endpoints. On failure of the primary link, the traffic is transitioned on the reroute. The traffic is put back on the primary path if proper re-establishment conditions persist.

Fig. 7. Delay when traffic is rerouted using TE technique

5.4. THROUGHPUT

Throughput is the count of packets which are delivered effectively to the destination in a unit of time. Hardware confinements, available bandwidth and SNR have a significant impression on network throughput. In the simulation results of fig. 8 network with MPLS-TE produces maximum throughout compared to the IP network. It is because network performance is optimized by the traffic engineering concept of the MPLS which utilizes the information about the traffic which enters into and leaves the network to generate a forward equivalence class(FEC). All the traffic of one type is assigned to the same FEC unlike IP where all the incoming traffic is directed along the shortest path between the two endpoints contributing in reduced throughput.

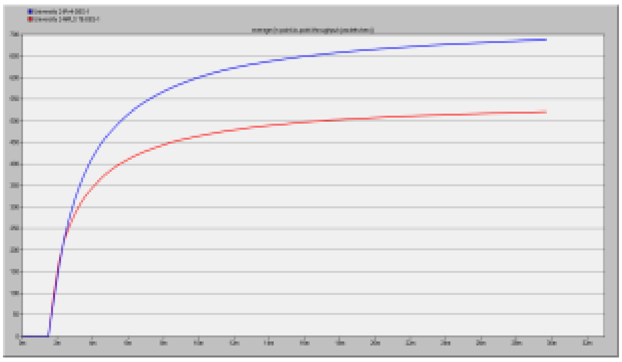

Fig. 8. Throughput.

VI. CONCLUSION

Although Best-Effort service is guaranteed by the Internet i.e., it attempts to direct traffic forward at its best but fails to provide assurance in terms of latency, bandwidth utilization and loss of packets. Such a service is satisfactory for few legacy applications like email and FTP but not desirable for real time applications like video conferencing, e-telephony, and the like. These applications necessitate Quality of Service(QoS) support; traffic engineering serves the purpose. Thus, we conclude that traffic engineering is related to the execution improvement of the networked systems. Its fundamental goal is to lessen congestion areas and enhance resource usage inside a system. Consequently, it helps in limiting packet loss, delay, and amplifying the throughput.

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