ISSN 2348 - 2249
Volume-6, Issue-4, October-December, 2018
International Journal for Multi Disciplinary Engineering and Business Management
(IJMDEBM)

QOS IN IP MPLS NETWORKS

Navjot Buttar
Research Scholar (M.Tech)
SVIET, Rajpura
India
navjot.buttar30@gmail.com

Rupali Zakhmi
Computer Science and Engineering Dept
SVIET, Rajpura
India
rupali2218@gmail.com

Abstract :**MPLS is the service provider technology that is used in the core of service providers to create virtual private networks. Data, Voice and Video traffic is increasing at a very rapid pace resulting in requirement of QOS and traffic engineering for critical VoIP traffic. In contrast to older algorithms in which traffic routing decision is taken on arrival at a node and selecting the best path available at that time we have created different tunnels for different types of traffic using experimental bits which can make delay much lower and provides better quality real time application performance than with simple MPLS or with other algorithms, It provides a better jitter and packet variation delays than normal and other MPLS QOS techniques. Mean Opinion Scoreof 4.4 shows that the voice quality is very good. MPLS is and will be the primary technology usedby the service providers because of its benefits that it provides, therefore MPLS has to have quality of service and MPLS traffic engineering enabled to make billions of bytes to data flow properlythrough the service provider with minimal packet loss or minimal delay.**

Keywords - IETF, RFC, NSFNET, FIB, DSCP, BGP, MPLS, QOS.

Introduction

Multiprotocol Label Switching or MPLS uses labels to forwards the packets within the Service Provider Networks, before MPLS, this process was done by using traditional packet forwarding using destination routing table lookups. With MPLS, Labels are embedded with the packets that enters from customer edge devices to the provider edge devices and all the forwarding in Service Provider is done hop by hop on the basis of the labels until the traffic reaches the egress port of the egress provider edge router. By default, when we enable MPLS, Label Distribution Protocol(LDP)is used for label distribution between the routers. Different Label Distribution protocols other than LDP are Resource Reservation Protocol(RSVP), Multi-Protocol BGP(MP-BGP). RSVP is mainly used for traffic engineering purposes while MP-BGP is used to distribute label bindings for BGP routes from one edge to other provider edge. Below is the figure of the Label Header :-

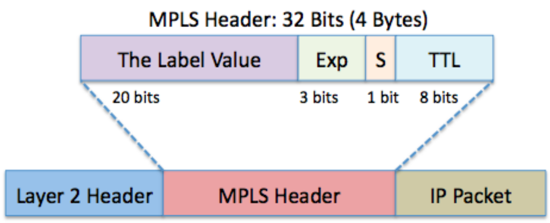

Figure 1.1 Label Header

With MPLS running in Service Providers, it also helps in having a BGP free core, as there is no need to run BGP in the core of Service Provider Network with all the decision making on packet forwarding can be done on the basis of labels and not on the destination routing table. The biggest advantage of using MPLS for Service Providers is that its ability to create both Layer 2 and Layer 3 VPNs so easily. Other important benefits of using MPLS is Traffic Engineering , use of one unified network infrastructure means that there's need not to buy extra infrastructure to run MPLS as it can run on Service Provider Routers and do not need any extra devices, MPLS also brings an optimal traffic flow. ISPs use MPLS at large extent to provider various applications or services to the customers. Below is the figure showing Vodafone MPLS Network worldwide :-

Figure 1.2 - Vodafone Global MPLS Network

2) MPLS Layer 3 VPN - MPLS Layer 3 VPN creates a peer-to-peer VPN network as customer edge shares the routing information with the provider edge device. With MPLS Layer 3 VPN, labels are added to simple IP traffic when it enters from CE device to the PE device, and all the forwarding within the MPLS Backbone network of Internet Service Provider is done using Label Switching, and labels

ISSN 2348 - 2249
Volume-6, Issue-4, October-December, 2018
International Journal for Multi Disciplinary Engineering and Business Management
(IJMDEBM)

are disposed when it goes out of Egress PE device. Routing Neighborship is made between PE and CE device.

MPLS L3 VPN Terminology

- **Label -** Label is a 4 byte identifier used by MPLS for label switching purposes.
- **LSR -** Label Switch Router is any router on which MPLS is running.
- **P -** Provider router that runs MPLS and is not a edge router connecting with CE device.
- **PE Router -** Provider Edge Router is an edge router in the Service Provider, labels are imposed and disposed.
- **CE Router -** Customer Edge Router is an edge router in the customer network which is connected directly with the provider edge router.
- **Ingress PE Router -** In this edge router, labels are imposed to the normal IP Packet.
- **Egress PE Router -** It is the edge-LSR device, and the destination CE is connected directly with this device. This device receives the labeled packet and dispose the label and sends a normal IP Packet to the customer edge device.
- **VRF -** Virtual Routing and Forwarding is used in Layer 3 MPLS VPNs to create different routing tables for different customers. VRF is implemented at PE routers and is integrated with the PE interfaces connected with CE interfaces. Every VRF interface has a different Routing Information Base(RIB), Forwarding Information Base(FIB), Label Information Base(LIB), Label Forwarding Information Base(LFIB) table.
- **Route Distinguisher(RD)** - RD is a very important part of the VRF. Route Distinguisher is a 64 bit value which is attached to the client's IP address and helps in uniquely identify a route by producing a unique 96 bit VPNv4 address. These VPNv4 routes are then taken from one PE to other PE via Multi-Protocol BGP(MP-BGP).
- **Route Target(RT)** - RT is a 64 bit community value which is attached to the VPNv4 routes and are used to import and export routes. RTs can either be imported or exported. We can also use "both" keyword to indicate export and import together. Import RTs are used to fetch the VPNv4 routes and add them to their specific VRF routing tables. Export Route Tags are embedded to the route when it is sent into VPNv4 Routing Table towards the other end of the customer. Below is the figure showing Route Propagation in Layer 3 MPLS VPN :-

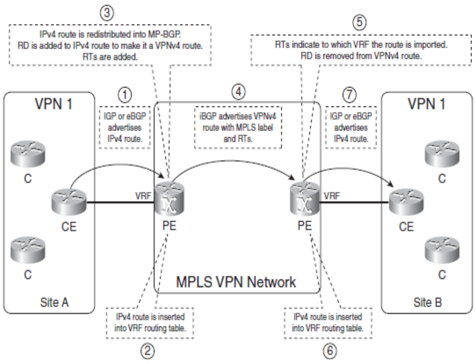

Figure 2.2 - MPLS Layer 3 Route Propagation

3.) MPLS Traffic Engineering

MPLS Traffic Engineering is used to utilize network resources and all the paths in a more efficient manner than with MPLS without traffic engineering. Protocol that we can use with MPLS traffic engineering is RSVP-TE. We can reserve explicit paths also which are not the best paths to reach destination according to Interior Gateway Routing Protocols like OSPF(Open Shortest Path First) or IS-IS(Intermediate-System to Intermediate-System) . The best thing about traffic engineering is that underutilized links can also be used, therefore load can be balanced in a much better manner. Fast Rerouting is another traffic engineering feature that helps in fast failover in case of primary Label Switch Path failure from one PE to other PE.In MPLS, Traffic engineering is solely based on Experimental bits and bandwidth can be reserved by using RSVP TE mechanisms. Below is the figure that displays the RSVP Path Reservation message flow:

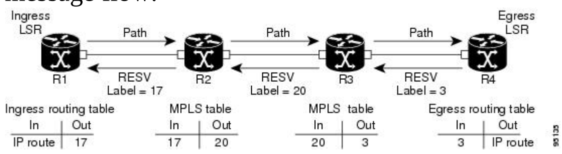

Figure 3.1 – RSVP Path Reservation

One of the reasons why MPLS is so much popular in Internet Service Provider industry and has overcome all the traditional ISP technologies like Frame Relay and ATM etc is traffic engineering options that MPLS provides to the Service Provider. MPLS Fast Reroute makes the MPLS convergence as faster as 50ms in case the link is converged from primary to backup link. Using MPLS FRR, multiple tunnels can be created between the PE routers and primary and backup tunnels are assigned to the traffic and in case the primary tunnel goes down, the backup tunnel comes up in around 50 ms. Below is the illustration in the figure that displays the MPLS FRR:

ISSN 2348 - 2249
Volume-6, Issue-4, October-December, 2018
International Journal for Multi Disciplinary Engineering and Business Management
(IJMDEBM)

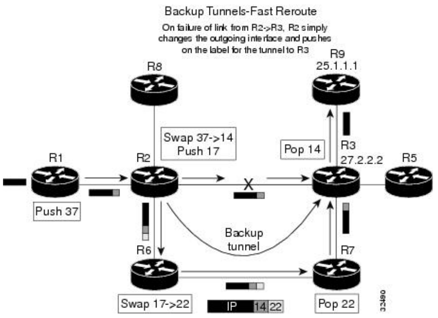

Figure 3.2 – MPLS FRR

4.) RESULTS

Performance of different traffic types over MPLS with Plain Traffic with no QoS and with QoS applied on it. By default when traffic is enters into Service Provider Core Network from Customer, MPLS labels are binded to the IP packets and all the forwarding is done on the basis of the Experimental Bits. Below is the topology used for MPLS QOS and TE in the thesis :-

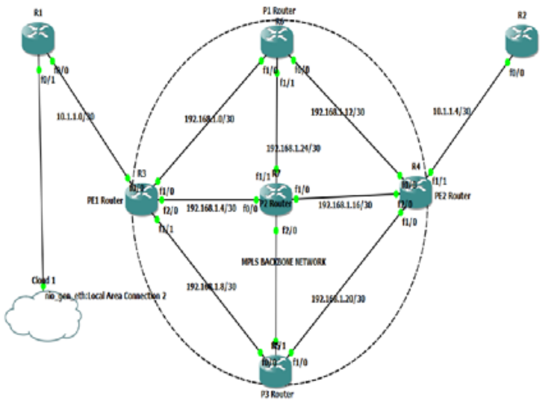

Figure 4.1 - MPLS Topology used for testing

Above is the MPLS topology used for qos testing in MPLS networks. R1 and R2 are used Customer Edge routers and SBI is the client of the Reliance Jio. R1 is SBI office in Chandigarh, while R2 is a SBI office in Bengaluru. Reliance Jio, which is one of the largest Internet Service Providers in the world connected different SBI sites using Layer 3 MPLS VPN. R3 is the Provider edge router in Reliance JioChandigarh while R4 is the Provider Edge router in Reliance JioBengaluru. Both the Ingress and Egress PE are connected using redundant links over Provider routers. Customer SBIChandigarh when sends some packets at SBIBengaluru, uses which link depends on the OSPF's Dijkstra's Algorithm by default. Below is the capture of traceroute from SBI-CHANDIGARH to SBI-BENGALURU displays which link is used from one PE to another PE in order to send traffic from SBI-CHANDIGARH TO SBI-BENGALURU

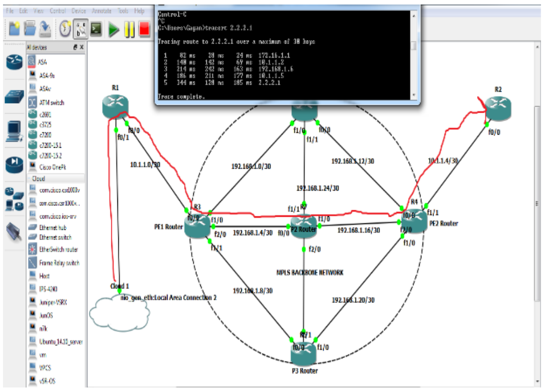

Figure 4.2 - Verifying which link is used from SBI-CHANDIGARH to SBI-BENGALURU over Reliance Jio.

As the traffic is using link PE1 - P2 - PE2 when transiting for traffic between SBI-CHANDIGARH and SBI-BENGALURU. Below is the capture of the normal mplspacket captured between PE1 - P2 to check the packet with no Experimental bits and no IP QoS by SBI-CHANDIGARH Customer :-

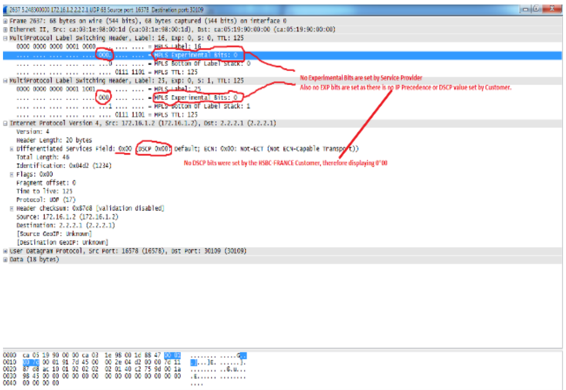

Figure 4.3 - Packet with no IP QoS or EXP bits set on MPLS Packets.

SBI-CHANDIGARH uses three different types of traffic like Voice, HTTP, and SMTP, HTTP and SMTP are TCP based while Voice uses UDP. HTTP is bursty traffic. Customer has attached DSCP Expedited Forwarding(EF) bit to the voice based UDP packets, As MPLS does not uses IP Forwarding mechanisms and use label switching techniques, DSCP or IP Precedence value is copied to the MPLS experimental bits.

On the next page is the packet capture at Customer Edge with EF applied on the UDP packet
uses different traffic engineering and QOS mechanism to prioritise customer traffic route.

ISSN 2348 - 2249
Volume-6, Issue-4, October-December, 2018
International Journal for Multi Disciplinary Engineering and Business Management
(IJMDEBM)

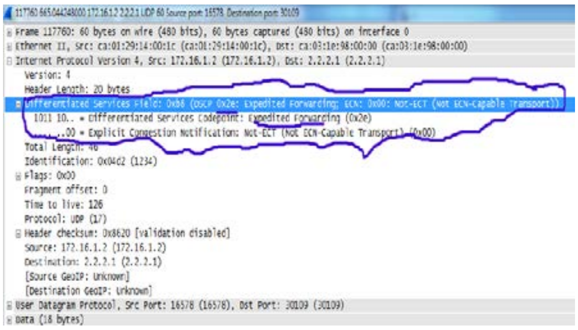

Figure 4.4 - DSCP-EF applied on the IP Packet.

When this traffic enters the service provider network the DSCP EF bit is copied to the MPLS Label Header Experimental Bits and MPLS uses those experimental bits. Service providers uses different Traffic engineering and QoS mechanisms to prioritize Customer traffic over its MPLS Backbone network. Below is the capture of IP traffic sent by SBI-CHANDIGARH to SBI-BENGALURU and packet is captured inside the transit MPLS Backbone network between PE1 and P :-

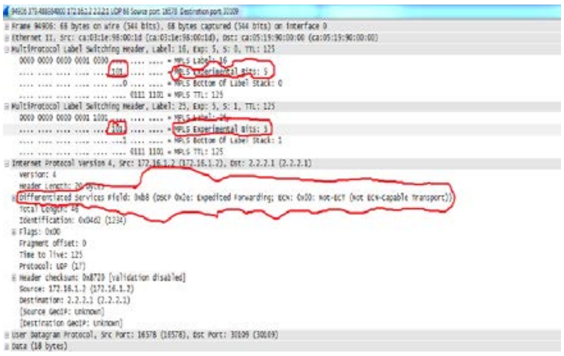

Figure 4.5 - DSCP EF applied to IP packet by customer is copied to the MPLS header

Now even though Experimental bits set automatically when IP QoS based traffic enters MPLS backbone network, but still there are lots of problems like :-
What if customer sets DSCP bit EF on every type of traffic they sent ?
What if there are several links present from ingress PE to egress PE, but one link is having most of the load, while others are not utilized properly ?
How to handle different types of traffic from different types of customers ? I used a real world scenario, where TCP always have a burst of traffic, while UDP traffic like of Voice is always in small UDP packets and needs to have a constant flow, otherwise if delay is increased, results in packet drops or disconnection of call in case of Voice based services. Below is the capture that was taken between the PE1 and P2 router, it shows that different types of traffic like UDP, TCP, ICMP all are going from ingress PE to egress PE through the same link :-

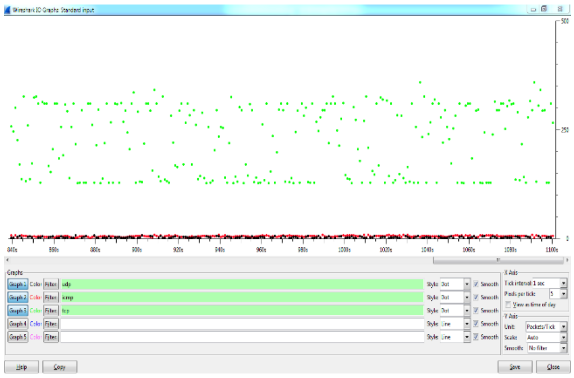

Figure 4.6- TCP Burst, UDP and ICMP traffic on same input queue.

Now that service providers always have multiple links from one PE to other PE, other links can be used to balance different types of traffic. It will also help in reduction of packet drops and lesser delay in case of Voice and Data traffic on same LSP. I used Ostinato traffic generator software to generate traffic bursts. Following figure shows how data starts to drop when traffic burst from TCP is started :-

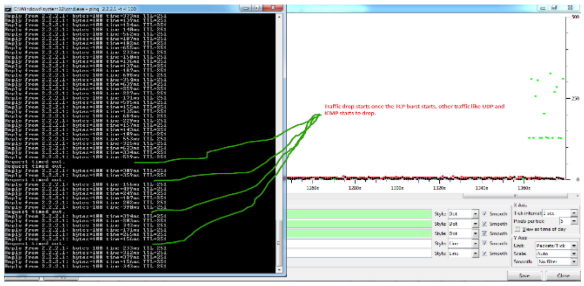

Figure 4.7 - Traffic Drop starts when TCP Burst starts.

The above problem can be reduced to large part if the proposed algorithm is used. Wang Crowcroft or simple pipe and short pipe models do not classify the different paths according to the traffic types that we have, on the other hand, in the above proposed algorithm, different types of traffic types are sent via different links and Voice and Video traffic is on a total different link which provides smooth flow for UDP traffic and any sort of TCP burst will not create any problem whatsoever. All the traffic is divided on the basis of experimental bits and traffic type with experimental bit 5 is on different link, traffic type with experimental bit 4 is on different, while we have explicitly defined the best paths for different types of traffic, a back dynamic path is also defined in order of primary link failure between ingress and egress Provider edge device.

Following are the results occured during the implementation of above steps and they are also comparison with the Uniform Model :-

ISSN 2348 - 2249
Volume-6, Issue-4, October-December, 2018
International Journal for Multi Disciplinary Engineering and Business Management
(IJMDEBM)

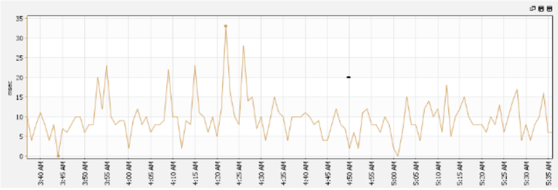

Figure 4.8 - Maximum Jitter during Voice traffic with our proposed algorithm

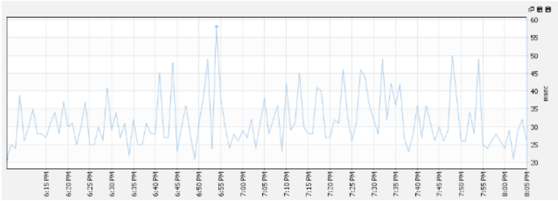

Figure 4.9 - Max Jitter with Uniform Model

Above graph taken in PRTG QoS sensor shows the maximum jitter in the voice traffic using Uniform Model and proposed algorithm. It clearly shows that our proposed algorithm provides better results.

Graph in figure 4.10 shows the average jitter between the two end points :-

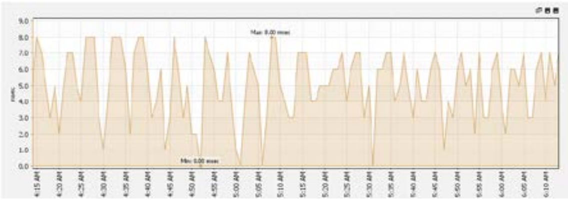

Figure 4.10- Average jitter between two voice endpoints using proposed algorithm

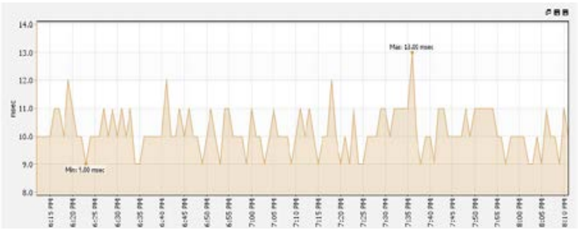

Figure 4.11- Average jitter using Uniform Model

Above graphs clearly shows that our proposed algorithm was much better when compared with uniform model when comparing average jitter.

Above graph shows that there is an average of 7-8 msec between the voice packets captured using our proposed algorithm while around 13 msec average jitter was experienced with Uniform model. This graph shows the average jitter between the Voice packets between the two customer edges connected through MPLS VPN. Below is the single graph showing minimum, maximum and average jitter between the two customer edge devices connected via MPLS Virtual Private Network.

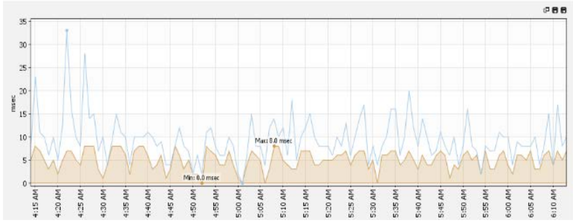

Figure 4.12 - Minimum, Maximum and Average Jitter between the two Customer Edge devices using proposed algorithm.

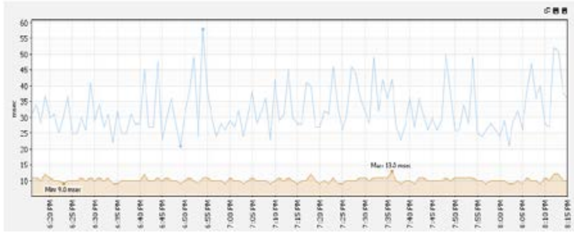

Figure 4.13 - Minimum, Maximum and Average Jitter between the two Customer Edge devices using uniform model.

Above are the jitter based graphs between the two customer edges. As specified before also, jitter is the variation in the packet delay, but this term is used differently by various people. Jitter actually has two meanings according to IETF RFC 3393, the first meaning is variation of a signal which is with respect to a clock signal, and here the arrival time of signal is expected to coincide with the arrival of the clock signal. This is used to measure the quality if a circuit emulation. Second meaning is related to variation in metric like delay with reference to some metric like minimum delay.

Another parameter that very much influence the Quality of Service and delivery of data is packet delay variation, it is just like jitter when we look at its definition, but it is different. Packet delay variation or PDV is the difference between end to end one way delay between some packets in a flow. Below is the graph captured using QoS sensor in PRTG shows the minimum packet delay variation between the two customer edges traffic :-

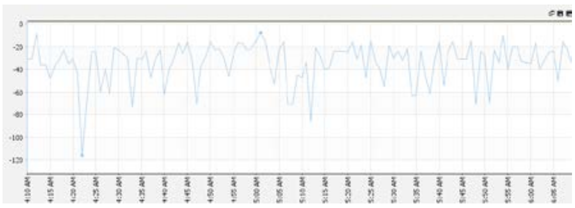

Figure 4.14- Minimum PDV between two customer edges using our proposed algorithm.

ISSN 2348 - 2249
Volume-6, Issue-4, October-December, 2018
International Journal for Multi Disciplinary Engineering and Business Management
(IJMDEBM)

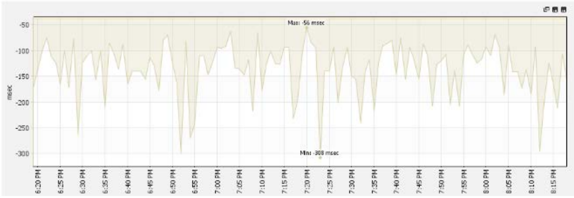

Figure 4.15 - Minimum PDV between two customer edges using our uniform model.

Above minimum PDV graphs shows that our proposed algorithm works better than the uniform model. For real time applications like voice, Packet delay variation is very important and VoIP environments have Quality of Service enabled networks for a high quality channel. The problems related with PDV can be reduced by using a proper sized buffer at the receiver end. Instantaneous packet delay variation or IPDV is the variation between successive packets which is sometimes referred as delay. If packets are sent every 20ms and the second packet is received after 30 ms of first packet, then the IPDV is -10ms, it is known as dispersion and if the second packet is received after the first packet then the IPDV is +10ms which is known as clumping. end to end experience of each packet is :-

***di* = *d*trans + *d*prop + *d*queue*i*.**

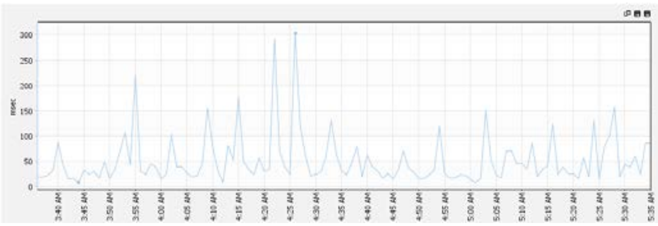

Figure 4.16 - Maximum Packet delay variation using our proposed algorithm

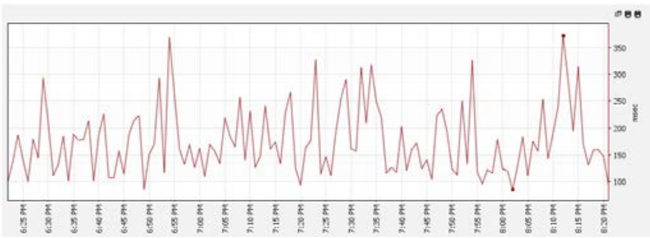

Figure 4.17 - Maximum Packet delay variation using the Uniform Model

Above graph comparisons of maximum PDVs shows that our proposed algorithm is slightly better than the Uniform model.
Above graph shows that maximum PDV is around 300 msec and average is around 70 msec using our proposed algorithm and maximum PDV is around 370 msec and average is around 180 msec with Uniform Model.

Mean Opinion Score (MOS) is used in telephony networks to get the human user's view of the quality of the network. It is a subjective measurement where listeners should sit in a quiet room and score the quality of the call as they perceived it. A Mean Opinion Score is a measure of an event or experience. MOS test ,Mean Score can be used to test VOIP and measure the quality of your VOIP calls.MOS is expressed as a single number that ranges from 1 to 5, where 1 is the lowest quality of audio and 5 is the highest audio quality measurement. Below are the MOS scores and their impairment :-

Table 4.1- MOS mean score and their impairments.

MOS	QUALIY	IMPAIRMENT
5	Excellent	Imperceptible
4	Good	Perceptible but not annoying
3	Fair	Slightly Annoying
2	Poor	Annoying
1	Bad	Very annoying

Below is the graph captured in PRTG that shows MOS for the call quality :-

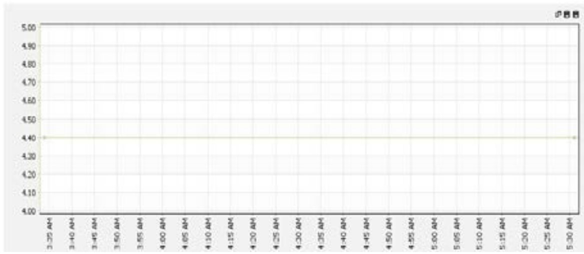

Figure 4.18 - MOS for the call quality between two customer edge voip devices using our proposed algorithm.

MOS score of 4.4 shows that the call quality is good and hence it shows that the algorithm scores great.

CONCLUSION

MPLS is the service provider technology that is used in the core of service providers to create virtual private networks. Service Providers uses Quality of service and Traffic engineering in their environment to create a traffic flow which has a low delay and jitter. Creating different tunnels for different types of traffic using experimental bits can create make delay much lower and provides better quality real time application performance than with simple MPLS or with other algorithms, It provides a better jitter and packet variation delays than normal and other MPLS QOS techniques. Mean Opinion Score of 4.4 shows that that the voice quality is very good. MPLS is and will be the primary technology used by the service providers because of its benefits that it provides, therefore MPLS has to have quality of service and MPLS traffic engineering enabled to make billions of bytes to data flow properly through the service provider with minimal packet loss or minimal delay.

FUTURE SCOPE

MPLS is expanding with time and is there to stay for a long time in service provider networks because of its benefits. Data transited over internet service providers is also increasing at a humongous rate which includes data, voice and video traffic. Service providers use quality of service and traffic engineering in their core to deliver the best possible results. The algorithm that we purposed is to segregate different traffic types over different paths toward destination and then apply quality of service over them. This definitely improves the results when compared them with Uniform Model and Wang Crowcroft, which has a distance vector behavior in its algorithm. As with Data Center traffic reached 4600 exabytes per year, Internet of Things etc, different types of devices and traffic is increasing which will further create some challenges as all the traffic will transit via service providers, where Quality of Service will have a big role to play in real time.

REFERENCES

[1] HESAM HOSEINZADEH (2015)"Path Selection Analysis in MPLS Network Based on QOS" under science journal (CSJ), Vol. 36, No: 6 Special Issue(2015) ISSN:1300-1449.

[2] Jyoti Aggarwal and Akanshadhall (2015)"Simulation Based Comparative Analysis of Voice over Internet Protocol over MPLS and Traditional IP Network" under International science journal ,Engineering and Technology Research (IJSER), Volume 4, Issue 6 (june 2015) ISSN:2278-7798.

[3] Ezeh G.N, Oneakusi C.E, Adimonyemma TM and Diala U.H (2014) "Comparative Performance Evaluation of Multimedia Traffic over Multiprotocol Label Switching using VPN and traditional IP networks" under IJETR-ISSN(E):2347-5900 ISSN(P): 2347-6079

[3] Rosen E ,Viswanathan A , and Callon. R.(2001) "MPLS Architecture"

[4] AnderssonLoa , and Rosen E. (2006)"Framework for layer 2 virtual private networks(L2VPNs)" RFC 4664.

[5] Martini and Luca. (2006) "Pseudowire Setup and Maintenance Using the Label Distribution Protocol(LDP)"

[6] Martini L (2006) " Encapsulation methods for transport of Ethernet over MPLS networks" .RFC4448.

[7] Kompella ,Kireeti , and akovRekhter(2007). "Virtual private LAN service (VPLS) using BGP for auto-discovery and signaling".

[8] Lassere , Marc , and VachKompella(2007). "Virtual private LAN service (VPLS) using label distribution protocol(LDP) signaling". RFC 4762.

[9] Isaac and Aldrin(2014) " Requirements for Ethernet VPN (EVPN) ".

[10] Armitage and Grenville (2000) " MPLS: the magic behind myths [multiprotocol label switching]. "Communications Magazine , IEEE 38.1(2000) : 124-131.

[11] Press , Cisco. " MPLS fundamentals . " Page 438, (2007).

[12] Cisco , " ASR 9000 Series L2VPN and Ethernet Services Configuration Guide " , http : // www.cisco.com/c/dam/en/us/td/i/300001400000/360001370000/361000362000/361074 . Eps/_jcr _ content/renditions/361074.jpg

[13] Sajassi , Ali , e al. "BGP MPLS Based Ethernet VPN ." (2011).

[14] Press , Cisco . " MPLS fundamentals. "(2007).

[15] Luo , Wei , et al . "Layer 2 VPN architectures ". Pearson Education , 2004.

[16] Darukhanawalla , Nash , et al. "Interconnecting data centers using VPLS ". Cisco Press, 2009.

[17] Zhang ,Lixia , et al. "Resource Reservation protocol (RSVP)—version 1 functional specification ." Resource (1997).

[18] Press , Cisco . "MPLS fundamentals."(2007).

[19] Ciscopress MPLS and Next Generation Networks , " Foundations for NGN and Enterprise Virtualization ", http://ptgmedia.pearsoncmg.com/images/chap3_9781587201202/elementLinks/md 100302.gif ' ISBN- 10: 1- 58720-120-8.

[20] Ma 2015 , Comparative Analysis of MPLS Layer 3 VPN and MPLS Layer 2 VPN by Umar BashirSofi , Er. Rupinder Kaur Gurm , of RIMT Institute of Engineering and Technology under (IJCST) – Volume 3 Issue , ISSN : 2347-8578.