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Comparative Analysis of Conventional IP Network and MPLS Network over VoIP Application

Rohit Mishra[#1], Hifzan Ahmad[*2]

[#]*Department Of Computer Science & Engineering, S.H.I.A.T.S, Allahabad, Uttar Pradesh, India*

[*]*Department of Computer Science & Engineering, Kamla Nehru Institute of Technology Sultanpur, Uttar Pradesh, India*

Abstract— **Multiprotocol Label Switching (MPLS) is the latest technology in the evolution of routing and forwarding mechanisms for the core of the Internet. It ensures the reliable delivery of the Internet services with high transmission speed and lower delays. Traffic Engineering (TE) in MPLS is used for effectively managing the networks for efficient utilization of network resources. MPLS technology makes it more suitable for implementing real-time applications such as Voice and video due to lower network delay, efficient forwarding mechanism, scalability and predictable performance of the services. In this paper the performance of Voice over Internet Protocol (VoIP) application is compared in MPLS network and conventional Internet Protocol (IP) network. The comparison is based on the performance metrics such as Voice jitter, Voice packet end-to-end delay, voice delay variation, voice packet send and received. The simulation results are analyzed and it shows that MPLS based solution provides better performance in implementing the VoIP application.**

Keywords— **Multiprotocol Label Switching (MPLS), Traffic Engineering (TE), Voice over Internet Protocol (VoIP), Internet Protocol (IP), Label Switching Router (LSR), Label Switched Path (LSP)**

I. INTRODUCTION

Internet is playing an important role in most of the people's life due to wide variety of applications and services provided on Internet. There have been an enormous growth in the use of Internet, and new real-time connection-oriented services like streaming technologies are in use and new ones are currently emerging. However providing the Real-time applications on Internet is a challenging task for the conventional IP networks as it uses best-effort services which doesn't provides guarantee of services and Traffic Engineering (TE). Multiprotocol Label Switching (MPLS) technology works to solve those shortcomings of IP. It is an emerging technology which plays an important role in the next generation networks by providing Quality of service (QoS) and TE. It overcomes the limitations like excessive delays and high packet loss of IP networks by providing scalability and congestion control. Due to the low latency and low packet loss during routing of packets MPLS is considered ideal for VoIP applications.

In this paper, a comparative analysis of the performance of Voice over Internet Protocol (VoIP) application is compared in MPLS network and conventional Internet Protocol (IP) network. The comparison is based on the performance metrics such as Voice jitter, Voice packet end-to-end delay, voice delay variation, voice packet send and received. The paper also shows the performance enhancement of MPLS networks over conventional IP networks. MPLS has improved network performance for multimedia type application in heavy load traffic environment. Based on the simulation results, it is shown that MPLS networks provide best performance in implementing the VoIP application as compared to conventional IP networks.

II. IP NETWORK

Internet Protocol (IP) allows a global network among an endless mixture of systems and transmission media [1]. The main function of IP is to send and receive data from the source to destination. In IP routing, source node sends the packet to the intermediate nodes, if any, and later to destination node based on destination IP address of the packet. In IP network data is sent in the form of packets. The decision on each incoming packet taken by the router is independent. When a router receives a packet, depending on the destination address in the packet header the router forwards the packet to the next hop by consulting its forwarding table. The process of forwarding the packets by the routers is continued until the packets reach the destination.

III. MPLS NETWORK

Multiprotocol Label Switching (MPLS) is an emerging technology which ensures high performance packet control and forwarding mechanism for routing the packets in the data networks [2]. It has evolved into an important technology for efficiently operating and managing IP networks by providing traffic engineering (TE) and virtual private network (VPN) services [3]. MPLS is not a replacement for the IP but it is an extension for IP architecture by including new functionalities and applications. The main functionality of the MPLS is to attach a short fixed-label to the packets that enter into MPLS domain. Label is placed between Layer2 (Data Link Layer) and Layer3 (Network Layer) of the packet to form Layer 2.5 label switched network on layer 2 switching functionality without layer 3 IP routing [3]. MPLS is an end to end protocol; its objective is to give the router a big power of communication [4]. The entire MPLS network can be divided into two parts namely MPLS edge and MPLS core [5]. MPLS edge is the boundary of the MPLS network consisting of ingress and egress routers shown in Fig. 1. MPLS core encompasses intermediate Label Switching Routers (LSRs), through which Label Switched Paths (LSPs) are formed. The use of LSPs in MPLS can help balance the traffic on network link event [6]. Ingress and egress router are the two types of edge LSR. The ingress router attaches a new label to every incoming packet and forwards it into MPLS core. On the other hand, the egress router removes the attached label from the incoming MPLS packet and forwards it further to destination. LSP is a route established between two edge LSRs which act as a path for forwarding labelled packets over LSPs. As soon as a packet arrives at ingress router, it assesses the QoS and bandwidth requirements of the packet and assigns a suitable label to the packet and forwards it into MPLS core. The labelled packet is transmitted over several LSRs inside the MPLS core till it reaches the egress router. Egress router takes off the label and reads the packet header and forwards it to appropriate destination node.

IV. TRAFFIC ENGINEERING (TE)

Traffic Engineering (TE) is a mechanism that controls the traffic flows in the networks and provides the performance optimization by optimally utilizing the network resources [7]. Some of the key features of TE are resource reservation, fault-tolerance and optimum Resource utilization [8]. Traffic engineering refers to the process of selecting LSPs chosen by data traffic in order to balance the load on various links, routers, and switches in the network. This is most important in networks where multiple parallel or alternate paths are available. The goal of Traffic Engineering is to facilitate efficient and reliable IP network operations while simultaneously optimizing resource utilization and network performance [9]. MPLS networks can use native TE mechanisms to minimize network congestion and improve network performance. TE modifies routing patterns to provide efficient mapping of traffic streams to network resources. This efficient mapping can reduce the occurrence of congestion and can play an important role in the implementation of network services with guaranteed quality of service (QoS) [10].

V. SIMULATION TOOL

Simulation is the process of testing a designed model on a platform which imitates the real environment. It provides the opportunity to create, modify and study the behaviour of proposed design so that one can predict its strengths and weakness before implementing the model in real environment. The OPNET Modeller has been used to perform the simulation on MPLS and traditional IP network.

A. OPNET Modeller

OPNET provides several modules for the simulation comprising a vast universe of the protocols and network elements [11]. It has gained popularity in academia as it is offered for free of cost to institutions and it is also obtained as a student version. The user doesn't need to have any programming knowledge in order to use OPNET; the user can directly concentrate in building and analysing model from simulation. The main feature of OPNET is that it provides various real-life network configuration capabilities that make the simulation environment close to reality [12].The advantages of OPNET compared to other simulators include GUI interface, comprehensive library of network protocols and models, graphical interface to view the results, availability of documentation for the user to develop the network models etc.

B. OPNET Simulation

The VoIP traffic is send from source (VoIP_1) to destination (VoIP_2) in the two networks (MPLS and Traditional IP networks).The main task is to compare the performance of VoIP traffic in the both networks by using performance metrics, i.e., voice jitter, packet End-to-End delay, packet loss and throughput. The simulation results obtained are analyzed to determine the efficient technology used for transmitting VoIP traffic.

It is difficult to predict the behaviour of the traffic in the network as the traffic in network varies from source to destination at anytime. The simulation of the conventional IP and MPLS models is performed by considering the worst case scenario in which the minimum number of VoIP calls that a network can support with acceptable quality has been estimated. We consider the background traffic excluding the VoIP traffic to be as 50% of link capacity, the link capacity is the max-utilization allowed of a link to protect it from bursts is 60% as explained in [13].

VI. NETWORK DESIGN

The simulation of both IP and MPLS networks are employed in the OPNET Modeler 14.5. Both the networks are simulated by considering the common topology.

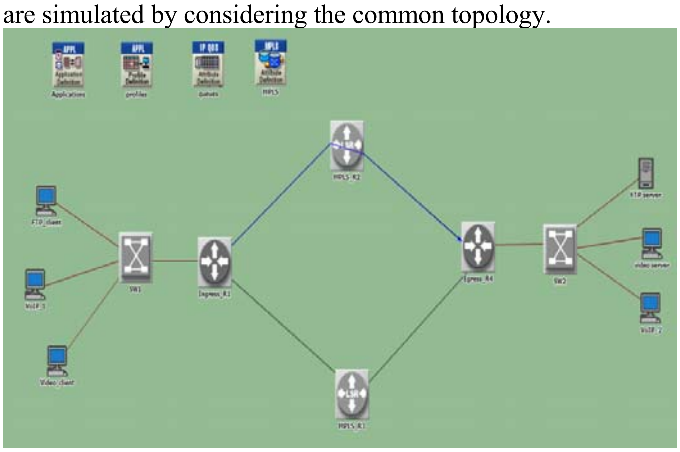

Fig. 1 MPLS Simulation model

Fig. 1 shows the MPLS network model which consists of the required network elements. TE is implemented in this simulation model. When congestion occurs in the network, the traffic is directed along LSP so that the traffic is evenly distributed in the MPLS network. This controls the congestion in the network and increases the efficiency in utilizing the network resources. In this model VoIP traffic is send from VoIP_1 to VoIP_2. The simulation is performed in order to obtain packet end-to-end delay, voice jitter, packet sent and packet received values.

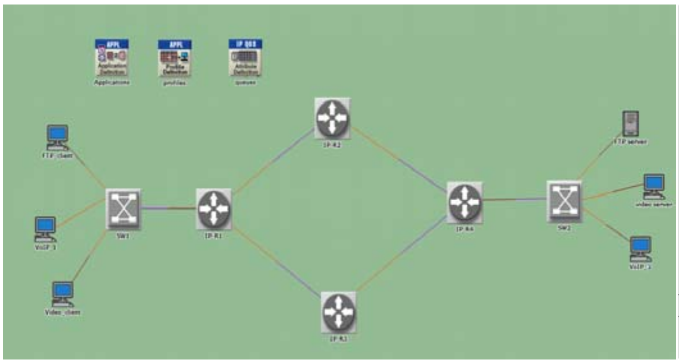

Fig. 2 IP Simulation Model

Fig. 2 shows the simulation model of conventional IP network without TE. In this model MPLS routers are replaced with normal IP Routers which doesn't support MPLS technology. The VoIP traffic is transmitted between the VoIP_1 and VoIP_2 and the procedure for setting VoIP calls is similar to that of MPLS model.

VII. Comparison of Performance Metrics

A. Voice Packet Send and Receive

It is observed from the graph shown in Fig. 3 that there is an increase in the performance when the VoIP traffic is transmitted using MPLS technology. The duration of the simulation is 420 seconds for each scenario. The VoIP traffic starts at the 100th second and ends at the 420th second of the simulation time. In both scenarios VoIP calls are added at fixed time intervals i.e., for every two seconds starting from 100th second till 420th second.

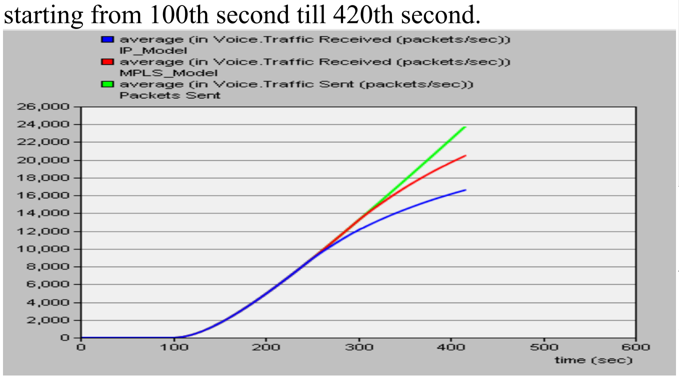

Fig. 3 VoIP packets send and received

The Fig. 3 gives the average number of packets send and received in both MPLS and conventional IP networks. By the end of simulation it is observed that MPLS model gives more throughput than the IP model. The graph in Fig. 3 shows that voice packets start to drop from 240 second in the IP network whereas in MPLS voice packets are started to drop from 300 second, this increases the throughput in the MPLS network.

B. Voice Packet Jitter

The graph in Fig. 4 shows the Voice packet jitter of MPLS and IP network model. It is noticed that Voice Jitter starts to increase at 240 second in IP network and for MPLS network it starts to increase at 300 second; this increases the throughput in the MPLS network.

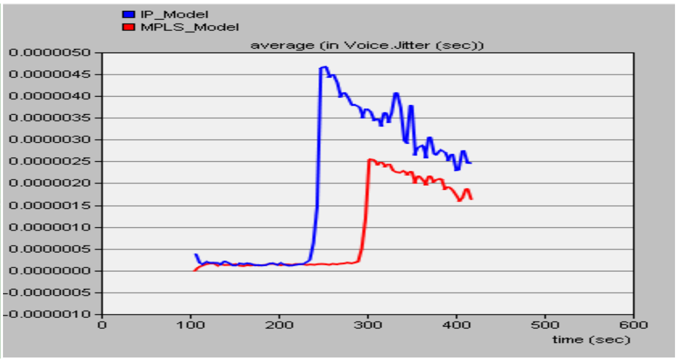

Fig. 4 Voice packet jitter

C. Voice Packet Delay

The voice packet delay variation shown in Fig. 5 has same variations in graphs as explained for Voice packet jitter. It is observed from the graph shown in Fig. 5 that Voice packet delay start to increase at 240 second in IP network and for MPLS network it starts to increase at 300 second which increases the throughput in MPLS network. By the end of simulation it is observed that MPLS model gives more throughput than the IP model.

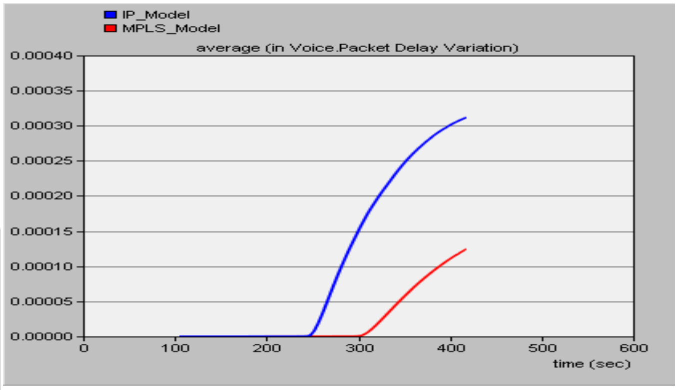

Fig. 5 Voice packet delay variation

D. Voice Packet End-to-End Delay

The voice packet end-to-end delay of MPLS and IP network model is shown in Fig. 6. It is noticed from the Fig. 6 that end-to-end delay in IP network exceeds the threshold at 240 sec and the MPLS network reaches the end-to-end delay threshold at 300 seconds. The IP network reaches the threshold early than MPLS network, is due to that TE is implemented in MPLS network.

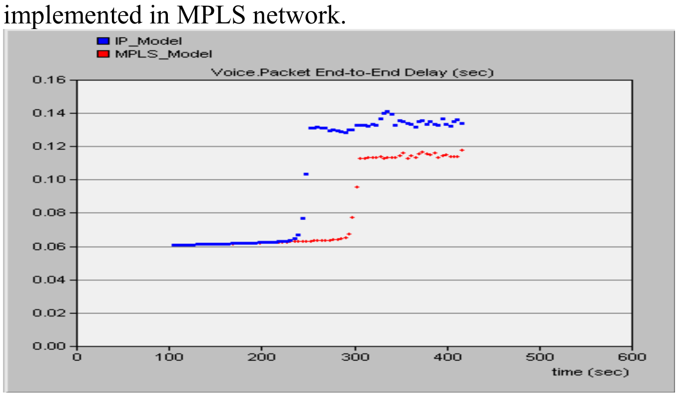

Fig. 6 Voice packet end-to-end delay

VIII. CONCLUSIONS

The comparative analysis in MPLS network and conventional IP network is made on focusing on the performance metrics such as Voice jitter, Voice packet delay variation, Voice packet End-to-End delay, Voice packet send and received. Based on the simulation results it can be concluded that MPLS provides best solution in implementing the VoIP application as compared to conventional IP networks because of the following reasons

- MPLS takes less processing time in forwarding the packets which is more suitable for the applications like VoIP
- Implementing of MPLS with TE minimizes the congestion in the network
- MPLS suffers minimum delay and provides high throughput compared to conventional IP network

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