Performance Study of Multiprotocol Label Switching (MPLS) In Service Providers Network

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***Abstract*—People out of curiosity and inventiveness built networks to facilitate information exchange. These networks has got this popularity by its reliability, efficiency, and QoS which has been developing at a rapid rate to facilitate the needs of these people. However extra care should be taken for this real time traffic (i.e, data and voice) because of delay sensitivity, QoS, limited bandwidth. One such technology that has the scope of expanding these features to provide a super highway for all the types of transmission is Multiprotocol label switching (MPLS). The main advantage of this is that it operates in between layer 2 and layer 3 protocols, in other words it is called a layer 2.5 protocol. MPLS uses the technique of packet forwarding based on labels, to enable the implementation of a simpler high-performance packet forwarding engine. Other technologies such as Internet Protocol (IP) and Synchronous Optical Networking (SONET) are also few standardized protocols that transfer files over the internet, but when compared MPLS technology has improved efficiency and reliability over IP and SONET. This paper presents the performance study of all these three technologies over a service provider network with its voice and data results. In this we used GNS3 simulation tool to simulate these networks.**

Keywords— Internet Protocol (IP), Synchronous optical network (SONET), Multiprotocol label switching (MPLS) Voice over Internet Protocol (VOIP) & GNS3.

I. INTRODUCTION

In environment of World Wide Web (WWW), internet has exponential growth in real time application such as data and voice over IP (VoIP). It is an indication of evolution of network protocol. We need an intelligent backbone support protocol which full fills requirement of low end – end delay and guarantees to QoS. There are number of challenges for network in that 1st to enhance network to that extend to accommodate and increasable demand of band width , another one is to manage installed capacity effectively and efficiently to enhanced end user service quality and last important challenge is survivability i.e. fast recovery and restoration [1].Rapid growth and increasing requirements for service quality, reliability, and efficiency have made traffic engineering an essential consideration in the design and operation of large public internet backbone networks. Internet traffic engineering address the issue of performance optimization of operational networks. A paramount objective of internet traffic engineering is to facilitate the transport of IP traffic through a given network in the most efficient, reliable, and expeditious manner possible. Historically, traffic engineering in the internet has been hampered by the limited functional capabilities of conventional IP technologies [9]. With the advent of the World Wide Web the internet has seen enormous growth from its roots as a network of modest proportions, mostly used by the research and academic community, to a large public data network. Several thousands of corporate users and several millions of dialing residential users have gone online in the last few years, making the internet a true public data network [3]. We define flow distribution as selecting one of the available label switch paths (LSPs) to carry one aggregated traffic flow. Flow splitting is, however, the mechanism designed for multiple parallel LSPs to share one single aggregated flow. Our studies show that flow distribution and flow splitting approaches readily solve the routing problems such as bottleneck and mismatch problems. An algorithm based on network bandwidth utilization is also proposed to integrate both approaches[4].Multi- Protocol Label Switching (MPLS) has been proposed as a new approach which combines the benefits of interworking and routing in layer 3and layer 2 i.e. Network layer and Data Link Layer. But its major technological significance lies in implementing Traffic Engineering[5].Network layers are analyzed for their design and issues of researches, while dense wavelength division multiplexing equipment has been deployed in networks of major telecommunications carriers for a long time, the efficiency of networking and relation with network control and management have not caught up to those of digital cross-connect systems and packet-switched counterparts in higher layer networks[6].

II. INTERNET PROTOCOL (IP)

IP transport information in theform of packet which have variable length. IP hasconnectionless approach. Internet consists of many computernetworks connected with router. Router forwards packet fromincoming link to outgoing link.

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A. *Network design for Data packets:*

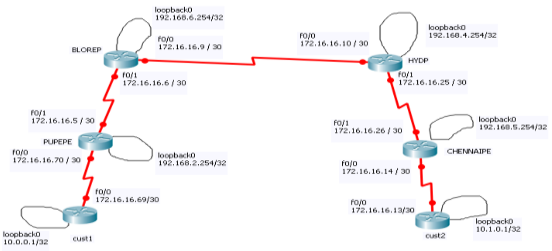

Fig.1 IP Network Design for Data

In fig.1 we used two costumer edge routers and four service providers and we assigned IP address & Loopback address to every router in these we used serial port interface next we configured a protocol named open shortest path first (OSPF) after these we started sending packets from one service edge router to the other service edge router for that we calculated Jitter, Latency, Throughput and the following results were plotted the above simulation was done in GNS3 simulation tool.

Simulation Code for IP data packets:

PUNE preliminary configuration

```
PUNE> en
PUNE# config t
PUNE (config)# interface Loopback0
PUNE(config-if)# ip address 192.168.2.254 255.255.255.255
PUNE(config-if)# no shutdown
PUNE(config-if)# exit
PUNE(config)# interface f0/1
PUNE(config-if)# ip address 172.16.16.5 255.255.255.252
PUNE(config-if)# no shutdown
PUNE(config-if)# exit
PUNE(config)# interface f0/0
PUNE(config-if)# ip address 172.16.16.70 255.255.255.252
PUNE(config-if)# no shutdown
PUNE(config-if)# end
PUNE# write memory
```

BANGLORE preliminary configuration

```
BLORE> en
BLORE# config t
BLORE(config)# interface loopback0
BLORE(config-if)# ip address 192.168.6.254 255.255.255.255
BLORE(config-if)# no shutdown
BLORE(config-if)# exit
BLORE(config)# interface f0/0
BLORE(config-if)# ip address 172.16.16.9 255.255.255.252
BLORE(config-if)# no shutdown
BLORE(config-if)# exit
BLORE(config)# interface f0/1
BLORE(config-if)# ip address 172.16.16.6 255.255.255.252
BLORE(config-if)# no shutdown
BLORE(config)# end
BLORE# write memory
```

HYDERABAD preliminary configuration

```
HYD> en
HYD# config t
HYD(config)# interface loopback0
HYD(config-if)# ip address 192.168.4.254 255.255.255.255
HYD(config-if)# no shutdown
HYD(config-if)# exit
HYD(config)# interface f0/0
HYD(config-if)# ip address 172.16.16.10 255.255.255.252
HYD(config-if)# no shutdown
HYD(config-if)# exit
HYD(config)# interface f0/1
HYD(config-if)# ip address 12.16.16.25 255.255.255.252
HYD(config-if)# no shutdown
HYD(config)# end
HYD# write memory
```

CHENNAI preliminary configuration

```
CHENNAI> en
CHENNAI# config t
CHENNAI(config)# interface loopback0
CHENNAI(config-if)# ip address 192.168.5.254 255.255.255.252
CHENNAI(config-if)# no shutdown
CHENNAI(config-if)# exit
CHENNAI(config)# interface f0/1
CHENNAI(config-if)# ip address 172.16.16.26 255.255.255.252
CHENNAI(config-if)# no shutdown
CHENNAI(config-if)# exit
CHENNAI(config)# int f0/0
CHENNAI(config-if)# ip address 172.16.16.14 255.255.255.252
CHENNAI(config-if)# no shutdown
CHENNAI(config-if)# end
CHENNAI# write memory
```

Checking the configuration

```
#sh ip int brief
```

Configuring OSPF

PUNE

```
PUNE(config)# roter OSPF 100
PUNE(config-router)# network 172.16.16.4 0.0.0.3 area 0
```

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PUNE(config-router)# network 192.168.2.254 0.0.0.0 area 0
PUNE(config-router)# passive-interface loopback 0
PUNE(config-router)# end
PUNE# write memory

BANGLORE

BLORE(config)# router ospf 100
BLORE(config-router)# network 172.16.16.4 0.0.0.3 area 0
BLORE(config-router)# network 172.16.16.8 0.0.0.3 area 0
BLORE(config-router)# network 192.168.4.254 0.0.0.0 area 0
BLORE(config-router)#passive-interface loopback0
BLORE(config-router)# end
BLORE# write memory

HYDERABAD

HYD (config)# router ospf 100
HYD (config-router)# network 172.16.16.24 0.0.0.3 area 0
HYD (config-router)# network 172.16.16.8 0.0.0.3 area 0
HYD (config-router)# network 192.168.4.254 0.0.0.0 area 0
HYD (config-router)# passive-interface loopback 0
HYD (config-router)# end
HYD# write memory

CHENNAI

CHENNAI(config)# router ospf 100
CHENNAI(config-router)# network 172.16.16.24 0.0.0.3 area 0
CHENNAI(config-router)# network 192.168.5.254 0.0.0.0 area 0
CHENNAI(config-router)#passive-interface loopback 0
CHENNAI(config-router)# end
CHENNAI# write memory

To check OSPF connectivity

Run these show commands in previledge mode in all routers to check the routing protocol and to display routing table

#sh ip route
#sh ip protocols
#sh running-config

PUNE# ping 192.168.5.254
CHENNAI# ping 192.168.2 254

100% successful ping result shows the OSPF connectivity is done.

III. DESIGN FOR VOIP NETWORK:

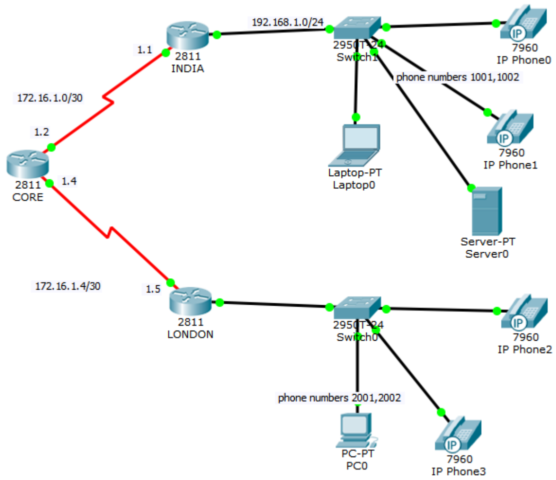

Fig.2IP Network Design for Voice

Simulation Code for IP VOIP packets:

step 1: Configuring the interfaces on the routers connected in the topology

INDIA>enable

INDIA#configure terminal

INDIA(config)#interface FastEthernet0/0

INDIA(config-if)#ip address 192.168.1.1 255.255.255.0

INDIA(config-if)#no shutdown

INDIA(config-if)#exit

INIDA(config)#interface serial 0/0/0

INDIA(config-if)#ip address 172.16.1.1 255.255.0.0

INDIA(config-if)#encapsulation PPP

INDIA(config-if)#no shutdown

INDIA(config-if)#exit

INIDA(config)#

step 2: Configuring a Routing Protocol enabling routing in the topology

INIDA(config)#router eigrp 100

INIDA(config-rtr)#network 192.168.1.0

INIDA(config-rtr)#network 172.168.0.0

INIDA(config-rtr)#end

INIDA#write

Step 3: Configuration of LONDON similar to that of INDIA as per the toplogy

LONDON>en

LONDON#config terminal

LONDON(config)#interface fa0/0

LONDON(config-if)#ip address 192.168.100.1 255.255.255.0

LONDON(config-if)#no shut

LONDON(config-if)#exit

LONDON(config)#interface s0/0/0

LONDON(config-if)#ip address 172.16.1.5 255.255.255.252

LONDON(config-if)#encapsulation ppp

LONDON(config-if)#no shut

LONDON(config-if)#end

LONDON#wr

step 4: Configuring a Routing Protocol enabling routing in the topology

LONDON#config t

LONDON(config)#router eigrp 100

LONDON(config-rtr)#network 192.168.100.0

LONDON(config-rtr)#network 172.16.0.0

LONDON(config-rtr)#end

LONDON#wr

step 5:configuration of routing in the core router

CORE>en

CORE#config t

CORE(config)#router eigrp 100

CORE(config-rtr)#network 172.16.0.0

CORE(config-rtr)#end

CORE#wr

Note: After the configuration, check the connectivity from the routers of INDIA to LONDON through the ping command[Reply must be given by the destination]

LONDON#ping 192.168.1.1

INDIA#ping 192.168.100.1

step 5: Connect IP phones (Power on) and configure DHCP server on LONDON (2811 router)

The DHCP server is needed to provide an IP adress for each IP phone connected to the network.

LONDON(config)#ip dhcp pool voips

LONDON(dhcp-config)#network 192.168.100.0 255.255.255.0

LONDON(dhcp-config)#default-router 192.168.100.1

LONDON(dhcp-config)#option 150 ip 192.168.100.1

LONDON(dhcp-config)#exit

LONDON(config)#ip dhcp excluded-address 192.168.100.1

LONDON(config)#exit

LONDON#write

Note: After the configuration, wait a moment and check that 'IP Phone 1' has received an IP address by placing your cursor over the phone until a configuration summary appears.

Step 6: Connect IP phones (Power on) and configure DHCP server on INDIA (2811 router)

INDIA(config)#ip dhcp pool voipi

INDIA(dhcp-config)#network 192.168.1.0 255.255.255.0

INDIA(dhcp-config)#default-router 192.168.1.1

INDIA(dhcp-config)#option 150 ip 192.168.1.1

INDIA(dhcp-config)#exit

INDIA(config)#ip dhcp excluded-address 192.168.1.1

INDIA(config)#exit

INDIA#write

Note: After the configuration, wait a moment and check that 'IP Phone 1' has received an IP address by placing your cursor over the phone until a configuration summary appears.

Step 7:Configure the Call Manager Express telephony service on RouterA

You must now configure the Call Manager Express telephony service on INDIA/LONDON to enable voip on your network.

INDIA(config)#telephony-service

INDIA(config-telephony)#max-dn 2

INDIA(config-telephony)#max-ephones 2

INDIA(config-telephony)#ip source-address 192.168.1.1 port 2000

INDIA(config-telephony)#exit

INDIA(config)#ephone-dn 1

INDIA(config-ephone-dn)#number 1001

INDIA(config-ephone-dn)#exit

INDIA(config)#ephone-dn 2

INDIA(config-ephone-dn)#number 1002

INDIA(config-ephone-dn)#exit

INDIA(config)#ephone 1

INDIA(config-ephone)#mac-address ***.***.*** <* must be filled as per the mac address of the ip phone>

INDIA(config-ephone)#button 1:1

INDIA(config-ephone)#exit

INDIA(config)#ephone 2

INDIA(config-ephone)#mac-address ***.***.*** <* must be filled as per the mac address of the ip phone>

INDIA(config-ephone)#button 1:2

INDIA(config-ephone)#end

INDIA#write

Note: Same config for LONDON

LONDON(config)#telephony-service

LONDON(config-telephony)#max-dn 2

LONDON(config-telephony)#max-ephones 2

LONDON(config-telephony)#ip source-address 192.168.100.1 port 2000

LONDON(config-telephony)#exit

LONDON(config)#ephone-dn 1

LONDON(config-ephone-dn)#number 2001

LONDON(config-ephone-dn)#exit

LONDON(config)#ephone-dn 2

LONDON(config-ephone-dn)#number 2002

LONDON(config-ephone-dn)#exit

LONDON(config)#ephone 1

LONDON(config-ephone)#mac-address ***.***.*** <* must be filled as per the mac address of the ip phone>

LONDON(config-ephone)#button 1:1

LONDON(config-ephone)#exit

LONDON(config)#ephone 2

LONDON(config-ephone)#mac-address ***.***.*** <* must be filled as per the mac address of the ip phone>

LONDON(config-ephone)#button 1:2

LONDON(config-ephone)#end

LONDON#write

Step 8 :Configure a voice vlan on SwitchA

Apply the following configuration on Switch interfaces. This configuration will separate voice and data traffic in different vlans on Switch, data packets will be carried on the access vlan.

Switch connected to INDIA

Switch(config)#interface range fa0/1 – 5

Switch(config-if-range)#switchport mode access

SwitchA(config-if-range)#switchport voice vlan 1

Switch connected to LONDON

Switch(config)#interface range fa0/1 – 5

Switch(config-if-range)#switchport mode access

SwitchA(config-if-range)#switchport voice vlan 1

Step 9 :call routing from LONDON to INDIA must be configured

LONDON(config)#dial-peer voice 10 voip

LONDON(config-dial-peer)#destination-pattern 100.

LONDON(config-dial-peer)#session-target ipv4:172.16.1.1

LONDON(config-dial-peer)#end

LONDON#write

Step 9 :call routing from INDIA to LONDON must be configured

INDIA(config)#dial-peer voice 20 voip

INDIA(config-dial-peer)#destination-pattern 200.

INDIA(config-dial-peer)#session-target ipv4:172.16.1.5

INDIA(config-dial-peer)#end

INDIA#write

IV. SONET (SYNCHRONOUS OPTICAL NETWORKING)

Synchronous Optical Networking (SONET) and Synchronous Digital Hierarchy (SDH) are standardized protocols that transfer multiple digital bit streams synchronously over optical fibre using lasers or highly coherent light from light-emitting diodes (LEDs). At low transmission rates data can also be transferred via an electrical interface. The method was developed to replace the plesiochronous digital hierarchy (PDH) system for transporting large amounts of telephone calls and data traffic over the same fibre without synchronization problems. Generic criteria applicable to SONET and other transmission systems SONET is a set of transport containers that allow for delivery of a variety of protocols, including traditional telephony, ATM, Ethernet, and TCP/IP traffic. SONET therefore is not in itself a native communications protocol and should not be confused as being necessarily connection-oriented in the way that term is usually used. SONET and SDH often use different terms to describe identical features or functions. This can cause confusion and exaggerate their differences. With a few exceptions, SDH can be thought of as a superset of SONET. Here to configure SONET we used Packet over SONET (POS) port, the protocol we used is open shortest path first (OSPF).

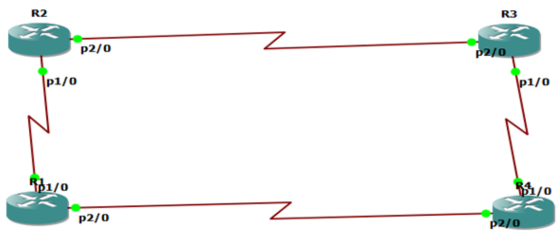

Fig.3SONET network design for Data.

V. MULTIPROTOCOL LABEL SWITCHING (MPLS)

MPLS is Internet Engineering Task Force (IETF), MPLS is advanced technology that supports IP services. MPLS iscapable of allowing multiple locations to communicate witheach other & share bandwidth. MPLS gives varies types of Services like voice, data & video over single network .MPLSarranged between layer 2 & 3 as shown below,

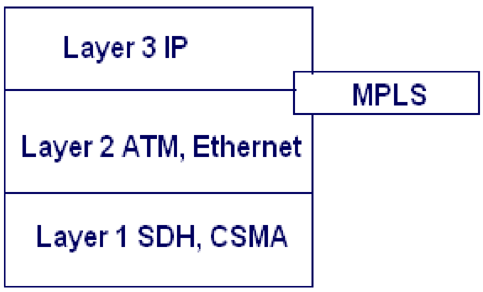

Fig.4 MPLS arrangement

MPLS is based on label switching. In this label can enter into MPLS network & exist from MPLS network, this entry & exit point called Label edge router(LER).MPLS perform simply push pop operation means push on MPLS label on incoming packets & pop it off from outgoing packets for this push pop operation MPLS implements Label Switched Router (LSR) . Labels are distributed between LERs & LSRs using label distribution

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protocol (LDP).Label switch path (LSP) are established by network. Now each packets carries label which associated with LSP. Each LSR maintain label forwarding table, when LSE receives packets simply it extracts label use it to index into forwarding table & replace by new label & forward packet in next LSP.

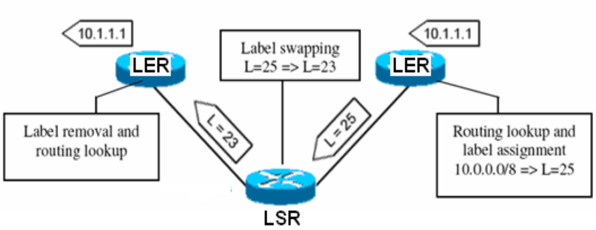

Fig.5 Label forwarding and swapping

LSR does forwarding process & replace label by new label with in fraction of second means MPLS offer less forwarding time & less propagation delay.

A. *Network design for data packets:*

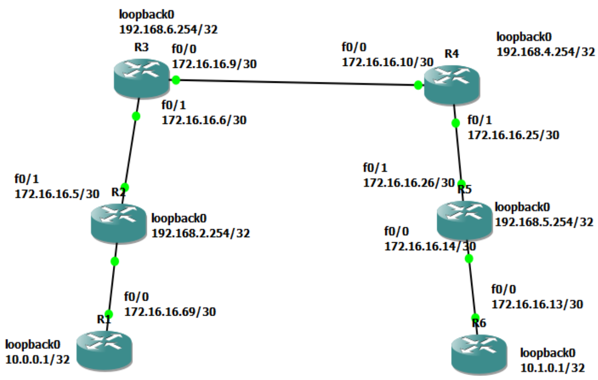

Fig.6MPLS Network Design for Data

In the above fig.6 MPLS network we assigned IP address & Loopback address to every router, the protocol used is open shortest path first, we started sending packets from one router to the other router and collected the delay values using those delay values we calculated the Jitter, Latency and Throughput values. When we compare normal IP data forwarding, SONET and MPLS networks the delay for MPLS should be very low & we obtained the same results and plotted them.

Simulation Code for MPLS data packets:

Write the code until OSPF as written for IP data packets then write the MPLS code

Configuring MPLS on all interfaces

<u>PUNE</u>

```
PUNE (config)# mpls ip
PUNE (config)# mpls label protocol ldp
PUNE (config)# interface f0/1
PUNE (config-if)# mpls ip
PUNE (config-if)# mpls label protocol ldp
PUNE (config-if)# end
PUNE#wr
```

<u>BANGLORE</u>

```
BLORE (config)# mpls ip
BLORE (config)# mpls label protocol ldp
BLORE (config)# interface f0/1
BLORE (config-if)# mpls ip
BLORE (config-if)# mpls label protocol ldp
BLORE (config-if)# exit
BLORE (config)# interface f0/0
BLORE (config-if)# mpls ip
BLORE (config-if)# mpls label protocol ldp
BLORE (config-if)# end
BLORE# wr
```

<u>HYDERABAD</u>

```
HYD (config)# mpls ip
HYD (config)# mpls label protocol ldp
HYD (config)# interface f0/1
HYD (config-if)# mpls ip
HYD (config-if)# mpls label protocol ldp
HYD (config-if)# exit
HYD (config)# interface f0/0
HYD (config-if)# mpls ip
HYD (config-if)# mpls label protocol ldp
HYD (config-if)# end
```

<u>CHENNAI</u>

```
CHENNAI (config)# mpls ip
CHENNAI (config)# mpls label protocol ldp
CHENNAI (config)# interface f0/1
CHENNAI (config-if)# mpls ip
CHENNAI (config-if)# mpls label protocol ldp
CHENNAI (config-if)# end
CHENNAI# wr
```

<u>Checking LDP</u>

Run these show commands in previledge mode in all routers to check LDP

```
# sh mpls interfaces
# sh mpls ldp discovery
# sh mpls ldp parameters
# sh mpls ldp neighbour
# sh mpls ldp bindings
# sh mpls ip bindings
```

<u>Configuring customer 1</u>

```
Cust1> en
Cust1 (config)# interface loopback 0
Cust1(config-if)#ip address 10.0.0.1 255.255.255.255
```

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Cust1 (config-if)# no shutdown
Cust1 (config-if)# exit
Cust1 (config)# interface f0/0
Cust1(config-if)# ip address 172.16.16.69 255.255.255.252
Cust1 (config-if)# no shutdown
Cust1 (config-if)# end
Cust1 (config-if)# wr

<u>Configuring customer 2</u>

Cust2> en
Cust2# config t
Cust2 (config)# interface loopback 0
Cust2(config-if)#ip address 10.1.0.1 255.255.255.255
Cust2 (config-if)# no shutdown
Cust2 (config-if)# exit
Cust2 (config)# interface f0/0
Cust2(config-if)#ip address 172.16.16.13 255.255.255.252
Cust2 (config-if)# no shutdown
Cust2 (config-if)# end
Cust2 # wr

VI. NETWORK DESIGN FOR VOIP:

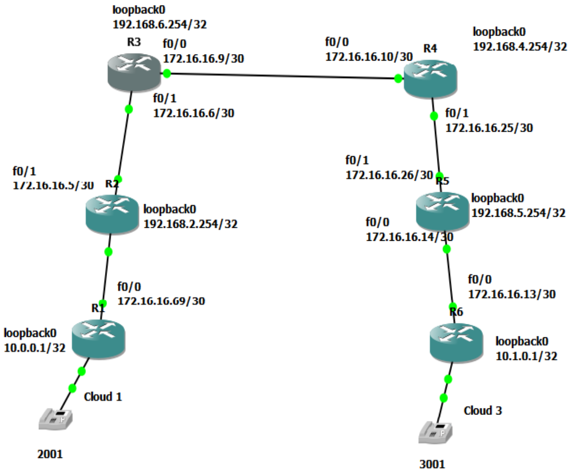

Fig.7 MPLS Network Design for Voice

Simulation Code for MPLS voice packets:

Write the code until OSPF & MPLS then write the code for MPLS voice packets.

Router# config t
Router(config)# int fa 0/0
Router(config-if)# ip address 192.168.1.1 255.255.255.0
Router(config-if)# no shutdown
Router(config-if)# exit
Router(config)# ip dhcp excluded-address 192.168.1.1 192.168.1.5
Router(config)# ip dhcp pool MYPOOL
Router(dhcp-config)# network 192.168.1.0
Router(dhcp-config)#default-router 192.168.1.1
Router(dhcp-config)#option 150 ip 192.168.1.1
Router(dhcp-config)# exit
Router(config)#wr

After configuring this code download the virtual box and upload any 2 operating systems with that download the vbox software which consists of 'cme' file in the virtual machine.

Router# erase flash:
Router# format flash:
Router# archive tar /xtract tftp://192.168.1.6/cme-full-4.3.0.0_minimized.tar flash:

After this download cisco IP communicator in both the operating systems.

Router# config t
Router(config)# telephony-service
Router(config-telephony)# ip source-address 192.168.1.1 port 2000
Router(config-telephony)# max-dn 10
Router(config-telephony)# max-ephones 10
Router(config-telephony)# exit
Router(config)# exit
Router# show ephones

Now give phone numbers to both the phones

Router# config t
Router# ephone-dn 1
Router(config-ephone-dn)# number
Router(config-ephone-dn)# number 2001
Router(config-ephone-dn)# exit
Router(config)# ephone-dn 2
Router(config-ephone-dn)# number 2002
Router(config-ephone-dn)# exit
Router(config)# do sh phone

After giving this command mac-address for the two IP phones will be generated.

Router(config)# ephone 1
Router(config-ephone)# mac-address ****.****.****
Router(config-ephone)# button 1:1
Router(config-ephone)# reset

Now the phone 1 will be reseted

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Router(config)# ephone2
Router(config-ephone)# mac-address ****.****.****
Router(config-ephone)# button 1:2
Router(config-ephone)# reset

Now make a call from IP phone 1 to IP phone 2.

VII. MPLS HEADER & EFFICIENCY:

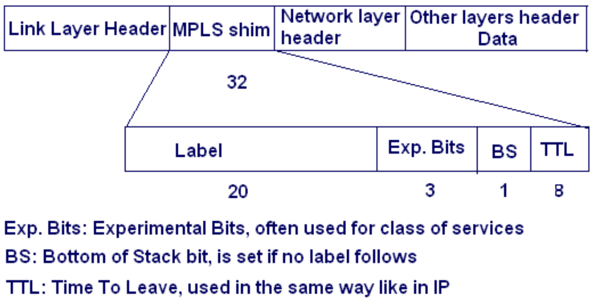

Fig.8 MPLS Header format

Field	Description
20 bit label	The actual label.
3bit experimental field	Used to define a class of services(QoS) (IP precedence)
Bottom of stack bit	MPLS allows multiple labels to be inserted; this bit determine if this label is the last label in the packet. If this bit is set (1), it indicates that this is the last label.
8 bit time to live (TTL) fields	A timer fields that has the same purpose as the TTL field in the IP header which is to track the lifetime of the datagram.

Table. 1 Description of MPLS Header

VIII. VOICE OVER INTERNET PROTOCOL:

Voice over Internet Protocol (VoIP) is a form of communication that allows you to make phone calls over a broadband internet connection. Basic VoIP access usually allows you to call others who are also receiving calls over the internet. Interconnected VoIP services also allow you to make and receive calls to and from traditional landline numbers, usually for a service fee. Some VoIP services require a computer or a dedicated VoIP phone, while others allow you to use your landline phone to place VoIP calls through a special adapter [10].over Internet Protocol (VoIP) is one of the most important technologies in the World of communication. VoIP is simply a way to make phone calls through the internet. VoIP transmits packet via packet-switched network in which voice packets may take the most efficient path. On the other hand, the traditional public switched telephone network (PSTN) is a circuit-switched network which requires a dedicated line for telecommunications activity. Furthermore, Internet was initially used for transmit data traffic and it is performing this task really well. However, Internet is best-effort network and therefore it is not sufficient enough for the transmission of real-time traffic such as VoIP [14].That the questions to be addressed were superordinate to VoIP became apparent during the early discussions of the Summit. Many (most) topics seemed to transcend VoIP to encompass campus networking as it evolves from today's legacy data networks to an environment that became known as "Integrated Communications Services (ICS)." VoIP, initially thought of as merely running telephones over an IP network, is no longer a technology problem (if it ever was). Rather, it represents a class of business and policy problems that surface as one contemplates an integrated, multi-services networking strategy, and hence the decision to change the name of the project. Early adopters are moving to multi-services environments that encompass voice, data, and video today and that contemplate a rich variety of network-connected devices[13].

IX. SIMULATION RESULTS:

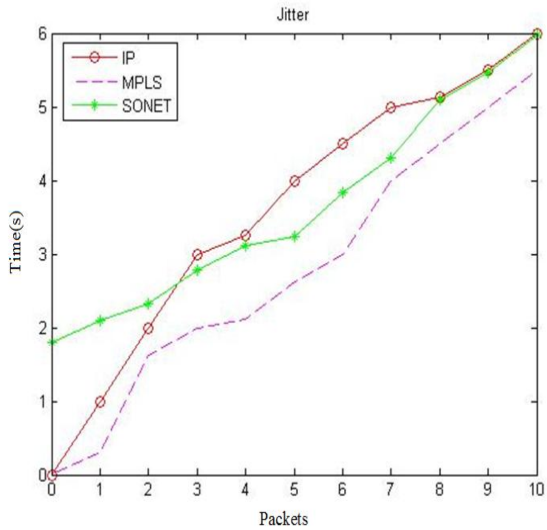

Fig.9Comparative jitter graph between IP, MPLS, and SONET network for Data.

In the above figure.9 if we observe IP data forwarding, 1 packet was transmitted in 1 second, 4 packets was transmitted in 3.2 seconds and 10 packets was transmitted in 6 seconds & for SONET 1 packet was transmitted in 2.1 seconds, 4 packets was transmitted in 3 seconds and 10 packets was transmitted in 6 seconds and for MPLS 1 packet was transmitted in 0.2 seconds, 4 packets was transmitted in 1.8 seconds and 10 packets was transmitted in 5.5 seconds.

From the above values we can say that the Jitter value is reduced for MPLS when compared with normal IP data forwarding and SONET.

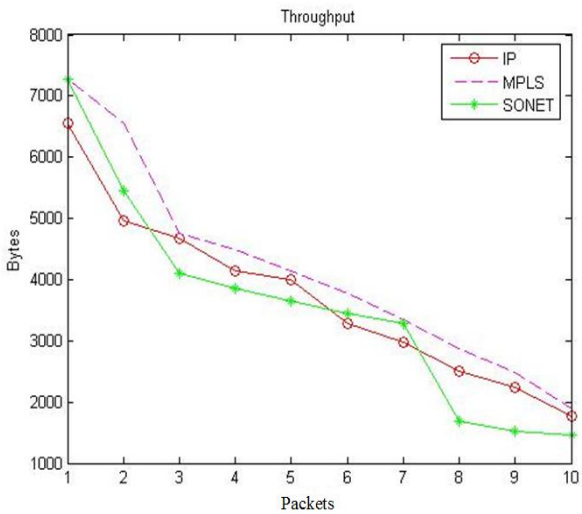

Fig.10Comparative throughput graph between an IP, MPLS, and SONET network for Data.

In the above figure.10 if we observe for normal IP data, 1 packet was transmitted with 6553 bytes, 4 packets was transmitted with 4147 bytes and 10 packets was transmitted with 1771 bytes & for SONET, 1 packet was transmitted with 7281 bytes, 4 packets was transmitted with 3855 bytes and 10 packets was transmitted with 1456 bytes and for MPLS, 1 packet was transmitted with 7281 bytes, 4 packets was transmitted with 4488 bytes and 10 packets was transmitted with 1883 bytes.

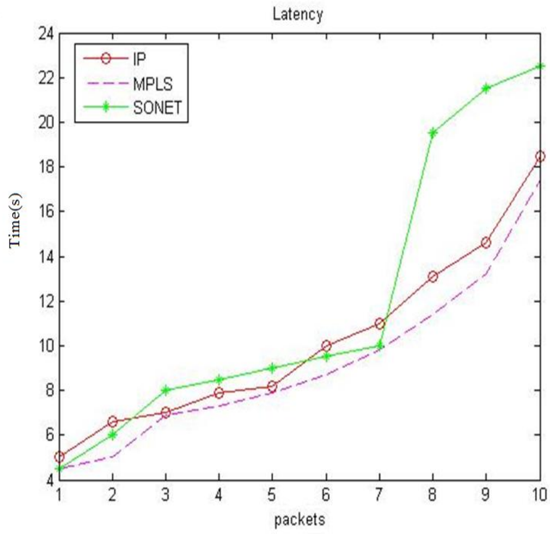

Fig.11Comparative latency graph between an IP, MPLS, and SONET network for Data.

In the above figure.11 if we observe for normal IP data, 1 packet was transmitted in 4.5 seconds, 4 packets was transmitted in 7.4 seconds and 10 packets was transmitted in 18.5 seconds& for SONET, 1 packet was transmitted in 4.5 seconds, 4 packets was transmitted in 7.3 seconds and 10 packets was transmitted in 17.4 seconds and for MPLS, 1 packet was transmitted in 4.5 seconds, 4 packets was transmitted in 6.6 seconds and 10 packets was transmitted in 17 seconds.

From the above values we can say that the Latency value is reduced for MPLS when compared with normal IP data forwarding and SONET.

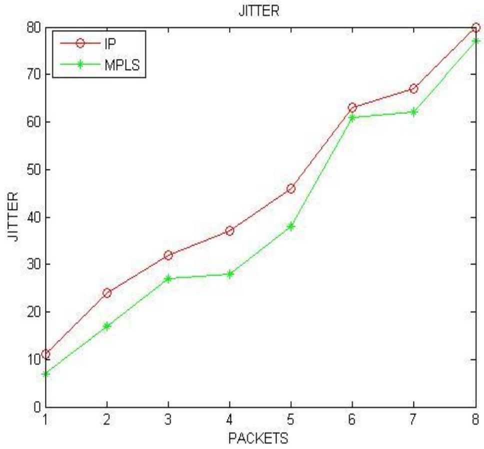

Fig.12 Comparative jitter graph between IP, MPLS network for Voice.

In the above figure.12 if we observe IP voice packet forwarding, 1 packet was transmitted in 11 seconds, 4 packets was transmitted in 37 seconds and 8 packets was transmitted in 80 seconds and for MPLS 1 packet was transmitted in 7 seconds, 4 packets was transmitted in 28 seconds and 8 packets was transmitted in 77 seconds.

From the above values we can say that the Jitter value is reduced for MPLS when compared with normal IP voice forwarding.

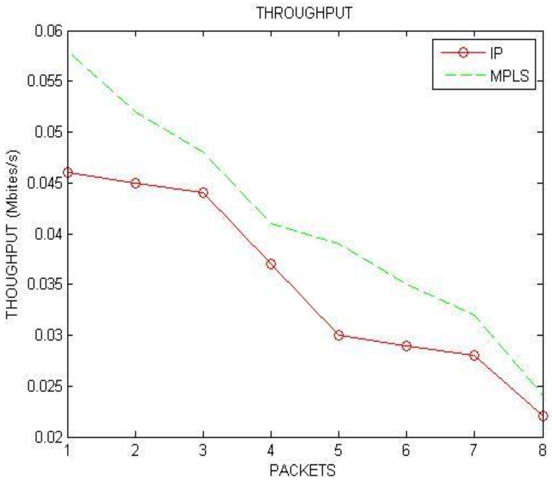

Fig.13 Comparative throughput graph between an IP, MPLS network for Voice.

In the above figure.13 if we observe MPLS voice packet forwarding, 1 packet was transmitted with 0.058 Mbits/s, 4 packets was transmitted with 0.041 Mbits/s and 8 packets was transmitted with 0.024 Mbits/s and for IP 1 packet was transmitted with 0.046 Mbits/s, 4 packets was transmitted with 0.037 Mbits/s and 8 packets was transmitted with 0.022 Mbits/s.

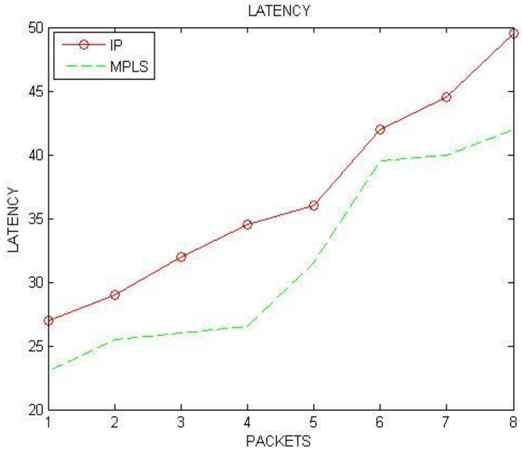

Fig.14 Comparative latency graph between an IP, MPLS network for Voice.

In the above figure.14 if we observe IP voice packet forwarding, 1 packet was transmitted in 27 seconds, 4 packets was transmitted in 34.5 seconds and 8 packets was transmitted in 49.5 seconds and for MPLS 1 packet was transmitted in 23 seconds, 4 packets was transmitted in 26.5 seconds and 8 packets was transmitted in 42 seconds.

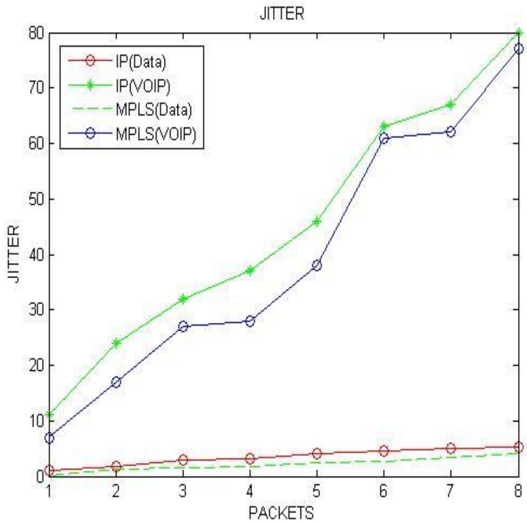

Fig.15 Comparative jitter graph between an IP (data), IP (VOIP), MPLS (data), MPLS (VOIP) network.

In the above figure.15 if we observe IP voice packet forwarding, 1 packet was transmitted in 11 seconds, 4 packets was transmitted in 37 seconds and 8 packets was transmitted in 80 seconds & for IP data packet forwarding 1 packet was transmitted in 1 second, 4 packets was transmitted in 3.2 seconds, 8 packets was transmitted in 5.2 seconds & for MPLS data forwarding 1 packet was transmitted in 0.2 seconds, 4 packets was transmitted in 1.8 seconds, 8 packets was transmitted in 4.2 seconds & for MPLS voice packet forwarding 1 packet was transmitted in 7 seconds, 4 packets was transmitted in 28 seconds and 8 packets was transmitted in 77 seconds.

If we compare above data and VOIP values for jitter, the data values are comparatively less when compared with VOIP values.

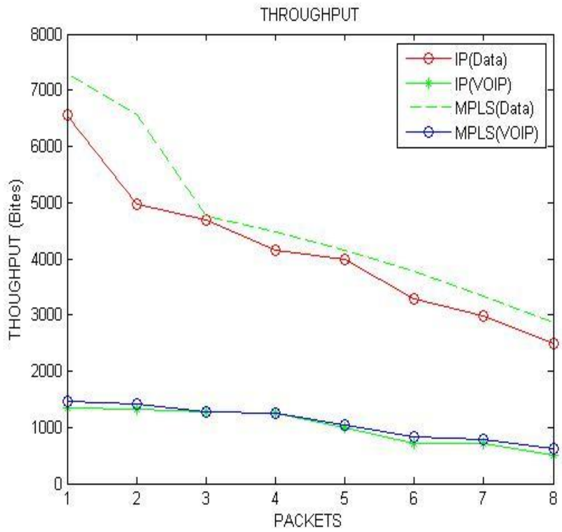

Fig.16 Comparative throughput graph between IP (data), IP (VOIP), MPLS (data), MPLS (VOIP) network.

In the above figure.16 if we observe MPLS voice packet forwarding, 1 packet was transmitted with 1456.33 bites, 4 packets was transmitted with 120.48 bites and 8 packets was transmitted with 612.47 bites & for MPLS data packet forwarding 1 packet was transmitted with 7281.66 bites, 4 packets was transmitted with 4488.69 bites, 8 packets was transmitted with 2874.34 bites and for IP voice packet forwarding 1 packet was transmitted with 1347.44 bites, 4 packets was transmitted with 1256.52 bitesand 8 packets was transmitted with 500.47 bites& for IP data packet forwarding 1 packet was transmitted with 6553.5, 4 packets was transmitted with 4147.7 bites and 8 packets was transmitted with 2501.33 bites.

If we compare above data and VOIP values for throughput, the VOIP values are comparatively less when compared with data values.

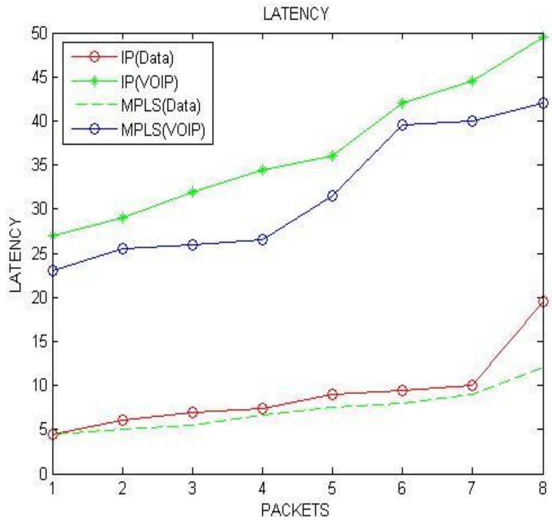

Fig.17 Comparative latency graph between IP (data), IP (VOIP), MPLS (data), MPLS (VOIP) network.

In the above figure.17 if we observe IP voice packet forwarding, 1 packet was transmitted in 27 seconds, 4 packets was transmitted in 34.5 seconds and 8 packets was transmitted in 49.5 seconds & for IP data packet forwarding 1 packet was transmitted in 4.5 second, 4 packets was transmitted in 7.4 seconds, 8 packets was transmitted in 19.5 seconds & for MPLS data forwarding 1 packet was transmitted in 4.5 seconds, 4 packets was transmitted in 6.6 seconds, 8 packets was transmitted in 12 seconds & for MPLS voice packet forwarding 1 packet was transmitted in 23 seconds, 4 packets was transmitted in 26.5 seconds and 8 packets was transmitted in 53.5 seconds.

Here we compared the data and VOIP values for latency, the data values are comparatively less when compared with VOIP values.

From the above graphs we conclude that by using MPLS better performance can be obtained and their following results can be verified by using above graphs.

X. CONCLUSION

In today's highly demanding world the need for a good network service is very important and challenging for the service providers to full fill all the needs of the customers in all the ways. But they have come up with this new MPLS technology that could facilitate efficiency and QoS, this paper has given the simulating test results of the three such parameters like jitter, latency and throughput of IP, SONET and MPLS under two conditions (one using data and other using voice) and comparatively MPLS has given a better performance in both the conditions which allows us to come to a conclusion that it is one of the best network technologies existing and also has also got scope for expansion of its services over the years.

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