PERFORMANCE ANALYSIS OF VOICE LOAD BALANCING CONFIGURATION FOR MPLS NETWORK AND IP NETWORK WITH MUTATION TESTING

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Abstract— Multiprotocol Label Switching technology is an evolving technology that provides the reliable and efficient distribution of the Internet services with high transmission speed and lower delays. The important feature of MPLS network is its Traffic Engineering (TE), which is used to manage the computer network effectively for efficient utilization of network resources such as bandwidth, link utilization etc. MPLS technology is generally used for implementing real-time applications such as voice and video applications because it provides efficient forwarding mechanism, lower network delay, scalability and anticipated results. As network applications such as voice, video are increasingly being used today, so the requirements for fault tolerant networks is also increasing in order to carry sensitive voice or video traffic. The network mechanism to tolerate Faults as provided by MPLS network provides end to end "Quality of Service" .In this paper the performance of Voice load is compared between MPLS network and conventional Internet Protocol (IP) network with load balancing and how MPLS increases the capability of the deployed IP network to transport voice traffic in-between end devices with unexpected failures in between links. In MPLS network, an incoming packet is classified only once as it enters into the MPLS domain and gets assigned label information and then all decisions over the path specified are based upon the attached label and not upon destination IP addresses. OPNET modeler 14.5 is used to simulate IP and MPLS networks and the comparison is made based on some performance metrics such as voice jitter, voice packet end-to-end delay, voice delay variation, voice packet sent and received. The simulation results are analyzed and it shows that MPLS based solution provides better performance in implementing the FTP, VoIP and video application.

I. INTRODUCTION

Today Internet is playing an indispensable role in most of the people‘s life due to different applications and services provided by the internet which results into an increased number of Internet users. To provide the real-time applications such as voice, video on the traditional IP networks is very difficult as it doesn‘t provide quality of services and Traffic Engineering (TE). In IP network, when a packet arrives at each node, it consults a pre computed routing table in order to forward the packet through the specified path. Routing tables are constructed using routing protocols or through manual configuration. Additionally, Internet Protocol networks provide minimum predictability of services which is unacceptable for the applications like telephony and multimedia services [30].

In conventional IP routing, it is not possible to provide a mechanism for load balancing across unequal cost path as there is always a single best path towards the destination even if we consider multiple path metrics. All data or voice packets from source to destination in an IP network adopt the best path through independent look up table at each intermediate node. So in uttermost situations, the best path in an IP network has to carry a large volume of data or voice traffic due to which packets may get drop or acquire a certain level of network latency, whereas the bandwidth also gets wasted because the not-so best network paths remains idle and are not being used for carrying packets.

MPLS technology provides better performance in implementing the real time applications such as Voice, video applications [8]. Multi-Protocol Label Switching (MPLS) is an evolving technology which utilizes Resource Reservation Protocol (RRP) and Path selection based on Available Bandwidth Estimation (ABE) to securely manage traffic from the source to Multiconsole MPLS VPN cloud [8]. MPLS networks plays an important role in the next generation computer networks by providing Quality of Service (QoS) and traffic engineering. MPLS networks provide high performance packet control and forwarding mechanism, which forwards the packets based on the labels [33]. It overcomes the limitations like bandwidth wastage, excessive delays and high packet loss of IP networks by providing scalability and congestion control mechanism. So MPLS networks are considered ideal for multimedia applications.

In MPLS networks, a specific path is determined for a given sequence of packets. Each packet is identified by a label. So time is saved and the router need not to look up the address of the next node in order to forward the packet. MPLS is called multiprotocol because it works with different protocols such as Internet Protocol (IP), Asynchronous Transport Mode (ATM), and frame relay network protocols.

It ensures the reliable distribution of the Internet services with high transmission speed and lower delays. The main feature of MPLS is its Traffic Engineering (TE), which can be used for managing the networks for efficient utilization of network resources such as bandwidth. This technology is more suitable for implementing real-time applications such as voice and video due to lower network latency, lower network delay, efficient forwarding mechanism, scalability and predictable performance of the services provided by MPLS.

II. Research Methodology

This research work involves the detailed study of the literature of Internet Protocol and Multi Protocol Label Switching network. In this research work both qualitative and quantitative approaches are used. In this paper, different network scenarios are implemented to gain a better knowledge about the characteristics of diverse applications. Different evaluation methods are chosen based on different parameters. The theoretical knowledge gained is implemented in the Optimized Network Engineering Tool research simulator.

A network model is designed and results are collected to compare the performance of voice load balancing configuration over MPLS network with IP network under mutation testing.

III. Network design

This section describes which network elements are used and how these network elements are placed to design a network topology in an OPNET modeler 14.5. In order to study the characteristics of the network, the baseline network remain consistent and only the configuration on the interacting nodes differ as per the study objectives. In this research paper, the network components that can be used from OPNET library are as follows:

ethernet2_slip8_ler: It is a Label Edge Router. It has 2 Ethernet ports and 8 serial interfaces for WAN Point to Point Protocol connections. It is used at edges of a multi-protocol label switching (MPLS) network. Label edge routers act as a gateway between the local area network and wide area network or the Internet itself. They handle the entrance and exit of packet information to the computer network. It is the configuration that dictates how to work in a respective configured environment. It runs IP routing protocols and provides the IP layer functionalities as routing. It works as a boundary router once it is MPLS labeled in MPLS domain and it is able to PUSH or POP the label on packet as required.

ethernet2_slip8_lsr: It is a Label Swapping/Switching Router. It has 2 Ethernet ports and 8 serial interfaces for WAN Point to Point Protocol connections. It is used specifically for the purpose of receiving an incoming labeled packet in an MPLS domain network and it swaps the label and forward to the next hop along the LSP. It constructs the LFIB once enabled for MPLS network based on advertised labels.

ethernet_server_adv: It is used to simulate the service server in the network. It contains one Ethernet connection to the switch.

ethernet16_switch: This OPNET module simulates the Ethernet switch with total 16 Ethernet ports available, on either side of the "ler". The end devices, **ethernet_server_adv** and **ethernet_server_adv** are connected to this module .

MPLS_E-LSP_DYNAMIC: As the network topology is configured for MPLS, the LSP are built automatically inside the network. But those LSP follow the IP shortest path in between two nodes. To develop an explicit LSP around the network, this OPNET element simulates the behavior of such dynamic LSP. If not configured with explicit nodes along the LSP path, the dynamic LSP adjusts itself with the changing network scenarios with guaranteed resources along the network. For most of time, an LSP with explicitly specified route is used. A dynamic LSP is signaled using RSVP or CR-LDP, at the simulation startup. CR-LDP makes use of the dynamic routing protocols to calculate the dynamic LSP towards a certain destination, as mentioned in its explicit path [27].

MPLS_E-LSP_STATIC: Static LSP are not signaled during the startup. Static LSP allow more routing control but fewer resiliencies to node or link failure [27]. Despite the fact that dynamic LSP behaves better following a failure, this thesis work takes into account both options for MPLS LSP to better understand the network characteristics following a failure. Besides the above mentioned OPNET network elements, there are certain OPNET control elements, used to configure policies, network wide configurations and adjusting scenarios. The OPNET control objects used in this research work, which includes:

Application Config: This element is used to tell OPNET which application is going to be modeled upon the underlying network. A single Application Config. is used to instruct . OPNET for multiple network applications. Application parameters for different application types being observed are configured in this element.

Profile Config: Profiles describe the activity patterns of a user or group of users in terms of the applications used over a period of (simulation) time [27]. There can be several different profiles running on a given network under observation. User profiles have diverse properties, so configuring a certain profile with a specific application is done here. The configured profiles are then assigned to the network users.

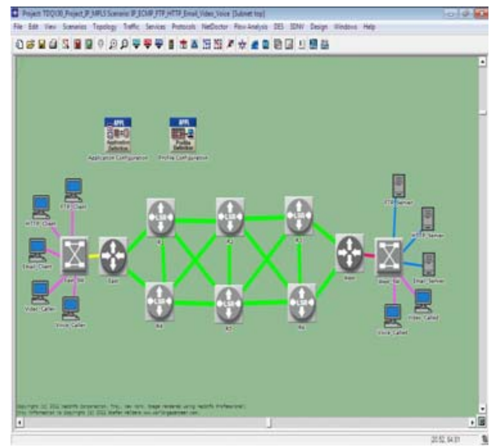


Figure1 : IP/MPLS architecture

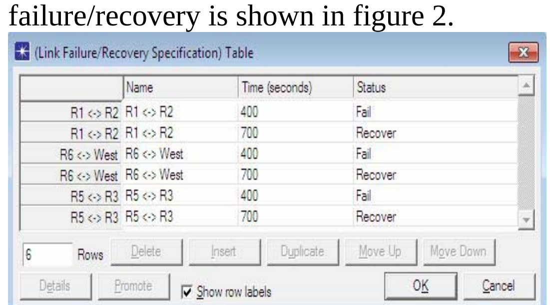
Figure 1 shows the basic IP/MPLS network architecture in which workstations are connected to LER through Ethernet switch. Packets are routed from LER at one edge through LSR at other edge.

IV. Internet Protocol Equal Cost Multiple Path Per-packet Load balancing configuration with Mutation Testing

On Internet Protocol Equal Cost Multiple Path, mutation testing is done with load balancing scenario. Three different network links are broken with the help of OPNET failure/recovery model, with respect to the simulation timing. The timing taken into account for three different scenarios is:

- Simulation time 400sec link(s) will go down
- Simulation time 700sec link(s) will come up again

Only the configuration for the three links failure/recovery is shown in figure 2.



(Link Failure/Recovery Specification) Table

	Name	Time (seconds)	Status
R1 <-> R2	R1 <-> R2	400	Fail
R1 <-> R2	R1 <-> R2	700	Recover
R6 <-> West	R6 <-> West	400	Fail
R6 <-> West	R6 <-> West	700	Recover
R5 <-> R3	R5 <-> R3	400	Fail
R5 <-> R3	R5 <-> R3	700	Recover

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Figure 2: Link Failure/Recovery specification table

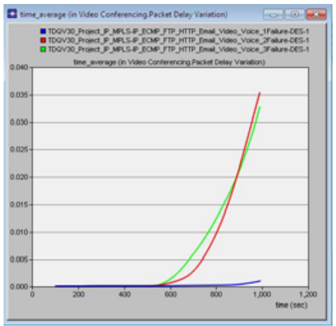

Figure 3: Video Conferencing Packet Delay variation

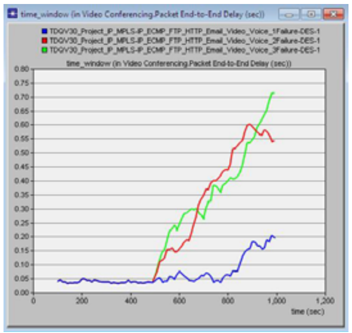

Figure 4: Video Packet End to End Delay

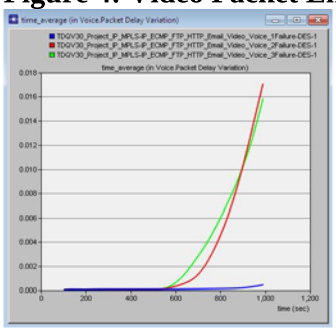

Figure 5: Voice Packet Delay Variation

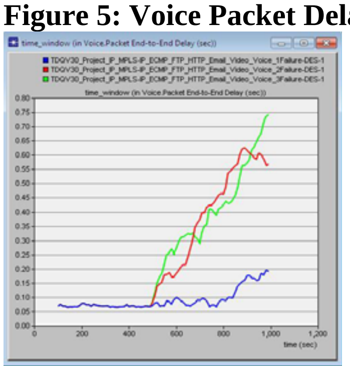

Figure 6: Voice Packet End to End Delay

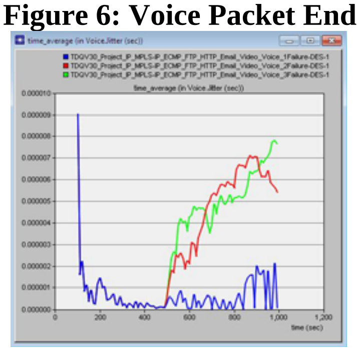

Figure 7: Voice Jitter

From the above network characteristics, it had been observed that when the link between router R6 and west switch fails and the link between router R3 and router R5 fails then voice, video packet delay variation, end to end delay and voice jitter increases in an IP network.

V. Internet Protocol Equal Cost Multiple Path under Loaded Network configuration with Mutation Testing

In this scenario the affect of load in the network has been considered. The computer network load with failure scenario will help understand network statistics in a better way. Different failure scenarios have been made and the link bandwidth has been adjusted to be reserved at 20%. It means that 1Mbps of core transmission links is being reserved. With network traffic, the links are being filled which makes transmission links busy in to and fro directions. The same configuration is used to fill up all core transmission links with network traffic at 20%.

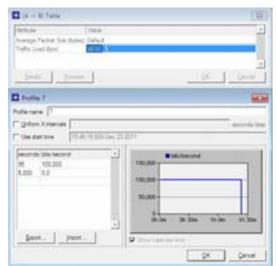

Figure 8: Link Utilization in OPNET Configuration

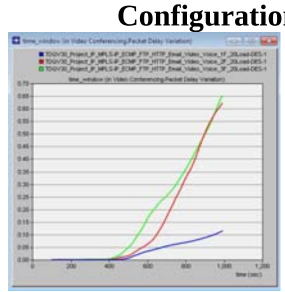

Figure 9: Video Conferencing Packet Delay Variation because link gets failed under loaded network configuration.

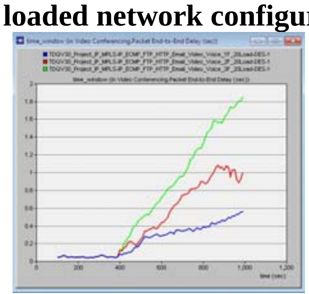

Figure 10: Video conferencing packet End to End Delay under mutation testing and network loading.

Figure 11: Voice Jitter: Increases because of link failure and increase in the network load.

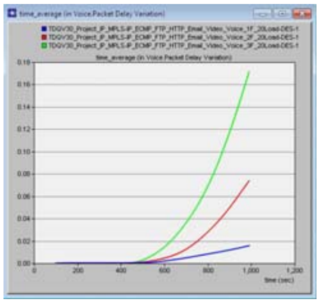

Figure 12: Voice Packet Delay variation: Increases because of link failure and with network loading.

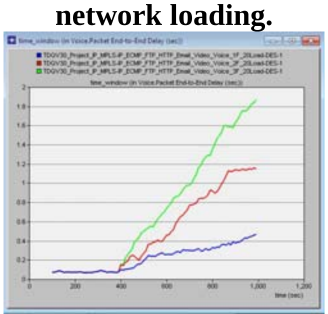

Figure 13:Voice Packet End to End Delay: Increases because of link failure and network loading.

VI. Multi Protocol Label Switching Baseline Network

In this scenario MPLS is being enabled at the core routers. So it constitutes an MPLS domain. If there is no Traffic Engineered tunnel, then the path taken by labeled packets would remain the same as Internet Protocol shortest path. Hence, just by enabling MPLS in a computer network without its Traffic Engineering ability pays less attention to applications using it. The dependence of MPLS on routing protocols provides the MPLS network to do load balancing across ECMP [19]. Given below are the network characteristics collected for different application traffic:.

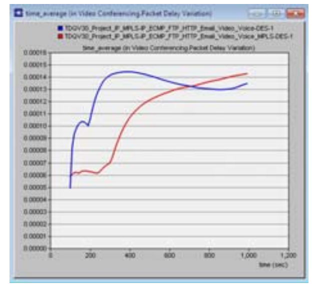

Figure 14: Video conferencing Packet Delay Variation

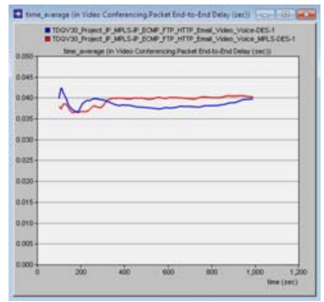

Figure 15: Video conferencing Packet end to end delay.

As shown in the figure 30 video conferencing packet end to end delay is minimum in MPLS network.

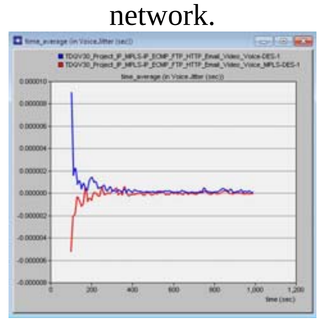

Figure 16: Voice Jitter

As shown in figure 31 that the voice jitter is very small i.e almost negligible in MPLS enabled network as compared to IP network .Voice jitter gets reduced when MPLS technology is being used.

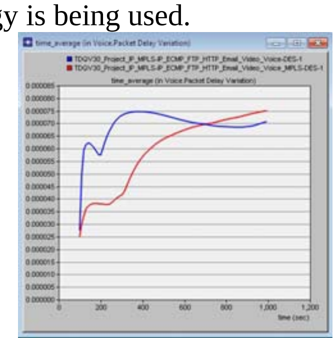

Figure 17: Voice packet delay variation.

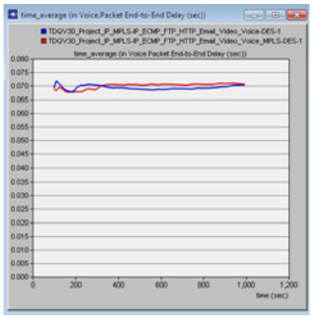

Figure 18: Voice Packet end to end delay

VII. Multi Protocol Label Switching network for Mutation Testing with Traffic Loaded Network configuration

In this scenario, the MPLS network is being configured for some load and then the network efficiency is being checked in response to link failure. The following network characteristics are being achieved when the network traffic load across all core transmission links become equal to 20% capacity of each link. It means it is approximately 1Mbps. The consideration for link failure and the recovery of the corresponding link in an MPLS network would result in a good design of the network.

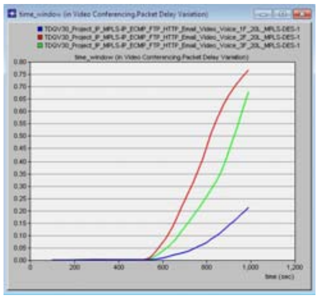

Figure 19: Video conferencing packet delay variation

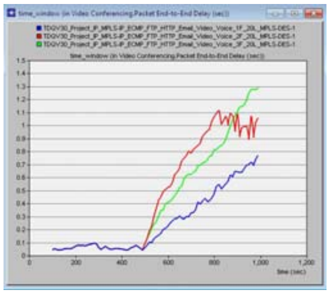

Figure 20: Video packet end to end delay:

Figure 21: Voice jitter

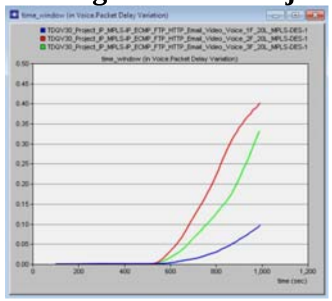

Figure 22 : Voice packet delay variation

Figure 23: Voice end to end delay

VIII. Conclusion

From above network characteristics, it can be concluded that to handle hard failures inside an IP network is difficult as compared to MPLS network. In an IP network, the only way to handle such hard failure i.e link failure is to build an alternative path i.e. secondary path. In order to handle such link failures in an IP network, routing protocols are required. The main drawback of this mechanism is that it depends upon the recovery time of routing protocol and moreover all routing protocols do not have equal time of calculation while creating a new shortest path first around a failed network resource. The drawback of IP networks in handling link (hard) failures in a better way can be handled by using IP/MPLS technology.

This technology has been prominent in internet service provider's domain as a network tool to handle congestion and failure situations. The simulation results shown by IP/MPLS network to handle hard failures show effective recovery and protection schemes. In this paper, different network scenarios have been simulated in

OPNET simulator and found that IP/MPLS provides almost constant failover time.

Based on the simulation results it can be concluded that MPLS provides best solution in implementing the VoIP application (Internet Telephony) and video conferencing with fault tolerant mechanism compared to conventional IP networks because of the following reasons

- Routers in MPLS takes less processing time in forwarding the packets, this is more suitable for the applications like VoIP which posses less tolerant to the network delays.
- Implementing of MPLS with TE minimizes the congestion in the network. TE in MPLS is implemented by using the signaling protocols such as CR-LDP and RSVP.
- MPLS suffers minimum delay and provides high throughput compared to conventional IP networks.

REFERENCES

[1] Adrian, F., 2004 “The Internet and Its Protocols - A Comparative Approach”, Morgan Kaufmann Publishers.

[2]Atiquzzaman,M.,1999.,"Traffic Management and Switching for Multimedia", *IEEE Communications Magazine*, Vol. 37, pp. 30.

[3] Awduche, Daniel O.,1999.,"MPLS and Traffic Engineering in IP Networks", *IEEE Communications Magazine*, Vol. 37, No 12,pp. 42-47.

[4] Bernard, F., Jennifer, R., Mikkel T.,2002. “Traffic Engineering With Traditional IP Routing Protocols”, *IEEE Communications Magazine*, Vol 40, No.10, pp. 118-124.

[5] Braun, T., Diaz, M., Staub J., 2008 “End-to-End QoS over Heterogeneous Networks”, *Springer*, pp. 49-73.

[6] Breslau,L. ,Estrin, D., Fall, K., Floyd, S. Heidemann,J., Kelmy,A. Huang,P. McCanne, S. Varadhan,K., Xu,Y. and Yu, H. , 2000., “Advances in network simulation,” *IEEE* Computer, pp. 59–67.

[7] Bruce, S. , Adrian, F.,2008., “MPLS: Next Steps”, Morgan Kaufmann Publishers.

[8] Ezeh, G.N, Onyeakusi, C.E, Adimonyemma, T.M., Diala, U.H., 2014 “Comparative Performance Evaluation Of Network Traffic Over Multi-Protocol Label Switching using Virtual Private Network (VPN) Internet Cloud And Traditional Internet Protocol Networks”, *International Journal of Emerging Technology & Research* Volume 1, Issue 3,pp. 130-140.

[9] Feldmann, A., Greenberg A., Lund C., Reingold, N. and Rexford J,2000., “Netscape: traffic engineering for IP networks,”*IEEE Network Magazine*, vol. 14, no. 2, pp. 11–19.

[10] Finsiel, Luca D. and Stefano, S.,2000., "Network Traffic Measurements and Experiments: Effective Traffic Measurement ", IEEE Communications Magazine, pp. 138-143.

[11] Floyd, S. and Paxson, V., 2001. ,"Difficulties in Simulating the Internet", *IEEE*/ACM Transactions on Networking, Vol.9, No. 4, pp. 392-403.

[12] Frost, V.S. and Benjamin, M., 1994., "Traffic Modeling For Telecommunications Networks" *IEEE Communications Magazine*, pp. 70-81.

[13] Ghanwani, A.,Jamoussi, B., Fedyk D., Ashwood ,S., Peter, Li. Li, and Feldman N.,1999, "Traffic Engineering Standards in IP Networks Using MPLS", *IEEE Communications Magazine*, Vol 37, No 12, pp. 49-53

[14] Goralski W., “The Illustrated Network”, Elsevier, 2008

[15] Hussein, A., Adnan, H., Hawraa, J. ,2013“The Affects of Different Queuing Algorithms within the Router on QoS VoIP application Using OPNET” ,*International Journal of Computer Networks & Communications (IJCNC)* Vol.5, No.1, pp. 117-124.

[16] Jeff, D., Jennifer, C, 2005 “Routing TCP IP” Volume 1, 2nd Edition, Cisco Press.

[17] Jim W.Roberts: "Traffic Theory and the Internet" *IEEE* Communications Magazine, January 2001, pp. 94-99.

[18] Jong-Moon, C., Elie, M., Sandhu H., and Sang-Chul, K., 2001. “VoIP over MPLS Networking Requirements”, *ICN* 2001, LNCS 2094, pp. 735–744.

[19] Julian, L., Ina, M., 2010“MPLS enabled applications: emerging developments and new technologies”, 3rd edition, Wiley.

[20] Kaur, G. and Kumar, D., 2010,” MPLS Technology on IP Backbone Network”, *International Journal of Computer Applications*, Volume 5– No.1, pp. 13-16.

[21] Keshav, S., 1997., “An Engineering Approach to Computer Networking: ATM Networks, the Internet, and the Telephone Network", Addison-Wesley, Inc., Reading, Massachusetts.

[22] Luc De ,C. “MPLS Fundamentals”, , Cisco Press 2007

[23] MPLS Model Description. OPNET Documentation
[24] Mir, N.F., Chien, A., 2002. "Simulation of Voice over MPLScommunicationsNetworks",IEEE ICSS'02,conference,pp. 389-393.
[25] Naoum, R.S., Maswady, M., 2012. "Performance Evaluation for VOIP over IP and MPLS", *World of Computer Science and Information Technology Journal (WCSIT)* ,Vol. 2, No.3,pp.110-114.
[26] Newman, David,Network Computing, "Internet Traffic Management: From Chaos, Order", Vol. 11, No. 11, June 12, 2000, pp. 85-94.
[27] Opnet Product Documentations, Version 14.5, OPNET Inc..
[28] Paxson, V., and Floyd, S., 1995: "Wide Area Traffic: The Failure of Poisson Modeling", *IEEE*/ACM Transactions on Networking, Vol. 3, No. 3,pp. 226-244.
[29] Paxson, V. and Floyd, S., 1997., "Why We Don't Know How To Simulate The Internet" Proceedings of the Winter Simulation Conference, pp. 1037-1044.
[30] Porwal, M.K, Yadav, A., Charhate, S.V,2008., "Traffic Analysis of MPLS and Non MPLS Network including MPLS Signaling Protocols and Traffic distribution in OSPF and MPLS", International Conference on Emerging Trends in Engineering and Technology, ICETET, pp. 187-192.