

# Comparing the Performance of Real-Time Applications based on IPv4 and IPv6 Networks

Vahid Ghoreishi<sup>1</sup>, Shahram Mohammadi<sup>2</sup>

MSc graduate<sup>1</sup>, Assistant professor<sup>2</sup>  
Department of electrical and electronic engineering  
University of Zanjan  
Zanjan, Iran

**Abstract**—With the expansion of Internet, the current protocol address space (IPv4) is faced with a shortage and the new generation Internet (IPv6) is raised in order to solve this problem. Also with increasing interest of users in real-time and multimedia applications, the Internet and how to implement these applications to improve the quality of service (QoS) has become a significant challenge. In this paper, a network with both IPv4 and IPv6 protocols is simulated by using OPNET Modeler and implementation of QoS is tested on it. Packet loss, end-to-end delay and jitter were evaluated as network performance metrics. The results showed that satisfying the needs of multimedia applications on IPv6 are slightly weaker than IPv4, but the benefits have evolved more and more and the difference is negligible. Also according to the methods used in terms of this study, the combination of DiffServ and MPLS QoS implementation is the best option for both Internet Protocol versions.

**Keywords**—IPv4, IPv6, real-time applications, Quality of Service (QoS), BE, DiffServ, MPLS

## I. INTRODUCTION

Nowadays, Internet is the most important and popular network of the world. But with the unexpected increase of number of users, the current Internet (IPv4) is not able to expand and due 32-bit address space, it is not possible to connect more than four billion hosts on the network. In 1991, IETF developed a new generation of Internet Protocol with a 128-bit address space, currently known as IPv6 [1] [2]. On the other hand, real-time and multimedia applications such as voice and video, from the perspective of an Internet user, have a high degree of importance. Thus improving the quality of service (QoS) and needs of the new generation of real-time applications should be considered. Quality of service of an application can be defined as the level of user satisfaction with using the program. Networks where QoS is not activated there, are known as Best Effort (BE). Differentiated Service (DiffServ) [3] and Multi-Protocol Label Switching (MPLS) [4] structures have been proposed by the IETF are useful for guaranteeing QoS [5].

DiffServ architecture has features such as traffic classification and scalability and can easily handle a large volume of data [6]. In this mechanism, a bit is added to the packet header. By this bit, a packet that arrive a router, declare belonging to a particular class of traffic. Routers in the face of

this bit behave a certain way. This manner known as Per-Hop Behavior (PHB) and during it the router needs more than one bit to make decisions [1]. IETF assigned six valuable bits of TOS byte in the IPv4 header and TC byte in the IPv6 header to the DiffServ Code Point (DSCP). DSCP is used for selecting a PHB by a packet [7]. Three types of PHBs have been introduced by IETF. Default PHB tries to act as BE and has no guarantee in typical IP networks [8]. Expedited Forwarding (EF) has minimum loss and delay, and can be accessed by giving high priority to packets of EF or implementing WFQ with giving more weight to these packets [1]. The third PHB is Assured Forwarding (AF) that is rooted in RED method. AF is composed from four classes and each class has three different probability values to packets drop [1] [9].

MPLS improves scalability and flexibility of IP network and by optimizing bandwidth minimize the congestion effect [10]. The main idea behind MPLS networks is to provide facilities for Forwarding Equivalence Classes (FEC). All packets of a FEC accept similar label and transmit only through a path called LSP. Routers allocate a FEC to each of packets before sending them and then map each FEC to next step. So next routers don't need to analyze the packet header. It increases the speed of the network [4]. In addition, the resources needed along the way, are already stored. Shim header is added to the start of IP header to insert MPLS label. This header is 32 bit and composed of four parts. An important part is EXP (or QoS) that defines the class of service [1].

In this study a network is designed under two separate IPv4 and IPv6 protocols and QoS performance metrics including delay, jitter, packet loss rate and throughput of the links in the BE, DiffServ and combining of MPLS and DiffServ are tested. At the end the results are reviewed with a comparative style.

The second part will point to related works. In the third part we will propose a method with its simulation. Section IV presents the results of the simulation, and finally a conclusion in Section V will be presented.

## II. RELATED WORKS

After IPv6 is proposed by IETF, attempts to compare this protocol with IPv4 were done and still continue. It not only helps to standardize IPv6, but leads to the evolution of the current version of Internet. [11] provided two same workstations under Windows 2000 and Solaris 8 and IPv6 and

IPv4 on these operating systems are implemented. Based on testing, IPv6 has lower throughput and higher delay than IPv4. In [12], delay and packet loss rate in large scale IPv6 are studied. Results showed that the delay in IPv6 is higher than IPv4 and more packets are lost. In [13] VOIP performance was tested by a softphone for LAN networks based on IPv4 and IPv6. The values obtained from the experiments show that there is little difference between the performances of VOIP in the two versions of the protocol. Even the maximum jitter and packet loss rate of IPv6 are slightly more than IPv4.

[14], [15], [16] and [17], implemented a QoS service based on DiffServ (EF) on a real IPv6 network connected to 6NET that has the lowest latency, jitter and packet loss for real-time traffic. In [18] a DiffServ network can be seen in all path from source to destination and the IntServ traffic is mapped to DiffServ by a mapping function. As we can see from the results, the QoS requirements can be achieved clearly in this way. [19] studied DiffServ QoS mechanisms under the three service classes EF, BE and LBE on both versions of IP in two separate test beds and used classification with access list to use flow label field in IPv6 header. The successful implementation of these tests have proven that the flow label classification based on DSCP is possible within a crowd. In [20] DiffServ is used to support QoS, but since DiffServ cannot control traffic congestion of end-to-end paths, MPLS do this. The results suggest that Packet Delay Variation (PDV) in IPv6 is more than IPv4.

### III. THE PROPOSED METHOD AND SIMULATION PROCESS

#### A. The Scheme and Network Topology

Here's a simple computer network intended. Audio and video conferencing applications as network traffic was taken into account and can occupy the entire network bandwidth. BE, DiffServ and combining of MPLS and DiffServ architectures were used at three separate mode and their effectiveness in providing end-to-end QoS were compared. Desired network is investigated in two independent modes with different traffics and architectures. At the first, network elements are configured to support IPv4 and in the other case, to support IPv6 only. Fig.1 shows the network created by OPNET Modeler 14.5 simulator.

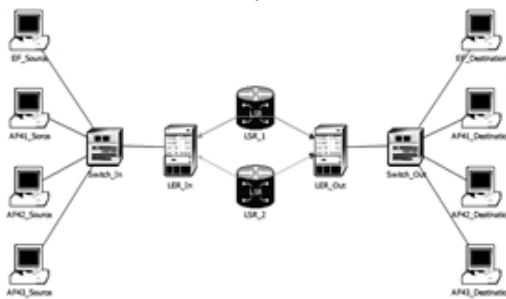


Fig. 1. The network configuration in OPNET simulator

#### B. Network Traffic

To test the method proposed in this study, two types of multimedia traffic such as voice and video conferencing traffic is taken into account. For voice traffic, conversation with PCM quality, has been chosen. PCM coding scheme for transmitting a digital phone system is discussed in [21]. PCM data rate is 64 kilobits per second and the default size of the frames is 10 ms, i.e., an audio frame's size is 640 bits or 80 bytes and 100 frames will be sent per second. The audio used in EF\_Source and EF\_Destination workstations and to be close to the volume of traffic on the other stations, 13 audio applications are used simultaneously. Then, video with low resolution is used for video conferencing. Each pixel of the video, is equivalent to 9 bits and data transmission rate in bits per second is equal to 1,382,400. The video application is located on three couples of workstations (AF4x\_Destination and AF4x\_Source). Here to measure the impact of congestion on the network, the traffic began to flow at a time and will continue until the end of the simulation.

Backbone of the network which is located between LER\_In and LER\_Out, is the main domain of DiffServ and MPLS. In this area, there are two quite similar paths and the use of OSPF algorithm will divide the traffic approximately equal between paths. At the end, experimental data rate of 8.2 Mbps on the links in this area is defined.

#### C. Design Test

The Test consists of three parts, which in turn, study influence of BE, DiffServ and MPLS on the network and each of these sections are implemented separately on the IPv4 and IPv6. To prepare the test bed, the interfaces are addressed and then as OSPFv2 and OSPFv3 routing algorithms are implanted for IPv4 and IPv6 respectively in the backbone network. To apply BE to the system, the value of TOS and TC fields and consequently DSCP should be zero.

In the second part, the DSCP field in the audio application goes to EF mode and in video applications takes AF41, AF42 and AF43 values. EF and AF4x services are used because of their appropriateness and acceptability in VOIP and video conferencing [22]. By applying EF, AF41, AF42 and AF43, DSCP value becomes 46 (101110), 34 (100010), 36 (100100) and 38 (100110) respectively. These PHBs allocate applications to separate classes, especially in video applications, each pair of workstations in the first part of the experiment those were the same, will act differently. After separation of traffic, applications should be transmitted to the backbone of the network according to their priorities. This should be done at the edge of the area (LER\_In router). To prepare this router, first an access list (ACL) is defined on it, which helps router to identify traffic and provides a classification based on the source address. Once the traffic is identified based on the source address and is classified and marked based on DSCP field at the input interface of LER\_In, it turns queuing traffic. CBWFQ mechanisms have been used for this work. Next, apply the WRED traffic classes are available.

The final section of test is the implementation of MPLS on a test bed which DiffServ enabled on it. Under this part of the

test, packets sent from a predetermined path, regardless of the routing algorithm. This path is determined for each class of service depending on the type of application. To do this, two round trip are made up and down the MPLS domain to transfer voice and video applications. Then FECs are defined. In our network, according to the application, four types of FECs is defined those are separated according to the DSCP in the header of IP packets. The second general definition for a MPLS structure is traffic body that characterize incoming traffic flow to LSPs and bound FECs. By definition FECs and traffic body profiles based on common PHBs, turn is to adapt MPLS to provide QoS. That must be a mapping between the EXP bits in the MPLS shim header and DSCP field of the IP header to make them understandable for each other and classes of service are defined for MPLS. OPNET Modeler has a standard EXP $\leftrightarrow$ PHB mapping that its values in this study according to the guidelines [23] are given in Table 1. Finally, the general definitions above must be called in two edge routers in the MPLS domain and LSPs should be dedicated. In this experiment, the upper path is used for the transmission of audio and first pair's video conferencing application and two other video applications are transmitted by lower path.

TABLE I. EXP $\leftrightarrow$ PHB MAPPING

PHB	EXP
EE	0
AF41	1
AF42	2
AF43	3

IV. TEST RESULTS

The Results which we focus on their, are the so-called QoS performance metrics. QoS parameters are defined depends on the application that uses it and different applications, may have different definition for those. But the following criteria are considered as the basis of QoS and other definitions can also be converted to this form [24] [25].

- **Delay:** shows the period between data transferring from the source to the destination until it arrive. Mostly expressed in terms of end-to-end delay.
- **Jitter:** This measure has several definitions. The main definition introduced jitter as the difference between the delays of two consecutive data units.
- **Loss:** The percentage of data units that don't reach the destination at specified time.

A. Delay

In figures 2 to 5 audio and video packets end-to-end delay at the source node can be seen. The results show that IPv4 transmit packets slightly faster than IPv6. The reason is that in IPv6 networks, packet segmentation and reconstruction is performed only at the source and destination nodes and packet payload in the entire path is constant. But in IPv4 networks, segmentation is done at the network nodes [26]. Another important point is further delay of DiffServ to BE. The reason for this paradox is the time spent in the DiffServ domain edge routers for classification and queuing of packets. This unexpected delay notes that the DiffServ is not able to meet the needs for QoS and MPLS should be used to increased efficiency. MPLS applied in AF42 and AF43 services also

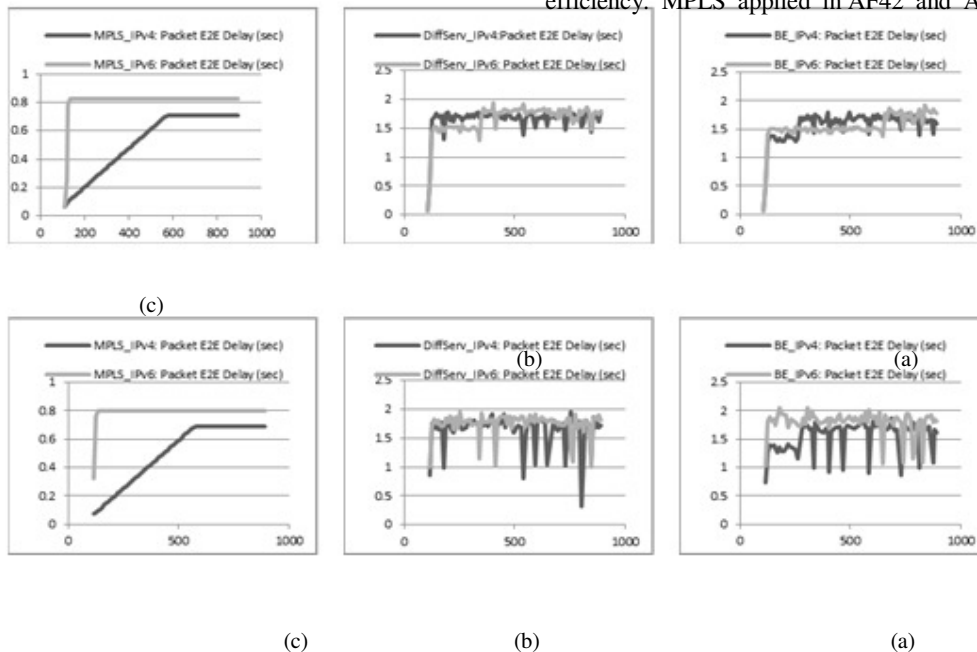


Fig. 3. End-to-end delay of video packets in AF41\_Source a) BE, b) DiffServ, c) MPLS

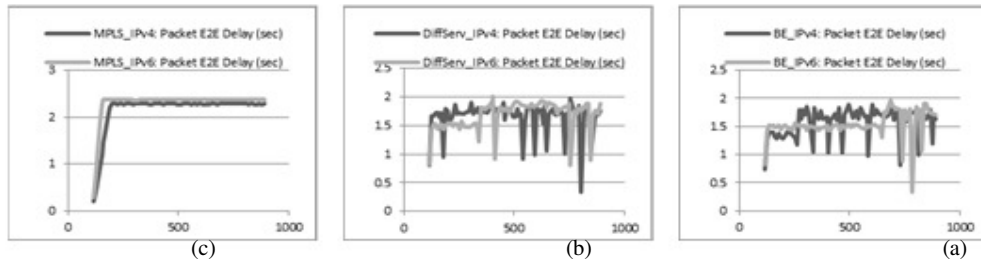


Fig. 4. End-to-end delay of video packets in AF42\_Source a) BE, b) DiffServ, c) MPLS

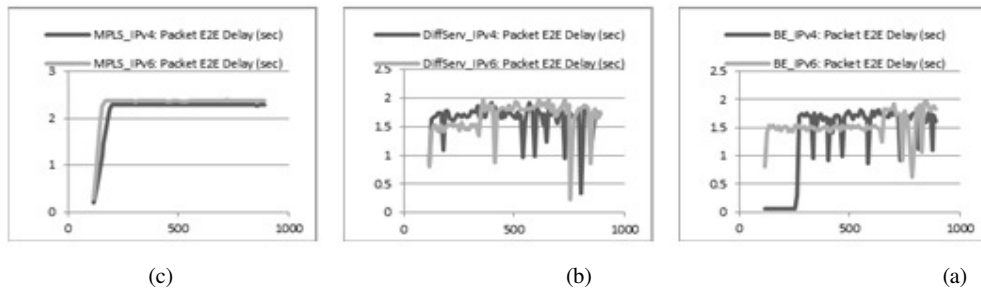


Fig. 5. End-to-end delay of video packets in AF43\_Source a) BE, b) DiffServ, c) MPLS

increases the delay. This delay comes from overcrowding of down path that is embedded to these two services pass through. But the significant point is the stability of this delay that is desirable to reduce the jitter.

**B. Jitter**

To investigate the jitter on the network, source stations are used. In OPNET this measure in video applications is named as Packet Delay Variation (PDV). The obtained jitters of experiments are observed in figures 6 to 9. Jitter in IPv6 is generally better than IPv4. This point is quite true about the EF and AF41 services that are transmitted well over our network. AF42 and AF43 services also have such a situation before applying MPLS, but after the path they are intended to be more crowded, IPv4 jitter is less than IPv6. DiffServ create more jitter than BE. MPLS is applied in the EF and AF41 PHBs

improve jitter, but on the other two PHBs due to path congestion, this standard is increased.

**C. Loss**

To check the amount of packet loss, received traffic can be addressed workstations and compare it with sent traffic. The same as before, received traffic at the source stations is studied to observe the packet loss rate. Results of the simulation are shown in Figures 10 to 13. With an overall view we can see that in the absence of Traffic Engineering with MPLS, IPv6 packet loss is less than IPv4. This architecture allows separation of traffic paths and reduce IPv4 loss. Here BE acts better than DiffServ and has less loss. Finally, as expected, EF and AF41 PHBs have fewer losses than AF42 and AF43. This returns to their inherent prioritization.

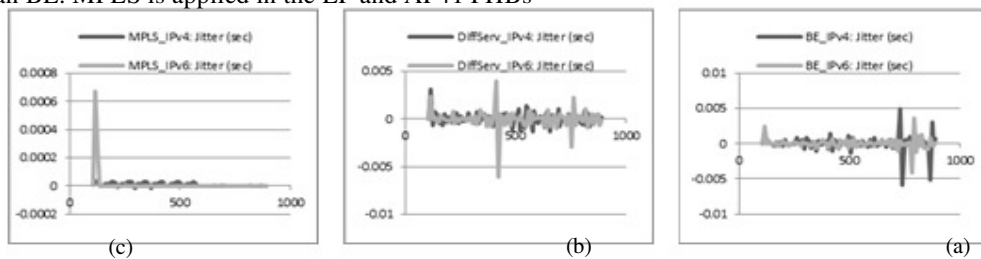


Fig. 6. Jitter in EF\_Source a) BE, b) DiffServ, c) MPLS

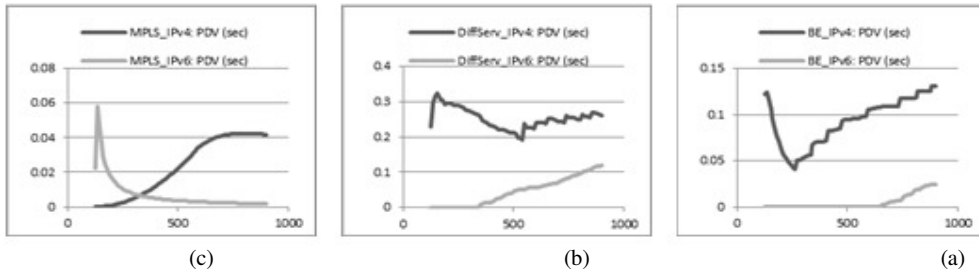


Fig. 7. Jitter in AF41\_Source a) BE, b) DiffServ, c) MPLS

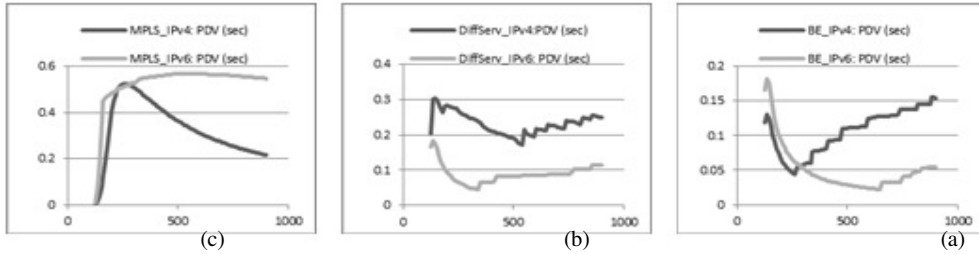


Fig. 8. Jitter in AF42\_Source a) BE, b) DiffServ, c) MPLS

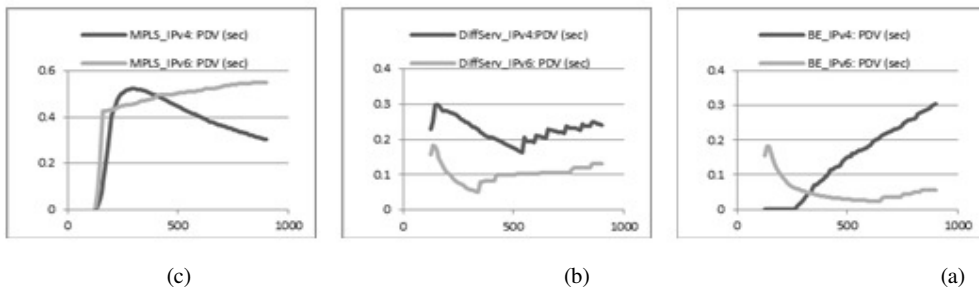


Fig. 9. Jitter in AF43\_Source a) BE, b) DiffServ, c)

V. CONCLUSION

IPv4 provides QoS requirements slightly better than IPv6. But

The results show that the four criteria of interest almost have direct relationship to each other and with improvement of it is not too much difference between them and other benefits of IPv6 could make the difference tolerated. Another important

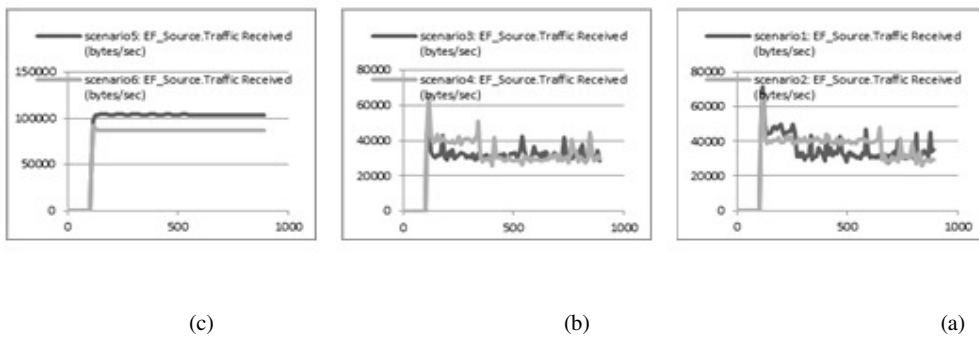


Fig. 10. Traffic received in EF\_Source a) BE, b) DiffServ, c) MPLS

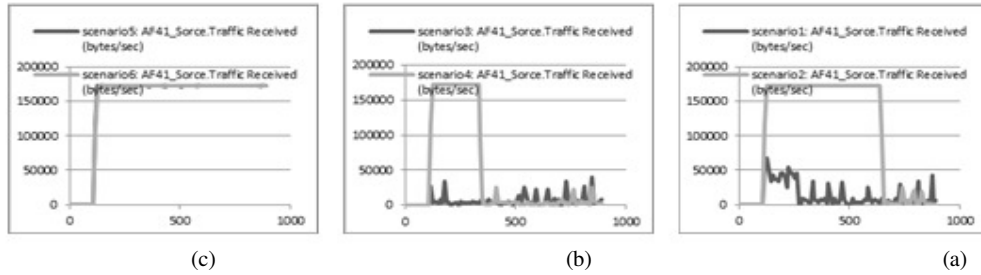


Fig. 11. Traffic received in AF41\_Source a) BE, b) DiffServ, c) MPLS

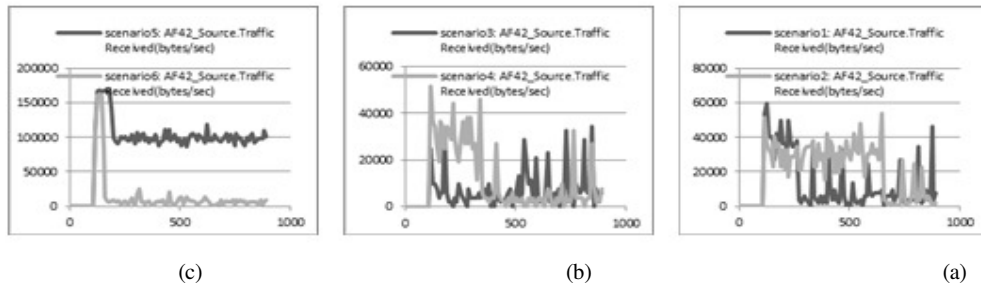


Fig. 12. Traffic received in AF42\_Source a) BE, b) DiffServ, c) MPLS

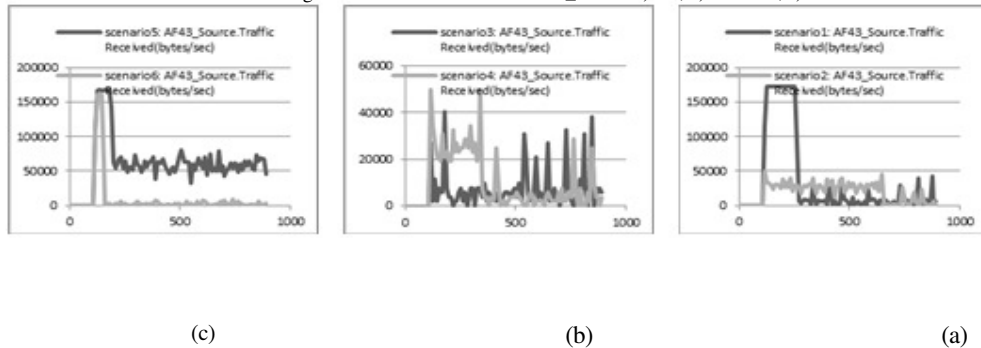


Fig. 13. Traffic received in AF43\_Source a) BE, b) DiffServ, c) MPLS

result of the experiment is that the DiffServ architecture alone cannot provide QoS for real-time applications and it is not much different to BE. Even it might work worse. For this purpose, MPLS architecture must be used in combination to DiffServ to QoS needs be satisfied as possible.

REFERENCES

- [1] Larry L. Peterson, Bruce S. Davie, "Computer networks: a systems approach," 4th edition, Morgan Kaufmann, 2007, pp. 318-329, 426-437, 499-524.
- [2] Sandeep Lugani, "Introduction to Internet Protocol - Version 6," WHITE PAPER, Wipro Infotech, 2002.
- [3] S. Blake, D. Black, M. Carlson, E. Davies, Z. Wang, W. Weiss, "An Architecture for Differentiated Service," RFC 2475, Internet Engineering Task Force, December 1998.
- [4] E. Rosen, A. Viswanathan, R. Callon, "Multiprotocol Label Switching Architecture," RFC 3031, Internet Engineering Task Force, January 2001.
- [5] D. Zhang, D. Ionescu, "QoS performance analysis in deployment of Diff-Serv-aware MPLS Traffic Engineering," in Proc. Eighth ACIS Int. Conf. Software Engineering, Artificial Intelligence, Networking, and Parallel/Distributed Computing SNPD 2007, vol. 3, pp. 963-967.
- [6] S. Deering, R. Hinden, "Internet Protocol, Version 6 (IPv6) Specification," RFC 2460, Internet Engineering Task Force, December 1998.
- [7] Md. Tariq Aziz, Mohammad Saiful Islam, "Performance Evaluation of Real-Time Applications over DiffServ/MPLS in IPv4/IPv6 Networks," Blekinge Institute of Technology, School of Computing, MS Thesis, May 2011.
- [8] K. Nichols, S. Blake, F. Baker, D. Black, "Definition of the Differentiated Services Field (DS Field) in the IPv4 and IPv6 Headers," RFC 2474, Internet Engineering Task Force, December 1998.
- [9] J. Heinanen, F. Baker, W. Weiss, J. Wroclawski, "Assured Forwarding PHB Group," RFC 2597, Internet Engineering Task Force, June 1999.
- [10] G. Swallow, "MPLS advantages for traffic engineering," Communications Magazine, IEEE, 1999, vol. 37, pp. 54-57.
- [11] S. Zeadally, I. Raicu, "Evaluating IPv6 on Windows and Solaris," IEEE Internet Computing, 2003, pp. 51-57.

- [12] Z. Xiaoming, M. Jacobsson, U. Henk, M. Piet Van, "IPv6 delay and loss performance evolution," *International Journal of Communication Systems*, vol. 21, pp. 643-663, 2008.
- [13] Roman Yasinovskyy, Alexander L. Wijesinha, Ramesh K. Karne, Gholam Khaksari, "A comparison of VoIP performance on IPv6 and IPv4 networks," *Computer Systems and Applications, IEEE/ACS, AICCSA 2009*, page 603.
- [14] C. Bouras, A. Gkamas, D. Primpas, K. Stamos, "Quality of Service aspects in an IPv6 domain," *International Symposium on Performance Evaluation of Computer and Telecommunication Systems (SPECTS'04)*, 2004, pp. 238-245.
- [15] C. Bouras, A. Gkamas, D. Primpas, K. Stamos, "Performance Evaluation of the Impact of QoS Mechanisms in an IPv6 Network for IPv6-Capable Real-Time Applications," *Journal of Network and Systems Management*, 2004, vol. 12, no. 4, pp. 463-483.
- [16] C. Bouras, D. Primpas, K. Stamos, "QoS issues in a Large-scale IPv6 network," *International Symposium on Performance Evaluation of Computer and Telecommunication Systems (SPECTS' 05)*, 2005, pp. 406-415.
- [17] C. Bouras, A. Gkamas, D. Primpas, K. Stamos, "IPv6 deployment: Real-time applications and QoS aspects," *Computer communications*, 2006, vol. 29, no. 9, pp. 1393-1401.
- [18] H.Bai, M. Atiquzzaman, W. Ivancic, "Achieving End-to-End QoS in the Next Generation Internet: Integrated Services Over Differentiated Service Networks," *NASA/TM-2001-210755*, March 2001.
- [19] C. Bouras, D. Primpas, K. Stamos, "IPv6 QoS testing on dual stack network," *ACM International Conference Proceeding Series*, 198, 1190186, 2006.
- [20] Md. Tariq Aziz, Mohammad Saiful Islam, Md. Nazmul Islam khan, Adrian Popescu, "effect of packet delay variation on video/voice over DiffServ-MPLS in IPv4/IPv6 networks," *International Journal of Distributed and Parallel Systems (IJDPS)*, Vol.3, No.1, January 2012.
- [21] N. Kitawaki, K. Itoh, K. Kakehi, "Speech quality of PCM system in digital telephone network," *Electronics and Communications in Japan (Part I: Communications)*, Volume 65, Issue 8, pages 1-8, 1982.
- [22] Imad J. Mohamad, Tat-Chee Wan, Faizal Y. AL Zyoud, Putra Sumari, "Optimizing the MPLS Support for Real Time IPv6-Flows using MPLS-PHS Approach," *TENCON2009*, Singapore, November 2009.
- [23] F. Le Faucheur, L. Wu, B. Davie, S. Davari, P. Vaananen, R. Krishnan, P. Cheval, J. Heinanen, "Multi-Protocol Label Switching (MPLS) Support of Differentiated Services," *RFC 3270*, Internet Engineering Task Force, May 2002.
- [24] H. Knoche, H. de Meer, "QoS parameters: A comparative study," *University of Hamburg, Hamburg, Germany, Tech. Rep.*, 1997.
- [25] M. A. El-Gendy, A. Bose, K. G. Shin, "Evolution of the Internet QoS and support for soft real-time applications," *Proceedings of the IEEE* Volume 91, Issue 7, pp. 1086 - 1104, July 2003.
- [26] R. AlJa'afreh, J. Mellor, I. Awan, "A Comparison Between the Tunneling Process and Mapping Schemes for IPv4/IPv6 Transition," in *Advanced Information Networking and Applications Workshops, 2009. WAINA'09. International Conference on. IEEE, 2009*, pp. 601-606.