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Analysis of Impact of Differentiated Services (DiffServ) on the Quality of Services (QoS) Parameters of Major Services of Internet

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Abstract

Objectives: Differentiated Services are implemented by marking in the Internet Protocol (IP) packet header and treat them differently on the basis of the requirements of the services to which a packet belongs. Objective of this study is to determine the impact of Differentiated Services on the different parameters of Quality of Services (QoS) of major services of the Internet. This study aims to investigate the impact of Differentiated Services on Quality of Services (QoS) of different services of internet. **Method**: In order to determine the impact of the Differentiated Services on the Quality of Services parameters of the different services like Electronic-Mail, web browsing, IP telephony are selected for assessing the impact on Response time, waiting time, end to end delays and jitter. For this purpose, network simulator is used. **Findings**: It is observed that Differentiated Services is very successful for the implementation of Quality of Services of the Internet for various services of the Internet. It is observed that Differentiated Services has substantial impact on the response time, waiting time, end to end delays, packet delays and jitter. These are the major parameters to measure the Quality of Service of different services of the Internet. **Application**: This finding would be helpful to design the comprehensive Quality of Services framework in future and would be helpful for appropriate decisions for the researcher and technology development organization to make future Internet services to operate at acceptable level.

Keywords: Application Response Time, Differentiated Services, Internet Engineering Task Force, Jitter, Quality of Services (QoS), Throughput

1. Introduction

Internet is a system of billions of devices interconnected with different technologies to offer different types of services. In recent years, growth of internet has increased to large extent due to its ability to provide new and exciting services along with capability to offer existing services in new and novel ways. Telephony, Electronic mail, video services are the core example of services. Internet is a multiservice media with capability to replace existing

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media. Internet has the capability to offer new and exciting services with provision of providing existing services in a novel way. Each of services of the Internet has its own requirements to operate at reasonable performance level known as Quality of Services (QoS) of Internet. On the other hand, Internet architecture is based on the best effort delivery effort. The unique requirement of different services of the Internet is very hard to incorporate due to current Internet architecture. Keeping in view different solutions were proposed. Differentiated Services is one of the proposed solution in which packets of different services are identified and treated in preference way on the basis of type of service.

1.1 History of Internet

Internet emerges as a result of United Sates defense project ARPANET for packet switched network. Major aim of this project is to stream line the research activities. In 1980 the ARPANET begins to act as backbone of network between academic institutes, research agencies and US defense department. In 1990's commercialization of Internet begins with linkage of private commercial organization. In 1995, traffic for commercial organization was allowed result into shift of paradigm. In the same time (1980's) Time Berners Lee presented the idea of most popular service named as World Wide Web (WWW) to transfer contents on the Internet in the form of hypertext using the Hyper Text Transfer Protocol (HTTP). At that point in history many other popular services like email, video calling begins to emerge on the horizon[1].

1.2 Growth of Internet

It is estimated that about 40% of world population is using the Internet that is all due to exciting services of the

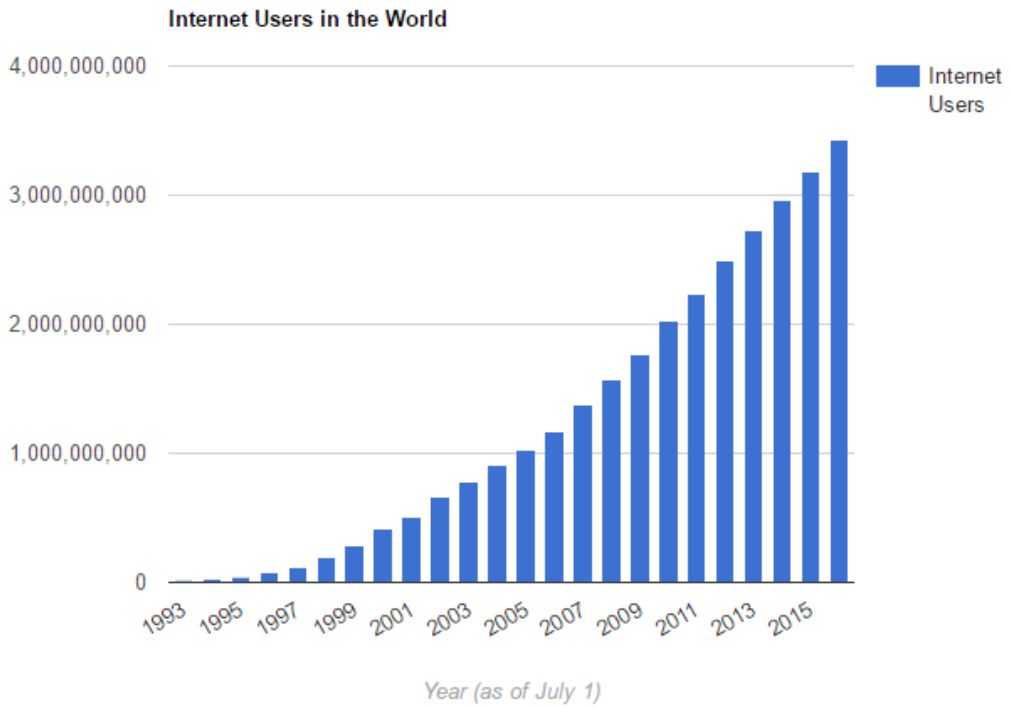

Figure 1. Internet Growth from 1993 to 2015 [6].

Year	Internet Users**	Penetration (% of Pop)	World Population	Non-Users (Internetless)	1Y User Change	1Y User Change	World Pop. Change
2016*	**3,424,971,237**	46.1 %	7,432,663,275	4,007,692,038	7.5 %	238,975,082	1.13 %
2015*	**3,185,996,155**	43.4 %	7,349,472,099	4,163,475,944	7.8 %	229,610,586	1.15 %
2014	**2,956,385,569**	40.7 %	7,265,785,946	4,309,400,377	8.4 %	227,957,462	1.17 %
2013	**2,728,428,107**	38 %	7,181,715,139	4,453,287,032	9.4 %	233,691,859	1.19 %
2012	**2,494,736,248**	35.1 %	7,097,500,453	4,602,764,205	11.8 %	262,778,889	1.2 %
2011	**2,231,957,359**	31.8 %	7,013,427,052	4,781,469,693	10.3 %	208,754,385	1.21 %
2010	**2,023,202,974**	29.2 %	6,929,725,043	4,906,522,069	14.5 %	256,799,160	1.22 %
2009	**1,766,403,814**	25.8 %	6,846,479,521	5,080,075,707	12.1 %	191,336,294	1.22 %
2008	**1,575,067,520**	23.3 %	6,763,732,879	5,188,665,359	14.7 %	201,840,532	1.23 %
2007	**1,373,226,988**	20.6 %	6,681,607,320	5,308,380,332	18.1 %	210,310,170	1.23 %
2006	**1,162,916,818**	17.6 %	6,600,220,247	5,437,303,429	12.9 %	132,815,529	1.24 %
2005	**1,030,101,289**	15.8 %	6,519,635,850	5,489,534,561	12.8 %	116,773,518	1.24 %
2004	**913,327,771**	14.2 %	6,439,842,408	5,526,514,637	16.9 %	131,891,788	1.24 %
2003	**781,435,983**	12.3 %	6,360,764,684	5,579,328,701	17.5 %	116,370,969	1.25 %
2002	**665,065,014**	10.6 %	6,282,301,767	5,617,236,753	32.4 %	162,772,769	1.26 %
2001	**502,292,245**	8.1 %	6,204,310,739	5,702,018,494	21.1 %	87,497,288	1.27 %
2000	**414,794,957**	6.8 %	6,126,622,121	5,711,827,164	47.3 %	133,257,305	1.28 %

* estimate for July 1, 2016

** **Internet User** = individual who can access the Internet at home, via any device type and connection. More details.

Figure 2. Internet usage over the years [6].

Internet as shown in Figures 1 to 7 that shows the internet growth and usage over time. From these figures and statistics, it can be easily inferred the popularity of different services of the Internet.

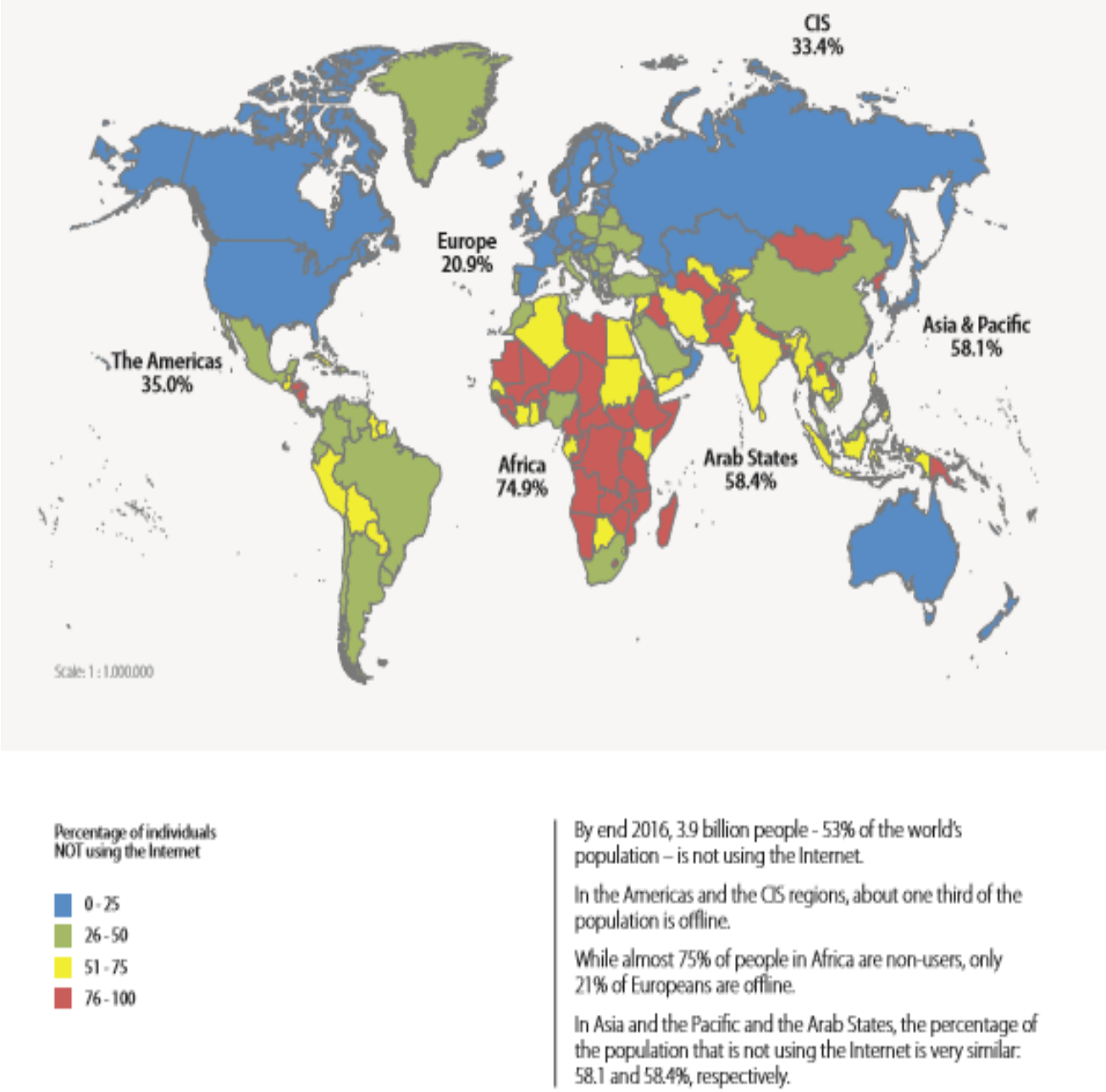

Figure 3. World population distribution of internet users[7].

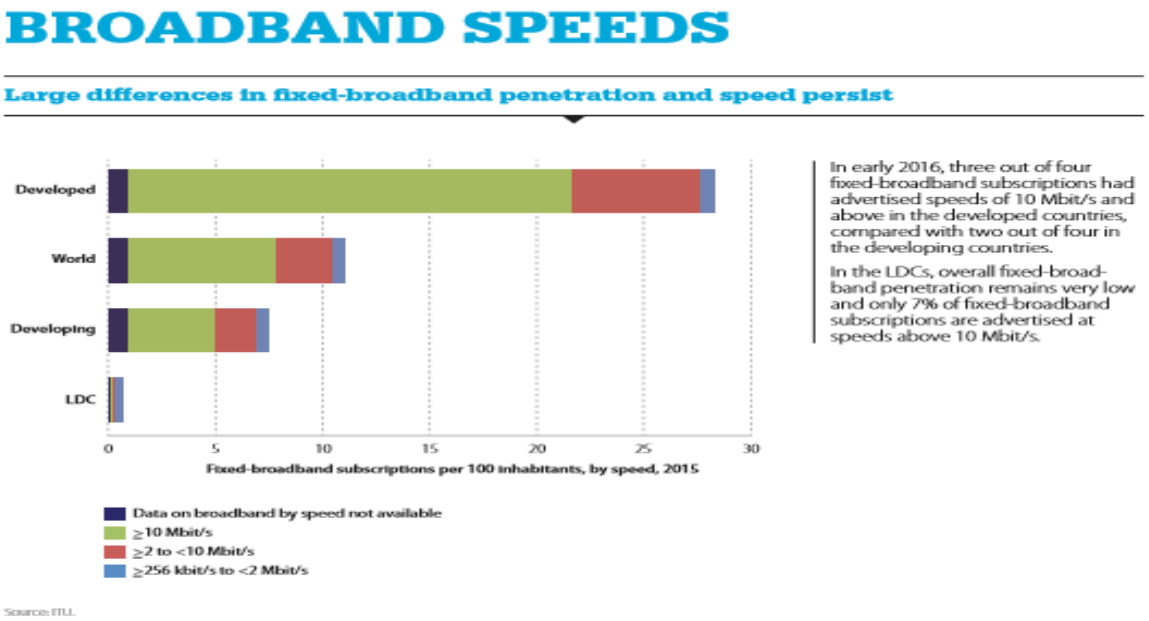

Figure 4. Internet Speeds by Regions[7].

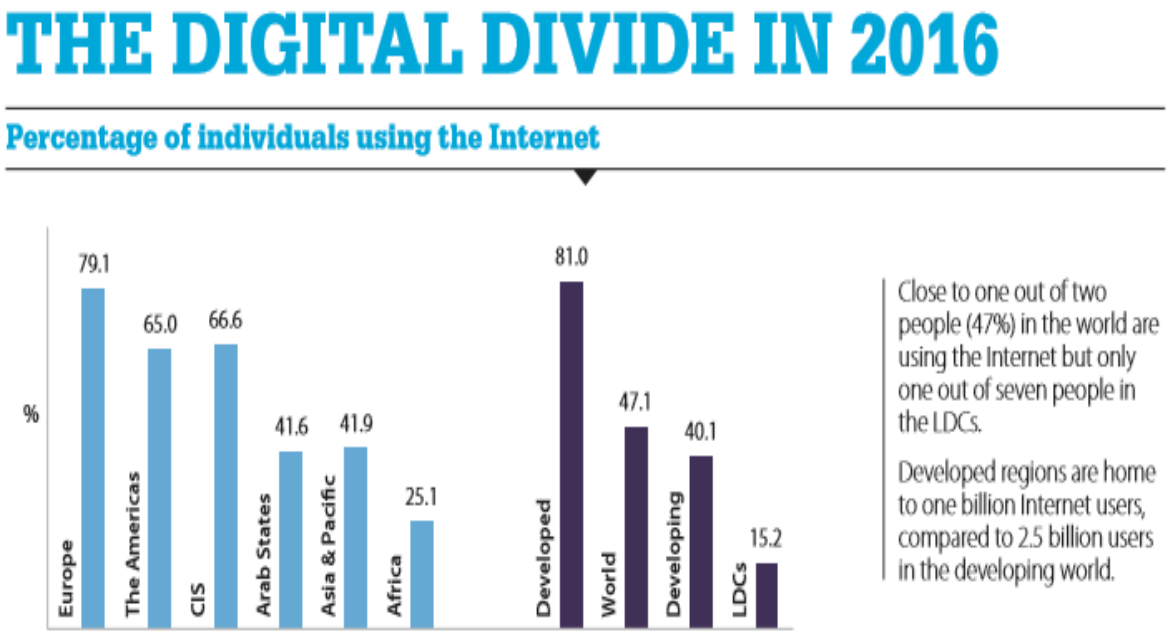

Figure 5. Region wise Internet usage[7].

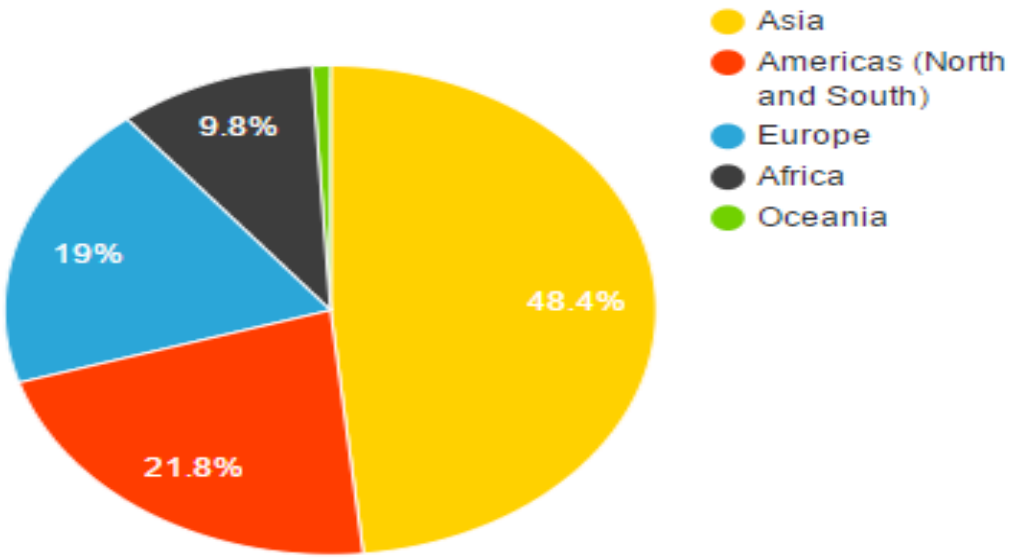

Figure 6. Internet Usage by region by 2013 [6].

Figure 7. IPV4 Header[4].

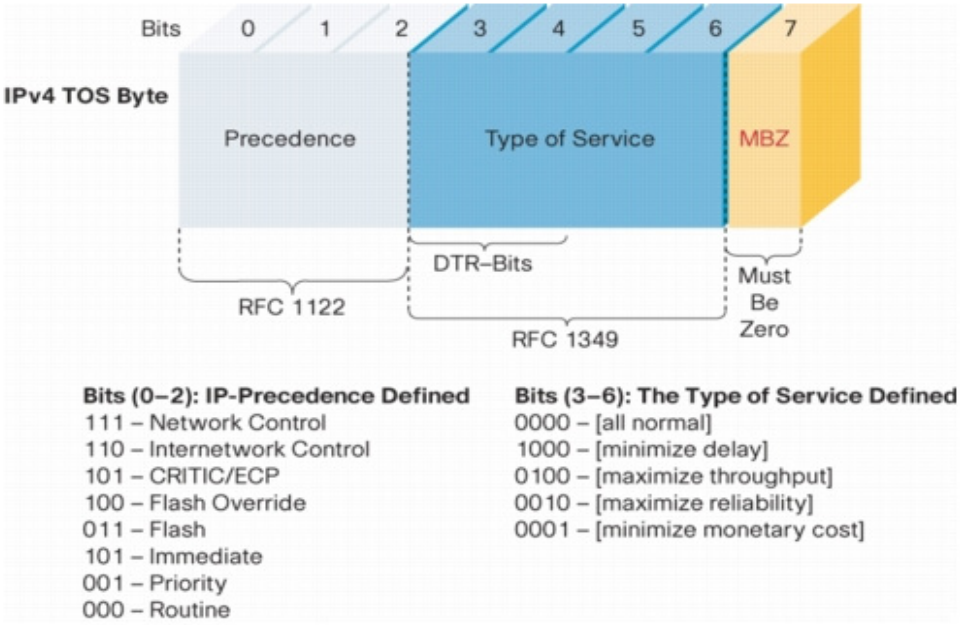

Figure 8. IPV4 Type of Service (ToS) Byte[4].

1.3 Major Service of Internet

Internet is a combination of exciting services like Web browsing, Communication, Electronic Mail (E-Mail), Social networking and data services. Let review each of the major service of the Internet.

1.3.1-World Wide Web (WWW)

World Wide Web (WWW) is the most popular Internet service that offer transfer of specially structured document (Hyper Text) using Hyper Text Transfer Protocol (HTTP). With this service user can view documents embedded with pictures sounds and videos. Perhaps this service is the major reason for the popularity of Internet that allows emergence web on the Internet that is capable of Information transfer, advertisements and Entertainment provisions to the users.

1.3.2 Communication

Communication another aspect of the Internet that has changed this services by offering this service in many shapes in a cost effective way. Major form of the Internet communication is Electronic Mail (E-Mail,), video conference, IP telephony, Interactive messaging, live chatting, blogs and many more.

1.3.3 Data transfer

Data transfer for organization information flow is another popular service of the Internet. Many Virtual Private Network (VPN) exist to support the independent work flow of the organizations on the Internet that exploits the Internet infrastructure. Many organizations have gone online to support their information flow.

1.3.4 Social Networking

Social networking is the one of the modern Internet service that has bring people together in an amazing way. People are connected with each other through sharing of their ideas, feelings about an event and many more.

1.4 Quality of Services (QoS) of Internet

Internet is a rich multiservice media that has the power to offer existing service in new ways and also new services that revolutionized the world. Each of the service of the Internet has its own requirements to operate at reasonable level of performance. On the other hand, Internet structure is based on the best effort delivery of the packets where each transferable unit is not discriminated as per their requirements. The idea behind the Quality of Services (QoS) of the Internet is to offer mechanism that can facilitates the Internet services to operate at reasonable or acceptable level of performance. In recent days the emergence of Internet of Things (IoT) paradigm also demands the concern for Internet QoS as heterogeneous devices need different criteria for smooth functioning of these type of applications[2,3].

Quality of Service (QoS) has cost in order to a specified service has to operate at reasonable level of performance. Let video service require minimum delays and jitter that could be possible with switched multiplexing, fixed virtual circuits, fixed capacity allocation, traffic engineering etc. Quality of Service (QoS) could be expensive in term of admission control and resource allocation. Provisions for resources allocations and circuit switched network would be costly. Sole Bandwidth increase cannot solve the problem to achieve the requirements for each service is not possible. In order to support the QoS of Internet services Differentiated Services mechanism is presented when it is observed that current routing protocol and best effort delivery of packets approach cannot serve the unique requirements of different services of the Internet. Differentiated Services (DiffServ) is the one of the main approaches to implement the Quality of Services (QoS)[2].

2. Material and Method

In this section first discuss about the Differentiated Services (Diff Services).

2.1 Differentiated Services

Differentiated Services or DiffServ is a network architecture that is a scalable approach to classify network

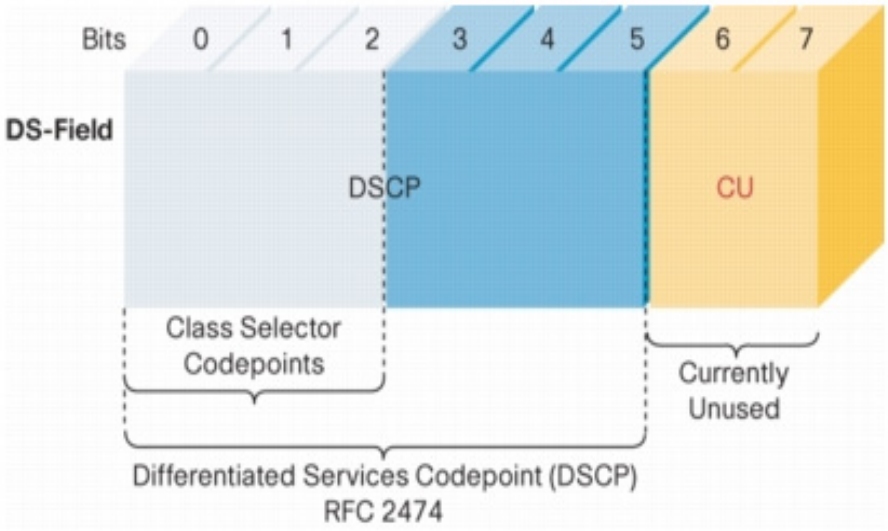

Figure 9. DS Field in IPV4[4].

traffic for provision of the Quality of Service (QoS). Differentiated Service is the mechanism in which packets of each service is discriminated to serve them as per requirements of the service. Based on the differentiated packets adaptive services according to the requirements of the services can be serviced. This approach is scalable to treat packets according to the requirements can be achieved. Actually this is the new mechanism in which resources can be allocated on the basis of differentiated packets[4]. In order to implement the QoS, in 1998 the Type of Service Field(TOS) of the IP header was changed with the Differentiated Service Field (DS Field) in IPV4 and IPV6 with RFC2474 of Internet Engineering Task Force (IETF)[5], as shown in Figure 9.

For packet classification eight-bit Differentiated Service Field (DS Field) in IP packet header is used for Differentiated Service Code Point (DSCP) as shown in Figure 10. The DSCP field is replaced by TOS field in IPV4. Second byte of IP header is used for implementation of Differentiated Service (DiffServ). There are two parts of this byte with first six byte corresponds to Differentiated Service Code Point (DSCP) and the least significant two bits for the Explicit Congestion Notification (ECN). DSCP is used for the classification of the packets or traffic to treat them on priority basis[4]. This is also described in Figure 9.

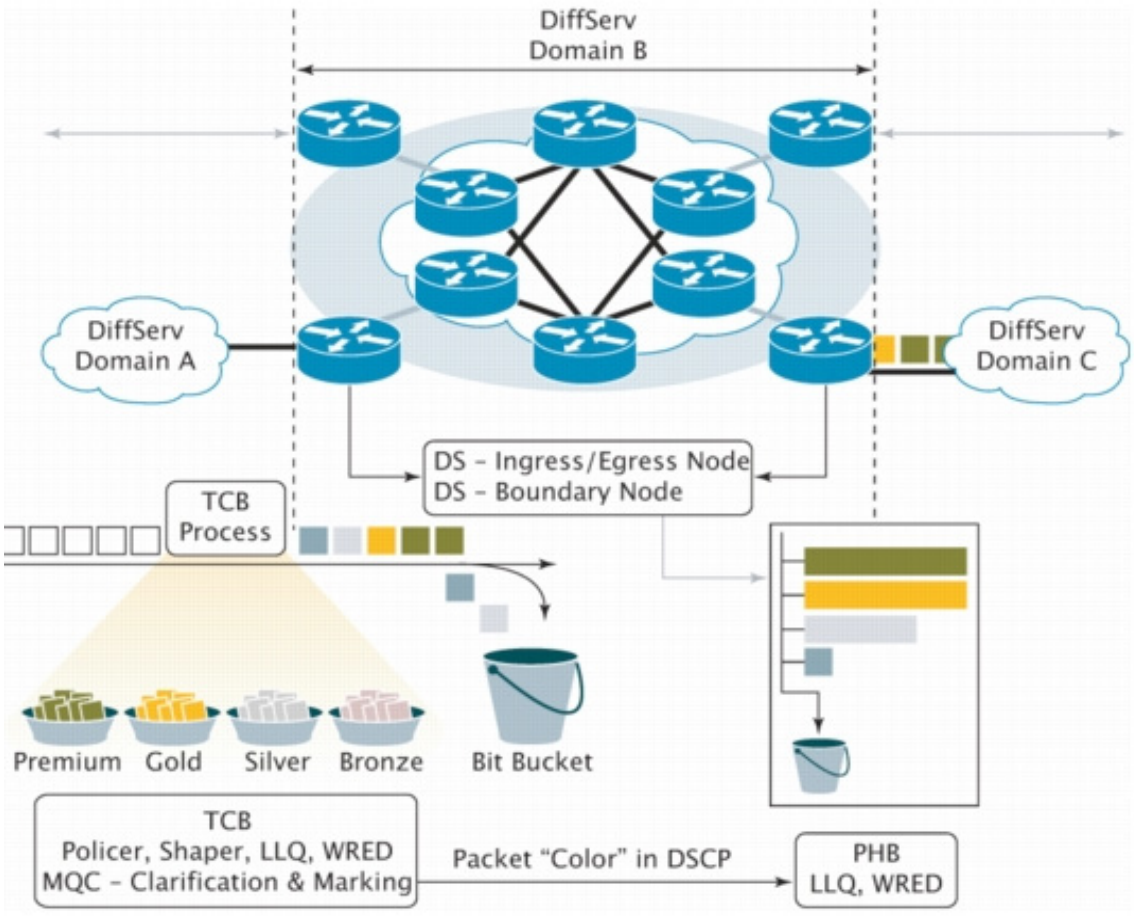

Figure 10. Mechanism of Differentiated Service (DiffServ)[4].

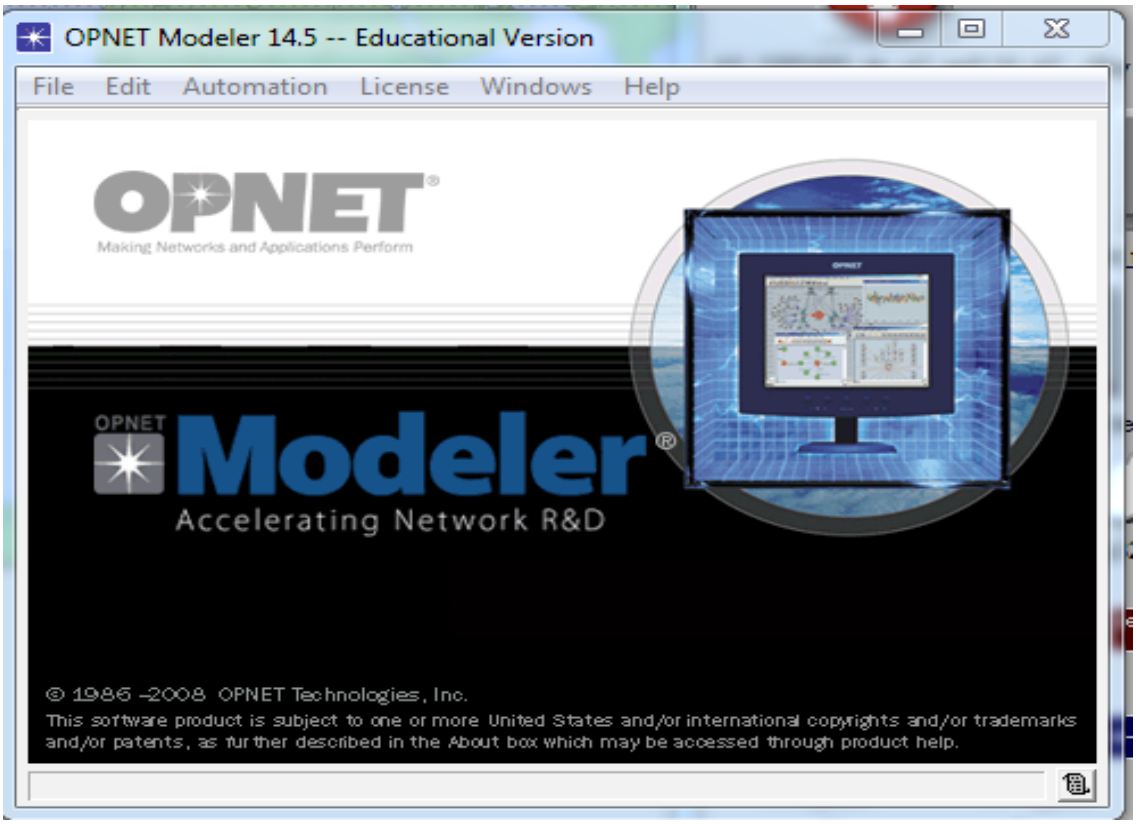

Figure 11. Interface of the OPNET Modeler.

Differentiated service (DiffServ) is a coarse grained traffic classification based mechanism that classifies the network traffic based on different classes. In DiffServ the router work on Per Hop Behavior (PHB) that forward network traffic based on the class of the packet defined in DS Field. Packets are classified into limited number of classes based on the requirements of the service to which these packets belong. In this way packets of different services are treated in different ways and managed in unique ways. Classification of packets depends upon different parameters like destination and source address and traffic type[4]. This mechanism is also described in Figure 11. On the basis of DS Field of Internet Protocol (IP) packet header determines the Per-Hop Behavior. In DS Field there is a 6-Bit *Differentiated Services Code Point (DSCP)* value. In this respect up to 64 different traffic classes are possible with DSCP. This is an easy way to classify the network traffic[4].

3. Evaluations and Research Design

In order to perform the analysis some common web services selected and are accessed with differentiated packets and without differentiated packets by associating the priority class in the DS Field of the IP header.

The Differentiated Quality of Service (QoS) parameters are observed for these applications. These Differentiated Quality of Service (QoS) parameters are listed below with selected applications.

3.1 Experiment Environment

To observe the impact on the Differentiated Quality of Service (QoS) parameters with differentiated services

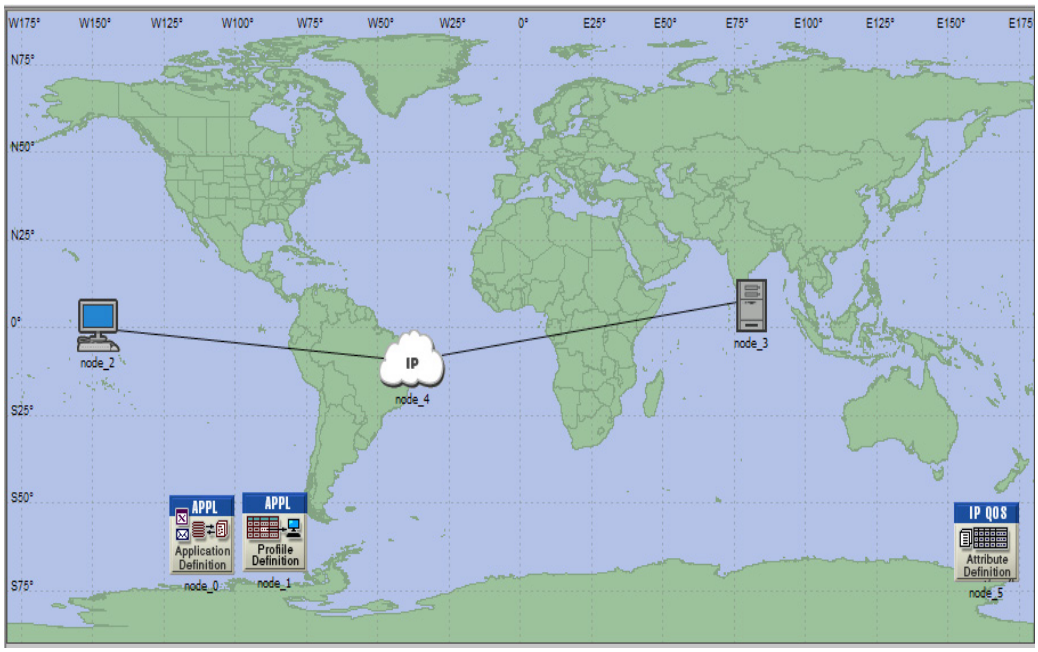

Figure 12. Internet service access with differentiated service approach.

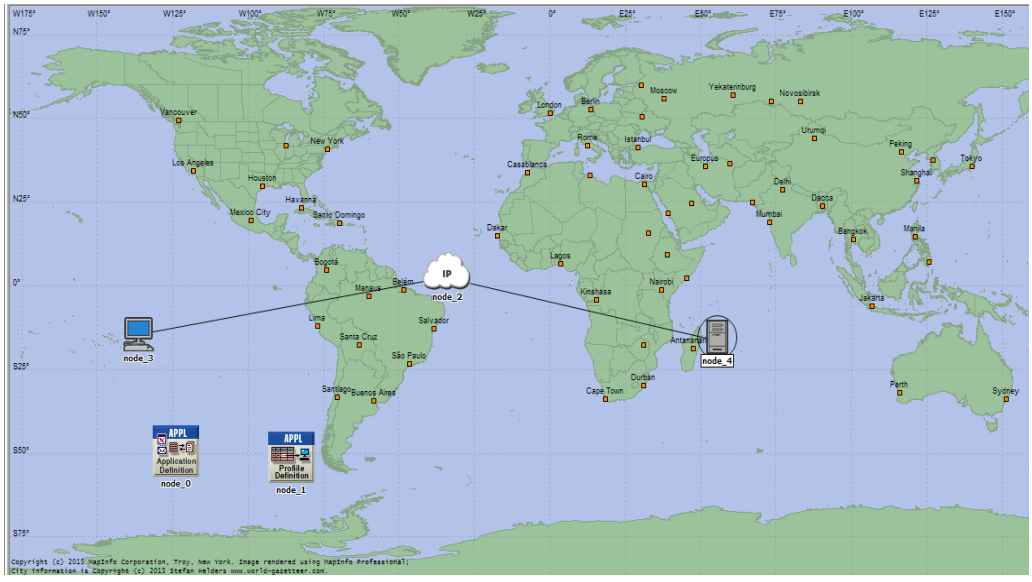

Figure 13. Internet services access without differentiated service approach.

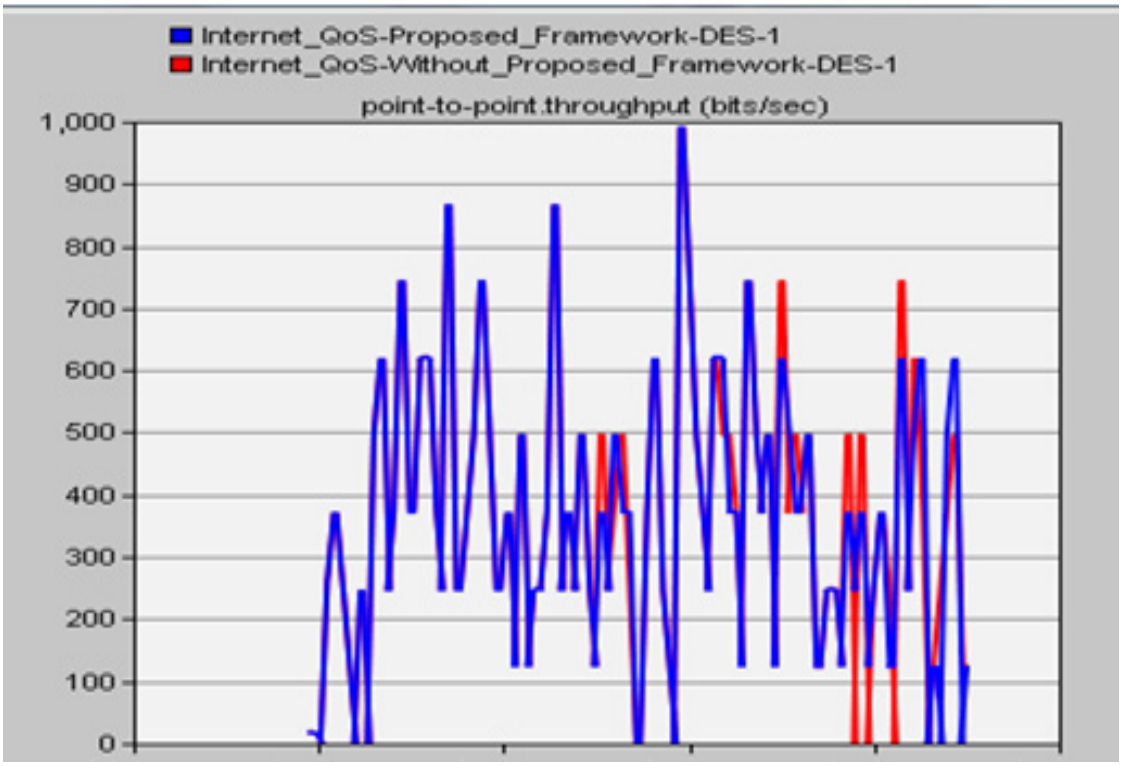

Figure 14. Database application throughput in bps.

OPNET 14.5 Modeler with simulator used. Interface of the opnet modeler and its setting are shown in Figures 12–14.

3.1.1 OPNET Modeler

It is network simulator with rich set of network technologies extensively used for research and development. Interface of the modeler is shown in Figure 12.

3.1.2 Simulation Environment and Tools used

Simulation environment for the OPNET is based on;

1. OPNET Modeler (Interface and Setting are shown in Figure)
2. Visual Studio 2013
3. Dot Net framework Version 4.5
4. Microsoft C++ redistributable library
5. Windows 10Application and Services used for experiments

Following are the services used for judging the impact of Differentiated services on their Quality of Service (QoS) parameters.

1. Database Access (Medium Load)
2. Email (Medium Load)
3. File Transfer using FTP (Medium Load)

4. HTTP, Heavy Browsing
5. Video Conferencing High Resolution
6. Voice with PCM quality

3.1.3 Quality of Services (QoS) parameters used for the experiments

Following are the parameters analyzed for the selected services with application of the Differentiated services;

a. Throughput
b. Response Time
c. Packet Delay Variations
d. End to End Delays
e. Jitter

4. Results and Discussion

In this section the experiments result is presented with discussion on the results.

4.1 Simulation Results

Let analyze simulation result for different services on Quality of Services (QoS) parameters one by One.

4.1.1 Throughput

Throughput means the number of tasks per unit time. A higher number in throughput measure is desirable. It is measured in Bits per second (bps) or packet per second. Simulated results for various Services for throughput is shown in Figure 15 to Figure 20.

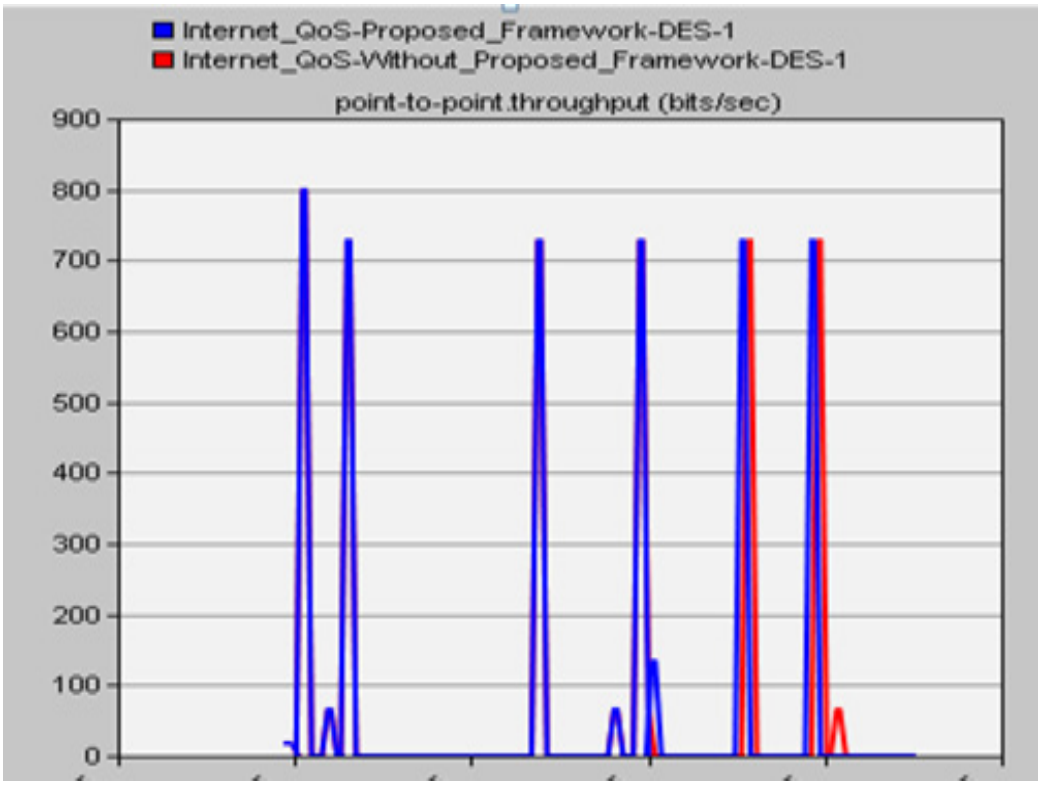

Figure 15. Electronic mail (E-mail) throughput in bps.

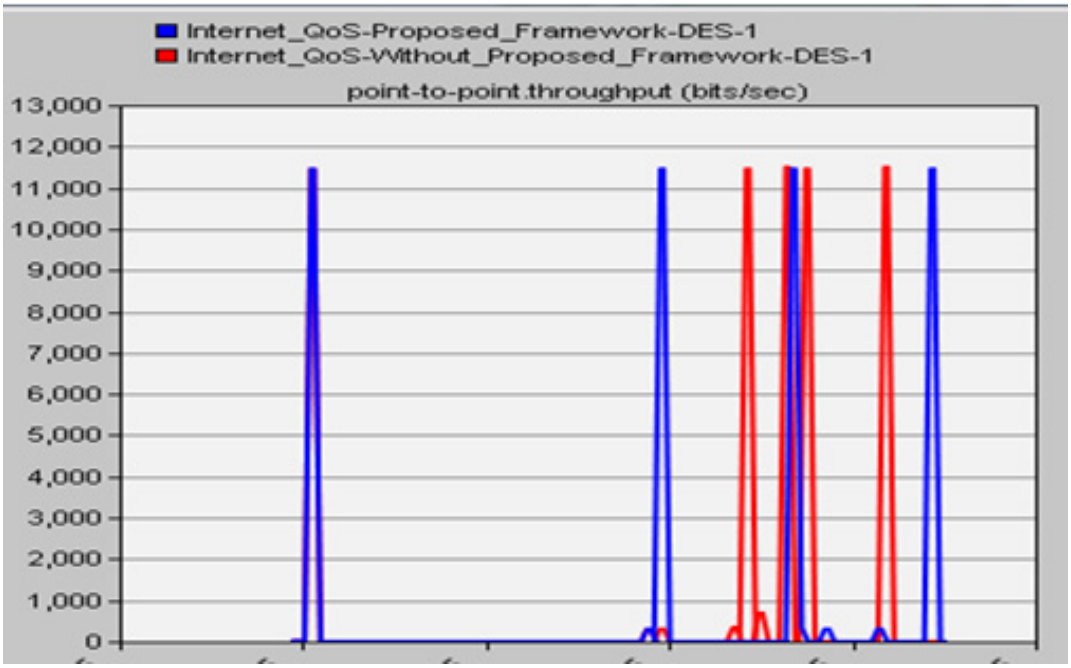

Figure 16. File Transfer Throughput (FTP) in bps.

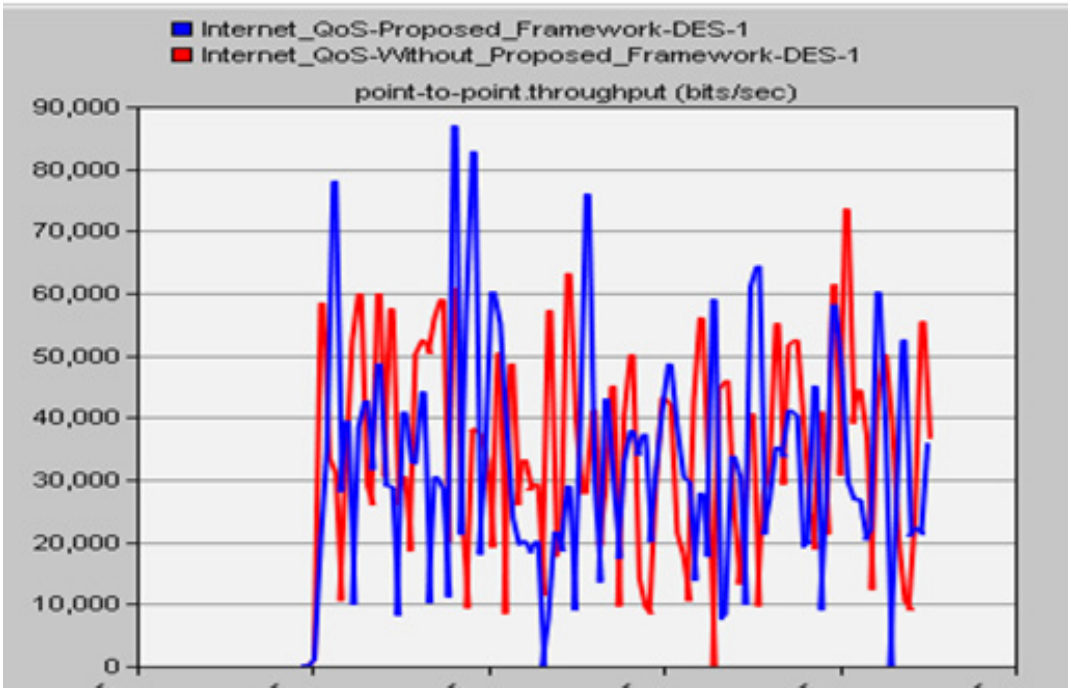

Figure 17. Web browsing throughput in bps.

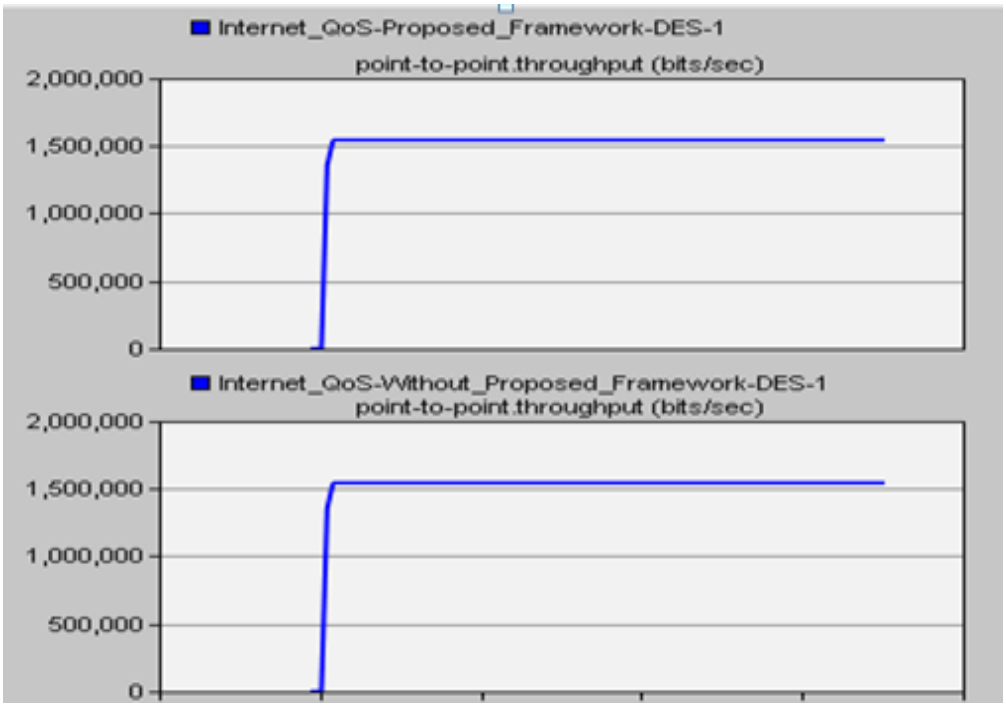

Figure 18. Video conference application throughput in bps.

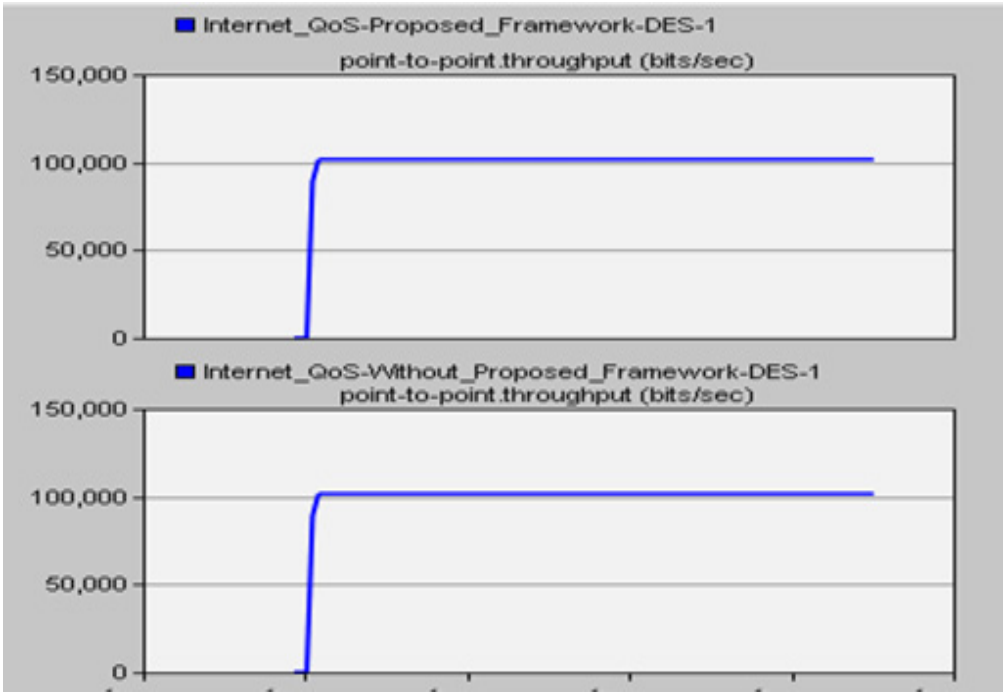

Figure 19. Voice application throughput in bits per seconds (bps).

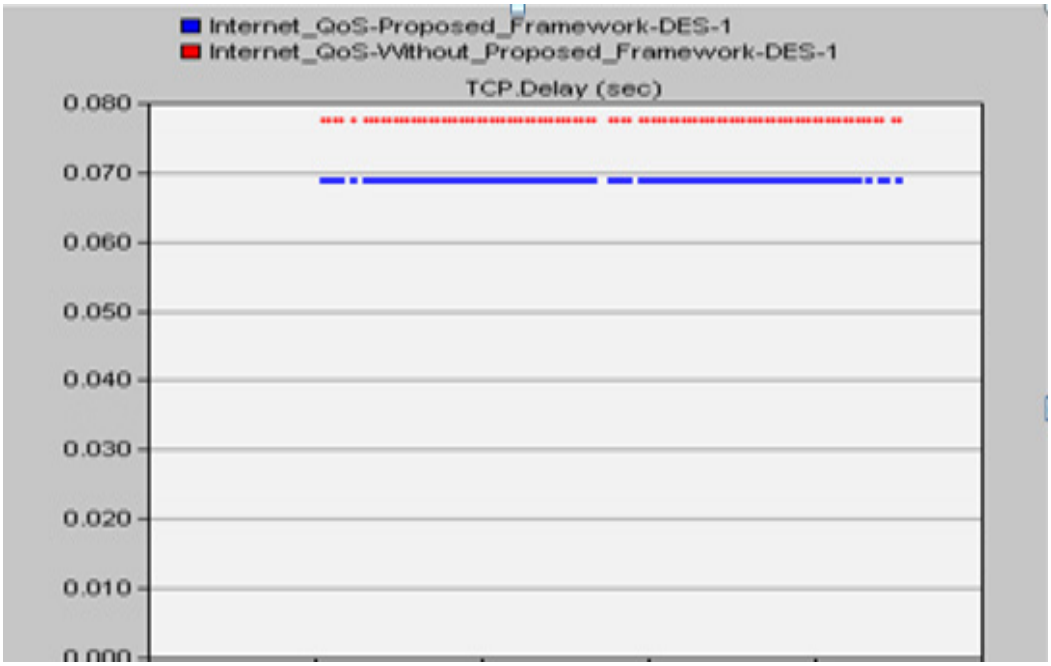

Figure 20. Database application TCP delays (seconds).

4.1.2 TCP Delays

Due to flow control mechanism, acknowledgments and retransmission the Transmission Control Protocol (TCP) delays occurred. Low values of TCP delays are a desirable attribute.Simulated results for various Services for TCP Delays is shown in Figures 21 to 24.

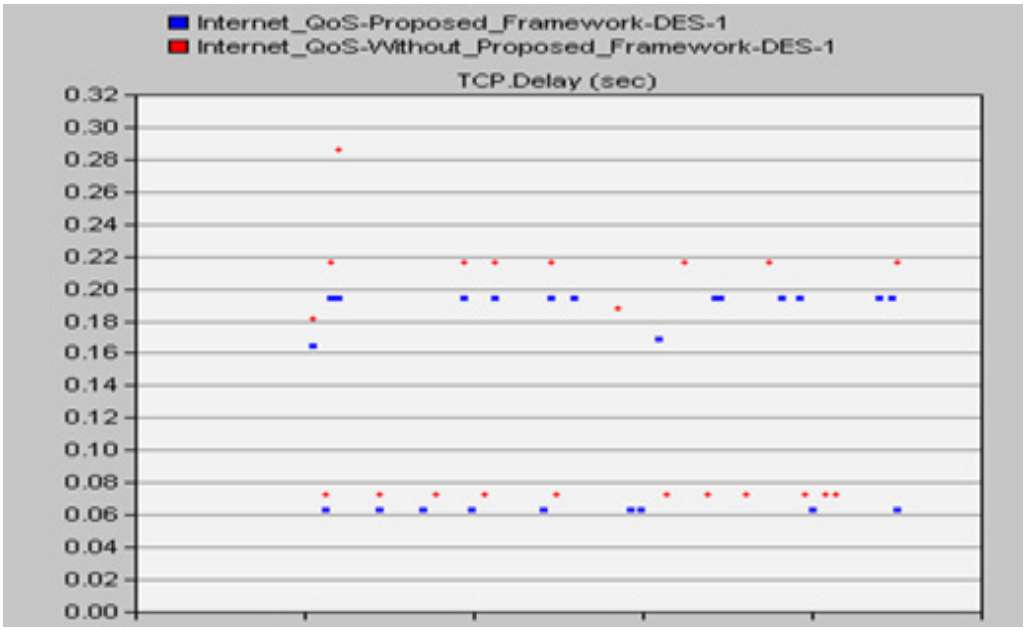

Figure 21. E-email application TCP delays (seconds).

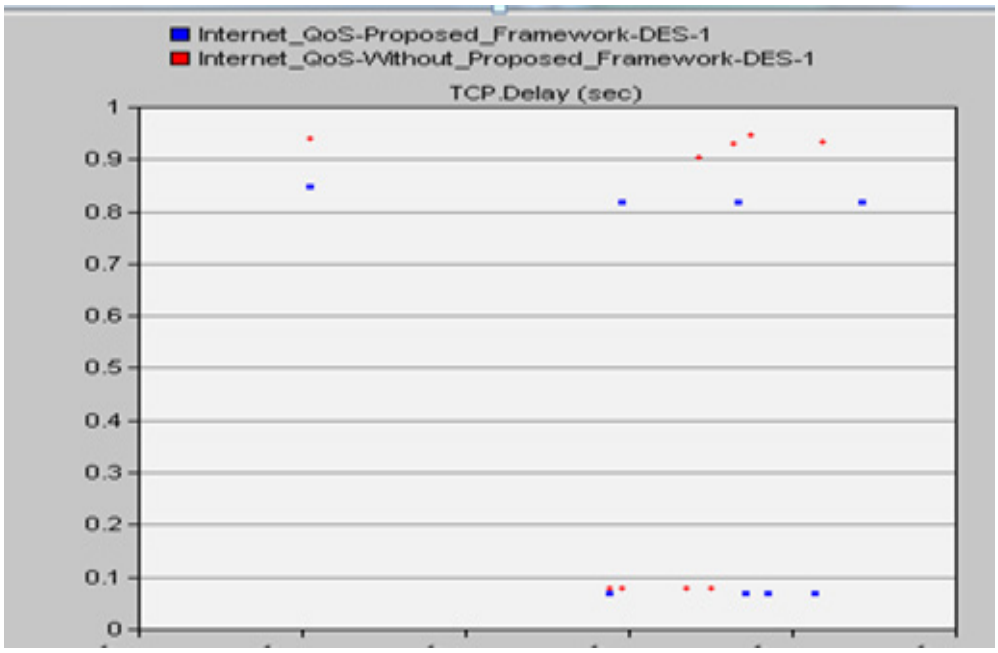

Figure 22. File Transfer (FTP) TCP delays (seconds).

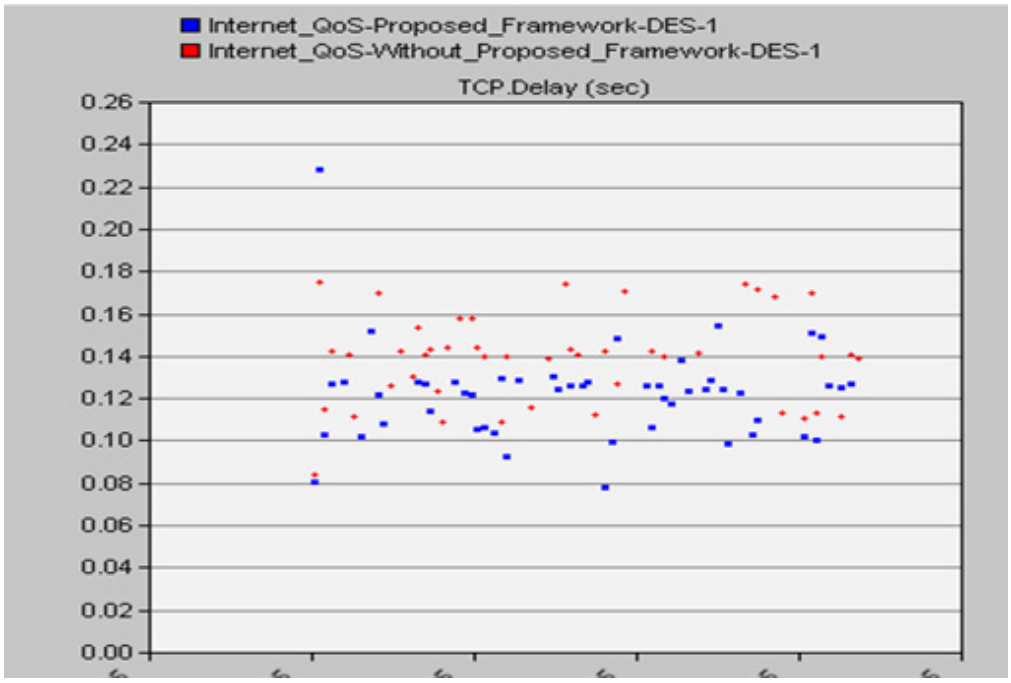

Figure 23. TCP delays (seconds) in Web browsing.

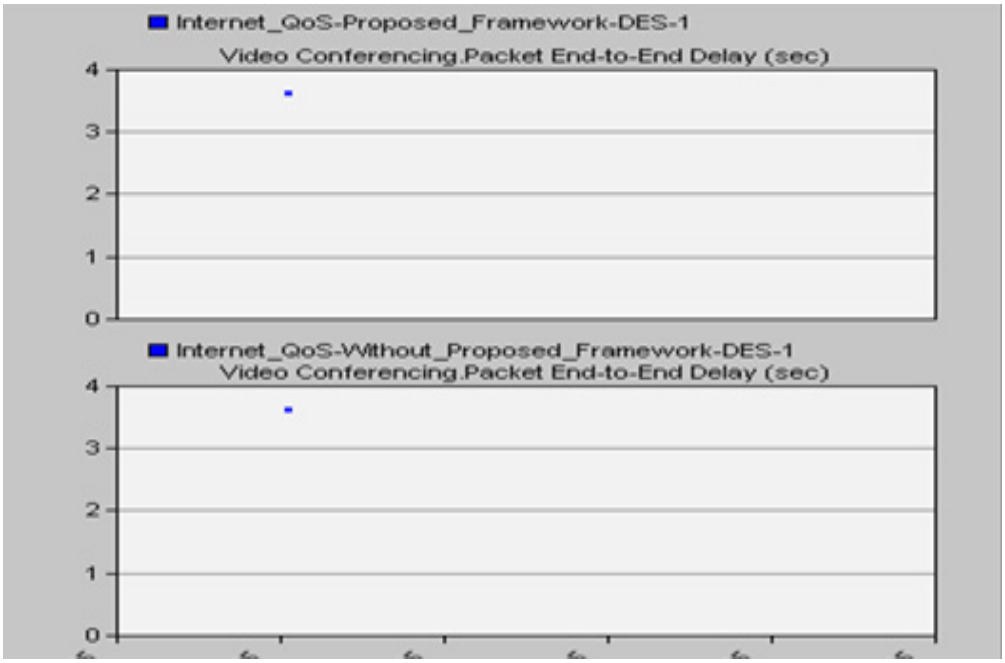

Figure 24. End to end delays in video conference.

4.1.3 End to End Delays

Difference in packets sending and receiving time of message is called end to end delays. Low value of end to end delay is desirable attribute. Simulated results for various Services for End to End delays are shown in Figures 25 to 27.

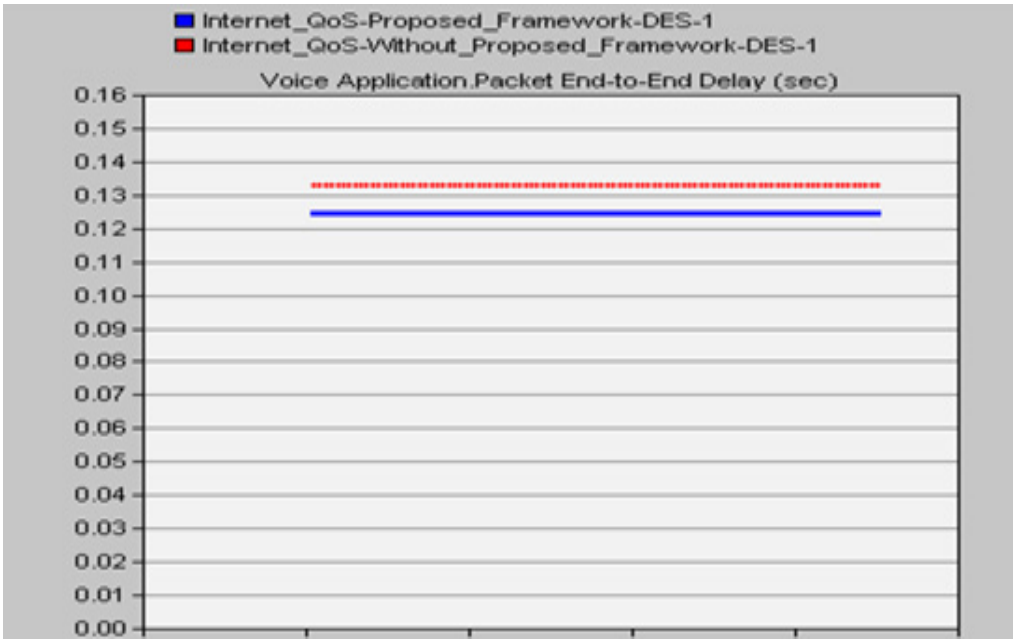

Figure 25. Voice quality speech end to end delays.

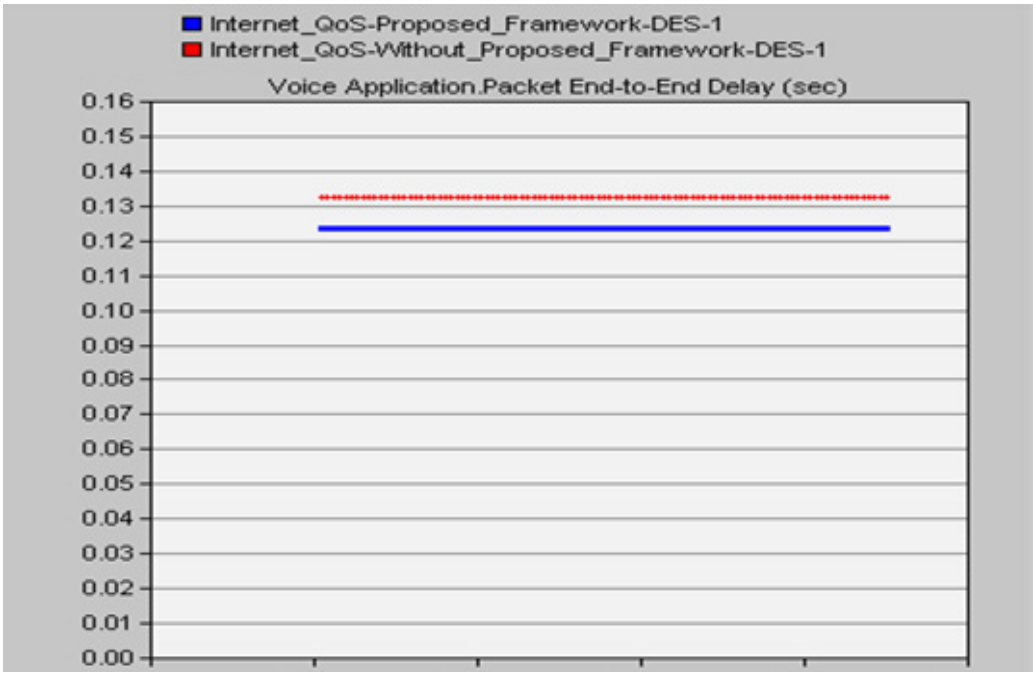

Figure 26. IP telephony end to end delays.

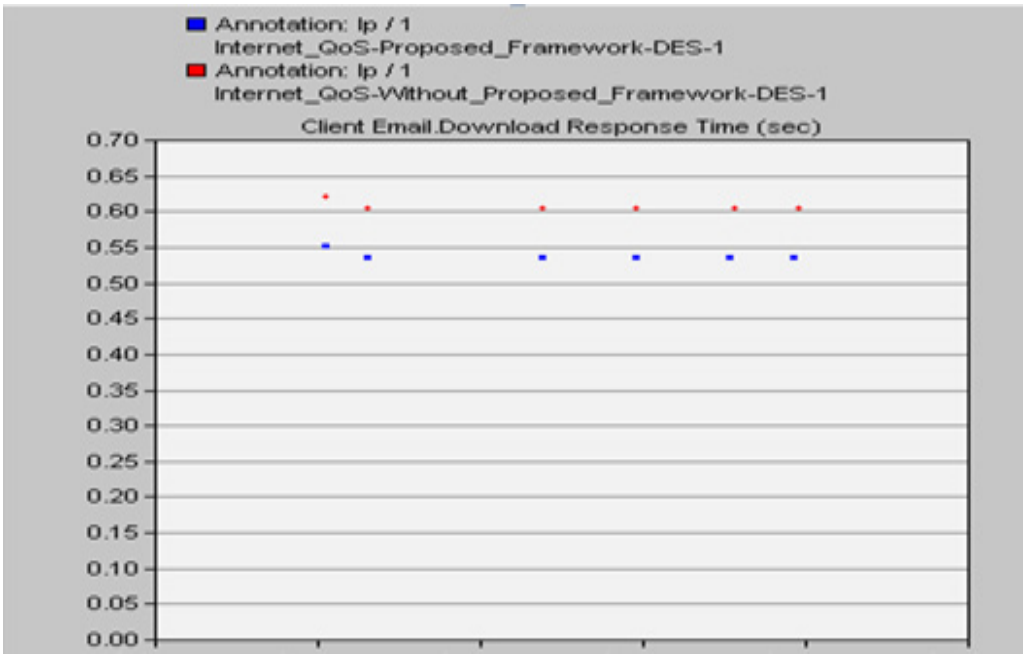

Figure 27. Response time in electronic mail application.

4.1.4 Response Time

Response time refers to the first instance of its output to user from its submission to the system. Low value of response time is desirable especially for the Internet services. Simulated results for various Services for Response time is shown in Figures 28 to 30.

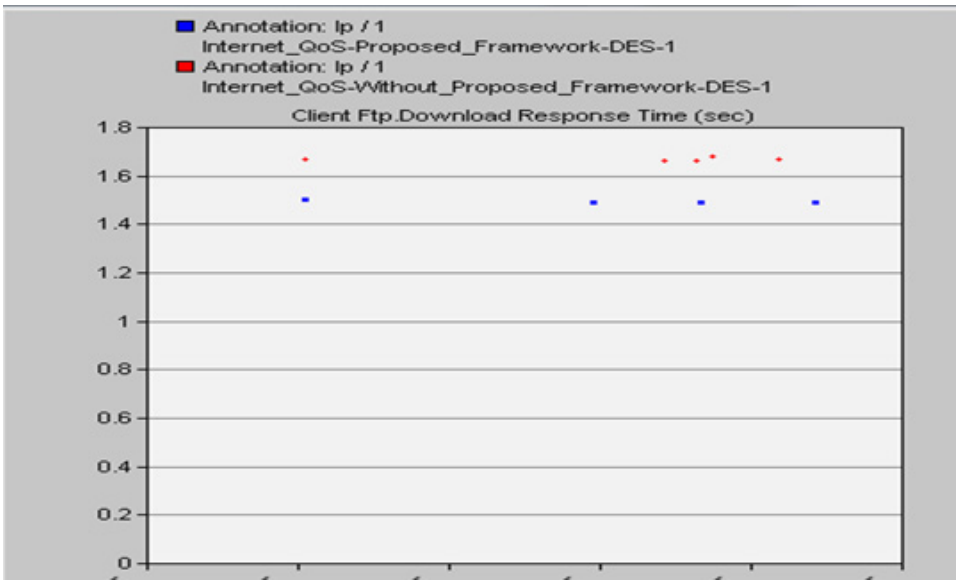

Figure 28. File transfer response time.

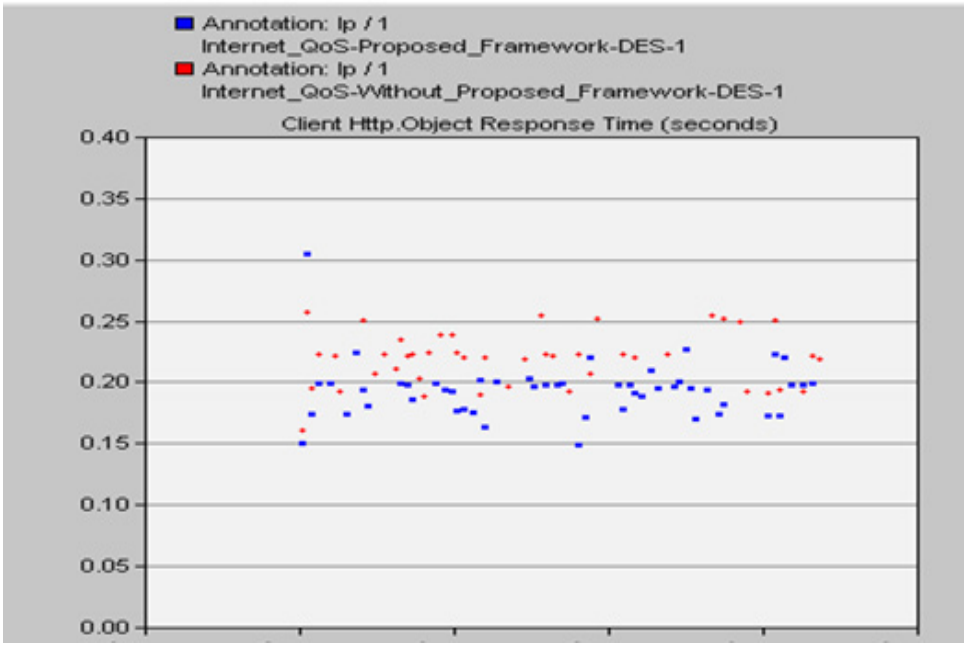

Figure 29. Web browsing response time.

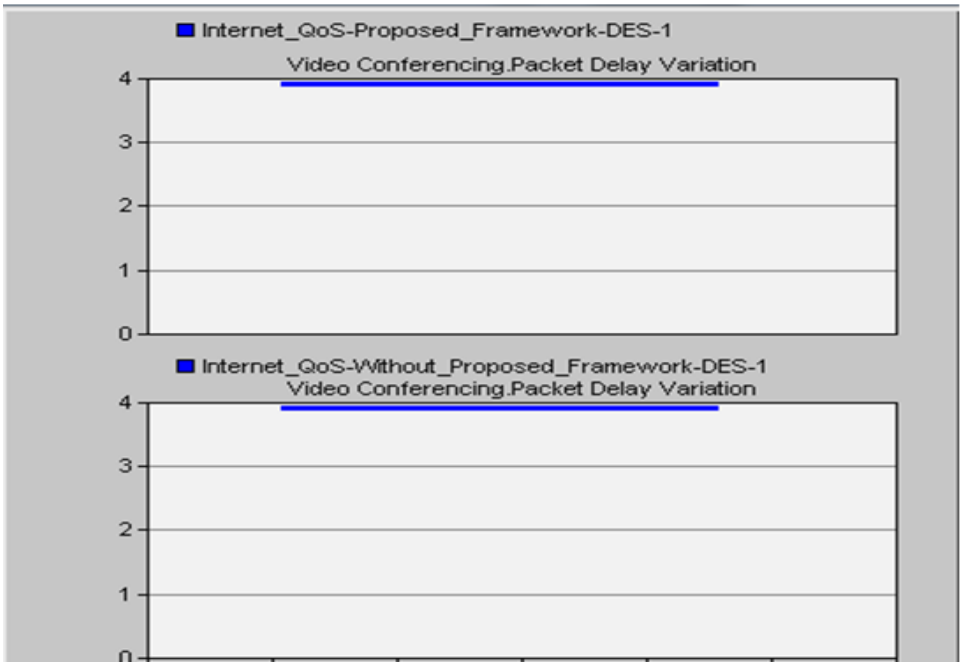

Figure 30. Delay variations in video conference.

4.1.5 Delay Variations

Difference in arrival time of the packets at destination refers the delay variations and in voice and multimedia services it should be low for continuity of service. Simulated results for various Services for Delay variation is shown in Figures 31 and 32.

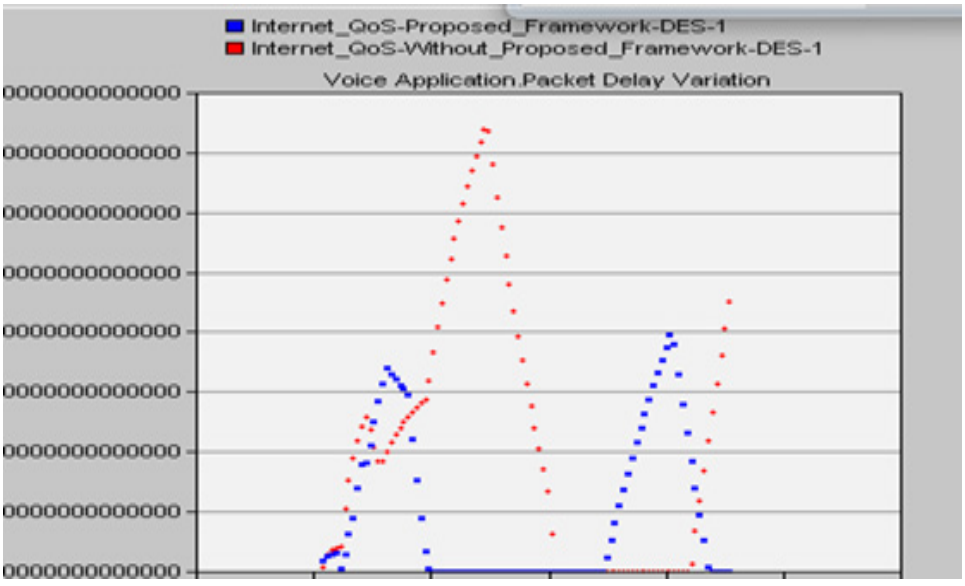

Figure 31. Delay variations of packets in video conference application.

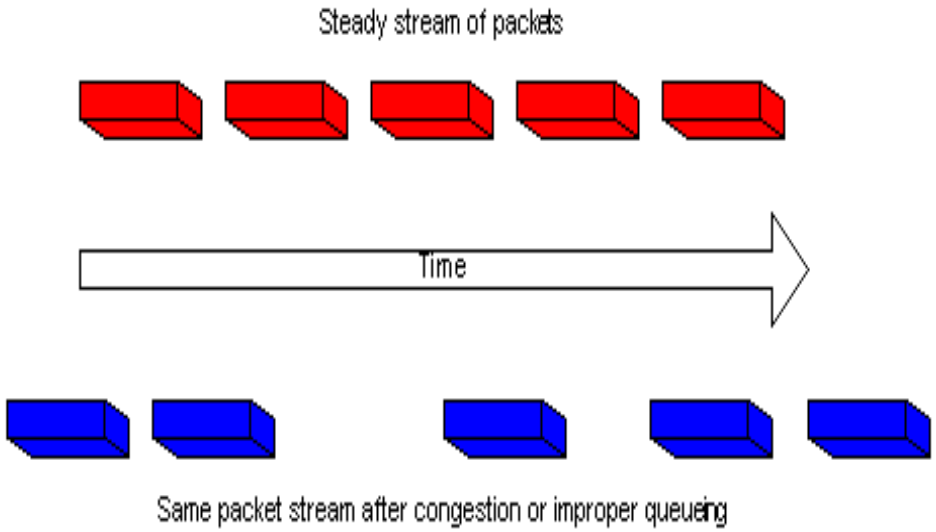

Figure 32. Variable time packet receiving results in Jitter.

4.1.6 Jitter

Delay variations or order variations in packets in voice and video based services result into jitter as shown in Figure 33. Simulated results for various Services for Jitter is shown in Figure 34 and Figure 35.

<insert figures 33-35 here>

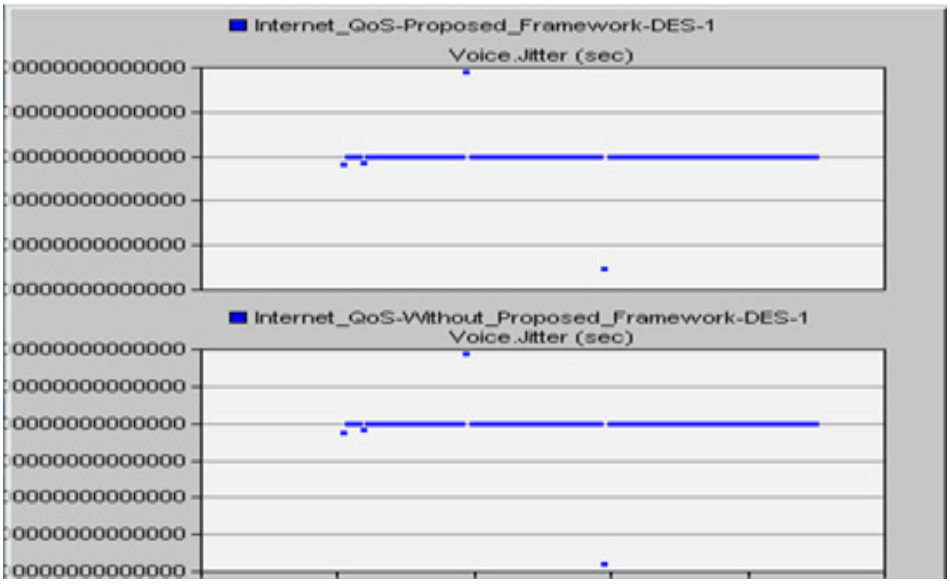

Figure 33. Jitter in voice application.

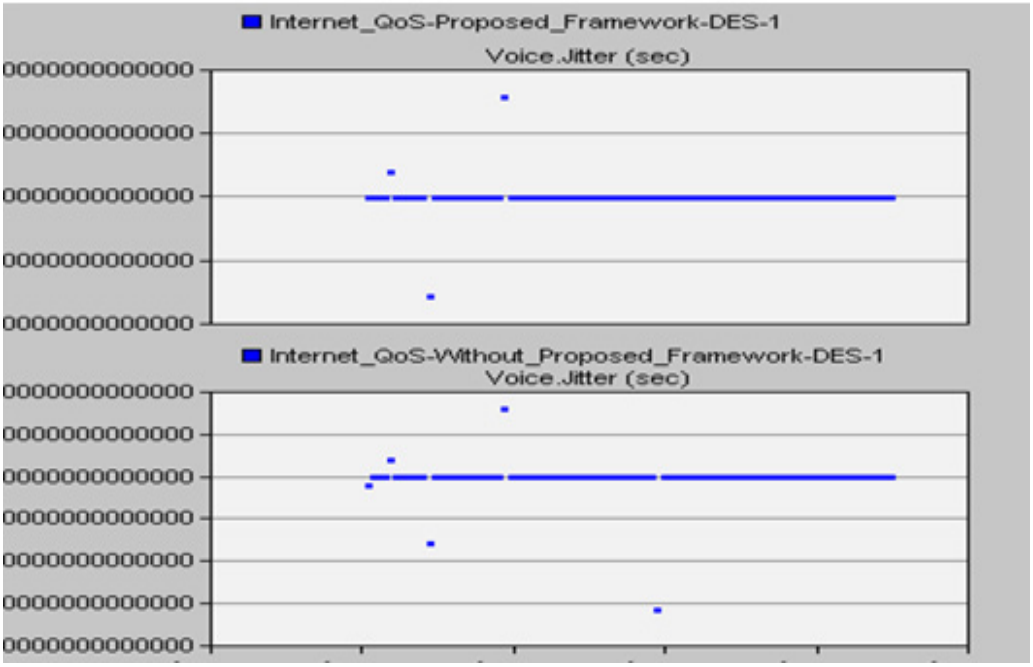

Figure 34. Jitter in IP telephony application.

5. Discussions and Findings

It is observed that there is significant increase in throughput and response time along with amazing reduction in packets delays, delay variations, and jitter. These parameters are very important for delivering quality of Internet for various services.

6. Conclusion

Internet is media of future that has embraced the world with exciting services. Many new and exciting service of the Internet has its own unique requirements to operate at reasonable level or acceptable level of the performance. In order to meet the requirements of each services Internet architecture needs to be manageable and scalable contrary to the existing Internet architecture that is based on the best effort delivery of the packets. Different schemas were proposed to implement the Quality of Service for the Internet. One of the several approaches Differentiated Service is a mechanism in which packets are classified as per the priority needs of the services. Based on the class to which a packet belongs is treated using the per hop behavior. Various services of the Internet like HTTP browsing, E-Mail, Video Conference, Speech are analyzed using the Differentiated mechanism to observe the Impact on the Quality of Service (QoS) parameters (TCP delays, End to End delays, delay variations, jitter). It is observed that there is a significant improvement in these quality parameters. It can easily infer that Differentiated Services mechanism is a successful approach for the Implementation of Quality of Service of Internet.

7. References

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