

“Performance Analysis of Voice and Video Applications over Evolving WiMAX Networks Using OPNET”

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ABSTRACT

In recent years, WIMAX technology has witnessed significant advancements, particularly in its capacity to support diverse multimedia applications such as voice and video. As the demand for high-quality, real-time communication continues to surge, the integration of voice and video applications within WIMAX networks has become a focal point for research and development. This thesis focuses on the optimization of multimedia communication in WIMAX networks, addressing different performance metrics such as voice Mos, jitter, voice end-to-end, video delay, voice delay and video end-to-end delay. Building upon earlier studies, the research endeavors to identify and implement improvements that contribute to a more seamless and efficient communication experience. The study commences with an in-depth review of existing literature, highlighting the challenges and advancements in multimedia communication within WIMAX networks. Subsequently, a comprehensive methodology is developed to measure and analyze voice throughput, jitter, and video end-to-end delay. Real-world scenarios are simulated to ensure the applicability of the findings to practical network environments. To achieve enhanced voice end to end delay, jitter as well as throughput, Quality of Service (QoS) implementations are investigated. Jitter mitigation techniques, are explored to minimize disruptions in voice transmission. Furthermore, innovative approaches to reduce video end-to-end delay, are examined. The experimental results demonstrate notable improvements in voice throughput, better jitter, and minimized video end-to-end delay compared to earlier studies. The proposed enhancements contribute to a more reliable and efficient multimedia communication experience in WIMAX networks, catering to the increasing demands of modern communication systems.

Keywords:

WiMAX Technology, Multimedia Communication, Voice over WiMAX (WiMAX), Video Transmission, Quality of Service (QoS), Jitter Analysis, End-to-End Delay, Video Delay Optimization, Voice Throughput, Network Simulation, Wireless Broadband Networks, Performance Evaluation, Communication Efficiency

Introduction

The rapid advancement of wireless communication technologies has significantly transformed the way we access the internet and communicate. Among these technologies, Worldwide Interoperability for Microwave

Access (WiMAX) has emerged as a promising solution for providing high-speed broadband access over long distances. This comprehensive paper explores the evolution, architecture, technical aspects, applications, challenges, and future prospects of WiMAX technology. Beginning with an overview of its historical development and standardization process, the paper delves into the technical underpinnings of WiMAX, including its architecture, modulation techniques, and quality of service mechanisms. It then examines the diverse range of applications and use cases of WiMAX, from broadband internet access to public safety communications and smart grid systems. Furthermore, the paper discusses the challenges and limitations faced by WiMAX, such as spectrum allocation issues and interoperability concerns. Finally, it explores future directions and emerging trends in WiMAX technology, including its integration with 5G networks and advancements in spectral efficiency. By providing a comprehensive analysis of WiMAX technology, this paper aims to contribute to the existing body of knowledge and stimulate further research and innovation in the field of wireless communication.

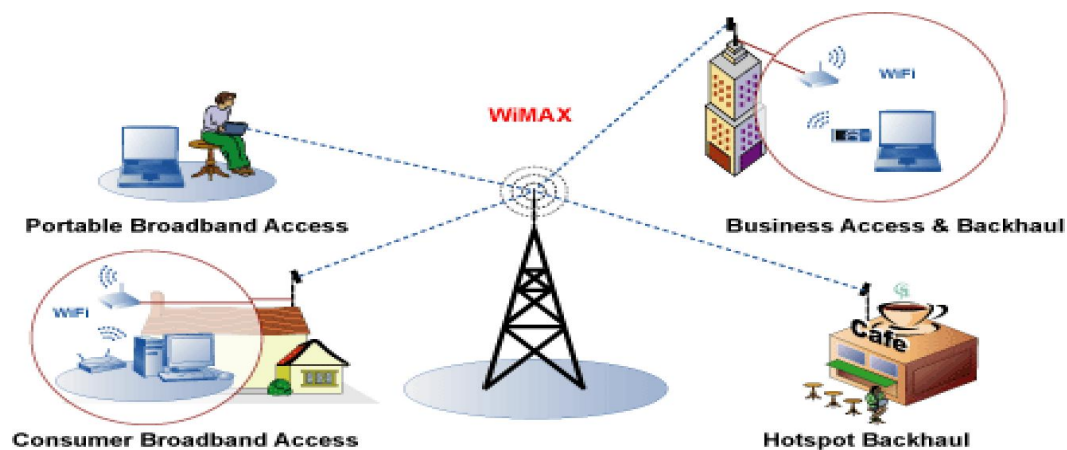


Figure 1.1 WiMAX

WiMAX (worldwide interoperability for microwave access) is the commercial name for products based on the IEEE 802.16 standard as trade marked by the WiMAX Forum, an association of companies representing the ecosystem of the WiMAX technology. The Institute of Electrical and Electronics Engineers (IEEE) is the main body responsible for defining the protocol on which the WiMAX technology is based. IEEE 802 LAN/WAN Standard Committee develops Local Area Network and Metropolitan Area Network standards. The IEEE has designated the number 802.16 for broadband wireless access on which WiMAX is based. While the IEEE standard defines the air interface, the WiMAX Forum has undertaken the task of defining the complete end-to-end network architecture and specifying the system profile to ensure worldwide interoperability of WiMAX equipment. The WiMAX Forum also undertakes the task of certifying vendor equipment as compliant with standard specifications in conjunctions with selected test and certification laboratories. At the current moment, there are two commercial versions of WiMAX: Fixed WiMAX based on IEEE 802.16d (or 802.16-2004, approved in June 2004) and Mobile WiMAX based on IEEE 802.16e2005 (ratified in December 2005). Mobile WiMAX can be used in both fixed and mobile scenarios

while Fixed WIMAX does not support mobility features. Mobile WIMAX is a feature rich technology with many aspects for improvements. The current Mobile WIMAX systems are based on so called “Release 1.0 system profile.” There is also a follow-on release “Release 1.5 system profile” which includes additional features not available in Release 1.0 such as Frequency Domain Duplexing (FDD) and uplink MIMO (multiple input multiple output) functionality. Release 2.0 system profile is based on a new iteration of the IEEE standard – 802.16m – which is planned to be completed by the end of 2010. Mobile WIMAX is the mainstream technology adopted by numerous wireless access service providers and supported by equipment vendors whereas the Fixed WIMAX standard has limited deployment and support within the larger WIMAX ecosystem.

WIMAX Wireless Network In practical terms, WIMAX would operate similar to Wi-Fi but at higher speeds, over greater distances and for a greater number of users. WIMAX could potentially erase the suburban and rural blackout areas that currently have no broadband Internet access because phone and cable companies have not yet run the necessary wires to those remote locations.

A WIMAX system consists of two parts:

- A WIMAX tower, similar in concept to a cell-phone tower - A single WIMAX tower can provide coverage to a very large area -- as big as 3,000 square miles (~8,000 square km).
- A WIMAX receiver - The receiver and antenna could be a small box or PCMCIA (Personal Computer Memory Card International Association) card, or they could be built into a laptop the way Wi-Fi access is today.

Literature Survey

[1] **Liton Chandra Paul et al** (2023) proposed A compact single band antenna with a wide operating frequency range (3.10–4.50 GHz) for WIMAX (3.4–3.6 GHz) and lower 5G (3.3–4.2 GHz) communications has been designed and analyzed in this paper. The proposed compact design provides improved antenna radiation parameters such as peak gain and directivity of 3.90 dB and 4.20 dBi, respectively.

[2] **Noor Nateq Alfaisaly et al** (2022) described the impact of node movements in specified directions on VoIP quality, the simulation contains Throughput (packets/sec), Mean Opinion Score (MOS), Jitter (sec), pathloss (dB), and signal to noise ratio (dB). A WIMAX network was used to deploy the voice application and test its quality for different trajectories.

[3] **Malebogo Mokeresete and Bukohwo Michael Esiefarienrhe** (2022) proposes a primary public network to meet universal and affordable connectivity and access. The changes could also force MNOs to

diversify away from the dominant voice services, thereby achieving the national goals for an information-based economy.

[4] **Dariusz Strzeciwiłk** (2021) described presents the results of research and analysis of voice data transmission quality in IP packet networks. It analyses mechanisms allowing for the assessment of packet telephony data transmission quality.

[5] **I.A. Almerhag and Nadia Aboalgasm** (2017) authors analyzed OPNET the simulation tool was used to test the effect of nodes movement in predefined trajectories on the quality of VoIP. A WIMAX network was used to deploy the voice application and test its quality for three different voice codecs schemes. Six scenarios were implemented.

[6] **Navjot Jyoti** (2017) presented a brief overview of WIMAX networks and WIMAX technology. WIMAX layers are also briefly discussed. This paper presents the emerging WIMAX technology review and benefits. It is expected that future work will focus on the mobility aspect and interoperability of mobile WIMAX with other wireless technologies.

Problem Definition

The WIMAX Model was created for the evaluation of VOIP Metrics in which Throughput, jitter and MOS Value has been analyzed with different subnet in Base Paper. We have deeply analyzed the research paper. There are needs lots of improvements. MOS value is considered in the Range of 5 to 1. The perceived quality of a voice call, 1 being the lowest score and 5 the highest for excellent quality. Researchers obtained the highest value that is 1.4 for MOS which is considered in between poor and bad. That is part of the necessary correction we have gone through. On the other hand, delay and jitter are also need to improve for VOIP Metrics. Secondly in today era Video Metric is also considered highly important so it is very important to create the Voice as well as Video WIMAX Model with containing optimum Outputs.

3.1 Objectives

The objective of study indicates what is to be achieved through the proposed model.

- To improve the Voice MOS Value up to minimum 3.5 and higher.
- To improve the Overall Throughput Value.
- To improve the Jitter Metrics in voice server.
- To obtain the Voice End to End Delay.
- To obtain the Video End to End Delay.

4.1 Introduction

Simulation can be defined to show the eventual real behavior of the selected system model. It is used for performance optimization on the basis of creating a model of the system in order to gain insight into their functioning. We can predict the estimation and assumption of the real system by using simulation results.

4.2 Simulator

In this thesis, network simulator, Optimized Network Engineering Tools (OPNET) modeler 14.5 has been used as a simulation environment. OPNET is a simulator built on top of discrete event system (DES) and it simulates the system behavior by modeling each event in the system and processes it through user defined processes. OPNET is very powerful software to simulate heterogeneous network with various protocols. OPNET software provides us output in a graphical manner, so we can analysis the performance of any device in the network.

4.3 OPNET Features

- Provides virtual real time environment for networks with GUI.
- Useful in evaluation of designs for new network models and architectures.
- Easy to understand the network behavior in various scenarios.
- It has Pre defined network models and designs for user education and development

4.4 Design and Analysis in OPNET

4.4.1 Model designing this section we design the network, it's all depends on the user, how can a user design its network .user choose the virtual devices according to its requirement.

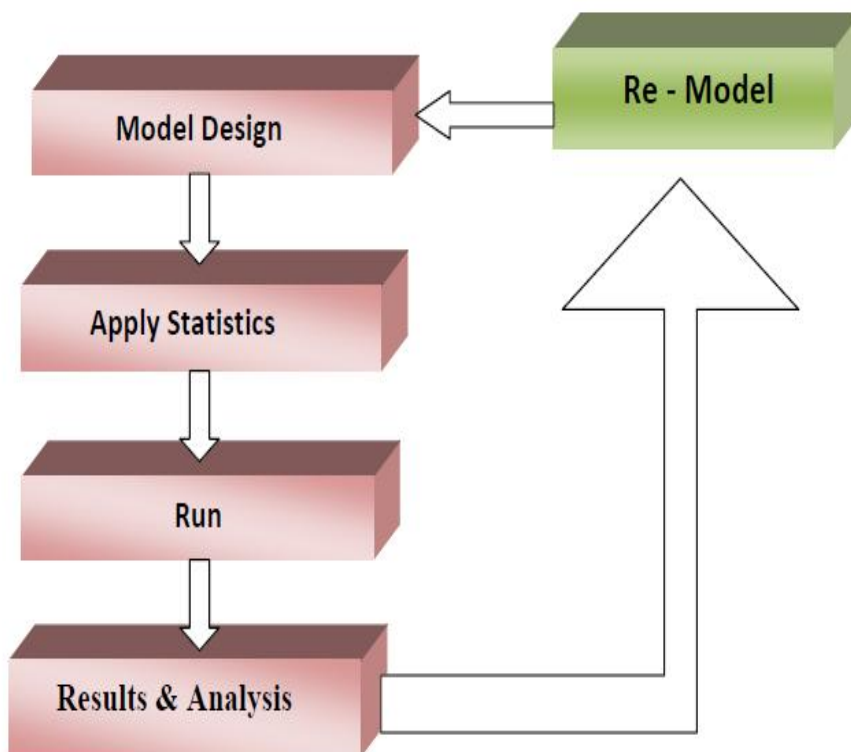
4.4.2 Apply Statistics In this section all the statistics are applied which is needed. When we complete the design network in opnet, then next step is applying the statistics which is needed, a user can easily choose the statistics by double click on the design palate.

4.4.3 Run In this section we run the scenario which is designed .in run section we can give the name to the scenario according to our choice, we can also set the time duration that will be the time for run.

4.4.4 Results In this section we obtain the Results which were the requirement. If the results are not according to our choice, then we can again change the design section and then run the simulator and again obtain the results. [16,19,33]

The present work is carried out through a number of stages starting from problem selection to literature review about the state of art technology specific to WIMAX, and its application. As well as performing the simulation in OPNET Modeler 14.5 tool. Most of the time is spent in identifying and selecting the problem and literature review. Selection of simulation tool and understanding the working of it also took a lot of time. The work in OPNET has to stream through some steps.

The work will execute step by step in OPNET, the first step will be making and setting up a WIMAX Network using a project window of OPNET modeler. In this master’s thesis we have to create a WIMAX Network to implement Voice and Video Server so that specific metrics Results can be obtained. Working mechanism of OPNET simulator is described as Follow.



Results & Discussion

In this chapter different kinds of Results have been obtained related with trajectories used in this thesis are Exam, Fixed, Vector and Manet Down Left and also analysis in the last that which Trajectory is provide best performs among the others. six different performance metrics i.e. Voice Jitter, Voice End to End Delay, Voice MOS, Voice Delay, Video End to End Delay Video Delay metric has been taken.

A trajectory is a path taken up by a moving object that is following through space as a function of time. Mathematically, a trajectory is described as a position of an object over a particular time. A much-simplified example would be a ball or rock was thrown upwards, the path taken by the stone is determined by the gravitational forces and resistance of air. Some more common examples of trajectory motion would be a bullet fired from a gun, an athlete throwing a javelin, a satellite orbiting around the earth etc. In this thesis Trajectory is described as mobile node position over a particular time. because with the changes of time mobile node with WIMAX Network will change the position also .so Trajectory will affect the overall performance of a particular network. we have implemented four different networks with different Trajectories as follow.

5.4 Manet down Left Scenario

As per the objectives of this thesis work, we have to configure last network with MANET DOWN LEFT Trajectory so as we configure first three scenarios with different Trajectory this time, we also configure a fourth network with MANET DOWN LEFT. Then individual DES statistics was chosen that would be viewed in the results from the DES menu. Finally, time duration to run the simulation was set.

5.5 Voice Jitter

Voice Jitter is defined as if two consecutive packets leave the source node with time stamps t_1 & t_2 and are played back at the destination node at time t_3 & t_4 , then $\text{jitter} = (t_4 - t_3) - (t_2 - t_1)$ Negative Jitter indicates the difference between the packets at the destination node was less than that at source node.

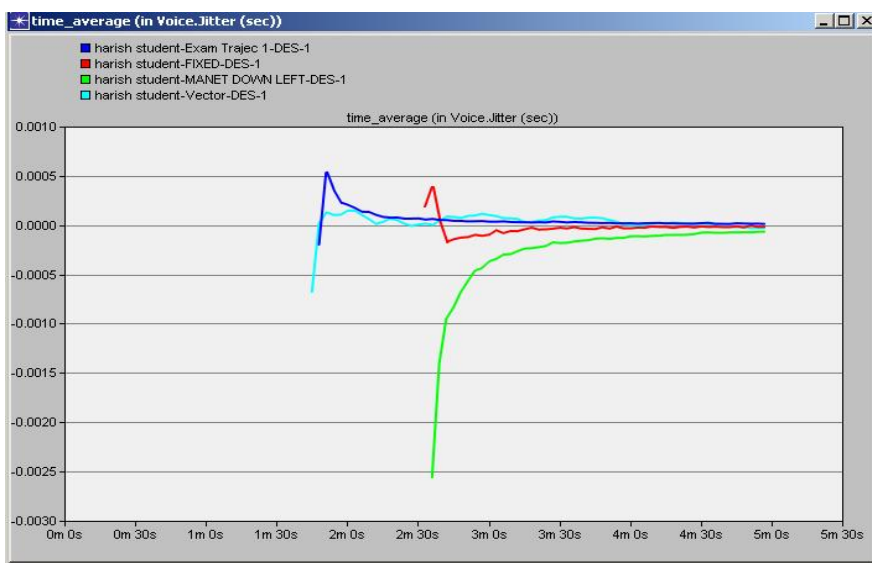


Figure 5.5: Voice Jitter

According to simulation, as it can be seen in Fig. 5.5 Voice jitter metric has been shown Exam, Fixed, Vector, and Manet Down Left In which all Trajectories jitter value is almost same but in terms of mathematics Networks with Exam Trajectory is best among as compare to all others.

5.6 Voice Packet Delay

Delay is caused when packets of data (voice) take more time than expected to reach their destination. This causes some disruption s the voice quality.

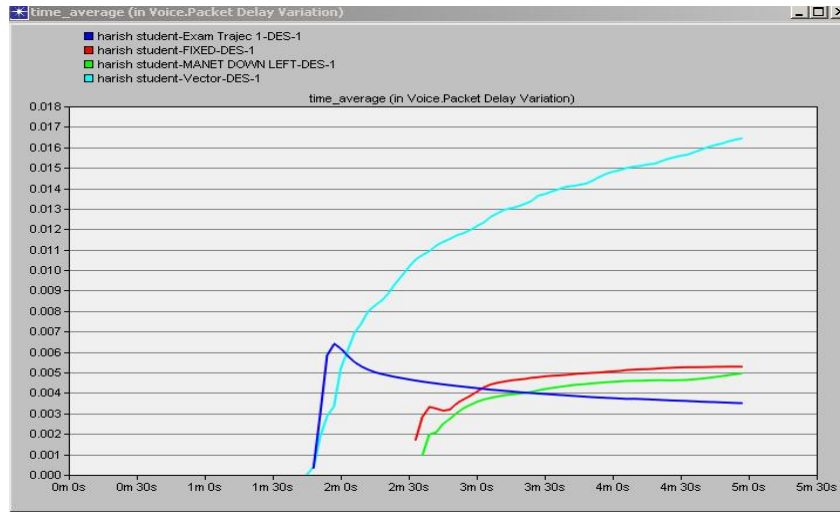


Figure 5.6 Voice Packet Delay

According to simulation, as it can be seen in Fig. 5.6 Voice Packet Delay metric has been shown Exam, Fixed, Vector,Manet Down Left.It can be seen that Voice Packet Delay of Exam is best that is 0.0034 after that Manet Down Left is providing 0.005,Fixed Response time is 0.0053 Voice Packet Delay of Vector is worst that is 0.0165 .so in Voice Packet Delay it can say that Exam is best Trajectory.

5.7 Voice End to End Delay:

Average number of Packets per second submitted to the transport layers by all voice application in the network .

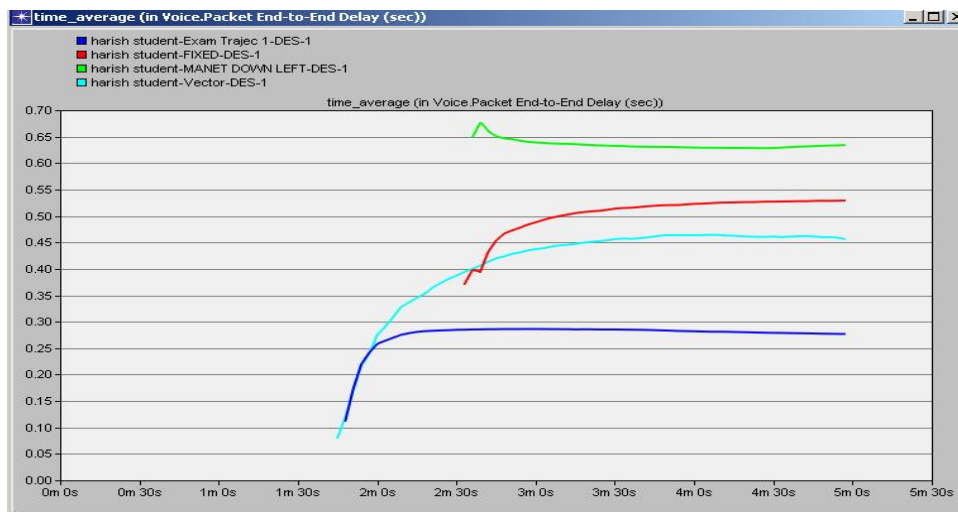


Figure 5.7 Voice End to End Delay

Voice End to End Delay metric has been shown in which Voice End to End Delay is present. Exam is best that is 0.256 after that FIXED is providing that is 0.525 second, Vector Response time is 0.456 but among of all MANET DOWN LEFT Voice Packet Delay is worst that is 0630 .so in Voice End to End Delay it can say that Vector (VECTOR) is best.

Table: 5.3 Voice End to End Delay

Scenario Name	Delay (sec)
EXAM	0.256
VECTOR	0.456
FIXED	0.525
MANET DOWN LEFT	0.630

5.8 Voice MOS: The Mean Opinion Score (MOS) is described as a commonly-used metric to measure the overall voice call quality for decades. That vary from 1 to 5 .1 will be minimum quality as worst ,5 will be best as optimum.

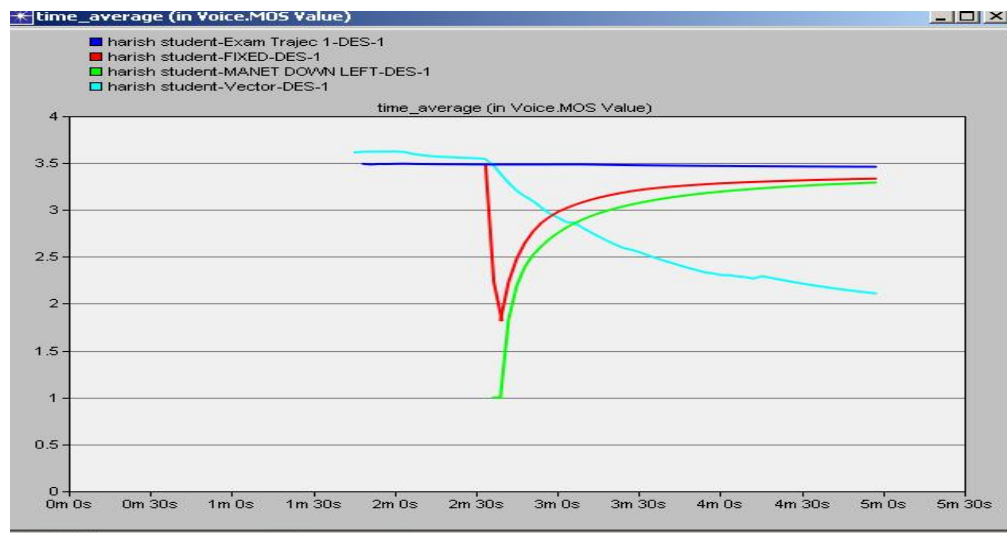


Figure 5.8 Voice MOS

The MOS test results in a single score that provides a concise summary of the VoIP call quality. It gives VoIP service providers and network administrator’s valuable feedback on how users perceive the quality of their VoIP service. A higher MOS score indicates better voice quality and a more satisfactory user experience.

5.9 Video End to End Delay

Variance among end-to-end delays for video packets. End to End Delay for video packets is measured from the time it is created to the time it is received.

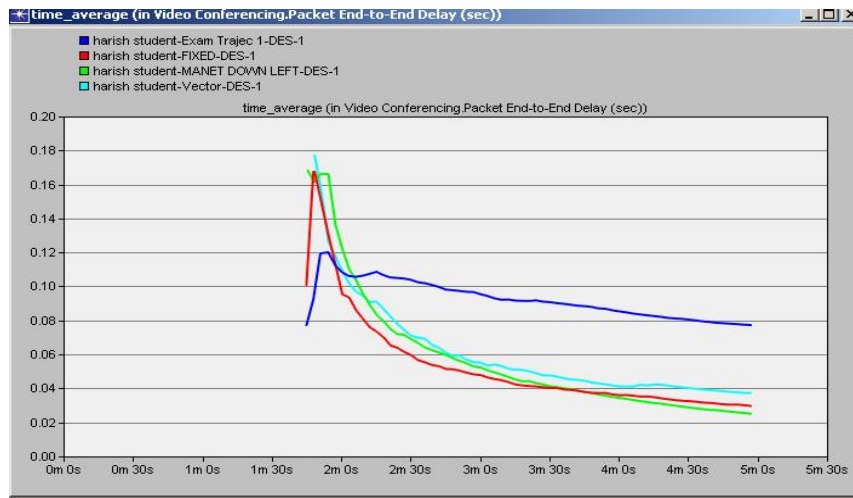


Figure 5.9 Video End to End Delays

According to simulation, as we can see in Fig:5.8 Video End to End Delay metric has been shown of Exam ,Fixed , Vector ,MANET DOWN LEFT In Table 5.5 in which it can be seen that Video End to End Delay of

Conclusion & Future Work

5.1 Conclusion:

In this thesis we concluded mainly two types of studies; one is analytical and second is Practical which is based on OPNET Simulator. Analytic Study concluded the behavior of each Trajectory System like EXAM, FIXEDVECTOR&MANET DOWN LEFT. All the Network Performance has depended on its Trajectory System. Each different Trajectory System has different processing Mechanism according to their environmental scenarios. From Simulator aspects we concluded that which is major factor that can affect the performance of

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