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Enhanced DWRR and Enhanced MWRR Scheduling Algorithms for WiMAX Networks

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***Abstract*— The IEEE 802.16 standard is supposed to provide a wide-range broadband wireless service, but it leaves the implementation of the wireless resource scheduler as an open issue. We have studied the scheduling problem and propose a scheduling scheme with support for quality of service and fairness guarantees for downlink traffic in a WiMAX network. A central controller Base Station has a number of users, and each mobile subscriber station has different channel conditions. The same mobile subscriber station may have different service requirements at different times in the WiMAX network. Based on OPNET simulation, the results show our scheduling algorithm can increase the network throughput, maintain relative fairness, and lower delay over the round robin and weighted round robin algorithms. This research proposes a fair and efficient QoS scheduling scheme for IEEE 802.16 BWA systems that satisfies both throughput and delay guarantee to various real and non-real time applications. The proposed QoS scheduling scheme is compared with an existing QoS scheduling scheme proposed in literature in recent past. Simulation results show that the proposed scheduling scheme can provide a tight QoS guarantee in terms of delay, delay violation rate and throughput for all types of traffic as defined in the WiMAX standard, thereby maintaining the fairness and helps to eliminate starvation of lower priority class services.**

***Index Terms*— WiMAX, QoS, DWRR, MWRR, OPNET**

I. INTRODUCTION

WiMAX (worldwide Interoperability for Microwave Access) is a wireless communications standard designed to provide 30 to 40 megabit-per-second data rates, with the 2011 update providing up to 1 Gbit/sec for fixed stations. The name "WiMAX was created by the WiMAX Forum, which was formed in June 2001 to promote conformity and interoperability of the standard [1]. The forum describes WiMAX as "a standards-based technology enabling the delivery of last mile wireless broadband access as an alternative to cable and DSL". It is one of the most emerging technologies for Broadband Wireless Access (BMW) that provides wireless transmission of data. WiMAX based on the standard IEEE 802.16. Which consist of one Base station (BS) and one or more subscriber stations (SSs). As shown in the Figure 1, the BS is responsible for data transmission from SSs through two operational modes: Mesh and point to multipoint. Meanwhile, transmission take place through two independent channels: Downlink channel (from BS to SS) and uplink channel (from SS to BS). In Mesh mode, SS can communicate by either the BS or other SSs, in this mechanism the traffic can be routed not only by BS but also by other SSs in the network; this means that uplink and downlink channels are defined as traffic in both directions, to and from the BS. In the PMP mode SSs can only communicate through the BS [6].

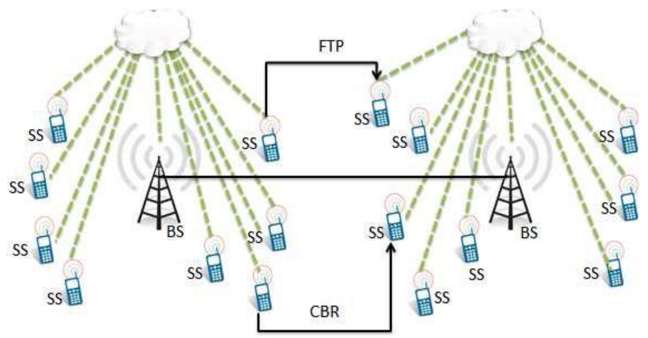

Figure1.1 Architecture of WiMAX [6]

WiMAX networks are providing a crucial element in order to satisfy on-demand media with high data rates. This element is the QoS and service classes per application. In Broadband Wireless communications, QoS is still an important criterion. So the basic feature of WiMAX network is the guarantee of QoS for different service flows with diverse QoS requirements [3]. The scheduling of both variable-size real-time and non-real-time connections is not considered in the standard. Thus, WiMAX QoS is still an open field of research and development for both constructors and academic researchers. The standard should also maintain connections for users and guarantee a certain level of QoS. Scheduling is the key model in computer multiprocessing operating system. It is the way in which processes are designed priorities in a queue. Scheduling algorithms provide mechanism for bandwidth allocation and multiplexing at the packet level [1]. WiMAX have five different QoS classes. Different scheduling algorithms are used for implementing these QoS classes and have different results for each of them. We aim to manage and maximize the utilization of the resources of WiMAX. Since all the scheduling algorithms are not best for all QoS classes, so we aim to find the best scheduling algorithm among DWRR, MWRR, Enhanced DWRR and Enhanced MWRR scheduling algorithm for each of the services classes with respect to scheduling parameters such as throughput, delay, load etc. The proposed scheduling technique has been designed and simulated using the OPNET 14.0. In order to evaluate the performance of our proposed approach, we compared our results to the results of well-known scheduling techniques (Deficit Weighted Round Robin and Modified weighted Round Robin).

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II. QoS CLASSES FOR WiMAX

QoS in WiMAX have been classified in five different classes [10]:

• **Unsolicited Grant Service (UGC**): Supports applications that require Constant Bit Rate such as voice-application.

• **Real Time Polling Service (rtPS):** supports real time data streams that contain variable size data packet which are issued at periodic interval such as MPEG video.

• **Extended Real Time Polling Service (ertPS):** applicable with variable rate real application that require variable data rate and delay guarantees like VOIP with silence suppression.

• **Non Real Time Polling Service (nrtPS):** supports delay tolerant data streams that contain variable size data packet.

• **Best Effort (BE):** supports data streams that do not need any QoS guarantees like HTTP.

III. PERFORMANCE METRICS

Following are the performance metrics used for the analyses of the results of the scheduling algorithms [3]:

• **Delay in the network:** The delay of a network specifies that how long it takes for a bit/sec of data to travel across the network from one node to another. Generally the network with less delay value is preferred.

• **Packet Delay Variance (jitter):** jitter could be termed as the variation in delay or packet delay variation. The value of jitter is calculated from the end to end delay. It is the variation in the time between packets arriving.

• **Load in the network:** The load refers to the amount of data being carried by the network.

• **Average Queuing Delay:** The time between the arrivals of a packet in the queue to the departure of the packet from the queue.

• **Average End to End Delay:** This performance metric represents the average delay between the time when the data packet was originated at the source node and the time is reaches the destination node.

• **Throughput of the Network:** Throughput is the average rate of successful message delivery over a network.

IV. IMPLEMENTATION

Enhanced DWRR: The administrator proposes an Enhanced Deficit Weighted Round Robin (Enhanced DWRR) scheduling algorithm which is enhancement to the Deficit Weighted Round Robin (DWRR) scheduling algorithm. In the DWRR scheduling scheme, network administrator divide the traffic generated into various classes and allocate the bandwidth to those traffic classes where as in case of proposed approach the network administrator can divide the traffic into various classes but also have to reserve a part of bandwidth from the total bandwidth. This is due to the reason if any traffic class have a burst of traffic then it can share the reserved traffic and can reduce the traffic drops in case of burst traffic also. First of all the queues are processed according to the priority given by the network administrator. During the processing of the traffic classes of queues if a burst is arrived then it can share the bandwidth that is kept reserved by the network administrator and after the burst processed away the class or queue can release that shared bandwidth so that any other queue can use it if required as represented in figure. Flow chart of Enhanced Deficit Weighted Round Robin is represented in figure.

Enhanced MWRR: The administrator proposes an Enhanced MWRR scheduling algorithm which is enhancement to the MWRR scheduling algorithm. In the MWRR scheduling scheme the weights are assigned to the traffic queues in which order these queues will process. In this scheduling scheme any queue can be processed until the tokens in its queue is greater than that of its residual queue. So this condition can put this scenario in case of starvation process. To avoid this condition the a way out is proposed in the proposed solution as represented in figure 5.3 in which a queue can be processed until its packets in the queue is less than that of residual packets or it will be processed until the time associated to it is completed. According to the proposed solution the scheduling will not face the condition of starvation because all the queues in the network will be processed according to the priority or the given time interval. For e.g. if a queue can-not satisfy the first condition then it will be processed only for a given interval of time and the scheduler will move to the next queue. In this manner all the queues will be processed in the network.

Flow chart of Enhanced DWRR and Enhanced MWRR are represented in figure.

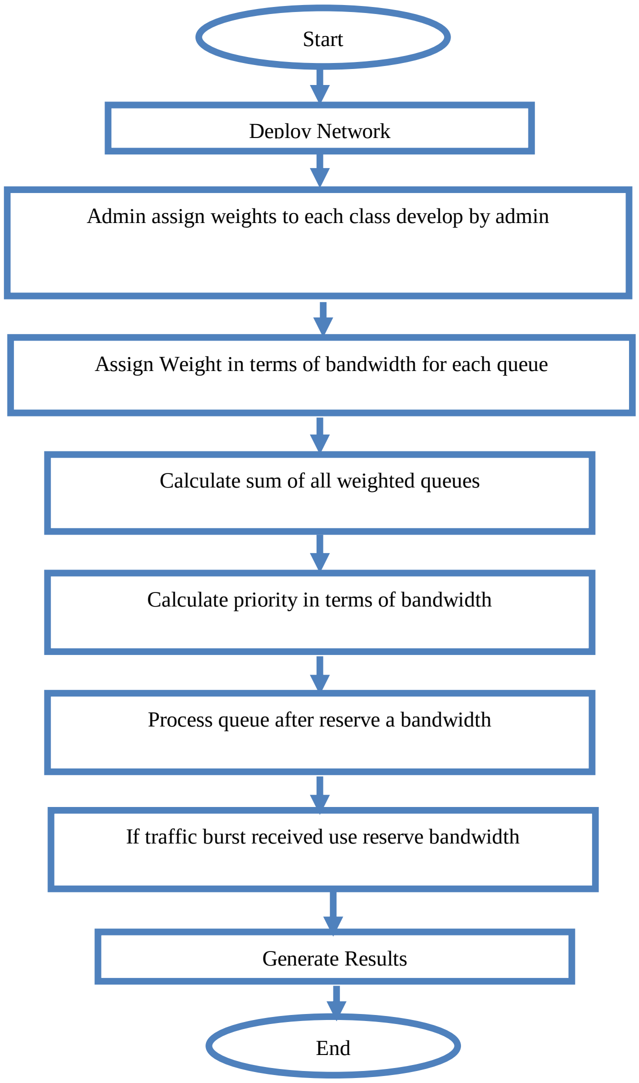

Figure 4.1 Flow chart of EDWRR

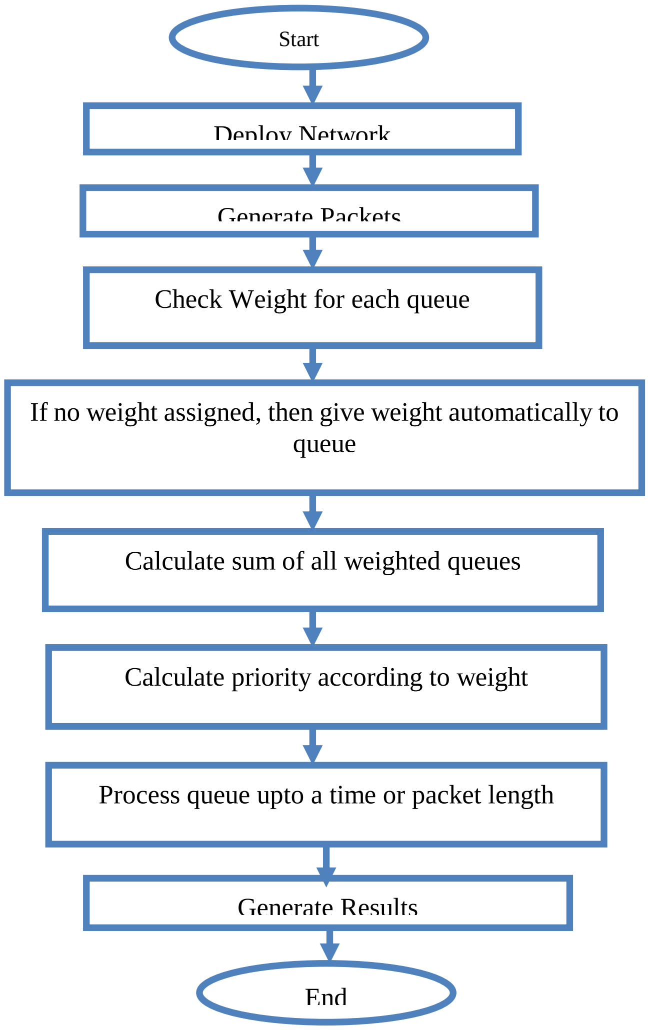

Figure 4.2 Flow chart of EMWRR

V. RESULTS AND DISCUSSION

With the implementation of MWRR, DWRR, Enhanced MWRR and Enhanced DWRR scheduling algorithms in WiMAX using OPNET Modeler, results have been obtained. In this chapter, the results of the four scheduling algorithms are analyzed and compared.

Comparison is done for the three scheduling parameters namely Delay, Throughput and Load.

- **Delay:** The delay of a network specifies how long it takes for a bit/packet of data to travel across the network from one node to another.
- **Load:** The load refers to the amount of data being carried by the network.it is expressed as bit/sec or packet/sec.
- **Throughput:** Throughput is the average rate of successful message delivery over a network. The throughput is usually measured in bits/sec or packet/sec.

For the evaluation of each performance metrics, scenarios of all four scheduling algorithms are compared.

Delay in the Network

The delay of a network specifies that how long it takes for a bit/sec of data to travel across the network from one node to another. Generally the network with less delay value is preferred. Simulation time is represented on x axis and delay on the y axis.

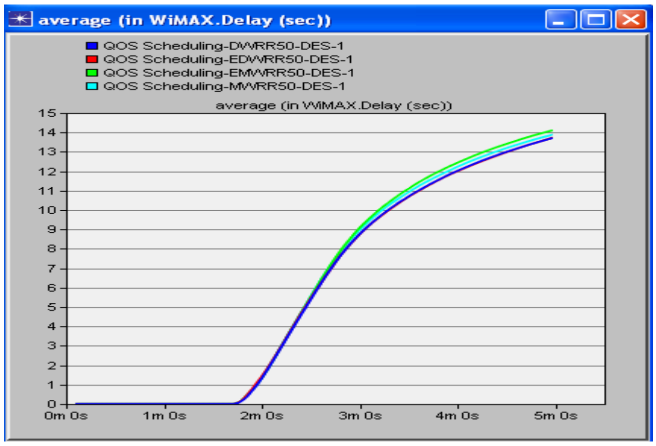

Figure 1 Delay in Network

Figure 1 represents the delay in the network of the four scheduling schemes called DWRR, EDWRR, MWRR and EMWRR. The delay is 12.6 sec at 4 minutes and is increased to 14 sec at 5 minutes in case of MWRR. Enhanced MWRR has least delay rate, at 12.4 sec at 4 minutes and reaches to its maximum value 13.7 sec at 5 minutes. From the figure it is clear that the delay in enhanced MWRR is better than that of MWRR.

Load in the network: The load refers to the amount of data being carried by the network. It is expressed as bits/sec. load and simulation time is represented on the y axis and x axis respectively.

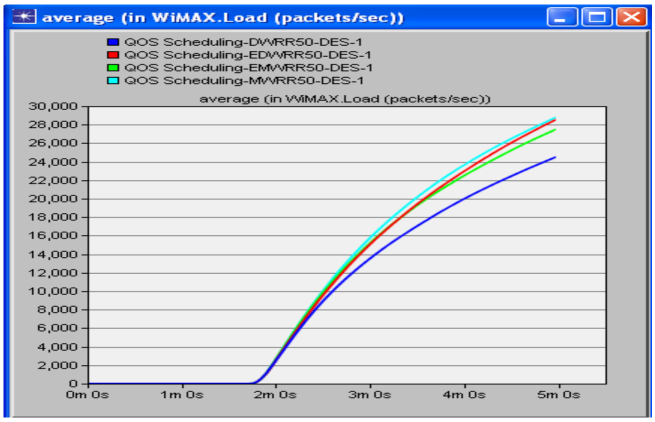

Figure 2Load in Network

Figure 2 defined about the load in the network in all the four scheduling schemes defined as MWRR, EMWRR, DWRR and Enhanced DWRR. Enhanced DWRR and DWRR have load value about 28000(bits/sec) and 26000(bits/sec), respectively. Load in case of Enhanced DWRR is more than that of DWRR because it can tolerate burst traffic which DWRR cannot. In case of burst traffic DWRR can drop packets from the network whereas enhanced version of DWRR can help the packets to reach their destination. In case of MWRR and Enhanced MWRR the load in MWRR is greater than that of Enhanced MWRR the QoS parameter is improved.

Throughput of the Network: Throughput is the average rate of successful message delivery over a network. The throughput is measured in bits/sec. Throughput is represented on the y axis and simulation time on x axis.

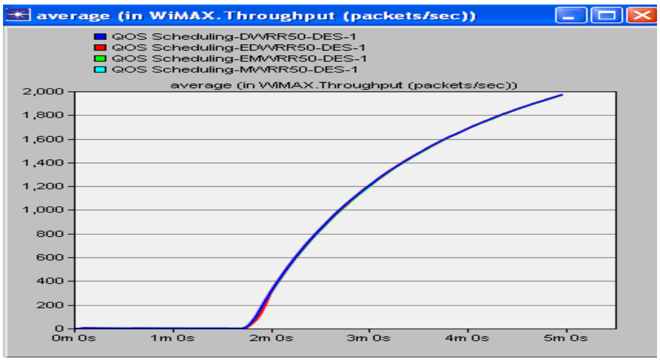

Figure 3 Throughput of the Network

Figure 3 is the throughput in the network. Throughput is same for all kind of scheduling schemes. They have about 1630 packet/sec of throughput at 4 minutes.

Results of various types of Applications: There are some other results of different QoS parameters according to different QoS classes.

Object Response Time in HTTP: BE class support data streams that do not need any QoS guarantees like HTTP. Figure 5.5 shows the object response time in HTTP. Simulation time is represented on x-axis and object response time on the y-axis.

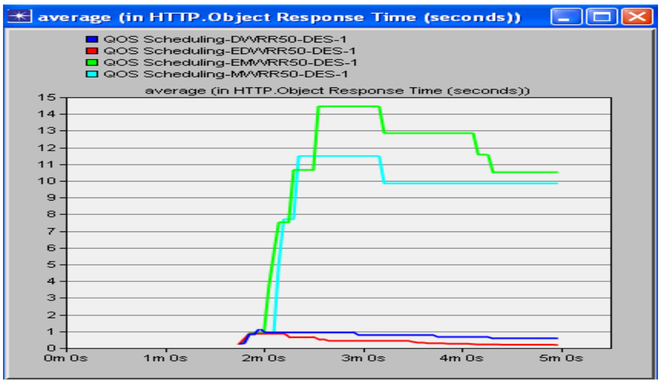

Figure 4 Object Response Time in HTTP

In BE class, Object response time in case of DWRR is about 0.8 where as in case of enhanced version it is 0.5 seconds at 4 minutes. Same pattern is followed in case of MWRR and EMWRR. In case of MWRR object response time is about 10 and about 13 in case of Enhanced MWRR at 4 minutes.

Page Response Time in HTTP: BE class support data streams that do not need any QoS guarantees like HTTP. Figure 5.5 shows the page response time in HTTP. Simulation time is represented on x-axis and page response time on the y-axis.

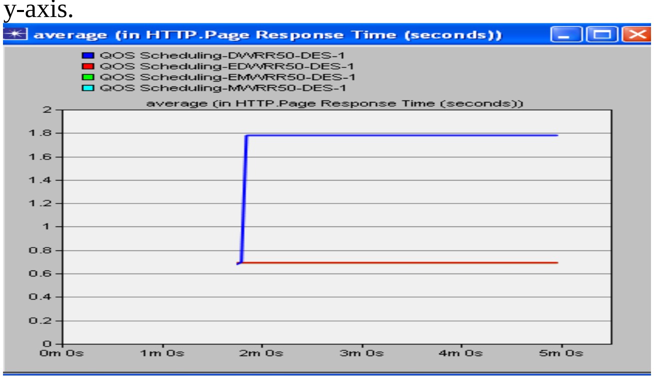

Figure 5Page Response Time in HTTP

Figure 5 represents about the Page Response time in HTTP applications. Object Response time in Enhanced MWRR is 1.8 seconds and that of MWRR is at 4 minutes.

End to End delay in Video Conferencing: The rtPS class supports real size data packets, which are issued at periodic intervals such as video conferencing. In rtPS class, End to End delay is high in DWRR as compared to Enhanced DWRR.

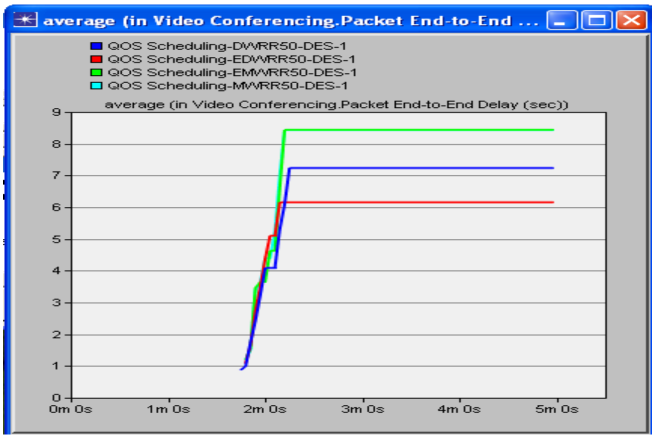

Figure6 Packet End to End Delay in video Conferencing

Figure 6 is the pictorial view of the Packet End to End delay. Packet End to End delay for Enhanced DWRR is about 6.2 seconds where in case of DWRR it is 7.2 seconds at 4 minutes.

End to End delay in Voice: The UGC supports applications that require Constant Bit Rate (CBR) such as voice applications. Simulation time is represented on x-axis and end to end delay is represented on y-axis. When scheduling algorithms are implemented in UGC service, Enhanced DWRR and DWRR have least end to end delay, about26 sec, when simulation time is 4 minutes, as shown in Figure6

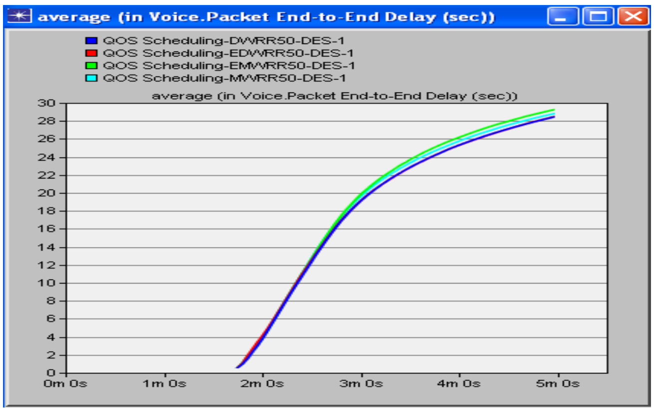

Figure 7 End to End Delay in Voice

Figure 7 is the pictorial view of the Packet End to End delay. Packet End to End delay for Enhanced MWRR is about 26.2 seconds where in case of MWRR it is 27 seconds at 4 minutes of simulation time.

Delay Jitter in Voice: Delay Jitter is the inter-packet time gap for arrival at the receiver. Simulation time is represented on x-axis and delay jitter is represented on y-axis

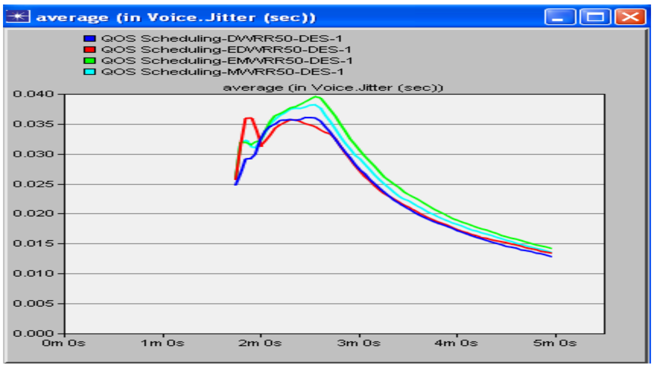

Figure 8 Delay Jitter in Voice

Figure 8 represents the jitter in case of various scheduling schemes. Jitter for MWRR and Enhanced MWRR is 0.31 sec and 0.32 sec respectively at 2 minutes simulation time. In case of DWRR and Enhanced DWRR it is 0.34 sec and 0.32 sec respectively at 2 minutes of simulation time.

Packet Delay Variation in Voice: This performance metric represents the average delay between the time when the data packet was originated at the source node and the time it reaches the destination node. Simulation time and packet delay represented on x-axis and y-axis respectively.

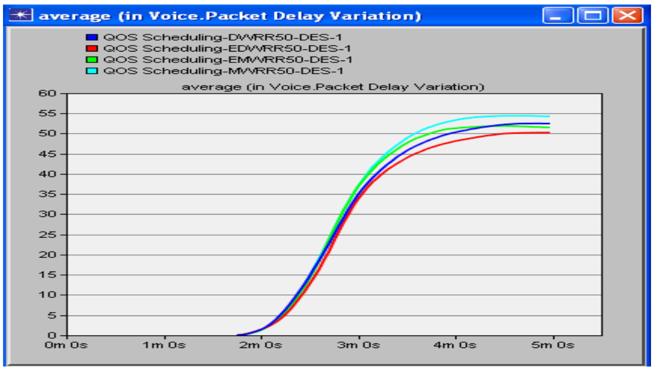

Figure 9 Packet Delay Variations

In figure 9 the results for packet Delay Variation is shown. Packet Delay variation for MWRR and Enhanced MWRR is 53 sec and 51 sec respectively at 4 minutes of simulation time. In case of DWRR and Enhanced DWRR it is 51 sec and 47 sec respectively at 4 minutes of simulation time.

VI. CONCLUSION AND FUTURE SCOPE

In this research we have made the enhancement of various scheduling schemes in WiMAX after drawing out the comparative study of existing scheduling algorithms. In the present research the enhancement of MWRR and DWRR is made after checking out the pros and cons of these two algorithms. We have simulated our WiMAX network on 35 subscriber stations, 7 base stations and 4 applications named voice, video, http and email. First of all the comparative study of existing scheduling schemes is made, in which MWRR and DWRR are compared. MWRR, DWRR are modified versions of weighted round robin scheme. Therefore to remove some of the cons in MWRR and DWRR the enhancement in the two scheduling scheme is made. After simulation of enhanced MWRR and DWRR QoS parameters are improved as compare to the existing MWRR and DWRR as shown in the results. To enhance the MWRR and DWRR the modifications is done in assigning weights to queues of various classes. By using the modification we have improved results of enhanced schemes.

Future scope of this research we can work out on the scalability of the proposed scheduling schemes. One can make a research in this proposal by assigning more number of service stations and by providing overloaded conditions to the proposed scenario. On the other hand further research can be done in this topic by provision of hybrid scheme in scheduling scheme by which one can improve the results of these schemes on a heavy load conditions and in case of thousands of nodes simultaneously working in network. One can provide a scheme in which delay can be controlled and drop ratios can be reduced.

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