Analysis of Packet Scheduling in WiMAX Network

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ABSTRACT
Interest in broadband wireless access (BWA) has been rising due to augmented user mobility and the requirement for data access at all times. The best available quality of experience is promised by IEEE 802.16 based WiMAX networks. For guaranteed services for voice, video and data, WiMAX networks include numerous quality of service (QoS) mechanisms at the Media Access Control (MAC) level. In order to provide different characteristics to Quality of Service (QoS) an effective scheduling is critical for the WiMAX system. Scheduling is an important part of WiMAX layers, which can be accomplished via downlink or via uplink scheduling. This paper gives a comparative analysis of two different schedulers Priority Queue (PQ) and Weighted Fair Queue (WFQ). The study has been carried out on a number of issues like: packet end to end delay and traffic received, and the simulation results shows that Weighted Fair Queue technique has a better quality than the other technique. OPNET Simulator has been used to create the Simulation scenario for WiMAX scheduling and result for different algorithm has been presented.

General Terms
Connection oriented, Downlink/Uplink scheduling, PQ, WFQ.

Keywords
WiMAX, QoS. VoIP, WFQ, PQ

1. INTRODUCTION
IEEE WiMAX also known as Worldwide Interoperability for Microwave Access, was actually given to IEEE 802.16 standard by WiMAX Forum, set up in mid 2001 to take care of conformity and interoperability. **I**EEE 802.16 is a group of telecommunications technology standards intended for providing wireless access over large distances in a variety of ways - from point-to-point link to full mobile cellular type access as shown in Fig. 1. It spread over a metropolitan area of few kilometres and is also called WMAN (Wireless MAN). Theoretically, for fixed stations a WiMAX base station can provide broadband wireless access up to 50 kms and 5 to 15 kms for mobile stations with a maximum data transfer rate of up to 70 Mbps, whereas 802.11a can support a data rate of 54 Mbps up to few hundred meters. But with the rising demand for transferring huge amount of data at faster rate, WiMAX has created a remarkable amount of attention inside the networking community in the last few years. WiMAX is an up-coming technology for broadband wireless access and for providing wireless last mile connectivity, and provides both mobile and fixed broadband wireless Internet access [1]. Several mechanisms are built into the physical and MAC layer of WiMAX in order to achieve high throughput, high reliability and very good efficiency. Security mechanisms QoS specifications and are built into the standard from the very start. The packet schedulers working at MAC layer are extremely significant for QoS delivery [2]. A basic WiMAX network contains a base station (BS) and several subscriber stations (SSs). An essential principle of WiMAX technology is that it is connection oriented.

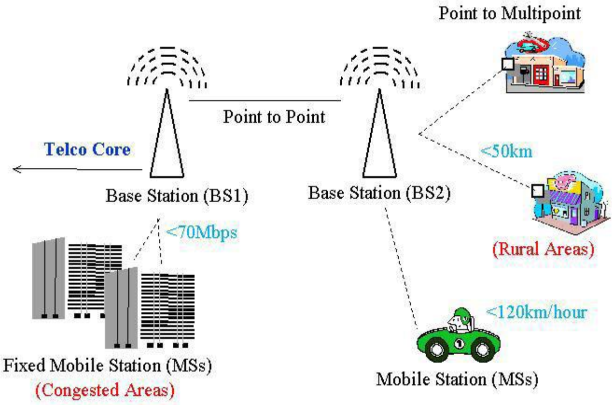

Fig 1: WiMAX Deployment Scenario

Connection oriented means that before the SS can start to send or receive data, SS must register itself to the base station in oder to initial Quality of Service (QoS) needs with the BS. Voice over IP (VOIP) is one of the important applications for WiMAX in order to support bidirectional voice conversation. Since its introduction, VoIP has been building up more and more prevalence and some services have widened their coverage.

The rest of this paper is structured as follows. Section 2 presents the WiMAX Scheduling schema. The parameters used and performance analysis to evaluate the effectiveness of the experiments are included in section 3 and the performance results of proposed technique are presented in section 4. Finally, section 5 concludes the paper.

2. WiMAX SCHEDULING
Scheduling is critical component of WiMAX network that impacts significantly on its performance. Scheduling schemes help in providing service guarantees to heterogeneous classes of traffic where there are a variety of different quality-of-service (QoS) requirements. Two types of scheduling schemes are supported by WiMAX i.e. uplink request/grant scheduling and downlink scheduling. The downlink scheduling scheme in the base station (BS) determines the transmission period and burst profile for every connection for downlink traffic, based

on the QoS profile as well as channel/queuing related criteria. Downlink scheduling is simpler than scheduling in the uplink direction. This is because in the downlink the BS has knowledge of all queues assigned to SSs, whereas it does not have in the uplink because the links are wireless in nature with random characteristics of channel and also the BS does not have complete information of all SSs.

In general, the designers of the scheduler should to be thoroughly familiar with the characteristics of WiMAX such as the registration process, frame format and so on. A scheduler for PMP mode in WiMAX network must have some characteristics such as simple, efficient, fair, scalable and have low computational complexity. The goals of the schedulers were basically to meet QoS guarantees for all service classes and various other characteristics. To meet all these goals was quite challenging since achieving one may require that to sacrifice the others. Recent scheduling disciplines were classified based on the channel awareness in making the decision [10].

For categorizing the inward bound packets into its sub-connections, a downlink scheduler is there at the SS. Further the uplink request/grant scheduling is performed by the BS with the aim of providing every subordinate SS with bandwidth for uplink transmission to request bandwidth. The scheduler functions as a distributor to allot the resources amongst MSs. We can define the allocated resource as the number of slots and further these slots are mapped into a number of subchannels (each subchannel is a group of multiple physical subcarriers) and time duration (OFDM symbols) [3], [4]. The performance of the scheduler is a potential differentiator among equipment providers in what is otherwise a quite standardized environment, as it helps operators use spectrum more efficiently and deliver better services. In simplistic terms, for, say, downlink operation, packets arrive from the network at the base station, and are placed in downlink user traffic queues [5]. The packet schedulers working at the MAC layer are extremely significant for QoS delivery. The IEEE 802.16 standard does not state the scheduling algorithm to be used rather it is up to vendors to implement an algorithm based on their network traffic. Vendors have the option amongst various existing scheduling techniques or they can build their own scheduling algorithms [6]. But in this paper only PQ (Priority Queue) and WFQ (Weighted fair Queue) algorithms will be discussed. Priority Queuing allocates multiple queues to a network interface with a priority level being given to each queue. A queue with higher priority is processed earlier than a queue with lower priority. Priority Queuing has four preconfigured queues, high medium, normal and low priority queue. By default every queue has 20, 40, 60 and 80 packets capacity. If packets arrive in the high priority queue then priority queuing drops everything it is doing in order to transmit those packets and the packets in other queue is again empty. The scanning of high priority queue is performed first, then the medium priority queue and subsequently other queues. For transmission purpose the packet at the head of the highest queue is chosen. Every time when a packet is to be sent, this procedure is repeated. Length limit is used to define the maximum length of a queue. When a queue is longer the limit packets are dropped [7]. In QoS, low-volume traffic is scheduled first by flow-based queuing algorithm, while allowing high-volume traffic sharing the remaining bandwidth. This is handled by allocating a weight to each flow, where lower weights are the serviced first [8]. Weighted fair queue is a generalization of fair queuing. Every data flow (both WFQ and FQ), has a separate FIFO queue. In FQ, having a link data rate of DR, and S active data flows are serviced concurrently at any given time, each at an average data rate of DR / S.

3. SIMULATION AND PERFORMANCE ANALYSIS

In this section, we conduct extensive simulations using OPNET simulator with WiMAX module to evaluate the performance of 0the one scheduler in several aspects and to compare it with other. To execute all the experimental works the following network design has been taken into consideration in which traffic is used for each of the functions such as Ftp, Video Conferencing and VOIP which is shown in Fig 2.

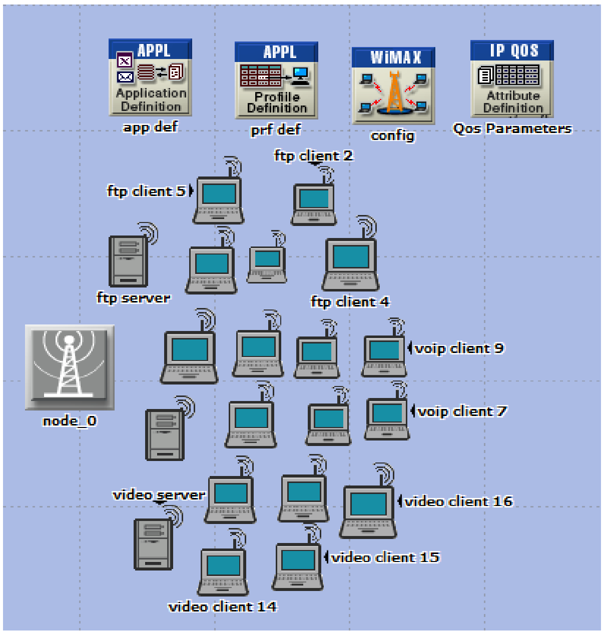

Fig 2: Simulation scenario

Simulations are executed for the two techniques that are PQ (Priority Queue) and WFQ (Weighted Fair Queue). The below configurations are applied in the **Opnet Modeler** and simulated to get results [9].

1. In the field of FTP application “High Load” has been selected, Constant (10) to Inter-Request Time and Constant (1000000) to File Size are assigned.
2. In the field of Video Application “Low Resolution Video” has been selected for Video Conferencing, Streaming Multimedia (4) to **ToS** is assigned.
3. In field of VoIP application PCM Quality Speech to Voice and Interactive Voice (6) to ToS is assigned.

In the simulation, we have used a topology that consists of one base station (BS), three Servers one each for ftp, video and voice traffic and seventeen fixed node (SSs). SS1 to SS5 sends ftp traffic, SS6 to SS12 sends voice traffic and SS13 to SS17 sends voice traffic. We have assumed error free link conditions. Wireless OFDM PHY layer of IEEE 802.16 standard is used with a channel bandwidth of 20 MHz The frame duration is 5 ms is used. ARQ and packing mechanisms are not used [11]. Other simulation parameters are provided in Table 1.

Table 1: Simulation Parameters

Simulation Parameters	Value
Channel Bandwidth	20 MHz
Frame Duration	5 ms
TTG	106 ms
RTG	60 ms
Modulation Scheme	64 QAM, 16 QAM
Duplexing Technique	TDD

4. SIMULATION RESULTS

Simulations have been executed using OPNET software for every queuing scheme in terms of traffic receiving, packet end-to-end delay, MOS Value etc and are tested for Video Conferencing, Voice Traffic and FTP.

i) Traffic received

a.) Voice over Internet Protocol (VOIP)

Traffic Received Statistics for VoIP is shown in Fig 3, where it can be perceived that with 40 SSs traffic received in first 360 seconds is almost same in both WFQ and PQ but after that WFQ shows increase in traffic.

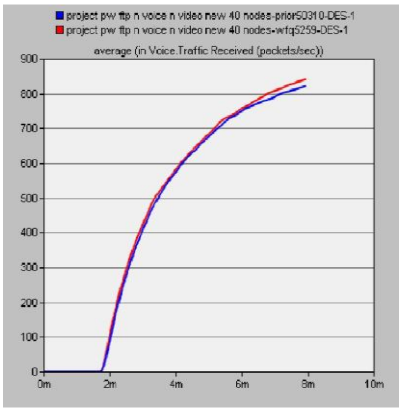

Fig 3: Traffic Received for WFQ and PQ

b.) Video Conferencing (VC)

Traffic Received Statistics for Video Conferencing is presented in Fig 4, where it can be observed that WFQ and PQ received almost equal traffic.

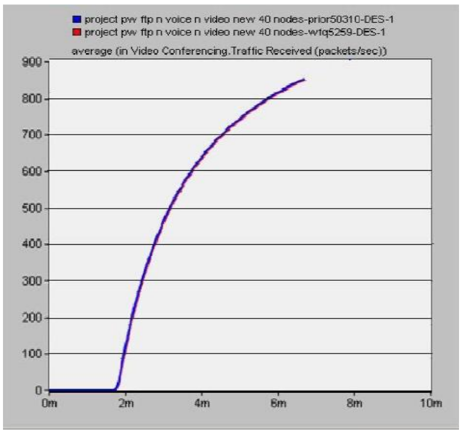

Fig 4: Traffic Received for WFQ and PQ

c.) File Transfer Protocol (FTP)

Traffic Received results for File Transfer Protocol is shown in Fig 5, where it can be seen that WFQ received more traffic as compared to PQ.

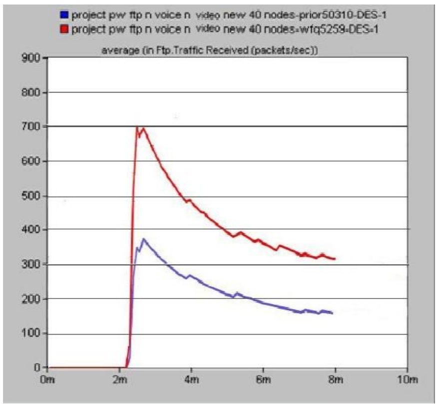

Fig 5: Traffic Received for WFQ and PQ

ii.) Packet end-to-end delay

a.) Voice Over Internet Protocol (VOIP)

Packet end-to-end delay for VoIP is shown in Fig 6 where it can be seen that packet end-to-end delay for PQ is more as compared to WFQ as the simulation time increases.

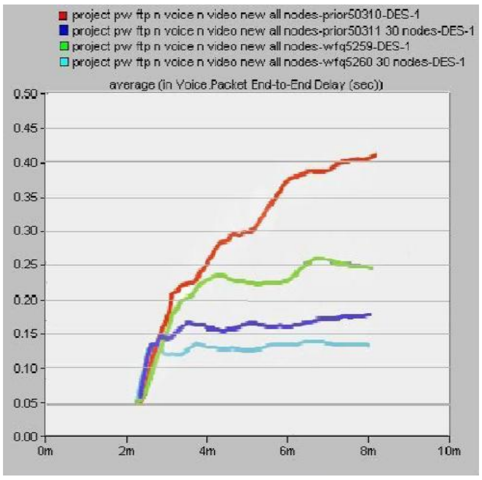

Fig 6: End-to-end delay for WFQ and PQ

b.) Video Conferencing (VC)

Packet end-to-end delay for Video Conferencing is presented in Fig 7 where it can be observed that as the traffic increase or time increases end-to-end delay increases for PQ whereas it is less in case of WFQ.

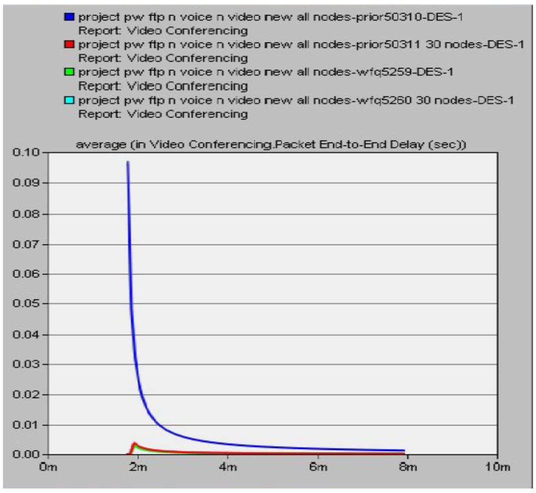

Fig 7: End-to-end delay for WFQ and PQ

iii.) MOS Value

a.) Voice Over Internet Protocol (VOIP)

Fig 8 shows the MOS Value in case of VoIP where it can be observed that the MOS Value for WFQ and PQ comes out to be 3.7 which is a very good value although WFQ starts showing MOS Value a little before PQ.

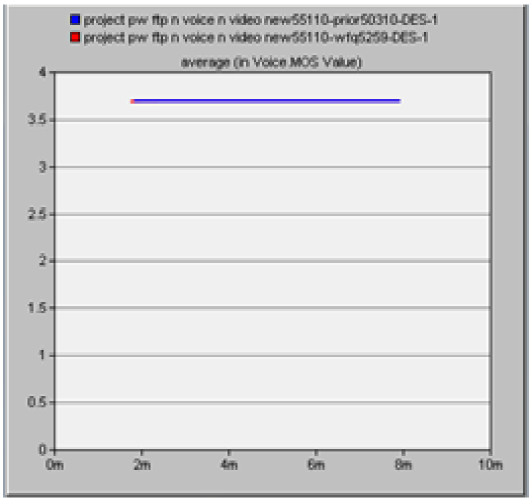

Fig 8: MOS value for WFQ and PQ

5. CONCLUSION

The results obtained from simulation have shown that Weighted Fair Queue scheduler provides efficient mechanism for service differentiation and hence provides better quality of service to the WiMAX as compared to Priority Queue scheduler. End-to-end delay of packets using WFQ scheduler is low than the PQ scheduler. In case of various applications like voice, ftp and video conferencing the average traffic received using WFQ scheduler is more than by using PQ scheduler. So in terms of overall performance (under the used simulation conditions in this particular study of QoS of WiMAX), WFQ performs marginally well than PQ.

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