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Performance Evaluation of WFQ Scheduling Algorithm at Different Antenna's Height in IEEE 802.16 Standards

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Abstract--Broadband Wireless Access (BWA) has become the easiest way for wireless communication and a solution to requirement of internet connection for data, voice and video service. Worldwide Interoperability for Microwave Access (WiMAX) networks were expected to be the main Broadband Wireless Access (BWA) technology that provided several services such as data, voice, and video services including different classes of Quality of Services (QoS), which in turn were defined by IEEE 802.16 standard. In this paper we present a simulation study of WiMAX that shows that in Weight Fair Scheduling, there is no effect on the Throughput, end-to-end Delay and Jitter when we change the number of output queues. We also show the effect on Throughput, end-to-end delay, Jitter by considering different heights of antenna.

Index Terms—WiMAX, Quality of Services (QoS), Weight Fair Queue Scheduling (WFQ)

1. INTRODUCTION

The IEEE working group has designed a standard based on BWA systems for last mile wireless access named IEEE 802.16 Wireless MAN which is cheap in comparison with fiber or coax cable. Other advantages of BWA are high scalability, lower maintenance and upgrade costs. The IEEE 802.16 can be deployed rapidly even in areas difficult for wired infrastructures to reach.

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The rest of the study is organized as follows: section 2 explains the brief architecture of WiMAX networks, next section 3 mentions the QoS classes, 4th section gives a brief introduction of Weight Fair queue (WFQ) scheduling algorithm, 5th section provides the simulation and analysis results. 6th section describes conclusion of this paper.

2. IEEE 802.16 ARCHITECTURE

The basic IEEE 802.16 architecture consists of one Base Station (BS) which is usually installed on top of buildings or towers to serve subscriber stations up to 50Km away from it and one (or more) Subscriber Stations (SSs) which is located in home and business premises as shown in below figure. Both BS and SS are stationary while clients connected to SS may be fixed or mobile.

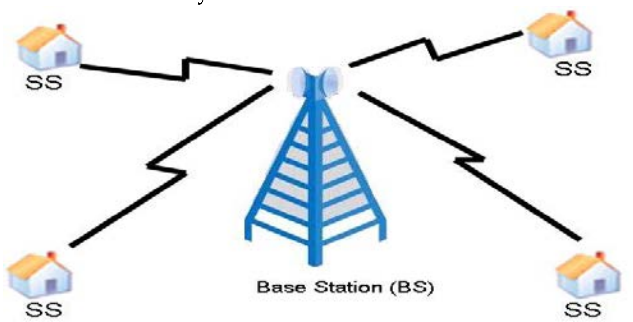

Figure 1: Architecture of IEEE 802.16

The BS is responsible for data transmission through two independent channels: the downlink channel (from BS to SS) which is only use by the BS, and the uplink channel (from SS to BS). Data transmission can take place from SSs through two operational modes: Mesh and Point-to-Multipoint (PMP). In Mesh mode, SS can communicate by either the BS or other SSs, in this mechanism the traffic can be routed not only by the BS but also by other SSs in the network; this means that the 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, which makes the provider capable of monitor the network environment to guarantee the Quality of Service QoS to the customers.

3. QUALITY OF SERVICE (QoS)

IEEE 802.16 defines five QoS service classes. Unsolicited Grant Service (UGS), Real-Time Polling Service (rtPS), Extended Real-Time Polling Service (ertPS), Non-Real-Time Polling Service (nrtPS), Best Effort (BE). Each of these has its own QoS parameters such as minimum throughput requirement and delay, jitter constraints.

Unsolicited Grant Service (UGS): it supports constant Bit Rate (CBR) such as voice applications. This service class provides a fixed periodic bandwidth allocation. Once the connection is set up, there is no need to send any other request.

Real-Time Polling Service (rtPS): this service class is for variable bit rate (VBR) real time traffic such as MPEG compressed video.

Extended Real-Time Polling Service (ertPS): this service is designed to support VOIP with silence suppression. No traffic is sent during silent periods.

Non-Real-Time Polling Service (nrtPS): this service class is for non-real- time VBR traffic with no delay guarantee. File Transfer Protocol (FTP) traffic is an example.

Best Effort (BE): Most of data traffic falls into this category. This service class guarantees neither delay nor throughput. The bandwidth will be granted to the MS if and only if there is a left over bandwidth from other classes. HTTP is an Example.

4. WFQ SCHEDULING:

Weighted Fair Queuing (WFQ) was developed independently in 1989 by Lixia Zhang and by Alan Demers, Srinivasan Keshav and Scott Shenke. In WFQ, if bit rate of the output port, the number of active queues, the relative weight assigned to each of the queues, and the length of each of the packets in each of the queues, it is possible for the scheduling discipline to calculate and assign a finish time to each arriving packet. The scheduler then selects and forwards the packet that has the earliest finish time from among all of the queued packets. The finish time is not the actual transmission time for each packet. Instead finish time is a number assigned to each packet that represents the order in which packets should be transmitted on the output port.

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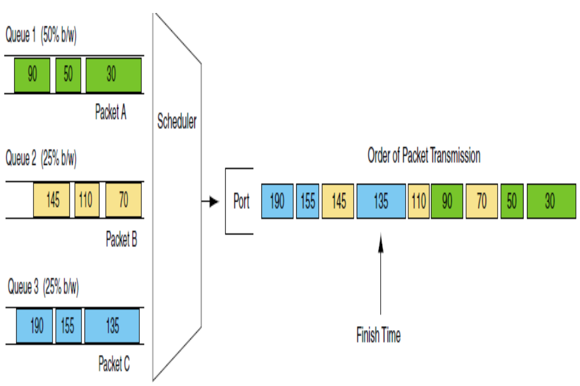

Figure 2: Weighted Fair Queue (WFQ) Scheduling

5. Simulation:

The simulation is performed using QualNet 6.1. A QualNet is a commercial network simulation tool implemented in C++ that simulates wireless and wired packet mode communication networks. QualNet used in the simulation of the MANET, WiMAX networks, satellite networks, wireless sensor networks etc. it has a graphical user interface and a sets of library function used for network communication.

5.1. Simulation model

The purpose of this simulation is to study the effect of number of queues and the height of antenna within the base station of a WiMAX network in Weighted Fair Queue (WFQ) Scheduling.

The simulated WiMAX network consist one Base Station (BS) and 29 Subscriber stations (SSs) which are distributed around the BS as shown in below figure.

The simulation parameters that we use in our simulation are shown in below table.

Parameter	Value
Channel bandwidth	2.4 MHZ
Number of BS	1
Number of SS	29
Simulation time	10 minutes
Items to send	100
Item size	512 bytes
FFT size	2048
Antenna model	Omni directional
Speed(mobility)	10 mps
Mobility model	Random waypoint
Routing protocol IPV4	Bellman Ford
Service types	BE, nrtPS, rtPS, ertPS, UGS

To simulate the different QoS types a mapping with different precedence values are used as shown in below table.

QoS	Precedence value
BE	0
nrtPS	1,2,6
rtPS	3

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ertPS	4
UGS	5,7

Simulation scenario

Two main simulation scenarios are simulated to evaluate the effect of number of queues and height of antenna on the end-to-end delay, jitter and throughput in weight fair queue (WFQ) scheduling algorithm. The first scenario is carried on by changing the number of queues i.e 2, 3, 4, 5, 6. The second scenario is carried on by changing the height of antenna. 6 different values are used (1.5, 2, 2.5, 3, 5 heights).

Simulation Results

The results of first scenario are presented in figures from 3 to 6, while figures 7 to 9 show the result of the second scenario.

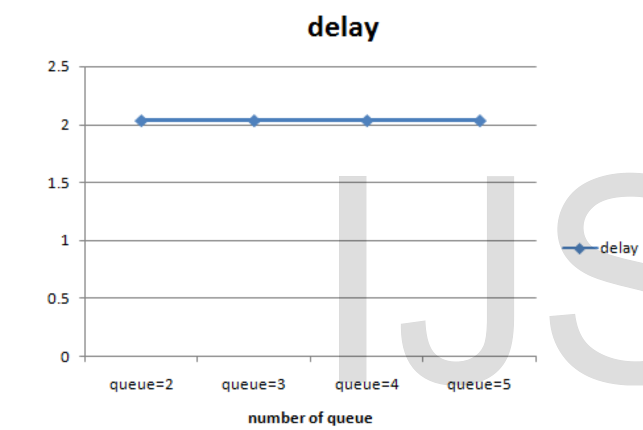

Figure 3: Delay (seconds) VS Number of queues

From the figure 3, it is clear that the delay remains same i.e 2.033419 even when the numbers of queues are different.

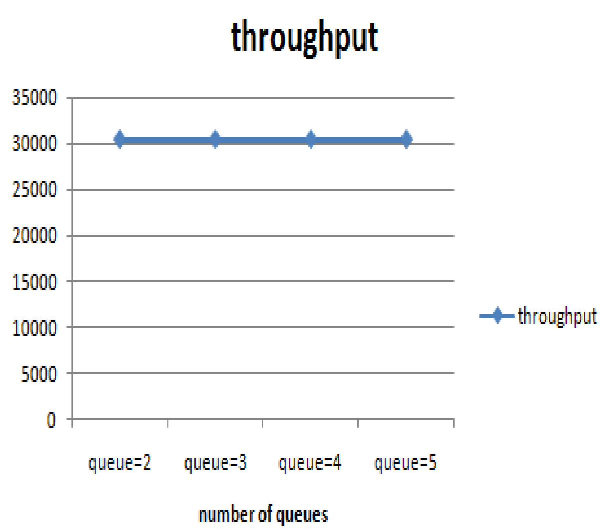

Figure 4: Throughput (bits /seconds) VS Number of queues

From the figure 4, it is clear that the throughput remains same i.e. 30417.64 even when the numbers of queues are changed.

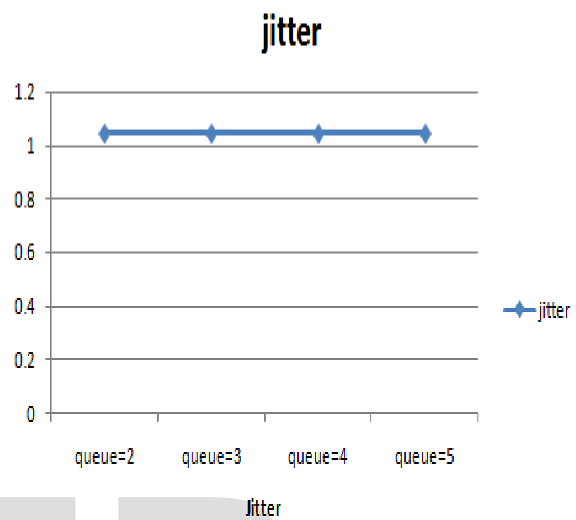

Figure 5: Jitter (seconds) VS Number of queues

Figure 5 shows that the jitter remains same i.e 1.043659 even when the numbers of queues are changed.

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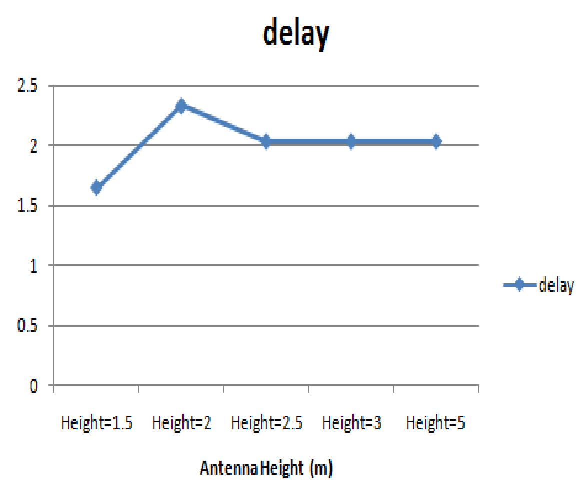

Figure 6: Delay (seconds) VS Antenna Height (m)

Figure 6 shows that the delay changes with the height of antenna. Initially when the height of antenna is 1.5 m, the delay is less i.e. 1.644664 in comparison with other heights. When the height of antenna is 2 m, delay increases to the 2.331096. When we increase height of antenna more than 2 m, it has same value of delay i.e 2.033419 (less than previous height's delay value) at 3, 4, 5, 10 meter.

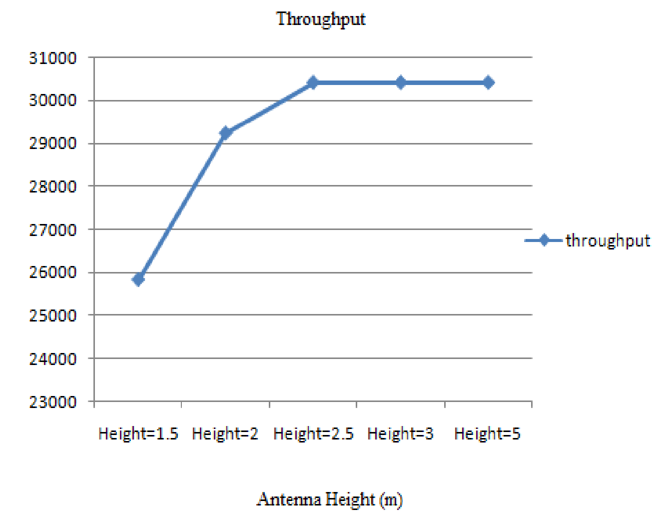

Figure 7: Throughput (bits/sec) VS Antenna Height (m)

Figure 7 shows that the throughput changes with the height of antenna to some extent. Initially when the height of antenna is 1.5 m, the throughput is less i.e. 25823.21 in comparison with other heights. When the height of antenna is 2 m, throughput increases to the 29230.96. When we increase height of antenna more than 2 m, it has same value and maximum value of throughput i.e. 30417.64 (greater than previous height's throughput value) at 3, 4, 5, 10 meter.

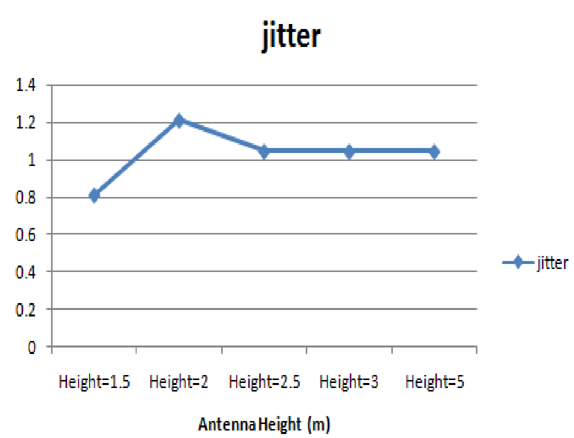

Figure 8: Jitter (seconds) VS Antenna Height (m)

Figure 8 shows that the jitter changes with the height of antenna to some extent. Initially when the height of antenna is 1.5 m, the jitter is less i.e. 0.809425 in comparison with other heights. When the height of antenna is 2 m, jitter increases to the 1.210347 which is greatest among all values of jitter. When we increase height of antenna more than 2 m, it has same value of
the jitter i.e. 1.043659 (less than previous height's jitter value) at 3, 4, 5, 10 meter.

Conclusion

The effect of antenna's height and number of output queue is studied. The five QoS classes are included in the simulation. The results showed that the output queue number does not affect the throughput, jitter and end-to-end delay in Weighted Fair Queue Scheduling. In second scenario, results showed that jitter, throughput and delay are affected with the antenna's height to some extent. After that value, throughput, delay and jitter remain constant at any height.

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