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PERFORMANCE ANALYSIS OF UNSOLICITED GRANT SERVICE (UGS) SERVICE CLASS IN WIMAX VOIP APPLICATION

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Abstract

Many researches deal with QoS (Quality of Service) and service classes in WiMAX but did not focus on the maximum sustained rate and minimum reserved rate. The value of this parameter directly affects the performance of the applications especially for VoIP application (Voice over Internet Protocol) and when the service class is UGS (Unsolicited Grant Service). The maximum sustained and minimum reserved value indicate the max and min bandwidth (in bps) for the service class used in the application; so, it should be chosen carefully. In this paper, three scenarios have been built in Opnet modeler to study the performance of the VoIP application by measuring the end to end delay, MOS (Mean Opinion Score) value, sent packets, received packets and throughput. The simulation results show that by decreasing the value of reserved bandwidth, the QoS parameters significantly enhanced in term of throughput and sent-received traffics but slightly enhanced in end to end delay and MOS.

Keywords: Maximum sustained value, Minimum reserved value, MOS, Throughput, UGS, VoIP QoS.

1. Introduction

In telecommunication networks, the need to a high data transfer rate leads to establish the most recent technology that support broadband wireless access network for wireless communications which is the IEEE802.16 WiMAX (Worldwide interoperability for microwave access technology). The infrastructure of the WiMAX communication system contains of two basic components: WiMAX base station and WiMAX receiver [1]. WiMAX based on standard the Institute of Electrical & Electronics Engineers 802.16 and it supports many multimedia applications such as VoIP, voice conference and online gaming ... etc. [2, 3]. The WiMAX technology is better comparing with 3G or wireless LAN networks (local-area network), it provides good connectivity using radio link with high data rates, its coverage area is large, has low deployment cost and ease to use [4, 5]. The throughput of WiMAX depends on the channel bandwidth used unlike 3G systems, which have a fixed channel bandwidth. WiMAX defines a selectable channel bandwidth which leads flexible deployment. Another advantage of WiMAX is its ability to efficiently support more symmetric links useful for fixed applications and support for flexible and dynamic adjustment of the downlink-to-uplink data rate ratios on the other hand, 3G systems typically have a fixed asymmetric data rate ratio between downlink and uplink [6].

Many authors studied the QoS and service classes from different points of view. In [7] a performance analyzation of the admission control of UGS, rtPS, and nrtPS has been done. It showed that the probability of blocking of a connection is higher for lower priority service classes, while delay of the UGS service class is much affected by the increase of the size of a contention window. In [8] analysed the performance of QoS for an IEEE 802.16 WiMAX. Different service flows have been investigated for various traffics types, results gave better choice of WiMAX's service classes investigated in the terms of various QoS related metrics. In [9] the authors investigated UGS scheduling service and proposed an efficient approach by applying various levels of MOS, they found the quality of experience provided to the users is enhanced in term of QoS parameters In [10] the authors Studied the UGS scheduling by introducing a new technique for UGS scheduling to meet an optimal QoS requirements through minimizing the delay jitter and burst overhead.

In this paper, three scenarios have been investigated, in the first one, the maximum sustained and minimum reserved (guaranteed bandwidth) for the UGS (Unsolicited Grant Service) WiMAX service class has been set to 384 kbps while in the second and third scenarios have been set to 1.5 Mbps and 5 Mbps respectively.

The rest of this paper is organized as follows. A short description of Quality of Service in WiMAX is given in section 2. In section 3, VoIP Application overview is presented. The proposed scenarios with simulation design and result analysis are described in section 4. Finally, section 5 concludes the paper.

2. Quality of Service in WiMAX Networks

Quality of service can be defined as the likelihood of getting a given traffic contract in a telecommunication network. In the networking field, it is the ability of network element (e.g., router, host or application) to get some assurance level that satisfy its traffic and service requirements. In the networks that enabled QoS, it must provide appropriate guarantees for various types of service and application while using the network resources efficiently [6].

In a particular network, like WiMAX, the level of performance could be measured using number of parameters including bandwidth, throughput, latency (packet or transmission delay), jitter, packets loss percentage, etc. [11]. The Bandwidth can be described as a fundamental parameter of QoS, and in WiMAX networks, it described by the link, in physical-layer, between a terminal client and a base-station and by the number of active terminals in the network. The data rate generated by an application is measured by the concept of throughput. Latency is the required time to transmit packet from source to destination which produced by physical layer chain granularity. The latency influenced by the queue of the packets, the different protocols of QoS and the charactering of the user implementation. Jitter is the slight difference of latency between different packets and it is constrained by the buffer of the end user, and because of this buffer usually small, the control will be on to the base station in the wireless networks to guaranteed that different priority that will be received by different packets if needed. packet loss (or corruption) can be caused by bit errors in an incorrect wireless network or when the networks suffering from congestion as a result of channel overload [12, 13]. A good QoS providing better throughput, latency, controlled jitter and improving the loss characteristics, taking in consideration that some of these parameters are required by interactive and real-time traffics [11].

2.1. The scheduling services or QoS classes in WiMAX

IEEE 802.16 standard provides five defined scheduling service types (also called QoS classes) for the different types of applications. These definitions facilitate the fact of sharing of the bandwidth between different users, and every user has a QoS class. According to this, the necessary bandwidth required for each application will be allocated by the base station that yields well planned allocation of the resources. Consequently, applications that classified as real-time applications will get priority in bandwidth allocation compared with email or FTP applications.

The five defined classes of QoS are: Unsolicited Grant Service (UGS), Real-Time Polling Service (Rt-PS), Non-real Time Polling Service (Nrt-PS), Best Effort (BE) and the fifth Extended Real-time Polling Service (Ert-PS) which added in 802.16e. These five QoS classes supplied by WiMAX via an architecture emphasize the process requests, access control and allocate the resources of radio frequencies to achieve the target through each service [14].

2.2. Unsolicited grant service (UGS)

The UGS is depicted to assist or designed to support fixed-size real-time data streams packets at a constant bit rate. T1/E1 emulation and VoIP without silence suppression can be considered as examples of applications that may use this service. The obligatory service parameters that define this service are: maximum-sustained traffic rate, maximum-latency, tolerated jitter and request/transmission policy [6, 15]. The scheduler for UGS needs to be designed to meet the four main QoS criteria for WiMAX. that’s are: optimize system throughput, the scheduler should guarantee the delay constraints, the scheduler should minimize delay jitter, and finally the scheduler should minimize number of bursts in order to reduce overheads that reduce system throughput [8].

3. VoIP Application

The broadly distributed technology, VoIP, is a voice communications and multimedia sessions delivered over internet protocol (IP). The infrastructure of the internet that already exist can used by the VoIP to make it efficient and have low cost. The problems that may face VoIP and affect its QoS implementation are latency, jitter and packet losses. The process of delivering the voice or multimedia sessions happen by fragment and defragment of the voice and isolate the jam signals then use the compression and decompression to compress the voice signals. The last process is to encapsulate the voice into packets and send them by way of IP to their destination addresses [16].

As known, the data in VoIP to be split to packets. The packetized data can arrive its destination by taking any route. Packets does not need to be reserved for whole duration of the call while its travel through a virtual circuit. Therefore, channels can be shared with other users and the utilization will be better than traditional analog circuit-switched public network [17].

3.1. VoIP Speech Quality Measurements

The user experience measurement during VoIP call is referred to Speech quality. The speech quality can be measured using subjective and objective measurements. The subjective test called Mean Opinion Score (MOS), which is a standard approved by the International Telecommunications Union Telecommunication (ITU-T), is listening test performed by the user by rating the speech quality during the call.

The MOS test can be accomplished by 12 to 24 participants, each of them listens several seconds to an audio stream and give a rating for the audio quality, the scale of rate will be 1 to 5 (as in Table 1). MOS test result will be the average score of the listeners gives, the rating between 4.5 and 5 refer to an excellent quality and a rating of 4 regard as reasonably acceptable [16, 18].

Table 1. MOS rating and classification.

Score	Listening Quality	Listening Effort Scale
5	E	No effort is required.
4	G	No considerable effort is required.
3	F	Moderate effort is required.
2	P	Considerable effort is required.
1	B	Not understood even with considerable effort

where: ‘E’ is Excellent, ‘G’ is Good, ‘F’ is Fair and ‘P’ is Poor and ‘B’ is Bad

4. Simulation Design and Result Analysis

To obtain accurate results, three WiMAX scenarios have been created in Opnet modeller 14.5. An investigation was studied to show the effect of the maximum sustained and minimum reserved values of the service classes on the VoIP application. Table 2 shows the main parameters of the WiMAX system used in the simulation.

The network topology that created in the simulation is shown in Fig. 1, twelve subscribers connected to the VoIP server through one base station. The subscribers that near from the base station have higher modulation and coding scheme while the far have lower modulation and coding scheme. This topology is used to study three different scenarios. In the first scenario, the maximum sustained and minimum reserved value was set to 384 kbps, while in the second scenario it was set to 1.5 Mbps and finally, in the third scenario was set to 5 Mbps.

Table 2. WiMAX parameters used in the simulation.

Parameter	Description
Application	IP Telephony
No. of subscriber station	12
No. of base station	1
Service class scheduling type	UGS
Max. sustained value and min. Reserved values	348 kbps, 1.5 Mbps, 5 Mbps
Channel Frequency (GHz)	5
Channel Bandwidth (MHz)	20
Multiple Access technique	OFDMA
Modulation and coding scheme	QPSK3/4, 16QAMK3/4,64QAM 3/4
Simulation Period	600 seconds

Fig. 1. Network scenario.

The Mean Opinion Score (MOS) value obtained from the simulation is shown in Fig. 2. This value is an indication for the quality of received audio after transition. It is noted that there is a slight difference between the values of MOS in the three scenarios.

The obtained WiMAX delay of our network is shown in Fig. 3. It is clear that the WiMAX delay in WiMAX system is little affected by the value of the maximum sustained and minimum reserved. The end to end delay for the Voice application from mouth to ear is shown in Fig. 4.

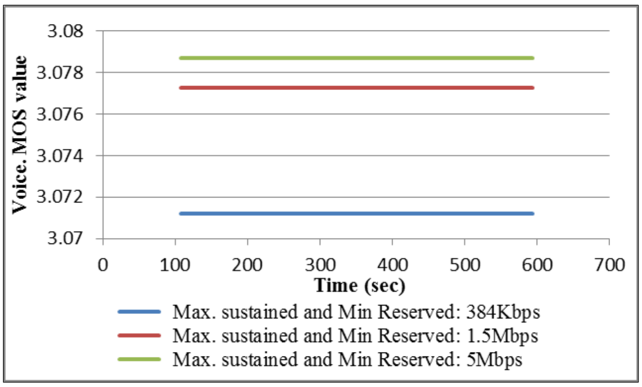

Fig. 2. Voice MOS value for different values of maximum sustained and minimum reserved bandwidth.

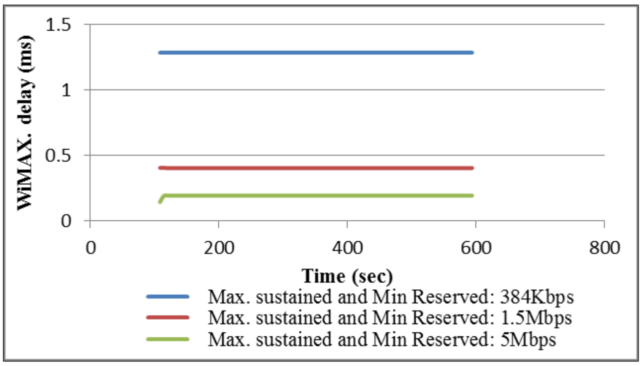

Fig. 3. Delay in WiMAX system for different values of maximum sustained and minimum reserved bandwidth.

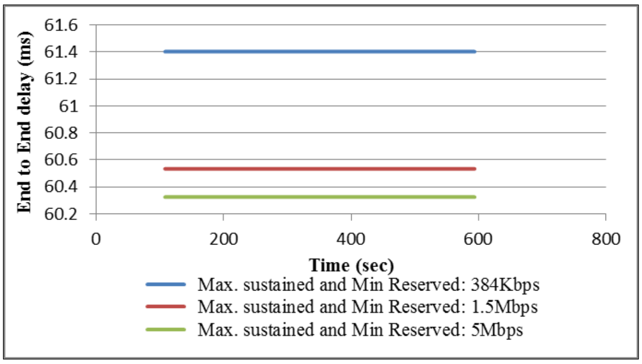

Fig. 4. Voice packet end to end delay for different values of maximum sustained and minimum reserved bandwidth.

Figures 5 to 7 show sent and received traffic (in Kbytes per second) for the traffic sent (forwarded to all voice applications by the transport layer of the network) and for the traffic received (submitted to the transport layers by all voice applications in the network) at different values of maximum sustained and minimum reserved 384 kbps, 1.5 Mbps and 5 Mbps respectively.

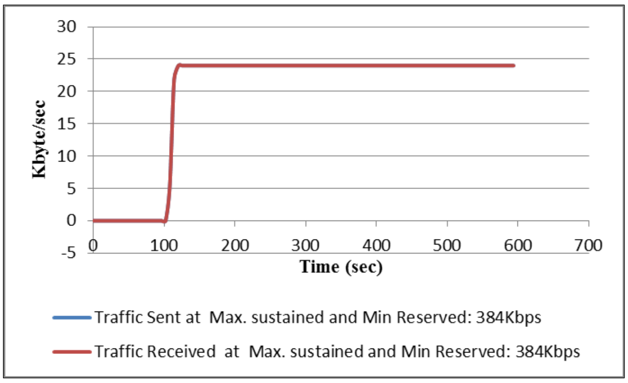

Fig. 5. Traffic sent and received at maximum sustained and minimum reserved bandwidth of 384 kbps.

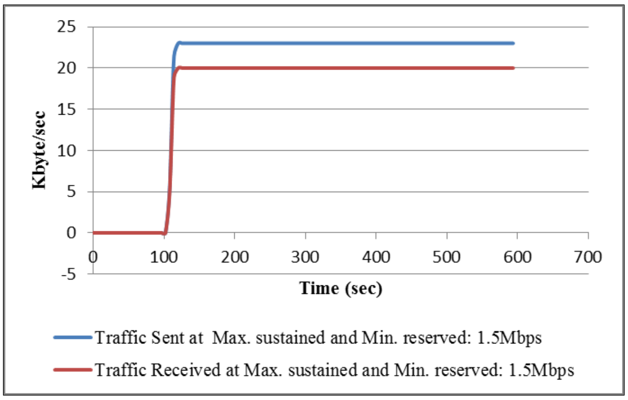

Fig. 6. Traffic sent and received (KB/sec) at maximum sustained and minimum reserved bandwidth of 1.5 Mbps.

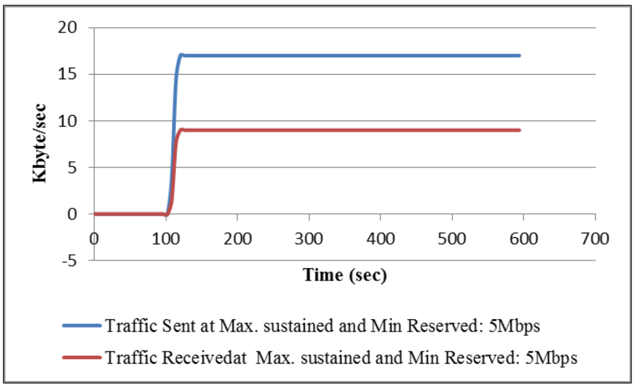

Fig. 7. Traffic sent and received (KB/sec) at maximum sustained and minimum reserved bandwidth of 5 Mbps.

On the other hand, the throughput (Mbps) that forwarded from WiMAX layers to higher layers in all WiMAX nodes of the network is shown Fig. 8.

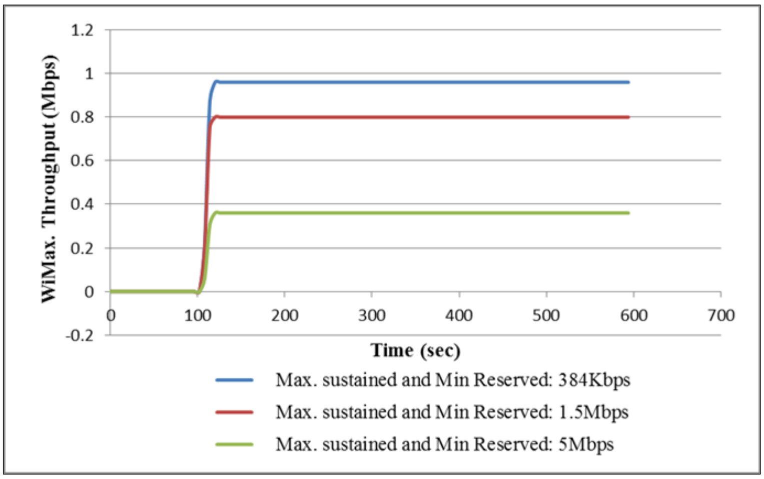

Fig. 8. WiMAX throughput for different values of maximum sustained and minimum reserved bandwidth.

Table 3 can show values which extracted from above figures for the purpose of comparison, those values belong to VoIP application statistics are for the three scenarios that simulated at 384 kbps, 1.5 Mbps and 5 Mbps.

Table 3. Comparison between the three scenarios.

	Maximum sustained and Minimum reserved in 384 kbps	Maximum sustained and Minimum reserved in 1.5 Mbps	Maximum sustained and Minimum reserved in 5 Mbps
Voice MOS value	3.071	3.077	3.078
WiMAX delay (ms)	1.28	0.404	0.194
End to End delay (ms)	61.4	60.53	60.32
Traffic sent (Kbyte/sec)	24	23	17
Traffic received (Kbyte/sec)	24	20	9
WiMAX Throughput (Mbps)	0.96	0.8	0.36

In the first scenario, all the packets that sent will be received, no connections rejected for any subscriber, the value of the traffic sent equal to the value of the traffic received as shown in Table 3. While, in the second scenario, not all packets that sent will be received, because some connections flows will be rejected as a result of the large value of guaranteed bandwidth that will forbid some of subscribers to get connection, the base station capacity will reach the maximum value. Finally, in last scenario, there is an increment in the number of sent packets that have not been received, that is a result of the increasing in the guaranteed bandwidth.

Tables 4 to 6 explain the BS admission control statistics for the three scenarios respectively. It's shoes that the number of rejected connections is equal to zero in the first scenario, while in the second scenario it is equal to four, and finally in third scenario it is equal to 15. That means, if the value of guaranteed bandwidth in service class has been selected as larger, then some connections may be rejected by the BS admission control as well as the send traffic, received traffic and WiMAX throughput will decreased significantly.

Table. 4. BS admission control statistics for scenario one.

Statistic	Value
Total Capacity (M Sample/s)	11.6544
Admitted Capacity (M Sample/s)	3.7728
Number of Admitted Connections	48
Number of Rejected Connections	0

Table. 5. BS admission control statistics for scenario two.

Statistic	Value
Total Capacity (M Sample/s)	11.6544
Admitted Capacity (M Sample/s)	11.2124
Number of Admitted Connections	44
Number of Rejected Connections	4

Table. 6. BS admission control statistics for scenario three.

Statistic	Value
Total Capacity (M Sample/s)	11.6544
Admitted Capacity (M Sample/s)	11.156
Number of Admitted Connections	33
Number of Rejected Connections	15

5. Conclusions

The performance of the VoIP application is measured through the parameters like throughput, sent and received traffic, end to end delay and MOS. The simulation results show that the values of throughput, sent and received traffic in the first scenario is better than that in second and third scenarios. When the reserved bandwidth has been set to 384 kbps (first scenafrio), the throughput value was 960 kbps, and this value decreased significantly when the reserved bandwidth value is increased as in second and third scenarios, i.e. the throughput value be 800 kbps and 360 kbps when the reserved bandwidth set to 1.5 Mbps and 5 Mbps respectively. That's because, in WiMAX, every base station has a total constant capacity, so in case of increasing the value of the reserved bandwidth to be greater than the application demand, the total capacity will be exhausted and that's will lead to increase the number of rejections for connections flow and that will decrease the throughput of the system as all. The end to end delay and the MOS values in the first scenario closed to that in second and third scenarios, the difference between the first and third scenarios was about 1.08 ms for end to end delay. Finally, as noted from Tables 4, 5 and 6, the admitted capacity increased with the increment of reserved bandwidth, it raised from 3.7728 Msps in first scenario to be 11.156 in third scenario, i.e. it became near the value of the total capacity of the base station and that's lead to increase the number of rejected connections from zero to 15.

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