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An Efficient Scheduling For Diverse QoS Requirements in IEEE 80.16

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ABSTRACT

Worldwide Interoperability for Microwave Access (WiMAX) supports multimedia applications. Then it is necessary to provide Quality of Service (QoS) guaranteed with different characteristics. Therefore, two parameters, the frame structure and effective scheduling are critical for the WiMAX system.
In this paper, we categorize and study various scheduling algorithms for the various traffics in mobile relay WiMAX in view of these objectives. The algorithms are studied under different frame structure, multi facet traffic and for various characteristics of the IEEE 802.16 such as uplink burst preamble, frame length, symbol rate, bandwidth request etc. Simulation results indicated that WRR algorithms with multi frame could not be suitable for the BE and nrtPS traffic in WiMAX as they do not explicitly incorporate the WiMAX QoS parameters.
KEYWORD: WiMAX, Scheduling, Quality of Service (QoS), Frame structure.

1. INTRODUCTION

Wireless broadband is a technology is a technology for providing high data rates in spacious area. This technology manages in two figurations: line of sight and none line of sight. In Line of sight, Base stations (BSs) and subscriber stations (SSs) have an obvious view of each other with average of up to 50 Km and gain data rate up to 100 Mbit/s [1]. In the other hand, in none line of sight, BSs and SSs do not have a clear view from each other with smaller rang for instance and lower data rate [2]. The core of WiMAX technology is specified by the IEEE 802.16 standard that provides specifications for the Medium Access Control (MAC) and Physical (PHY) layers [3].

In a cellular network such as WiMAX, traffic from the BS to the SSs is classified as downlink traffic while that from the SSs to the BS is classified as uplink traffic. A scheduling algorithm implemented at the BS has to deal with both uplink and downlink traffic [3]. In addition the design of a scheduling algorithm depends on the type of network it is intended for. Some of the desirable qualities a scheduling algorithm must possess and the issues that need to be addressed by the algorithms include [4, 5]:

Flexibility, Simplicity, Fairness, Power conservation on the mobile device and Link Utilization that means a scheduling algorithm is required to assign bandwidth to the users such that maximum link utilization is realized. Link utilization is a critical property for the service providers as it is directly linked to the revenue generated. A scheduling algorithm needs to ensure that resources are not allocated to users that do not have enough data to transmit, thus resulting in wastage of resources [6].

Five types of service flows with distinct QoS requirements [7]:

1. Unsolicited Grant Services (UGS): designed to support Constant Bit Rate (CBR) services like voice applications.
2. Real-Time Polling Services (rtPS): designed to support real-time services that generate variable size data packets on a periodic basis, such as MPEG video, but is sensitive to delay.
3. Extended Real-Time Polling Services (ertPS): support real-time applications with variable data rates, which require guaranteed data and delay, e.g. VoIP with silence suppression.
4. Non-Real-Time Polling Services (nrtPS): designed to support non-real-time and delay tolerant services that require variable size data grant burst types on a regular basis such as FTP.
5. Best Effort (BE): designed to support data streams that do not require any guarantee in QoS such as HTTP [8].

2. UPLINK SCHEDULING ALGORITHMS IN IEEE802.16

In this section, we provide detailed information of uplink scheduling algorithms in WiMAX. As part of the implementation details, we highlight any assumptions and implementation decisions made in the process.

2.1 Homogeneous Algorithms [3]

This category contains scheduling algorithms originally proposed for wired networks, but have also been widely adopted by cellular technologies such as GSM, UMTS and WiMAX [3]:

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1. Weighted Round Robin (WRR): It is a work-conserving algorithm in which it will continue allocating bandwidth to the SSs as long as they have backlogged packets. The WRR algorithm assigns weight to each SS and the bandwidth is then allocated according to the weights [8].
2. Earliest deadline first (EDF): In fact, it is a protective algorithm for network with spacious area. This algorithm refer to time for completing each packet and managing of bandwidth for SS in network which has the packet with earliest deadline. This algorithm is suitable for real time applications [8].
3. Weighted Fair Queuing (WFQ): In this algorithm, every queue has a special weight and priority is base on weight of queue. In WFQ pockets enter to queue with Poisson distribution and it is so suitable for real time services [8].
4. The First-in-First-out (FIFO) scheduling algorithm is known for its simplicity of serving packets with no priority considered. The FIFO algorithm [9] does not consider the QoS requirements of all packets in the network which makes it inappropriate for real-time applications [10].

2.2 Hybrid Algorithms

The two hybrid algorithms selected for evaluation use a different mechanism of overall bandwidth allocation [3]:
A) Hybrid (EDF+WFQ+FIFO)
The hybrid algorithm proposed in [11] uses strict priority mechanism for overall bandwidth allocation. The EDF scheduling algorithm is used for SSs of ertPS and rtPS classes, the WFQ algorithm is used for SSs of nrtPS class and FIFO is used for SSs of BE class. FIFO is used for BE class as SSs of this class do not have any QoS requirements.
B) Hybrid (EDF+WFQ)
The hybrid algorithm recommended in [12] propose a hybrid algorithm that uses the EDF scheduling algorithm for SSs of ertPS and rtPS classes and WFQ algorithm for SSs of nrtPS and BE classes.

3. WiMAX Multi-hop Relay

3.1 Mobile Multi-hop Relay WiMAX

Mobile Multi-hop Relay networks (MMRN) are the newest amendment of IEEE that the aim of it is increasing the coverage area. MMRN is like as a tree and relay stations (RS) transport massage between BSs and SSs. RSs in Mobile Multi-hop Relay WiMAX categorize in 2 parts: transparent relays that it shows in Figure1, and non-transparent relays inFigure2.

The main different between tRS and ntRS is transferring the information of frame header. In ntRS, the frame header convey from RSs to SSs or other RSs and RSs are not able to direct connection to BSs. However RSs which operate in transparent mode, does not have permission for sending header of frame. In addition, the main goal of utilize of these relay stations is expansion of capacity of cells [2].

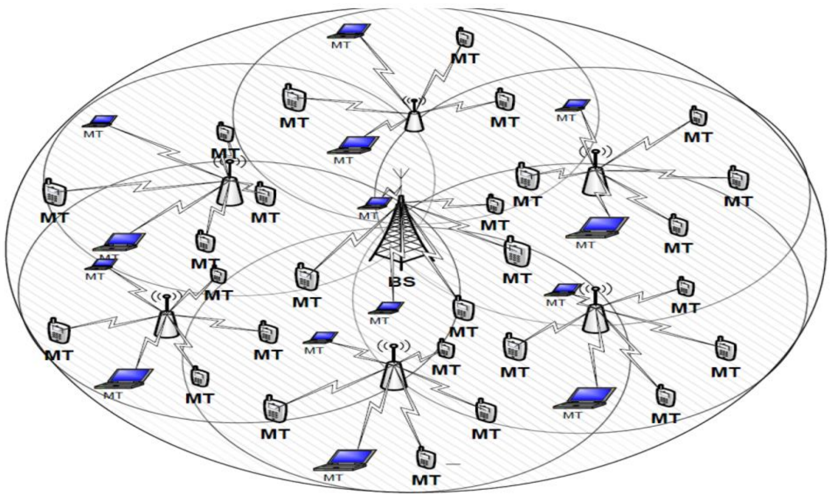

Figure 1- Transparent Relay Station (tRS) Configuration [2]

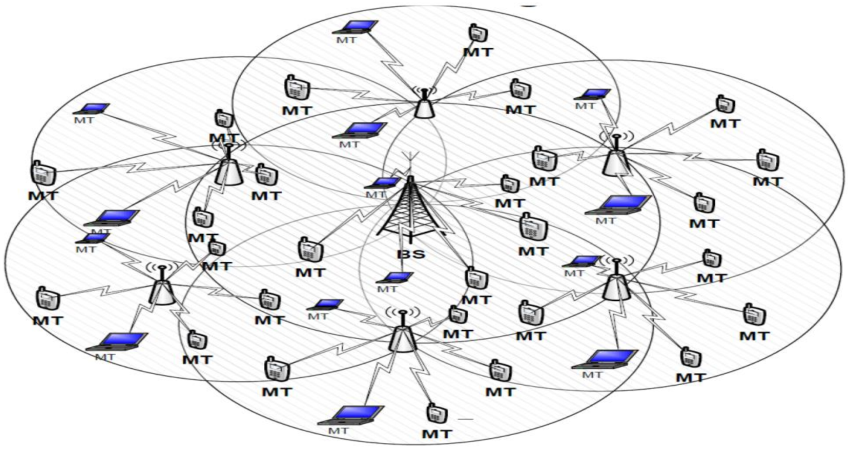

Figure 2- Non Transparent Relay Station (ntRS) Configuration [2]

3.2 Frame Structure

The performance of relay stations is dependent on design frame structure. In addition frame structure in MMRN is base on OFDMA modulation and it manages the channel allocation in frequency and time modes. Because of its flat all IP based architecture, application services that are utilizing WiMAX networks are not dependent on the underlying transport technologies. As such they all have different QoS requirements, such as packet error rate, jitter, data rate, system availability, and the like [13].

Frame structure in mobile multi-hop relay networks (MMRN) categorize to two parts: Single frame (SF) and Multi frame (MF). In single frame structure which is used for tRS, both header and body massage are sent in one frame. In the other hand, multi frame that is used for ntRS contains of many single frame [14].

4. SIMULATION MODEL

In this section we will go over several of the assumptions made in our simulations:

4.1. Channel Modes

Up to now, there are three radio propagation models in network simulator version 2 (NS2) that are shading model, two ray ground reflection model and free space model. In addition these models are used to predict the received signal power of each packet [15].

4.2 Traffic Model

In this paper, we have modeled types of services that provide the four QoS requirement: rtPS, ertPS, nrtPS and BE [16, 17]. Table 1 shows the QoS Parameters.

Table 1: QoS Parameters

Service Class	Data rate	Packet loss	Delay
ertPS	6Kbps–83KBps	< 2%	< 40ms
rtPS	7Kbps–495Kbps	< 4%	< 50ms
nrtPS/BE	0.01Mbps-100Mbps	0	Variable

3.3 Simulation Parameters

Table 2 lists parameters that are fixed throughout the simulation study whereas table 3 lists parameters whose values are varied in the experiments to study the performance of the scheduling algorithms.

Table 2: Fixed Simulation parameters

Parameter	Value
Simulation Grid Size	1500m x 2500m
Physical Layer	Wireless MAN-OFDMA
Simulation time	35 seconds
Uplink burst preamble	64 symbols
Allocation Start Time	ATDD split
Frame structure	TDD
System Bandwidth	20MHz
DL:UL frame ratio	1:1
OFDMA symbol duration	70.89 µs
Number of sub-channels for Uplink	50
Number of Frames per Second	100
Node placement	Random
Frame duration	4ms

Table 3: Variable Simulation parameters

Parameter	Value(Single frame)	Value(Multi frame)
Number of SSs	1-36	1-36
Number of Hop	1-2	1-2
Number of MT	1-60	1-60
Traffic Ratio (UGS:ertPS:rtPS:nrtPS:BE)	Variable	Variable
Frame Length	2.5ms, 4ms, 5ms, 8ms, 10ms, 12ms, 20ms	

5. SIMULATION RESULTS

In this section, we study the simulation of the uplink scheduling algorithms in one or two hop relay WiMAX network and with two frame structure under the context of IEEE 802.16j amendment. To analyze the performance of each uplink scheduling, number of hop and frame structure we have considered various network settings. More specifically, the effect of preamble symbols, frame length and bandwidth request mechanisms on the scheduling algorithms is studied.

The goal of this experiment is to study the performance of the scheduling algorithms under different mixes of traffic in varied frame structure. The traffic mix is supplied by the ertPS, rtPS, nrtPS and BE service classes – voice and video traffic, respectively. Each mobile terminal consists of one or more connection. Connections are set prior to each experiment and stay active throughout the simulation time.

We use 55 Kbps for traffic ertPS SSs for this simulation. The traffic arrival rate and throughput are calculated based on the number of hops available in the uplink single frame or multi frame. Each mobile station consists of one or more connection.

Figure 3 shows that when the hops of the ertPS class increases, single frame utilization yields higher on average throughput per hops. On the other side, the multi frame structure shows modified manner with increasing the hop. Such behavior is the result of scheduling algorithm for each frame structure. In terms of scheduling, in overall, when we use WRR, throughput for single frame and multi frame increase with raising the hops. In addition EDF in comparison with WFQ and WRR has a lower throughput. However MF-WFQ and SF-WRR in 5th hop cause the highest throughput. Figure 3 shows that SF-WFQ has the equable throughput in 3, 4 and 5hops but SF-EDF has a steady increasing in first to 5th hops. The WRR algorithm also indicates poor performance when hops are more than two.

In terms of rtPS traffic, when we see the figure 4, SF-EDF, MF-EDF, MF-WFQ and SF-WRR have the same throughput in per hops and they increase with raising the hops. But on the other hand MF-WRR has the soft growth in per hops. In general, as we see in figure 4, the average throughput of SSs of rtPS class increases with raising the hops. This is due to the total provisioning per class being constant and with more SSs, the load per SS decreases.

The nrtPS results in low average throughput of all the SSs (see figure 5). This behavior is due to the frame structure selecting only one SS in a frame. As the concentration of the hops of the nrtPS class increases, single frame utilization yields higher on average throughput per hop. On the other hand, when the multi-frame structure is utilized, we are able to achieve higher on average throughput when the ertPS to nrtPS class ratio is lower. Such manner is due to scheduling algorithms allocation for each frame structure. With smaller concentration of class 2 users in the network, SF(single frame) does not have enough symbols to allocate to each class 2 user; raising the queuing delays for each packets. MF (Multi frame) structure, on the other side, has adequate symbols to allocate to nrtPS users; enabling class 2 users to achieve higher rates. We also see that utilizing SF structure when the concentration nrtPS class increases, average throughput achieved by nrtPS class users increase as well. Although there are still packets in the network, on average there are enough symbols available per frame to satisfy more class 2 users; enabling them to achieve higher on average throughput.

Users utilizing BE class traffic show to experience on average somewhat worse throughput because of when the user utilize the single frame with EDF Scheduling and multi frame with WRR scheduling algorithm, we observe that the throughput become zero and we do not have any throughput in BE class. In addition for single frame with WRR algorithm just in first and second hops, users achieve throughput lower that 10 Kbps. Nevertheless, the difference is not critical to claim that single frame should be given preference over the multi frame structure in BE class (see figure 6).

In overall with comparing the figure 3 to 6 we observe that average throughput in 1, 2 and 4th hops are management below:

rtPS> ertPS> nrtPS> BE. However in the third hop, there is not a regular changing and we cannot clam anything. The algorithm results in a higher average throughput of rtPS SSs than SSs of other classes. Due to the narrow delay of rtPS SSs, they tend to get selected by the algorithm most of the time.

The WRR algorithm with multi frame structure (MF-WRR) indicates lower average throughput of SSs of the BE class compared to other legacy algorithms when the concentration of the SSs in the class is low. This is due to lower weight assigned to the SSs. The WFQ algorithm with multi frame structure (MF- WFQ) also assigns weights to the SSs, but since it allocates symbol rate according to the requirements, it results in higher average throughput.

The WRR algorithm also indicates low result when the packet size of the traffic is large like as single frame structure. This manner is suggested by the low average throughput of BE and rtPS traffic, even under high concentration of rtPS and BE.

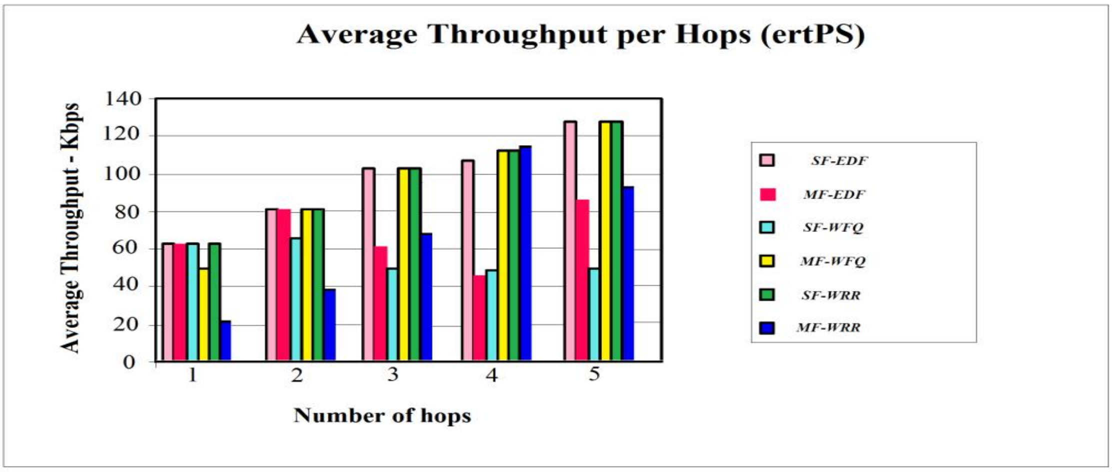

Figure 3- The effect of SS Ratio -Average Throughput - ertPS

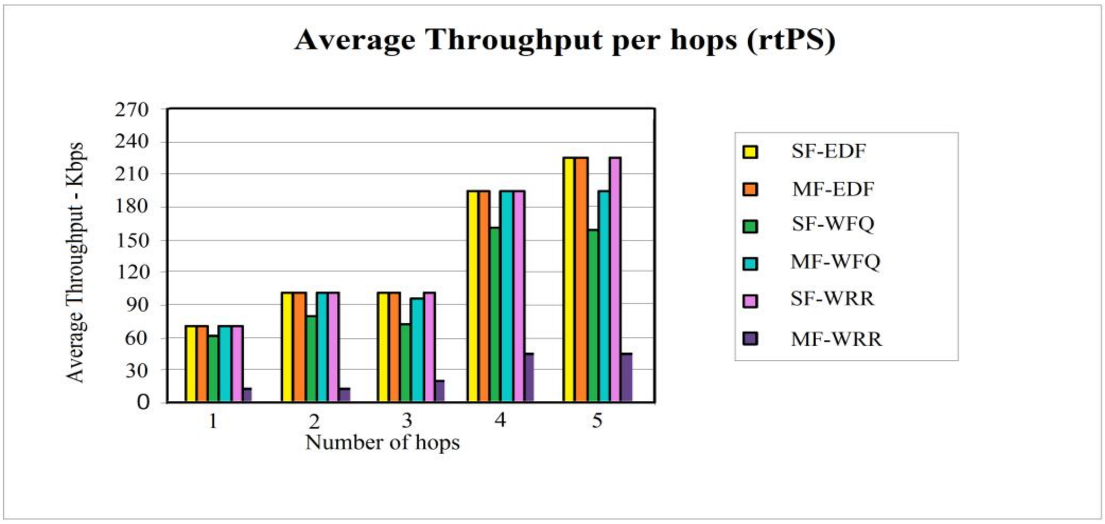

Figure 4- The effect of SS Ratio- Average Throughput – rtPS

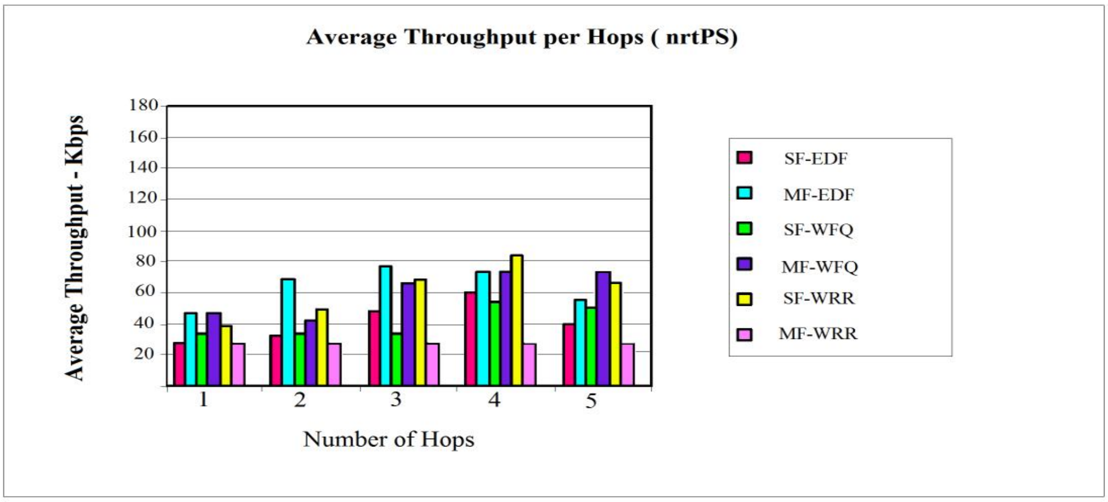

Figure 5- The effect of SS Ratio- Average Throughput – nrtPS

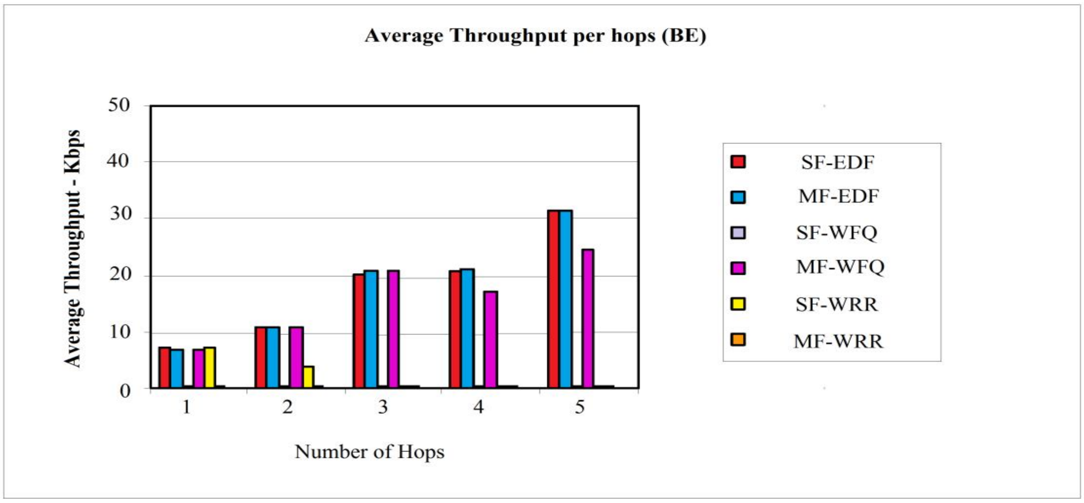

Figure 6- The effect of SS Ratio – Average Throughput – BE

6. CONCLUSION

In our experiments we compared the frame structure with different scheduling algorithm in many hops and we showed that choice of these factors under different network configurations with varied traffic can significantly impact on average performance of each user. In overall Multi frame structure achieves better average throughput when only one type of traffic is concerned however as the number of hops increases in a multi-hop environment a single type of traffic. Multi-frame, however, is able to support more users for the same network configuration.

Diverse traffic also plays a critical role in type of frame employment. Without considering the choose scheduling algorithm. It seems to single frame structure is better choice for networks with higher concentration in rtPS. On the other side multi frame is the best choice for network with higher concentration on nrtPS.

From our experiment, we can recognize that the single frame structure is capable to reach a suitable performance on average compared to the multi frame structure in same network, in terms of throughput utilizing only one type of traffic. The multi-frame structure however, is able to resist for more users.

Scheduling algorithms do not clearly consider all the required QoS parameters of the traffic classes in mobile relay WiMAX. The algorithms consider only some of the parameters which are not sufficient since the scheduling classes have diverse QoS parameters like as the rtPS class which requires throughput guarantee. The algorithms implicitly attempt to meet the QoS requirements such as the EDF algorithm fulfilling the throughput requirement of ertPS and rtPS SSs in three hops. On the other hand, the WRR algorithms have the higher delay, in the priority functions. Therefore, the WRR scheduling algorithms are not the most suitable for the BE, nrtPS and multi-class traffic in WiMAX for the requirements of the different traffic classes, Although, WFQ algorithms include all the QoS parameters in their functions.

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