Amendment of Energy Optimization & Modulations for IIoTs and Latest Generation of WiMAX Networks

Sachin M #1, Sindhu shree S #2, Srikantaraao S #3
1,2,3 Department of Computer Science
1,2,3 Amrita School of Arts and sciences
1,2,3 Amrita Vishwa Vidyapeetham University
1,2,3 Mysuru Campus, Karnataka, India
#1 sachinmallarappa95@gmail.com
#2 sindhu shree1606@gmail.com
#3 srikanta.bms@gmail.com

Abstract—Energy optimization and the effective modulations allow the users of the WiMAX devices to meet the QoS (Quality of Service) requirements. Therefore, it is important to minimize the usage of battery life of consumer equipment’s of the WiMAX. The trending IEEE 802.16e standard and IEEE 802.16s which is a narrow channel revision to 802.16 can become the reality for mobile users and IIoT (Industrial Internet of Things) which offers specific data flows by the connection identifiers (CID) which enables the QoS. It offers an amount of parameter propagations: Modulations and coding schemes. 802.16s a task group named GRIDMAN developed a project which leads to a publication on 13 October 2017. The energy conservation techniques are exists for WSN (Wireless Sensor Networks) such as, Adaptive link rate strategy for reducing the load, Switching off some of the non-working nodes in the network and power saving sleep modes for the nodes. All this mechanisms are analyzed and implemented to a typical latest generations WiMAX standard.

Acronyms & Keywords -WiMAX, QoS, Energy Optimization, Adaptive modulation, AEEMC, EEOT.

I. INTRODUCTION

In the latest years, attention on the ecofriendly solutions has drastically increasing. Since, the number of users to a network is increasing, these consumers are demanding for high data rates, at the same time consumption of energy of ICT has to be reduced.

The IEEE 802.16e is a mobile WiMAX (Wireless Interoperability for Microwave Access) had its adaption among mobile users mainly because of its mobility support. It supports communications over a large distances wireless and almost the combination of Wi-Fi (wireless Fidelity) and the cellular networks with high data rates and mobility. The architecture provides the specific data flows by the connection identifiers (CID) which enables the QoS. It offers the frames of three possibilities in PHYs: single carrier, and OFDMA (Orthogonal Frequency Division Multiple Access) and OFDM (Orthogonal Frequency Division Multiplexing), using FDD (Frequency Division Duplexing) or TDD (Time Division Duplexing). In a frame the bits of data which are sending to different users with unlike burst profiles include an amount of parameter propagations: Modulations and scheme of coding. A frame which is divided into DOWNLINK and the UPLINK frames associated in which the allocation of bandwidth is represented by UL-MAP and DL-MAP respectively as shown in fig 1.

This paper investigates the performance of WiMAX 802.16e standard that supports full range of highly intelligent antennas which includes STBC (Space-Time Block Coding) and to dynamically adapt to the modulations and coding schemes. 802.16s a task group named GRIDMAN developed a project which leads to a publication on 13 October 2017. The energy conservation techniques are exists for WSN (Wireless Sensor Networks) such as, Adaptive link rate strategy for reducing the load, Switching off some of the non-working nodes in the network and power saving sleep modes for the nodes. All this mechanisms are analyzed and implemented to a typical latest generations WiMAX standard.

II. MOTIVATION

The Willem Vereecken et al (2011) [1] concentrated on the consumption of power on the networks of telecommunications, overview and strategies for the reduction has been given by them. Designing of those technologies requires low power utilization, means offing the switch components wherever possible; loads reduction is done on the networks.

The Aymen Belghith et al (2016) [2] proposed a synchronized saving mechanism for power in the networks of WiMAX, features of IEEE 802.16 has given and the enhanced saving of power algorithm known SPSM.

The Claude Desset et al (2007) [3] introduced a method to put in order the downlink bursts in the frame OFDMA which is mentioned by 802.16e IEEE standard, because of this global consumption of power utilization is achieved for the
station of subscribers and to make best use of the duration of time through which recipient can sleep of time after the or turn off the relevant data which is received.

The D.Roselin Selvarani et al (2016) [4] implemented and approach called enhancement for security purpose of mobile WiMAX by safest message called MOB_TRF_MND. With the help of this method it is establish energy average utilization is done at the different stages of node is minimized by using this approach.

The tamer Z. Emara et al (2013) [5] given a VPSM approach to save the power for the services of VoIP over systems of WiMAX. This method can preserve additional power in the mutual period of silence. It has the ability to increase the utilization of bandwidth and to reduce the traffic of network. It also can reduce the power consumption efficiently at the Mobile Station (MS).

Authors called alaa M. Baker et al (2010) [6] discussed an energy optimization mechanism of energy in the system of mobile WiMAX at IEEE 802.16e, where the mode of sleep concept is introduced. The results says raise in the average/mean cycles of sleep per one mode of sleep operation while falling the average/ mean time for all cycles of sleep inside one mode of sleep operation.

Al Ameen N et al (2013) [7] projected an efficiency of energy in radio communication though a heterogeneous network of wireless. The method says that energy efficiency is done through the bandwidth joint and the allocation of power together with the mode of sleep which is investigated.

Raisa O.C. Hirafuji et al (2016) [8] anticipated the analysis of efficiency of energy of the mode of snooze watchful during the subsequent generation optical networks which are passive and the works says that without impair the requirements of QoS for the sensitive delay of applications.

Ali Sedighimanesh et al (2015) [9] given an improvised network of wireless sensor lifetime with the help of layering in routing it hierarchically. The method observed that increase in node size can increase the lifetime of network and from this it is inferred that increasing in the size of environment causes for the decrease in the lifetime of network and environment of heterogeneous in nature and it also leads to the lifetime environment increase.

An author Volker richter (2016) [10] projected an accurate shaping of traffic algorithms for the 2012-IEEE 802.16 which is based on the networks of WiMAX. The two type of algorithms is given one is ACC and another is APP, where ACC reserves the transmission of the packet which is not confirmed mean while APP provide an alternative for optimized memory.

P. Mangayarkarasi (2015) [11] gave a relay efficient scheme of selection by using degenerative and regenerative protocols for the 5g system of WiMAX. A relay selection is done by a combined technique with DF and AF protocols at the end of receiver which is analyzed by using throughput and FER and the results show the protocol DF outperforms to reduce FER about 0.005 which is compared with protocol AF with a FER about 0.007 of dB15 at SNR.

Manishankar, S et al (2016) [12] have analyzed and predicted the patterns purchase and a variety of constraints which are essential to mobile retail market using the algorithm Hybrid Market Segmentation (HMS) which is creature approved out the set of data which was gathered from a variety of groups of age. The outcome obtain support the planned method with a result improved which is compare with the algorithms which are existing used in the segmentation.

A. 802 16e Mobile WiMAX

WiMAX mobile users are limited in power supply for their devices as discussed in the introduction; WiMAX networks under the standard 802.16e can be reliably used by having a flexible PHY frame structure as shown in the fig 1, provides a frequent sub channelizing the frame structure and varying FFT (Fast Fourier transformation) with adaptive scheme of modulations and coding, dynamically adapting the energy conservation algorithms makes the CPE (Customer Premises Equipment) to consume low energy in a wireless communication.

\[ Ts = \frac{Nfft}{n \times B} \times (1 + Cp) \]  

(1)

An OFDM symbol (Ts) generation is computed in the above equation (1). Where Nfft gives the total number of subcarriers, n is the sampling factor, B is the bandwidth of the channel, Cp is the ratio of cyclic prefix time to the useful time.

Fig 1: A typical OFDM PHY frame structure

B. 802.16s for IIoTs

In 2015, the IEEE 802 Executive Committee approved a PAR (Project Authorization Request) to amend the existing worldwide IEEE 802.16 standard to respond to the wireless needs of the industrial internet. The technical
The purpose of the amendment was to design an air interface that would support channel sizes between 100 kHz and 2 MHz. This amendment allows for standards based interoperable IEEE 802.16 equipment in multiple nationwide licensed frequency bands including the Upper 700 MHz A Band, the 217 MHz and 219 MHz AMTS Bands, the 218 MHz IVDS bands, the 900 MHz NPCS bands and the legacy paging frequencies starting at 157 MHz, 454 MHz, 459 MHz and 931 MHz. Collectively, these frequencies represent up to 10 MHz of licensed spectrum that can be used for mission critical industrial networks. In the figure 2 the view of structural network of IIoT has been demonstrated. Unit sensing, unit processing, unit transmission, and unit of power are the major four components of nodes of sensors which are assigned with unlike jobs.

Where \( AVG_{sleep} \) gives us the window duration that calculates the shortcomings of \( T_{min} \) and \( T_{max} \) for the overall sleep cycle. Thus EEOOT optimize the mean delivery time when \( T_{sleep} \) window reaches the maximum value.

In addition we propose four sub-sleep modes because form the power consumption model it is found that in 50% of the overall power is consumed by the RF-front end (45%) and (7%) by the thermal sensors like TCXO (Temperature Compensated Crystal Oscillators). Since the time to wake up of RF-front end is very low, in order to efficiently reduce the power consumption these components should be completely shut down when the transmission is not happening. According to the power utilization different sleep mode are adapted, they are as follows:

- **Active mode**: Here the node is at its full operation and utilizes the 100% of the power; hence the wake up time is 0s.
- **Stand-by mode**: In this mode the node is at partial sleep and the wake up time is very less and RF and the TCXO heater are turned off; hence the wake up time is 0.5s and the 50% of the power is consumed.
- **Hibernation mode**: The nodes are placed into sleep of shallow and the wake up time is comparatively high about 10s and the power utilized is 15%.
- **Shut-down mode**: The nodes are completely shut down but still some amount of power is consumed to be back to active state, the time required for wake up is 30s.

In the above TABLE 1 we have compared our proposed power saving modes. We have considered random sleeping strategy for the MS nodes, in which each node operates at the probability given below in equation (3).

\[
P_{active} + P_{shb} + P_{hib} + P_{sd} = 1
\]  

Independent of all other nodes in the WiMAX network, \( P \) is probability of the proposed modes with the random generation of sleep cycles, the respected UL-MAP and DL-MAP is shown in the fig 3.
B. Adaptive energy efficient modulation for IIoTs

The executive committee of IEEE 802 has approved and amends the existing 802.16e to support channel size in between 100 kHz and 1.25 MHz for 802.16s. Full Spectrum announced their establishment of a network service for Industrial internet of things (IoT) based on 802.16s, scheduled to be finalized in the last year.

The IEEE 802.16s amendment is not final, but the current draft version appears to be rather stable. The draft was developed with input from the WiMAX Forum, the Electric Power Research Institute, Utilities Technology Council, and several utilities with specific use cases in mind.

Some parameters are modified for narrow-channel operation under 802.16s/Draft v2, but they are not user options:

- FFT size is 128 for all channel bandwidths below 1.25MHz.
- Band AMC permutation is used for all channel bandwidths below 125MHz.

- Band AMC 1x3, 1x6, and 2x3 are defined per bandwidth groups, as specified in the system profiles in 802.16s Draft v2

**Case A: High Throughput**

Choose 1 MHz channel, 25ms frame, 1:1 UL/DL ratio, CP=1/16, AMC 2x3

- 50ms ping latency
- 737 Kbps UL or DL throughput with 64 QAM
- 1.47 bps/Hz average cell spectral efficiency

**Case B: Low Latency**

Choose 1 MHz channel, 5ms frame, 1:1 UL/DL ratio, CP=1/16, AMC 2x3

- 10ms ping latency
- 461 Kbps UL or DL throughput with 64 QAM
- 0.9 bps/Hz average cell spectral efficiency

**Case C: Narrow channel**

Choose 100 KHz channel, 50ms Frame, 1:1 UL/DL ratio, CP=1/16, AMC 1x3

- 100ms ping latency
- 63.4 Kbps UL or DL throughput with 64 QAM
- 1.3 bps/Hz average cell spectral efficiency

These three examples show the performance results from optimizing parameters for specific objectives with frequency reuse 3 and SISO. Throughput values are at the MAC layer and do not incorporate any compression.

V. EXPERIMENTS AND RESULTS

A. Adaptive energy modulation

The below parameters are considered for implementing the AEEMC (Adaptive Energy Efficient Modulation and Coding) in MATLAB. In the table 2 the detailed parameters of simulation are planned is given below.

To maximize the battery life of WiMAX mobile stations we need to optimize the utilization of power, 802.16e IEEE

<table>
<thead>
<tr>
<th>Module</th>
<th>Parameters</th>
<th>Values</th>
</tr>
</thead>
<tbody>
<tr>
<td>Frame module</td>
<td>1. DL duration</td>
<td>5ms</td>
</tr>
<tr>
<td></td>
<td>2. UL duration</td>
<td>3ms</td>
</tr>
<tr>
<td></td>
<td>3. OFDM time</td>
<td>0.02ms</td>
</tr>
<tr>
<td></td>
<td>4. FCH</td>
<td></td>
</tr>
<tr>
<td></td>
<td>5. Preamble</td>
<td></td>
</tr>
<tr>
<td>Physical module</td>
<td>1. Bandwidth</td>
<td>5MHz for mobile</td>
</tr>
<tr>
<td></td>
<td>2. Sampling factor</td>
<td>&lt; 1.5 MHz</td>
</tr>
<tr>
<td></td>
<td>3. Cyclic preference Cp</td>
<td>1/4</td>
</tr>
<tr>
<td>Common power saving module</td>
<td>1. Tmin</td>
<td>1,2,4,6,8</td>
</tr>
<tr>
<td></td>
<td>2. Tmax</td>
<td>64</td>
</tr>
<tr>
<td>Proposed energy saving module</td>
<td>1. AVG</td>
<td>(Tmax+Tmin)/2</td>
</tr>
<tr>
<td></td>
<td>2. AVGmax</td>
<td>2* AVG</td>
</tr>
<tr>
<td>Message request of sleep mode and Awake mode</td>
<td>1. M-req</td>
<td>0.2ms</td>
</tr>
<tr>
<td></td>
<td>2. M-res</td>
<td></td>
</tr>
</tbody>
</table>

Introduced the simple mode of sleep mechanisms, we propose an enhanced technique by considering the above listed parameters for the BS. Form the graph and the results we can depict the power usage of each and every nodes. And the energy reduced for the efficient utilization of it limited supply of the power. The comparison of all the energy saving modes at it different modulation techniques is shown productively in the figure 4.
B. Energy parameters

The MS or SS (Subscriber Station) consists the radio module in addition we calculate the time requirements for each activity like, sending packets, awake mode, receiving packets, and energy consumed for each one of them are listed in the below table IV.

<table>
<thead>
<tr>
<th>Parameters</th>
<th>Values</th>
</tr>
</thead>
<tbody>
<tr>
<td>$S_e$</td>
<td>20 joules</td>
</tr>
<tr>
<td>$W_e$</td>
<td>7 joules</td>
</tr>
<tr>
<td>$R_t$</td>
<td>5ms</td>
</tr>
<tr>
<td>$U_e$</td>
<td>0.05 joules</td>
</tr>
<tr>
<td>$A_t$</td>
<td>0.5 joules</td>
</tr>
<tr>
<td>$T_r$</td>
<td>0.5 joules</td>
</tr>
<tr>
<td>$T_e$</td>
<td>0.5 joules</td>
</tr>
<tr>
<td>$R_e$</td>
<td>15 joules</td>
</tr>
</tbody>
</table>

$S_e$ = Energy utilized in favor of sending packets.  
$W_e$ = Energy utilized in mode of awake.  
$R_t$ = Taken time to receive a packets.  
$U_e$ = Utilized energy while node is non-active.

$A_t$ = Time taken while node availability.  
$T_r$ = Time required to receive M-req and M-res.  
$T_e$ = Energy utilized to receive M-req and M-res.  
$R_e$ = Energy utilized for receiving a packet.

In the simulation consists the module of energy, which is the majority intense component of the display place, it draw existing more or less up and about to 20mA. The exact and the healthy process are wanted since the point view of the radio and the regulator voltage which provide firmness of voltage of 1.7 to 1.9 V and it is used by the demanding radio unit, that is translated to extremely stable power utilization even though the difference of the batteries voltage as the reduce which is shown in the figure 5.

A parameters worn for the test which consists of 2 links, one link to a receiving PC the information which is available from the next one, which are configured with the examined operations every time and motorized both by a batteries or power supply generator. Every one of the operations comprises CPU on LPM0 condition and also the use of converter AD channel for the measurement of voltage battery, which helps to raise the present strained by approximately 2.3 mA on 3V. The lifetimes of battery which can be anticipated by incorporate the DCx coefficient, which represent the proportion time, everyplace x is the current demand and it is enabled.
In the figure 6 we show the average power consumption of the node within the time of its activity. In the below figure 7 graph predicts the energy and the time utilization of the existing system with excluding the additional parameters.

In figure 8, the graph shows the optimized energy consumptions with the added parameters of Enhance energy optimizing technique for the radio or MS. We have generated a random number of nodes according to the modulations and adaptive coding technique, We simulate the result by using some of the energy utilized and time consumed constrains by the components of the typical WiMAX mobility modeled network. The CPE or MS of the respected network can be efficiently utilized by the users by manual techniques like, reduced polling, disabling or changing the connectivity setting and using power saving modes in the node.

VI. CONCLUSION

A supposition for the Adaptive Energy Efficient Modulation and Coding technique and enhanced energy optimizing techniques using sleep modes, this paper has the simulated results. The reality is exposed only when the methodology is applied into the real world. The experiment results show that the optimization techniques are must to reduce the battery usage and enhancing the life time of the nodes connected to the WiMAX network, in order to maintain an eco-friendly radio communication. In future energy saving algorithms can be enhanced by developing intelligent algorithms and deep machine learning techniques.

REFERENCES
