QUALITATIVE ANALYSIS OF THE QOS PARAMETERS AT THE LAYER 1 AND 2 OF MOBILE WIMAX 802.16E

Arathi.R.Shankar [1] Adarsh Pattar[2] and V.Sambasiva Rao[3]

[1]Department of Electronics &Communication BMS College of Engineering, B'lore
arathi.rshekhar@gmail.com

[2] BMS College of Engineering, B'lore, India
techie04@gmail.com

[3] Department of Electroncics, PESIT, B'lore, India
vsrao@pes.edu

ABSTRACT

IEEE 802.16/WiMAX is the network which is designed with quality of service in mind. In this paper the authors have made an attempt to qualitatively analyse the performance factors at the physical layer of mobile WiMAX for Rayleigh and Rician channels using different modulation techniques. The comparison of quality of service parameters like BER and power spectral density between different channels in WiMAX physical layer is made. Orthogonal frequency division multiple access technique is adapted by WiMAX on its physical layer.. Scalable OFDM has been implemented for subcarriers ranging from 256 to 2048 and the performance factors have not changed. Quality of Service provisioning at the MAC layer is done by using Packet scheduling technique using RR & Fairness queue algorithms for rtPS & nrtPS service flows. Comparison of different scheduling schemes are made that ensure QoS with respect to delay, under the context of different service flows as defined in the WiMAX standard.

KEYWORDS

QoS,, OFDMA, Physical Layer, MAC, Scheduling, Round Robin and Fairness Queue

1. INTRODUCTION

Quality of service includes 6 primary components: Support, Operability, Accessibility, Retain ability, Integrity and Security. The IEEE 802.16 standard includes the QoS mechanism in the Physical (PHY) layer (layer 1) architecture and also the MAC layer (layer2).

This work focuses on the analysis of QoS in WiMAX networks. The details of the network's PHY layer QoS implementation are presented.

WiMAX IEEE Standard 802.16 also known as Air Interface for Fixed Broadband Wireless Access Systems operates in the 10 -66 Ghz frequency band and its extension 802.16a allows the usage of lower frequencies (2 -11 G Hz) many of which are unregulated, Additional standards 802.16a to 802.16e offers Quality of service, interoperability, to develop access points and support for mobile as well as fixed broadband. WiMAX can provide two flavours of wireless services, depending on the frequency range of operation, ie;LOS and NLOS operations .The standard operating between 10 – 66GHz requires LOS operations, while lower frequency bands 2-11GHz enable NLOS operations. The standard defines three different air interfaces that can be used to provide a reliable end-to-end link [3][4].

DOI : 10.5121/ijwmn.2012.4205

• SCa: A single-carrier modulated air interface.

• OFDM: Orthogonal-frequency division multiplexing (OFDM) with 256 carriers.

Multiple access of different SSs is time-division multiple access (TDMA)-based.

• OFDMA: A 2048-carrier OFDM scheme.

Mobile WiMAX is a rapidly growing broadband wireless access technology based on IEEE 802.16-2004 and IEEE 802.16e-2005 air-interface standards[7][8]. The WiMAX forum has provided mobile WiMAX system profiles that define the features of the IEEE standard .Mobile WiMAX . The technology is heading towards the 4G networks..

The features of mobile WiMAX

1. OFDMA: In non-line-of-sight (NLOS) environments to improve the multipath performance, the mobile WiMAX air interface uses Orthogonal Frequency Division Multiple Access (OFDMA) as the radio access method.
2. High data rates: High downlink and uplink high data rates can be achieved by the use of multiple-input multiple-output (MIMO) antenna techniques along with flexible sub channelization schemes, and different adaptive modulation and coding schemes are used.
3. Quality of Service: QoS is the fundamental criteria of the IEEE 802.16 medium access control (MAC) layer. Service flows of the MAC Layer can be mapped to the corresponding service flows of the IP layer to achieve end to end QoS.
4. Scalability: Scalable OFDMA (S-OFDMA) feature of Mobile WiMAX , enable it o operate in scalable bandwidths from 1.25 to 20 MHz to adapt for various spectrum allocations worldwide.
5. Security: The security aspects of Mobile WiMAX are well taken care off by EAP, AES, CMAC HMAC protection schemes.
6. Mobility: To support real-time applications such as Voice over Internet Protocol (VoIP) the mobile WiMAX uses optimized handover schemes with latencies less than 50 ms . [13][9].

The paper is categorised as follows – in Section-2 we present the proposed algorithm . Section-3 Simulation details and results.

The paper is concluded in section 4.

1.1 RELATED WORK:

The simulation model which has been used here is different from the related work done [17]. In the current work scheduling is performed on the mobile WiMAX compared to the fixed WiMAX used in [17].The packet loss and the delay violation rate is reduced . Scalable OFDMA, is implemented so that the carrier is divided into multiple sub carriers depending upon the application using different size of FFT's varying from 256 to 2048 .

2. PROPOSED SCHEDULING ALGORITHM

In this work, based on the per connection requests from SSs the uplink bandwidth is allocated to the BS . The bandwidth request messages should report the bandwidth requirement of each connection in SS because of multiple connections that can prevail in each SS[17]. The bandwidth allocated per connection is distributed to each SS. The SS in turn ,allocates the resource from its BS to the various connections according to their QoS specifications. Hence an additional scheduler will be required in each SS.After that the allocated bandwidth per connection is pooled together and granted to each SS.

.

1.Scheduling algorithm for UGS queues**:**

UGS service gets the highest prority because it generates fixed size data packets on a periodic basis and this service has a critical delay and delay jitter requirement. So, the UGS queues are given highest pririty by the SS scheduler.

2.Scheduling algorithm for rtPS queues:

The end-to-end delay of rtPS service is reduced to a significant amount because, each packet entering the rtPS queues should be assigned with a delivery deadline equal to t + tolerated delay, where t is the arrival time and tolerated delay is the Maximum Latency for such a service flow. The packet transmitted first will be the one with the least time deadline.

3.Scheduling algorithm for nrtPS and BE queues **:**

Deficit Fair Priority Queue (DFPQ) algorithm is used for nrtPS and BE services [17]. The algorithm is is suitable for datagram networkswith variable packet sizes.

ii. Since this algorithm requires prerequisite knowledge of packet size, it is used for the uplink traffic at SS scheduler.

iii. The algorithm is flexible and the scheduler can provide minimum bandwidth for every non real time services such as nrtPS and BE connection. Hence an acceptable throughput is maintained.

In every service round, the nrtPS queue is given higher pririty than the BE.In the algorithm, Q is assigned to each queue i. Queue i (Q[i]) represent the maximum number of bits that can be serviced in the first round. The scheduler visits every nonempty queue and analysis the number of bandwidth requests in the queue. If there are excess packets in the I th queue, after servicing the excess bits are stored in a queue state variable called Deficit Counter (DC[i]) and the scheduler serves the next non-empty queue. The bandwidth used by this flow is the sum of the value of DC[i] in the eprevious round added to Q[i]. Every flow has the Q[i] ie the Maximum Sustained traffic rate (rmax). Here connections with larger quantum get more service. The simulation model which has been used here is different from the related work done [17]. In the current work scheduling is performed on the mobile WiMAX compared to the fixed WiMAX used in [17].The packet loss and the delay violation rate is reduced . Scalable OFDMA, is implemented so that the carrier is divided into multiple sub carriers depending upon the application using different size of FFT's varying from 256 to 2048

3. SIMULATION AND ANALYSIS

3.1 PHYSICAL LAYER SIMULATION

An attempt was made to write an event driven simulation in MATLAB (7.10).Mersenne Twister - Random Number Generator (RNG) Algorithm is used. Mersenne twister generator generates a random number using a pseudorandom algorithm. It has a large linear feedback shift register. In order to generate a random number, this algorithm is used in rand function in MATLAB. Noise is Gaussian and Rayleigh fading is considered. Cyclic prefix is used. Plotting of BER Vs SNR is made to evaluate the performance. Confidence intervals used for 32times. Adaptive modulation techniques are employed here.

The adaptive modulation techniques that WiMAX uses are BPSK, QPSK, 16-QAM and 64-QAM. All modulation techniques are implemented in order to get the results on different models.

Based on these modulation techniques the following parameters were investigated.

- Bit Error Rate (BER)
- Signal to Noise Ratio (SNR)
- Power Spectral Density (PSD)
- Probability of Error (Pe)

OFDM WITH ADAPTIVE MODULATION TECHNIQUES IN PURE AWGN FOR RAYLEIGH & RICIAN CHANNEL

The initial results were observed in the pure AWGN channel condition using adaptive modulation techniques and the performance of these techniques were compared while using the 256 multicarrier OFDM waves.

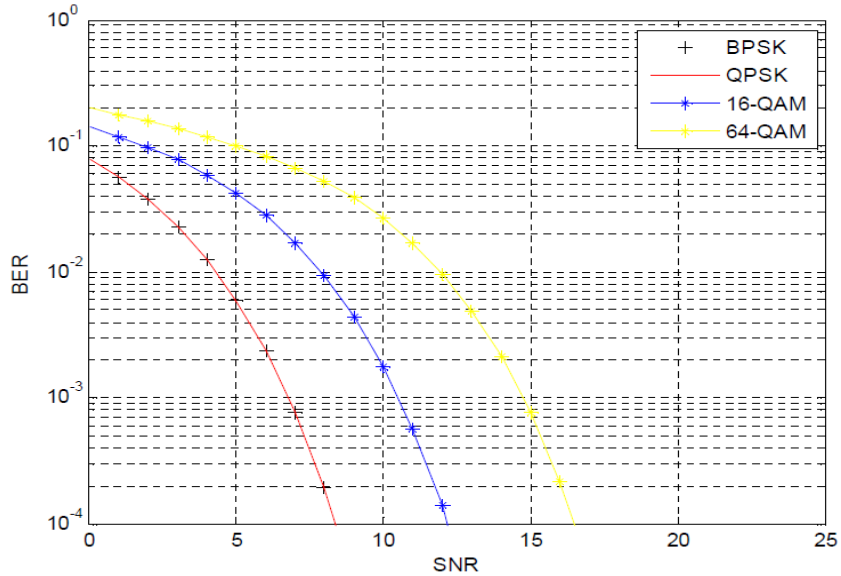

Fig 1. Adaptive Modulation Techniques in PURE AWGN for Rayleigh channel.

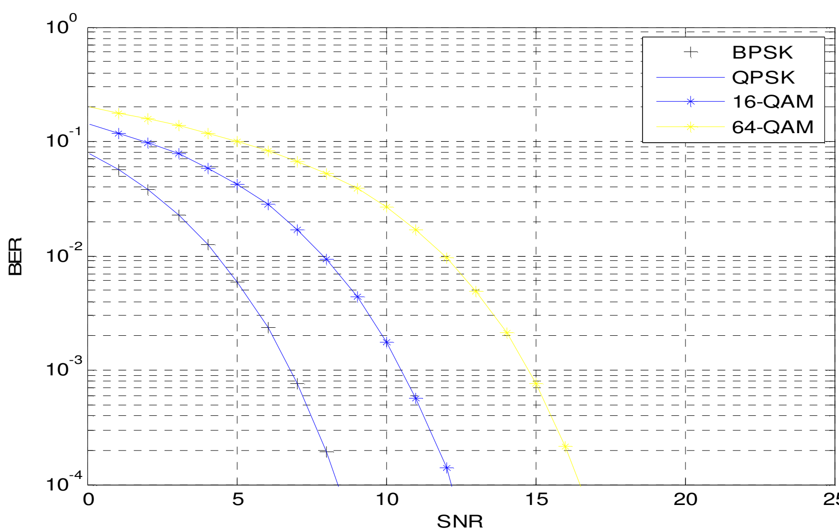

Fig 2 .OFDM with Adaptive Modulation Technique in PURE AWGN

WHEN BER = 10-3

Table 1 Adaptive Modulation In Pure AWGN , SNR and Bits/Symbol Comparison

Fading Channel	Modulation	SNR	Bits/Symbol
Rayleigh channel	BPSK	7	1
	QPSK	7	2
	16QAM	10.6	4
	64QAM	14.8	6
Rician channel	BPSK	7.4	1
	QPSK	7.4	2
	16QAM	10.8	4
	64QAM	15.0	6

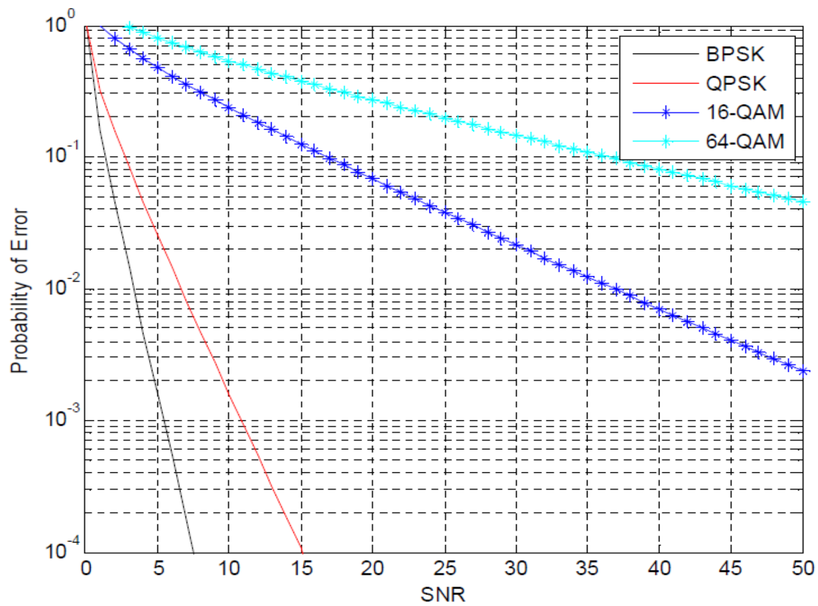

Fig .3 Probability of Error (Pe) for Adaptive Modulation
For Rician channel

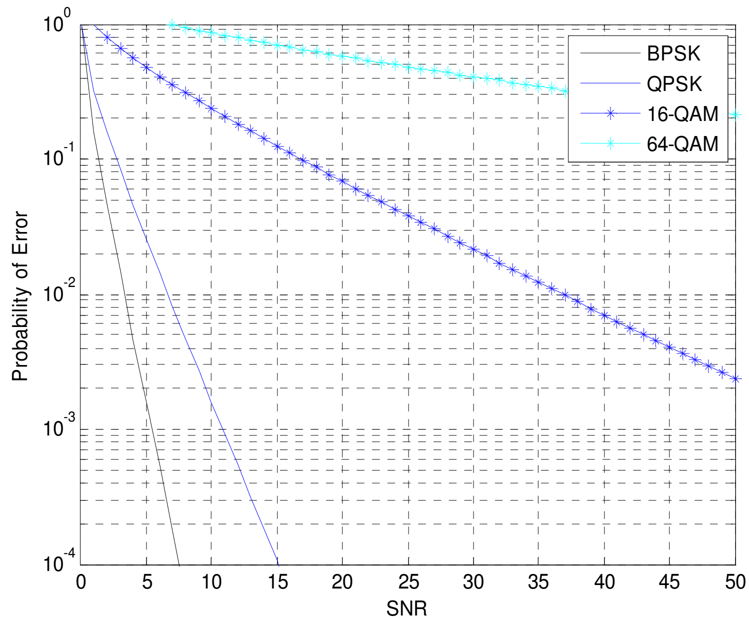

Fig 4 Probability of Error (Pe) for Adaptive Modulation
for Rayleigh channel

Due to noise and fading effects in the channel with some hardware losses at the transmitter and the receiver ends , error will be introduced in the system .

When BER = 10^{-1}

Table 2 Probability of Error (Pe) for Adaptive Modulation
Comparison SNR and Bits/Symbol

Fading Channel	**Modulation**	**SNR**	**Bits/Symbol**
Rayleigh channel	BPSK	2	1
	QPSK	3	2
	16QAM	16.7	4
	64QAM	36.5	6
Rician channel	BPSK	2.2	1
	QPSK	3.4	2
	16QAM	17	4
	64QAM	60	6

EFFECT OF SNR ON OFDM SYSTEM WITH RESPECT TO POWER SPECTRAL DENSITY FOR RAYLEIGH & RICIAN CHANNEL

In OFDM system the input and output signals power spectral densities differences are solely dependent on the channel conditions and the SNR levels. If the SNR level is high then the difference of the input signal with the output signal almost intermingle each others while it increases by reducing the SNR levels.

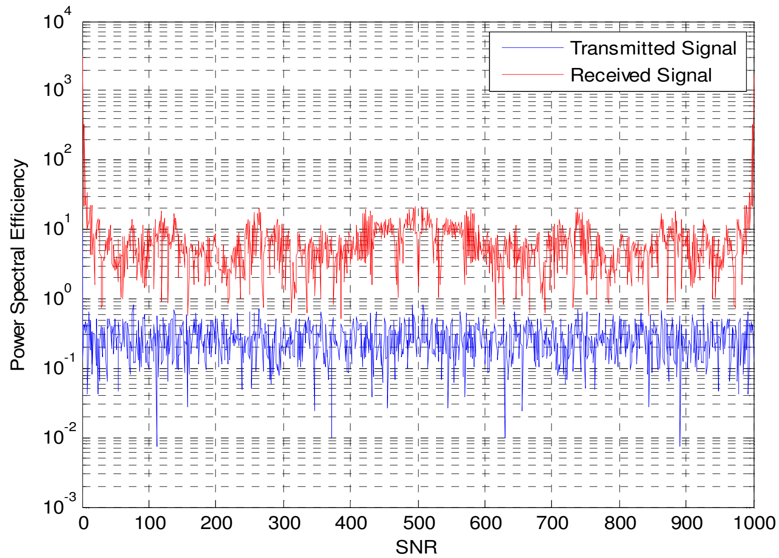

Fig. 5 Effect of SNR level 100 on OFDM system
With respect to power spectral density

SCALABLE OFDM

The scalable OFDM is implemented for the subcarriers by varying the FFT size from 128 ,256, 512 up to 2048. The simulation was performed on all 3 types of channels i.e. AWGN,Rayleigh and Rician channels. The performance of the channel is analysed w.r.t probability of error, BER and power spectral efficiency and the simulation results show the same performance as the number of carriers /FFT size is scaled up from 128 to 2048 Bit error

PROBABILITY CURVE FOR QAM USING OFDM

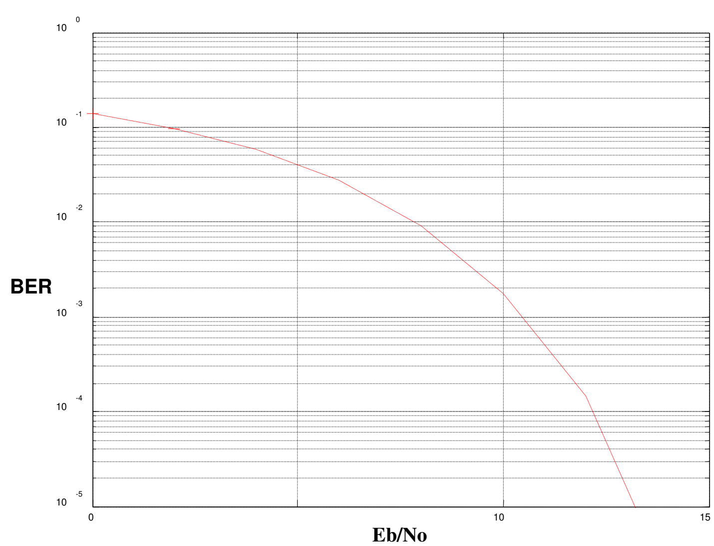

Fig .6 Scalable OFDM applied to 256 carriers through AWGN channel

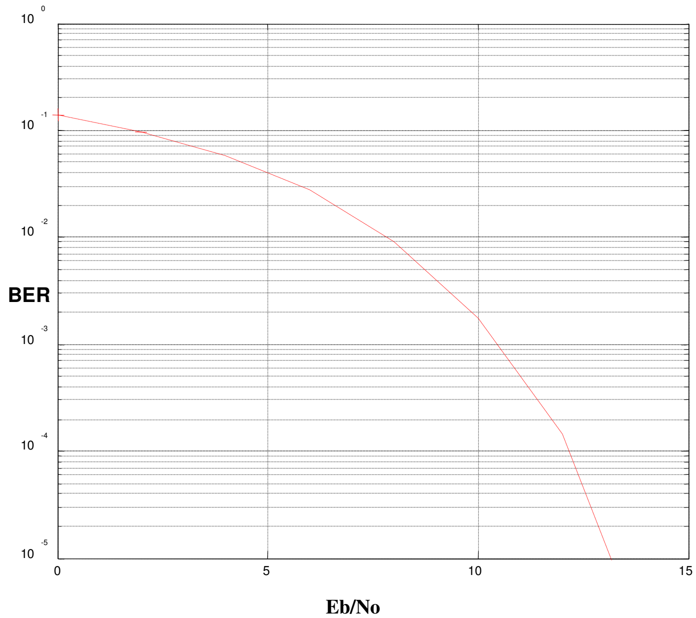

Fig .7 Scalable OFDM applied to 2048 carriers through AWGN channel

3.2 MAC LAYER SIMULATION ENVIRONMENT AND ANALYSIS

MATLAB under version 2009a is used to effectively use the proposed scheduler, at the IEEE 802.16 MAC layer protocol [19]. Simulations are conducted using a system which is of TDD – OFDM type and the MAC layer application parameters are indicated in table 3 The system is of TDD-OFDM type and the MAC layer application parameters are as shown in Table 3 and the network configuration is as shown in Figure 8 .The operating bandwidth is 4.3 M Hz and 10 ms is considered as the frame duration. Since the standard does not specify the values for the QoS parameters, we have assumed these values for the performance analysis

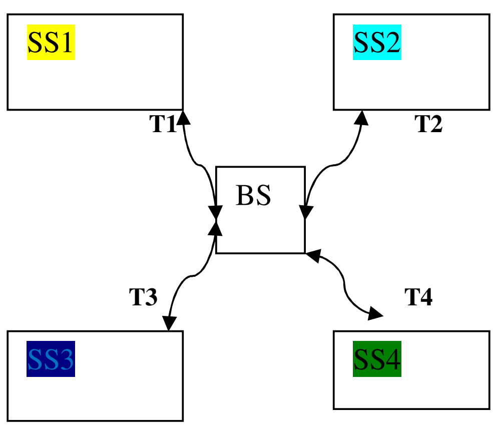

Figure 8. Proposed model architecture

T1:Traffic load1

T2:Traffic load2

T3:Traffic load3

T4:Traffic load4

Table 3. MAC layer configuration parameters

Service	Maximum sustain rate	Minimum Reserved rate	Delay In milisecs
UGS	256	-	-
RTPS	1024	512	20
NRTPS	1024	512	
BE	-	256	-

QoS parameters such as delay, delay violation rate are considered to validate our proposed scheduling scheme. The number of packets whose delay is larger than the ratio of Maximum Latency to the total amount of packets that have been received from network is called as Delat Violation Rate[13].

SIMULATION RESULT AND DISCUSSIONS

A 802.16 network is simulated with a single Base Station and 4 Subscriber stations.All the subscriber stations are assigned with 4 types of service flows like UGS, rtPS, nrtPS and BE, catering to different types of traffic flows. Simulation is performed with and without Scheduler and the effect of SS scheduler is studied.

Here, if the simulation is performed without scheduler, then Base Station assigns the bandwidth depending on the service flow , else if the case is with scheduler, then SS scheduler designates bandwidth to individual connection [17]. Here, UGS, rtPS, nrtPS and BE are the types of service classes that are considered. Since UGS generates fixed size data packets on a periodic basis and hence delay is negligible and throughput is constant ..

Figure. 9 shows the different services and their associated delays (with and without SS scheduler).

Low prority services suffer longer delay.

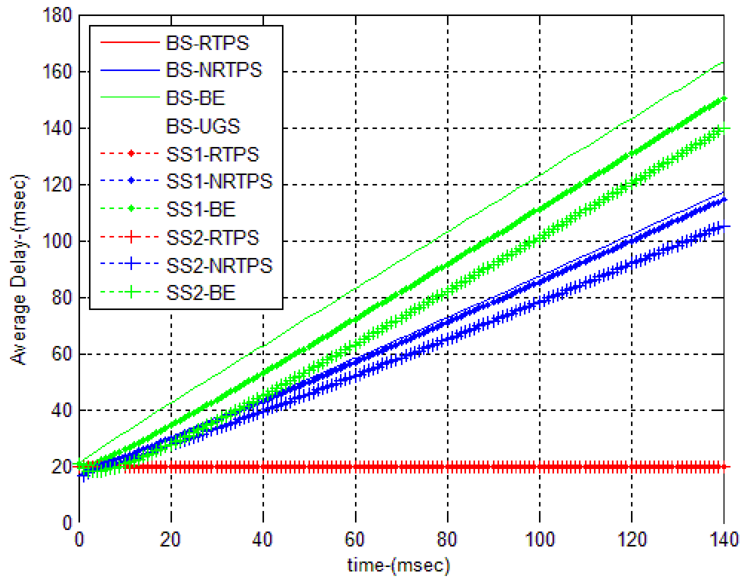

Figure .9 service delay comparison

The rtPS performance is analysed under the same number of background SS as given in Figure 10.

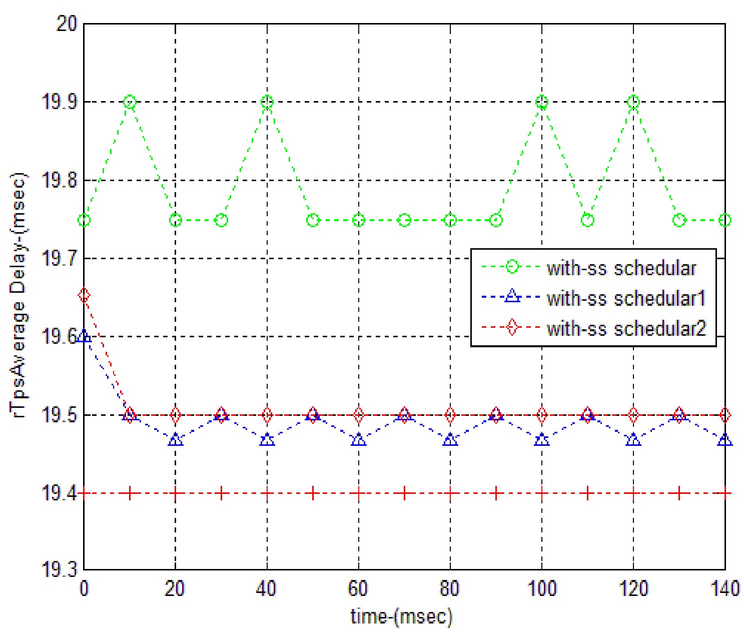

Figure.10 RTPS service delay

From Figure.11 we can see that the SS scheduler can effectively reduce the QoS violation rate of rtPS service flow

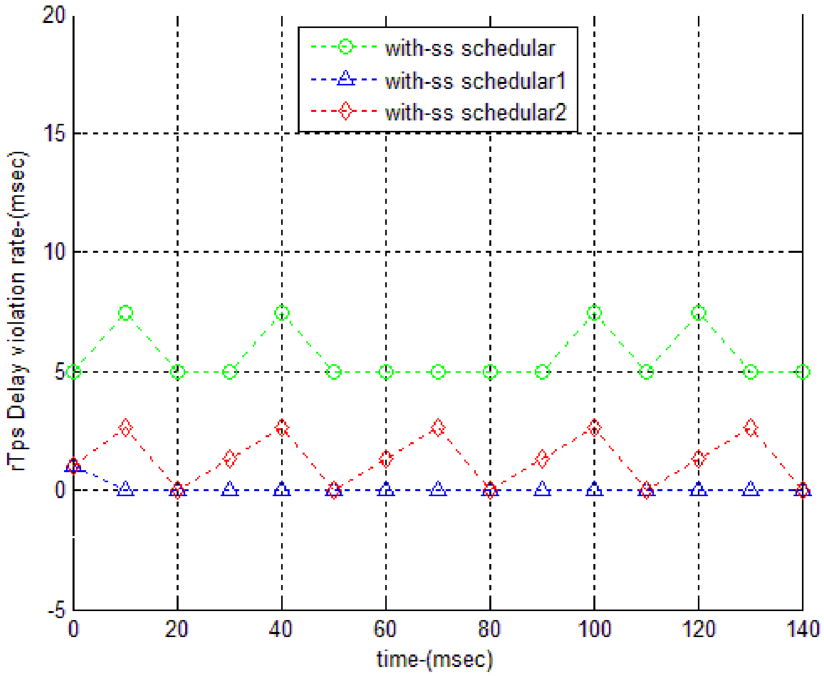

Figure.11 Packet drop comparison

4 . CONCLUSIONS

We have investigated four parameters: Bit Error Rate (BER), Signal to Noise Ratio (SNR), Power Spectral Density (PSD), Probability of Error (Pe).

We conclude that the probability of BER decrease as SNR increases more in Rician channel compared to Rayleigh channel in PURE AWGN. BPSK has the lowest BER while the 64-QAM has highest BER than others.

s

Cyclic prefix that is introduced , reduces Inter Symbol Interference and the impact of it is lower BER but the trade off is for the increase in the complexity of the system.

A hybrid packet scheduling scheme for mobile WiMAX has been implemented. A network model was developed to check the performance of the proposed scheme. Simulation results show that the proposed scheme is the best choice for QoS scheduling in Wi MAX in terms of delay, packet erro rate of the system compared to the schemes proposed in earlier methods. As a result of simulation, it can be concluded that the BS scheduler can provide each service flow with minimum required bandwidth and distribute excess bandwidth among all connections. The SS Scheduler provide differentiated QoS support for all types of service flows and reduce delay for real time applications and guarantee throughput for non- real time applications. With this the lower priority services can be eliminated of bandwidth and resource starvation.Hence tight QoS guarantee is provided for all service types.

4.1 FUTURE WORK:

To analyze the end-to end QoS variations in mobile WiMAX systems according to the QoS functions.

The end-to-end QoS may not be guaranteed even if the MAC layer QoS is definitely guaranteed. Therefore, cross-layer optimized design is necessary not only between MAC and PHY layers but also between the upper layer and MAC layer to guarantee the end-to-end QoS requirements. Schedulers can be designed taking into consideration the QoS performance factors.

REFERENCES

[1] IEEE 802.16-2004, “IEEE standard for Local and Metropolitan Area Networks — Part 16: Air Interface for Fixed Broadband Wireless Access Systems,” Oct. 2004.

[2] Rohit A. Talwalkar*, Mohammad Ilyas,” Analysis of Quality of Service (QoS) in WiMAX networks” ICON 2008 , p 1-8.

[3] Jeffery G.Andrews, Arunabha Ghosh, Rias Muhamed, “Fundamentals of WiMAX-Understanding Broadband Wireless Networking”, Pearson Education, March (2007).

[4] John Wiley & Sons,” WiMAX:”Technology for Broadband WirelessAccess”, Published Online: 22 JAN 2007 Print ISBN: 9780470028087Online ISBN: 9780470319055

[5] WiMAX Forum, “WiMAX System Evaluation Methodology V2.1,” Jul. 2008, 230 pp.

[6] Maode Ma,Mieso K Denko, Yan Zhang,” Wireless Quality of Service”@2009 CRC Press, by Taylor & Francis group,LLC

[7] Ho-Ting Wu, Kai-Wei Ke, and Chi-Fong Yang,” The Design of QoS provisioning mechanisms for Mobile WiMAX Networks”, 2009 International Conference on New Trends in Information and Service Science, 978-0-7695-3687-3/09 $25.00 © 2009 IEEE, DOI 10.1109/NISS.2009.49.

[8] Omar Arafat, K. Dimyati, "Performance Parameter of Mobile WiMAX : A Study on the Physical Layer of Mobile WiMAX under Different Communication Channels & Modulation Technique," Computer Engineering and Applications, International Conference on, vol. 2, pp. 533-537, 2010 Second International Conference on Computer Engineering and Applications, 2010.

[9] M. Ma J. Lu & C.P. Fu ,"Hierarchical scheduling framework for QoS& service in WiMAX point-to-multi-point networks",Published in IET Communications Revised on 7th August 2009

[10] Amir Esmailpour and Nidal Nasser ,"Packet Scheduling Scheme with Quality of Service Support for Mobile WiMAX Networks",The 9th IEEE International Workshop on Wireless Local Networks (WLN 2009) Zürich, Switzerland; 20-23 October 2009

[11] Jianhua He, Ken Guild, Kun Yang, and Hsiao-Hwa Chen ,"Modeling Contention Based Bandwidth Request Scheme for & IEEE 802.16 Networks" IEEE COMMUNICATIONS LETTERS, VOL. 11, NO. 8, AUGUST 2007

[12] K.Vinay, N.Sreenivasulu, D.Jayaram and D.Das, “Performance evaluation of end-to-end delay by hybrid scheduling algorithm for QoS in I EEE 802.16 network”, Proceedings of International Conference on Wireless and Optical Communication Networks, 5 pp., April (2006).

[13] J.Sun, Y. Yao, H. Zhu “Quality of Service Scheduling For 802.16 Broadband Wireless AccessSystem”, Advanced system technology telecom lab (Beijing) china, IEEE, (2006).

[14] Chakchai So-In, Raj Jain, and Abdel-Karim Tamimi ”Scheduling in IEEE 802.16e Mobile WiMAX Networks:Key Issues and a Survey” ieee journal on selected areas in communications, vol. 27, no. 2, february 2009

[15] Kalikivayi Suresh, Iti Saha Misra and Kalpana saha (Roy), "Bandwidth and Delay Guaranteed Call Admission Control Scheme for QOS Provisioning in IEEE 802.16e Mobile WiMAX" Proceedings of IEEE GLOBECOM, pp.1245-1250, December (2008).

[16] Chi-Hong Jiang, Tzu-Chieh Tsai, "CAC and Packet Scheduling Using Token bucket for IEEE 802.16 Networks", Consumer Communications and Networking Conf., 2006. CCNC 2006. 3rd IEEE Volume 1, pp. 183-187, Issue, 8-10 Jan. (2006).

[17] Prasun Chowdhury and Iti Saha Misra, "A Comparative Study of Different Packet Scheduling Algorithms with Varied Network ServiceLoad in IEEE 802.16 Broadband Wireless Access Int. Conf. Advanced Computing & Communications, Bangalore, Dec(2009).

[18] Ravichandiran,Dr.Pathuru Raj,Dr.Vaithiyanathan," Analysis and Modification of Scheduling Algorithm for IEEE 802.16e(Mobile WiMAX)" 2010 Second International Conference on Communication Software and Networks" 978-0-7695-3961-4/10 $26.00 © 2010 IEEEDOI 10.1109/ICCSN.2010.87

[19] Introduction to MATLAB by Rudra prathap

[20] Rakesh Jha, Hardik Patel, Dr Upena Dalal, Wankhede & Vishal A; "WiMAX System Simulation and Performance Analysis under the Influence of Jamming, Published inScientific Research journal, 2010, WET, July 2010

[21] D. S. Shu'aibu, S. K..Syed Yusof and N. Fisal; "Link Aware Unsolicited Grant Service Packet Scheduling for Mobile WiMAX" 978-1-4577-0005-7/11/$26.00 ©2011 IEEE

[22] Aldhaheri,R.W. Al-Qahtani,A.H. Dept. of Electr. & Comput. Eng., King Abdul Aziz Univ.Jeddah, Saudi Arabia;"Performance analysis of fixed and mobile WiMAX MC-CDMA-based system" WirelessCommunication Systems(ISWCS), 2010 7th International Symposium

[23] Omar Arafat,K. Dimyati ,Department of Electrical Engineering University of Malaya;"Performance Parameter of Mobile WiMAX :A Study on the Physical Layer of Mobile WiMAX under Different Communication Channels & Modulation Technique"2010 Second International Conference on Computer Engineering and Applications

[24] ZhenTao Sun,Abdullah Gani,XiuYing Sun,Ning Liu;"Improving QoS Of WiMAX By On_Demand Bandwidth Allocation Based On PMP Mode" JOURNAL OF COMPUTERS,OCTOBER 2011

[25] Sunghyun Cho,Jae-Hyun Kim & Jonghyung Kwun;"End-to-End QoS Model for Mobile WiMAX Systems"2011 35th IEEE Annual Computer Software and Applications Conference Workshops

AUTHORS

Dr. V. Sambasiva Rao, Professor in ECE Department of PES Institute of technology, Bangalore is an engineering graduate (1973) from College of Engineering, Kakinada, (Andhra University) and obtained Ph.D from BITS, Pilani in 2010.

He has 37 years of experience at ISRO and has contributed to the development of high bit rate data transmitters for all IRS series of satellites and has worked with various RF and microwave systems in S, C, X, Ku and Ka bands for IRS and INSAT missions.

He has successfully carried out numerous responsibilities as Project Manager/Deputy Project Director for different satellite projects and Deputy Director of Digital& Communication Area in ISRO Satellite Centre. He is also responsible for various studies related to satellite technologies. Dr. Sambasiva Rao, a Fellow of IETE and a Member of Astronautical Society of India, has received six distinguished awards and published over 50 technical papers.

Arathi R Shankar, Associate Professor(PG studies) in the Department of Electronics and Communication at BMS College of Engineering, Bangalore, India. She has received her BE(Telecommunication) and ME (Electronics) degree from Bangalore University. She is currently pursuing her P.hD from Visveswaraya Technological University, Karnataka, India.
She has 20 years of teaching experience and her research interests include Wireless Communications and Antennas.

Adarsh Pattar, final year P.G student in Digital Communication Department of at BMS College of Engineering, Bangalore, India. He has received his BE(Electronics and communication) degree from V .T .U Belgaum (India).
He has participated and organized many technical symposiums and Seminars in college. He has published 2 international technical papers and 4 national technical papers. His area of interest include MOBILE WIMAX, CROSS LAYER ISSUES IN WIMAX, OFDMA and SENSOR NETORKS.