Performance Evaluation of Adaptive Modulation Techniques and Offered Load in OFDM-based WiMAX Network by Considering Cyclic Prefix

Pratyush Sharma, Abhishek Sharma, Kailash C.Bandhu

Abstract— WiMax uses orthogonal frequency division multiple access technique in wireless communication. Orthogonal frequency division multiple access (OFDM) is what puts the max in WiMAX, OFDM delivers a wireless signal much farther with less interference.
This technique uses Adaptive modulation coding (AMC) on physical layer of WiMAX. Adaptive modulation technique uses the concept of cyclic prefix that adds additional bits at the transmitter end. The receiver removes these additional bits.
Cyclic Prefix is used to combat intersymbol inter-ference (ISI) and intercarrier interference (ICI) introduced by the multipath fading channel.
This paper investigates the performance of WiMAX network by varying physical layer parameter such as modulation and coding scheme and cyclic prefix. It also investigates the performance of WiMAX network by increasing traffic (number of downloading nodes) in network with different cyclic prefix.The performance of WiMAX network is measured in terms of throughput and goodput

Index Terms— Downlink (DL), Adaptive Modulation techniques, IEEE-802.16, OFDMA, Cyclic Prefix, Throughput, Goodput

1 INTRODUCTION

WiMAX is abbreviation `Worldwide Interoperability for Micro-wave Access', is a new wireless OFDM-based technology that provides high throughput broadband connection over long distances based on IEEE.802.16 wireless
WiMAX network increasingly more intelligent and agile communication systems, capable of providing spectrally efficient and flexible data rate access.

The WiMAX standard supports adaptive modulation, effectively balancing different data rates and link quality.

The modulation method may be adjusted almost instantaneously for optimum data transfer. WiMAX is able to dynamically shift modulations from 64-QAM to QPSK via 16-QAM, displaying its ability to overcome QoS issues with dynamic bandwidth allocation over the distance between the BS and the SS.

As the range increases, modulation step down to lowermodulations (in other words, BPSK), but as you are closer you can utilize higher order modulations like QAM for increased throughput.

- *Pratyush Sharma is currently pursuing masters degree program in Information Technology from MIT,Ujjain, RGPV University, Bhopal(M.P), India.*
  E-mail:pratyush.sharma@yahoo.co.in
- *Abhishek Sharma working as a Reader. in Computer sc. Dept. in MIT,Ujjain, RGPV University, Bhopal(M.P),India*
  E-mail: abhi_ujn9@yahoo.co.in
- *Kailash C Bandhu working as a Astt.Prof. in Computer sc. Dept. in AITR,Indore, RGPV University, Bhopal(M.P),India*
  E-mail: kailash_bandhu@yahoo.co.in

Thus the modulation coding schemes ensure a qualitysignal is delivered over distance by decreasing througput.

An example of utilization of the cited adaptive modultion and coding scheme is illustrated in Fig. 1. It shows that as the range increases, the system steps down to a lower modulation, but as closer to the base station, higher order modulations can be used for increased throughput.

The rest of the paper is structured as follows. The system model for the investigation is introduced in Section 2.

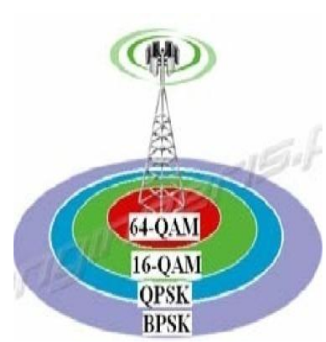

Fig. 1 Scheme for the utilization of AMC

ISSN 2229-5518

In Section 3, simulation scenarios are presented and the results are discussed. Finally, we present our conclusions in Section 4.

2 System Model

This section present the system model used in our investigation. The network setup is shown in Fig. 2.

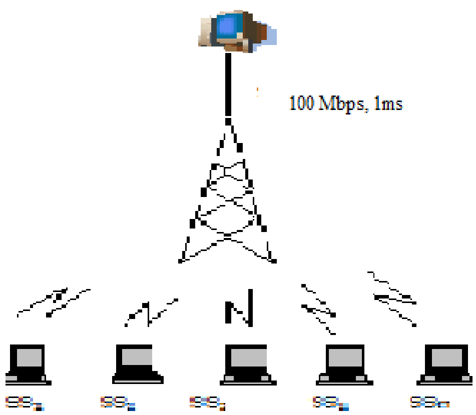

Fig. 2 The network setup

2.1 Simulation Environment

The investigation was through simulation. The simulation platform is *ns-2* and the WiMAX module is from the National Institute of Standards and Technology (NIST) [1]. The simulation parameters are summarized in Table I .

2.2 Performance Metrics

We study performance by means of three metrics:

• Throughput that measures the amount of raw bytes sent by a source.

• Goodput that measures bytes that are sent and successfully acknowledged.

• Cyclic Prefix act as a buffer region where delayed information from the previous symbols can get stored.

In our system we investigated the behavior of adaptive modulation technique of WiMAX network. The adaptive modulation used Binary Phase Shift Keying (BPSK), Quadrature Phase Shift Keying (QPSK),16-Quadrature Amplitude Modulation(16-QAM),64-Quadrature Amplitude Modulation(64-QAM) for modulating and demodulating the signal. Based on these modulation techniques the throughput and goodput were investigated

TABLE I

SIMULATION PARAMETERS

WiMAX and OFDM Parameters	
Channel bandwidth	7 MHz
Frame duration	5ms
Modulation & Coding	7=64QAM 3/4,6= 64QAM 2/3, 5=16QAM 3/4,4= 16QAM 1/2, 3=QPSK 3/4,2= QPSK 1/2, 1=BPSK1/2
Cyclic prefix	0.0625ms,0.125ms,0.25ms,0.8ms,1.0ms, 1.2ms,1.5ms
Contention size	5
Traffic Source and Other Parameters	
TCP version	New Reno
TCP segment size	960 Bytes
Delayed ACK factor	2
TCP start time	1s
Simulation duration	300s

3 Simulation Results

This section, present the simulation scenarios and discuss the results obtained. Several scenarios are considered to highlight the effects of offered load and modulation and coding schemes with cyclic prefix

3.1 Scenario 1: Effect of Load

In the first scenario, all SSs download FTP traffic from the server. It has been study the impact of offered load (i.e. number of SSs) and cyclic prefix on aggregate throughputs and goodputs of the system for fixed downlink and uplink ratio (i.e. DL:UL). The value of DL:UL ratio is fixed at 0.5 The results are presented in Fig. 3 & 4.

As can be seen, the throughput and goodput increases with offered loads are increases and cyclic prefix decreases. cyclic prefix is added to reduce the effect of fading and to give sufficient time to the receiver for storage of signal[2-7]. As distance increase fading is more and signal strength is going low. For this higher value of cyclic prefix is consider because large cyclic prefix means large time gap between two frames. Large value gives extra time to receive signal from multipath signals.

It is observed that for large value of cyclic prefix throughput and goodput are decreases.

For cyclic prefix 0.0625ms, maximum throughput is around

10.58 Mbps for 30 downloading nodes, 8.89 Mbps for cyclic prefix 0.25ms and 5.72 Mbps for cyclic prefix 0.8ms respectively.

It is also observed that throughput and goodput increases with offered loads increase (i.e. number of SSs) for all cyclic prefix values. The system is more utilized with more downloading SSs (loads). However, the system resources are finite, and when its capacity is reached new connection cannot be admitted

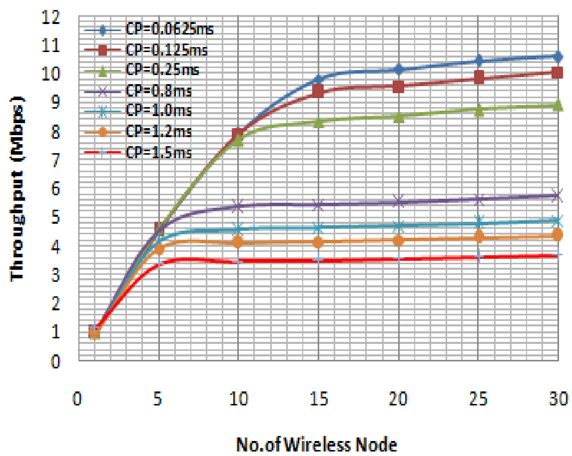

Fig. 3 Aggregate throughput
(All wireless nodes (SSs) are downloading)

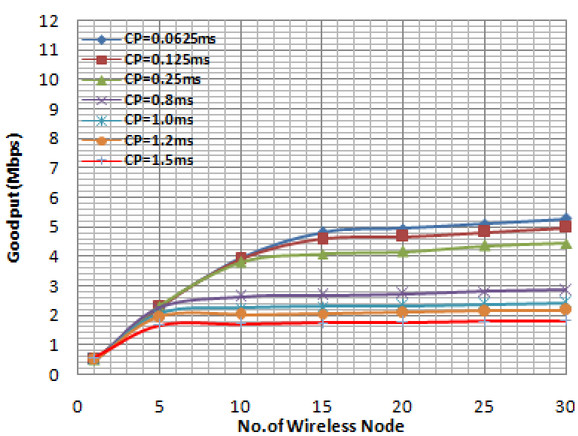

Fig. 4 Aggregate goodput
(All wireless nodes (SSs) are downloading)

3.2 Scenario 2: Effect of Modulation and Coding Scheme

This study considers the same radio conditions and hence the same modulation and coding schemes (MCS) for all SSs. In this section, we change the MCS for all SSs. The offered load is constant with 15 downloading SSs. It has been plot the throughputs and goodput against MCS for fixed DL:UL ratio 0.5 in Fig. 5 and Fig. 6.

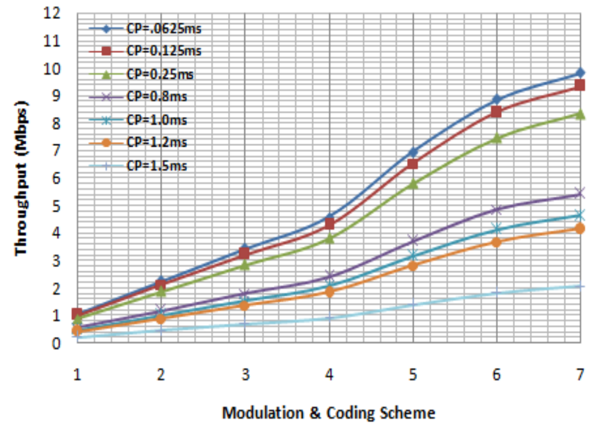

Fig. 5 Aggregate throughput for MCS
(For 15 downloading wireless nodes)

It is observed that for higher order modulation coding scheme, the value of throughput and goodput is maximum. Higher order modulations like QAM for increased throughput and goodput.

For cyclic prefix 0.0625ms, maximum throughput is around 9.80Mbps for 64QAM 3/4 modulation coding scheme which is higher order modulation coding scheme, 8.3Mbps for cyclic prefix 0.25ms and 5.4Mbps for cyclic prefix 0.8ms respectively.

For cyclic prefix 0.0625ms, maximum, goodput is around 4.82Mbps for 64QAM 3/4 modulation coding scheme, 4.09Mbps for cyclic prefix 0.125ms and 2.68Mbps for cyclic prefix 0.8ms respectively.

It is also observed that for higher cyclic prefix values and lower modulation coding scheme, coverage area that would be covered by the signal is increases but throughput and goodput are decreases.

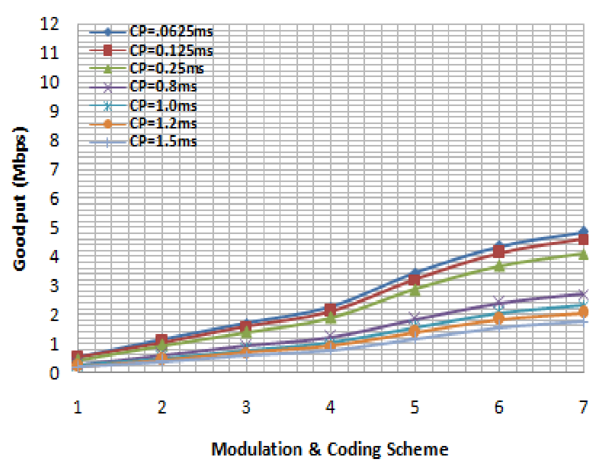

Fig. 5 Aggregate goodput for MCS
(For 15 downloading wireless nodes)

4 Conclusion

In this paper investigates that the performance of WiMAX network is highly dependent on Cyclic Prefix and Modulation and Coding Scheme.

It is concluded that Cyclic Prefix is key player in WiMAX Network. It is observed that the modulation and coding scheme and Cyclic Prefix affect the performance of WiMAX network. The Cyclic Prefix play an important role to increase and decrease the throughput and goodput.

By increasing the value of Cyclic Prefix the throughput and goodput of WiMAX network are decreases and gap between throughput and goodput occurred because of lost of packet in network.

As the distance increases signal strength decreases and SNR also decreases, at lower SNR fading is more and signal strength goes low. To overcome this problem by selecting higher Cyclic Prefix and Lower order modulation and coding scheme but these two parameters is cause of less throughput and goodput. Higher Cyclic Prefix means large time gap between two frames and large Cyclic Prefix give extra time to receive signal from multipath channel.

It is observed that when increase the number of downloading wireless nodes the throughput and goodput are also increases for different Cyclic Prefix because of better utilization of bandwidth, it is also observed that the lower Cyclic Prefix support higher throughput and goodput.

So the selection of Cyclic Prefix value is based on the coverage area that would be covered by the signal and keeping throughput and goodput parameter in consideration.

References

[1] *R. Rouil, "The NIST WiMAX Network Simulator," NIST, Tech. Rep., 2007.*

[2] T.-L. Tung and K. Yao, "Channel estimation and Optimal power allocation for a multiple-antenna OFDM system," *EURASIP Journal on Advances in Signal Processing*, vol. 2002,no. 3, pp.330–339, 2002.

[3] N. Balamurali and D. Jalihal, "An efficient algorithm For joint carrier frequency offset and channel estimation in IEEE 802.16 OFDM systems," in *Proceedings of the 1st International Symposium on Wireless Communication Systems (ISWCS '04)*, pp. 428–432, Port Louis, Mauritius, September 2004.

[4] W. H. Nicholson and A. A. Sakla, "The sampling and Full reconstruction of band-limited signals at sub-Nyquist rates," in *Proceedings of the IEEE International Symposium on Circuits and Systems (ISCS '90)*, vol. 3, pp. 1796–1800, New Orleans, La, USA, May 1990.

[5] R. Andraka, "A survey of CORDIC algorithms for FPGABasedcomputers," in *Proceedings of the ACM/SIGDA International Symposium on Field Programmable Gate Arrays (FPGA '98)*pp. 191–200, Monterey, Calif, USA, February 1998.

[6] Xilinx, "ISE Foundations," http://www.xilinx.com/tools/designtools.htm.

[7] O. Fern andez, M. Domingo, and R. P. Torres, "Outdoor to indoor 2 × 2 wideband MIMO channel modelling," in *Proceedings of the IEEE 69th Vehicular Technology Conference (VTC '09)*, pp. 1–5, Barcelona, Spain, April 2009.

[8] J. G. Andrews, A. Ghosh, R. Muhamed, *Fundamentals of WiMAX : Understanding Broadband Wireless Networking*, Prentice Hall, 2007

[9] IEEE Standard, 802.16e – 2005. Part 16 : Air Interface for Fixed and Mobile Broadband Wireless Access Systems, December 2005.

[10] K. Fazel and S. Kaiser, *Multi-Carrier and Spread Spectrum System*, 2nd edition, New York : John Wiley and Sons Ltd, 2003.

[11] D. Borio, L. Camoriano, L. Presti, and M. Mondin , "Beamforming and Synchronization Algorithms Integration for OFDM HAP-Based Communications," *International Journal of Wireless Information Networks*, Vol. 13, January 2006.

[12] V. Erceg, K. V. S. Hari, et al., "Channel models for fixed wireless applications," Tech. Rep., IEEE 802.16 Broadband Wireless Access Working Group, January 2001.

[13] M. Hata, "Empirical formula for propagation loss in land mobile radio services," *IEEE Transactions on Vehicular Technology*, Vol. VT-29, pp. 317–325, August 1980.

[14] Syed Ahson, Mohammad Ilyas, *WiMAX Technologies: Performance Analysis and QoS*, CRC Press, 2007.