BER PERFORMANCE REVIEW OF WIMAX MIMO SYSTEM

Parul Sangwan
M.Tech Scholar: Department of ECE
UIET, MDU
Rohtak, Haryana, India

Mr. Vikas Nandal
Assistant Professor: Department of ECE
UIET, MDU
Rohtak, Haryana, India

Abstract: The demand for high data rate is increasing day-by-day in today’s scenario. With limited bandwidth resources, WiMAX can be viewed as efficient solution to this problem. WiMAX technology is based on IEEE 802.16 standard and is able to support greater number of customers at higher data rates. Although WiMAX standard can support both fixed and mobile applications, but the latter have larger demand. Its performance can be further boost up by utilizing MIMO techniques. This paper reviews the BER performance analysis of WiMAX system with MIMO technique.

Keywords: IEEE802.16; WiMAX; OFDM; OFDMA; MIMO

I. INTRODUCTION

WiMAX, an acronym of Worldwide Interoperability for Microwave Access, is a technology developed to satisfy high data rate requirement for wireless broadband access services. Based on IEEE802.16 standard, it is one of the hottest wireless broadband access technique in today’s scenario. Prior to the development of WiMAX system, T1, Digital Subscriber Line (DSL) or cable modem were effective methods to attain wireless broadband access. However, these wired infrastructure have high cost associated with them. This limitation instigated the industry to evolve an alternative method to obtain broadband access with wireless medium.

In June 2001, a non-profit organization called WiMAX Forum consisting of network operators, component vendors, equipment manufacturers and system integrator was set up to maintain interoperability among WiMAX products from different manufacturers. The name WiMAX was propounded by WiMAX forum. WiMAX functions in similar way as Wi-Fi but provide higher speeds for longer distances and for more no. of users. It is a wireless metropolitan area technology and is able to support high data rate applications requiring variety of quality of service (QoS).

Some of the key features of WiMAX systems are: utilization of OFDMA technique, use of any channel width, time and frequency division multiplexing, modern antenna techniques, various QoS classes per user adaptive modulation, use of advanced codes like space time codes and turbo codes.

WiMAX based on IEEE802.16d standard, introduced in 2004, was capable to support only fixed application [1]. It works on frequency range 2-11GHz. The mobile WiMAX variant of the system based on IEEE802.16e [2], was added with the feature to support secure seamless handover of ongoing connection from one base station to another. Both techniques MIMO and OFDMA are included in WiMAX 802.16e specification to improve the coverage and multiply the system capacity.

Modern wireless communication systems are moving from SISO and SIMO systems to MIMO systems to attain increase in the channel capacity and to suppress the fading effects. MIMO systems have been greatly employed in several wireless communication standards such as IEEE802.11n standard for local area network and IEEE802.16e-2005 standard for portable broadband access. MIMO system uses a number of parallel channels to achieve multiplexing gain [3]. Using MIMO systems increased bandwidth efficiency can be attained at the cost of increased computational complexity. This bandwidth efficiency can be used to acquire higher data rates and capacity without requiring any extra bandwidth resources and power.

The overlay of this paper is: Section 1 gives brief introduction to WiMAX system, its layer architecture and MIMO techniques. It is followed by section 2 which describes the literature review of WiMAX MIMO system. Conclusion concludes the paper in section 3.

A. WIMAX LAYER ARCHITECTURE

WiMAX reference model includes two layer: Physical layer and MAC layer as shown in fig. 1. Both of these layers are explained below: -:

1) Physical Layer: Variety of physical layer, each having unique feature, are supported by IEEE802.16 standard. For band of frequency 10-66GHz, single carrier (SC) PHY is designed. Line of sight link is required for this PHY. For frequency band below 11 GHz, IEEE802.16 designed OFDM PHY in order to accommodate Non-Line of sight (NLOS) communication. This PHY design is used in most of the WiMAX products used nowadays.

For mobile users, ODFMA PHY is designed. OFDMA performs much better than OFDM [4]. It provides more robustness to fading and interference effects as compared to OFDM.

Since PHY of WiMAX is quite flexible, acquired data rate varies depending on the parameters such as modulation, coding technique, no. of subcarriers and channel bandwidth.
2) **MAC Layer**: The primary job of MAC layer is to act as an interface between higher layers and physical layer. It is designed in such a way that it supports point-to-multipoint application. It includes 3 sub-layers given below:

- MAC Privacy Sub Layer
- MAC Common Part Sub Layer
- MAC Convergence Sub Layer

**MAC Privacy Sub Layer** - is responsible for functions such as authentication, encryption and key management.

**MAC Common Part Sub Layer** - Scheduling, spectrum allocation, QoS functions are supported by common part sub layer.

**MAC Convergence Layer** - is responsible for mapping addresses of upper layer into WiMAX protocol architecture.

The benefits of using MIMO schemes are increased spectral efficiency, high transmission rate and increased throughput. But the main challenge faced by MIMO systems is the requirement of complex DSP circuitry and maintainance of isolation characteristics between antennas. Few of the MIMO techniques are given below:

- **Spatial Diversity** – Multiple versions of the same information is transmitted across independent fading channels. The probability of all the transmitted signal to be in deep fade at certain time is very small. Atleast one of the copy will be very less affected by fading and an optimized signal can be thus received and robustness of the system is improved.

- **Spatial Multiplexing** – is an effective technique to increase the peak user throughput by sending independent streams of data in same time slot and frequency band simultaneously and then differentiating the multiple data streams by using channel information associated with each propagation path [11].

### C. MIMO in WiMAX

For further evolution of WiMAX, MIMO schemes have been adopted to get improved performance in terms of increased bandwidth efficiency and capacity. WiMAX Forum has defined two obligatory MIMO formats which can be used on the downlink. One of the format makes use of space time code, referred to as Matrix A in WiMAX systems. For obtaining diversity, Alamouti proposed space time code in 1998 [10].

The another format denoted by Matrix B in WiMAX is dependent on spatial multiplexing (SM) in which two independent streams of data is sent by using two antennas at transmitter side. At best, second order diversity can be attained using this scheme with two antennas at the receiver side.

Analysis have shown that, desired quality of service can’t always be attained by Matrix A or Matrix B. So, a new code which combines the benefits of both Alamouti code and SM should be introduced. Such a code is already defined in Mobile WiMax specification released in 2005 [2], where it is denoted as Matrix C. Matrix C provide improved performance over Matrix A and Matrix B but the decoder complexity associated with it has inhibit its acceptance.

### II. LITERATURE SURVEY

This section provides a brief summary of work held on WiMAX MIMO system.

In [12] the gain achieved by adopting MIMO techniques has been empirically evaluated. 2×2 MIMO system based on space time coding is compared with single antenna system employed in Mobile WiMAX testbed. Several measurement runs have been carried out with different types of traffic in vehicular mobility scenario by taking critical QoS parameter such as delay and throughput (packets/second) into consideration. With TCP traffic, it is clearly evident that by utilizing MIMO techniques over wireless channels, data propagation reliability increases by many folds.

In [13] the performance of OFDMA over physical layer of mobile WiMAX with different SUI channel models and
different modulation technique has been analyzed. Simulation is done with the help of MATLAB software. With less SNR, the system exhibit improved performance for lower modulation and coding technique. For same coding rate, BLER vs SNR plot follow same pattern but pattern increases as coding rate increases for each modulation technique. From the analysis, it is clear that performance over physical layer of mobile WiMAX under varying channel condition is greatly affected by modulation and coding rate used.

In [14] both technical and non-technical issues have been explored to evaluate the quality experienced by end user in a WiMAX based system. The test was conducted on WiMAX broadband network configuration in Tanzania. From the study, it is determined that base station with sectorized antennas outperform those with omnidirectional antennas. Also, WiMAX configuration with outdoor CPE outperformed TTCL DSL network. But performance of indoor CPE is similar to that of TTCL network. Thus it can be concluded that in all prevailing environmental conditions, outdoor CPE provides improved performance than indoor CPE.

In [15] capacity of an online, interference based pre-coding algorithm for MU-MIMO system has been evaluated. Also the concerns related to its implementation has been considered. Simulation is done with the help of WiMAX 802.16-2004 compliant simulator. From the analysis, it is clear that with the selected technique, capacity of the system is improved, but there are many issues associated to its implementation such as number of required iteration increases linearly as number of users multiplexed increases. Such issues are prohibiting the system designer to introduce this technique into the wireless specification.

In [16] MIMO techniques with space time block code modulation scheme is focused upon to increase the overall capacity of the system and to deliver enhanced service to users at cell boundary. Multiple antennas are implemented both at transmitter and receiver terminal. It is seen that for user at boundary of cell the receiver SNR is very low and BER is reduced as no. of antennas are increased at transmit or receive side.

In [17] WiMAX system is tested under various fading channels-Rayleigh, Rician, Nakagami, Lognormal shadowing channels for different modulation schemes to examine BER with respect to SNR. From BER vs SNR plot, it is observe that on increasing SNR, BER decreases. Among different fading channels, it is found that Nakagami channel shows improved performance at high SNR and also among various modulation schemes, BPSK modulation provide lowest BER. Thus it can be deduced that to attain efficient bandwidth utilization Nakagami channel is best.

In [18] MIMO OFDM physical layer performance with QC LDPC codes using different modulation schemes is evaluated. From the evaluation of BER performance of proposed system, it is clearly evident that higher order modulation provides higher data rates but they are less resilient to noise. Hence, dynamic adaptive modulation schemes along with forward error correction code are used widely.

In [19] WiMAX system with WPM technique has been proposed. The BER performance of proposed system is evaluated in both AWGN and Rayleigh fading condition and compared with conventional WiMAX system based on OFDM. DQPSK modulation scheme is opted for WiMAX based on WPM. From the results found using simulation done with MATLAB software, it is clear that the performance of WiMAX system based on WPM is better than WiMAX system with OFDM technique, in terms of low BER, in both channel condition by 4dB. The result obtained for Rayleigh frequency selective channel is further enhanced. Also the multicarrier based on wavelet transform gives improved performance than multicarrier based on Fourier transform.

| Year | Authors                      | Title                                           | Contribution                                                                 | Major Findings                                                                 |
|------|------------------------------|-------------------------------------------------|------------------------------------------------------------------------------|--------------------------------------------------------------------------------|
| 2009 | Esa Piri, Jarno Pinola, Ilkka Harjula, Kostas Penti Kousis[12] | Evaluating Mobile WiMAX along with MIMO schemes empirically | 2×2 MIMO system based on space time coding is compared with single antenna system employed in Mobile WiMAX testbed. Thorough measurement have been carried out with different types of traffic in vehicular mobility scenario. | It is clearly evident that by utilizing MIMO schemes over wireless channels data propagation realibility increases by many folds. |
| 2010 | Omar Arafat, K. Dimyati[13]  | Mobile WiMAX performance parameters              | Performance of OFDMA over PHY layer with different channel models and different modulation techniques has been analyzed. | With less SNR, the system exhibit improved performance in terms of low BER, for lower modulation and coding techniques. |
| 2010 | Eliamani Sedyoeka, Ziad Hanaiti and Daniel Tairo[14] | WiMAX QoS evaluation in developing country environment | Both technical and non-technical issues have been explored to evaluate the quality experienced by end user in WiMAX based system. | From the study it is determined that BS with sectorized antennas outperform those with omnidirectional antennas. |
### III. CONCLUSION

This paper reviews the performance of WiMAX system along with MIMO technique which offers potential advantages such as increased utilization of spectrum bands, increased system capacity and improved coverage. The results of some recent work held on WiMAX—MIMO systems are reported and an ample survey of recent and relevant work published in this field is properly studied and is specified in chronological order.

### IV. REFERENCES

[1] IEEE Std. 802.16TM-2004, “Part 16: Air Interface for fixed broadband wireless access system”, October 2004.

[2] IEEE 802.16-2005: IEEE Standard for Local and Metropolitan Area Network-Part 16: Air Interface for fixed and Mobile Broadband Wireless access system Amendment 2: Physical layer and medium access control layers for combined fixed and mobile operation in Licensed Brands, Feb 2006.

[3] D. Gesbert, H. Bolcskei, D. Gore and A. Paulraj, “MIMO wireless channels: Capacity and performance prediction”, Global Telecommunication conference, 2000.

[4] X. Zhang, Y. Wang and W. Wang, “Capacity analysis of adaptive multiuser frequency-time domain radio resource allocation in OFDMA system s”, in Proc. IEEE Int. Symp. Circuits and systems, 2006.

[5] G.J. Foschini, “Layered space-time architecture for wireless communication in a fading environment when
using multi-element antennas”, Bell Laboratories Technical Journal, Vol.2, pp 41-59, October 1996.

[6] P.W.Wolniansky, G.J.Foschini, G.D.Golden and R.A.Valenzuela, “ V-BLAST: An architecture for realizing very high data rates over the rich-scattering wireless channel”, URSI International Symposium on Signals, Systems and Electronics, 1998.

[7] D.Gesbert, University of Oslo, “ Lecture to 5-th year NTNU students”, September 2003.

[8] D.Gesbert, M.Shafi, D.Shiu, P.Smith and A.Naguib, “ From theory to practice: An overview of MIMO space-time coded wireless systems”, IEEE Journal on selected areas of communication, April 2003.

[9] M.Jankiraman, “ Space-time codes and MIMO systems”, July 2004.

[10] S.M.Alamouti, “ A simple transmit diversity scheme for wireless communications”, IEEE Journal on selected areas of communication (JSAC), Vol.16, pp1451-1458, October 1998.

[11] G.J.Foschini and M.J.Gans, “ On limits of wireless communication in a fading environment when using multiple antennas”, Wireless Personal Communication, Vol. 6, no.3, March 1998, P.311.

[12] Esa Piri, Jarno Pinola, Ikka Harjula, Kostas Pentikousis, “ Empirical evaluation of Mobile WiMAX with MIMO”, IEEE GLOBECOM Workshops, 2009.

[13] Omar Arafat, K.Dimyati, “ Performance Parameter of Mobile WiMAX: A Study on the Physical Layer of Mobile WiMAX under different Communication Channels and Modulation Technique”, IEEE, Second International Conference on Computer engineering and application (ICCEA), 2010.

[14] Eliamani Sedoyeka, Ziad Hanaiti, Daniel Tairo, “ Evaluation of WiMAX QoS in a Developing Country’s Environment”, IEEE, ACS International Conference on Computer Systems and Application (AICCSA), 2010.

[15] Andrea F. Cattoni, Yaunick Le Moulllec, Claudio Sacchi, “ Zero-Forcing Pre-Coding for MIMO WiMAX Transceivers: Performance analysis and Implementation Issues”, IEEE, Aerospace Conference, 2013.

[16] Nirmal S. Kothari, Vijay S. Patil, “ Performance of Space-Time Block Coded MIMO systems for cell edge users in Rayleigh fading Channel”, IEEE, International Conference on Electronic Systems, Signal Processing and Computing Technologies, 2014.

[17] Mranali Joshi, Amar Nath Dubey, Debendra Kumar Panda, “ Analysing various fading channels using different Modulation Techniques under IEEE 802.16 standard”, IEEE, ICECS, 2015.

[18] Monika Cheema, Sukanya A. Kulkarni, “ Analysis of MIMO OFDM Based WiMAX system with LDPC”, IEEE, Fifth International Conference on Advances in Computing and Communication, 2015.

[19] Sayali S. Band, Megha S. Dorle, Dr. S. S. Dorle, “ BER Performance of WiMAX system using Wavelet Packet Modulation Technique”, IEEE, World Conference on Futuristic Trends in Research and Innovation for Social Welfare, 2016.