DOI: http://dx.doi.org/10.26483/ijarcs.v8i9.5085

ISSN No. 0976-5697

Volume 8, No. 9, November-December 2017

International Journal of Advanced Research in Computer Science

REVIEW ARTICLE

Available Online at www.ijarcs.info

BER PERFORMANCE REVIEW OF WIMAX MIMO SYSTEM

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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 wirelesss 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 speed for larger 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 serviceS (QoS).

Some of the key features of WiMAX systems are: utilization of OFDMA technique , use of any channel width ,time and frequency division duplexing ,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-2005standard 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, OFDMA PHY is designed. OFDMA performs much better than OFDM [4].It provide 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.

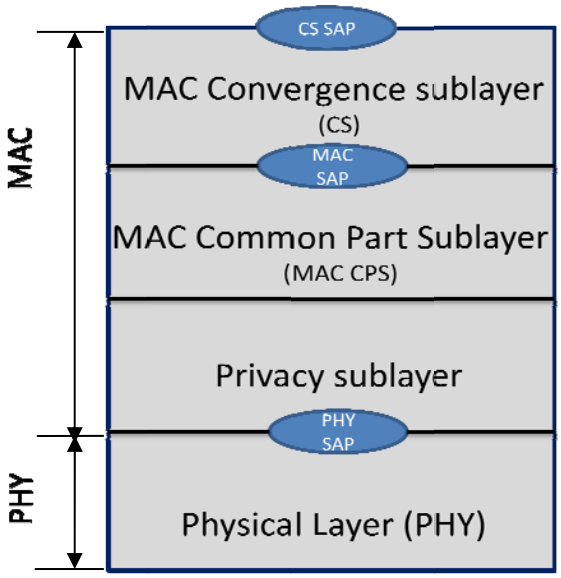

Fig 1: IEEE 802.16 Reference model

B. MIMO

MIMO solves the bottlenecks linked with the traffic capacity of broadband access networks like WiMAX. In MIMO multiple antennas are employed at both transmit and receive sides to achieve increase data rate by using space-time signal processing, in which time is complemented with spatial dimension.

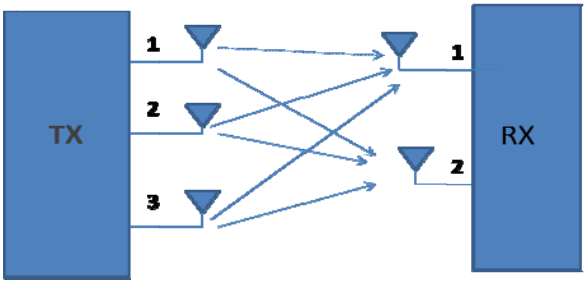

Fig 2: 3×2 MIMO system illustration

MIMO systems can be employed in various ways , such as BLAST ,described by G.J Foschini [5,6], space time coding [7-9] and many more. In 1998,Siavansh Alamouti described Alamouti space time block code [10] with which maximum diversity can be attained by using two transmit antennas. One of the greatest benefit it provides is minimum probability-of-error. At the receiver terminal, maximum likelihood detection is used to find optimum received signal among all the received signal[9].

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 circuitary 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 a optimized signal can be thus received and robustness of the system is improved.

Spatial Multiplexing – is a 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 realibility 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.

Table I. Literature survey table

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 Sedoyeka, 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.

2013	Andra F.Cattoni,Yaunick Le Moullec and Claudio Sacchi[15]	Analyzing zero forcing pre-coding for transceivers of MIMO WiMAX	Capacity and concerns related to the implementation of an online, interference based pre-coding algorithm for MU-MIMO system has been evaluated.	With the selected technique capacity of the system is improved, but there are many issues associated to its implementation such as no. of required iteration increases linearly as no. of users multiplexed increases.
2014	Nirmal S.Kothari, Vijay S.Patil[16]	Evaluating performance of MIMO systems with space-time block codes in Rayleigh fading channel for cell edge users	MIMO scheme with space-time block code modulation is focused upon to increase the overall capacity of the system and to provide enhanced service to users at cell boundary.	It is found that even for user at boundary of cell , the receiver SNR is low, the BER is reduced as no. of antennas are increased at transmit side.
2015	Mranali Joshi ,Amar Nath Dubey and Debendra Kumar Panda[17]	With various modulation schemes analyzing different fading channels under IEEE802.16 specification	WiMAX system is tested using various fading channels for different modulation schemes and BER with respect to SNR has been examined.	Among different fading channels , Nakagami channel shows improved performance at high SNR and out of various modulation schemes ,BPSK modulation provides lowest BER.
2015	Monika Cheema, Sukanya Kulkarni[18]	MIMO OFDM based WiMAX system analysis with LPDC codes	MIMO OFDM physical layer performance with QC LPDC codes using different modulation schemes is evaluated.	From the BER performance of the system , it is evident that higher order modulation provides higher data rates but they are less resilient to noise.
2016	Sayali R.Band,Megha S.Dorle ,Dr. S.S.Dorle[19]	Analysing BER performance of WiMAX system with WPM	BER performance of proposed system is evaluated in both AWGN and Rayleigh fading channel and compared with conventional WiMAX system based on OFDM	From the results found using simulation done with MATLAB software, it is clear that BER performance of WiMAX system based on WPM is better than WiMAX system with OFDM technique in both channel condition by 4dB .

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.

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