PERFORMANCE ANALYSIS OF ANTENNA DIVERSITY IN WIMAX SYSTEM

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ABSTRACT
Multipath propagation is the characteristic feature of any wireless communication system. This results in multiple versions of the transmitted signal that arrive at the receiving antenna. These received signals have random phase and amplitude that cause fluctuations in the signal strength inducing fading and signal distortion. Diversity technique has been a key factor in improving system's operation by providing performance almost equivalent to that of the least distorted path among various multipath at any given time and thereby accounting for the losses in corruptive communication channels. WiMAX (Worldwide Interoperability for Microwave Access) a technology well known for its radical entry into the wireless communication market of WMAN is intertwined with space diversity techniques. Multiple Input Single Output (MISO) and Multiple Inputs Multiple Output (MIMO) are the two-space diversity techniques employed in WiMAX standard. This paper discussed the performance of various space diversity techniques and modulation schemes by comparing their Bit Error Rate (BER).

Keyword: - WiMAX, Wireless, MISO, BER Etc.

INTRODUCTION

Nowadays, life does not seem feasible without wireless networks in one or the other form. Wireless is becoming the leader in communication choices among users. In the current era life is converging towards the cable less environment where the last mile connectivity can be easily achievable without the need of physical connections. So the field of wireless communication is continuously emerging one which is the demand for the transfer of data with high speed and with long coverage range. The claim for broadband mobile services continues to grow. Usually, high-speed broadband solutions are based on wired-access technologies such as digital subscriber line (DSL). This type of solution is not easy to deploy in remote rural areas, and furthermore it lacks support for terminal mobility. [1]

Also the gradual development in the use of wireless networks has led to the requirement for the design of new modern communication networks with higher capacity and lower error rate. The telecommunication industry is also upgrading, with a requirement for a greater range of services, such as video conferences, or applications with multimedia contents.
The increased dependence on computer networking and the internetwork has resulted in a larger demand for connections to be allotted any time, any place, leading to a increase in the requirements for greater capacity and ultimate reliable broadband wireless communication systems. For this issue, new technologies with high throughput with less requirement of bandwidth have been designed. As a matter of fact the requirements on bandwidth and spectrum availability are endless. As a result, the designers working in the domain of wireless communication has to face the lots of difficulties to fulfill the requirement of bandwidth for the efficient and accurate transmission and reception. Moreover the problems of time varying nature of channel such as fading and multipath put the limitation on the performance of high data rate with good quality of service. The demands for greater capacity, high reliability as well as accuracy are the prime requisites for the forth coming generations of the wireless networking systems such as Wi-Fi, WiMAX, etc.

II PRELATED WORK

The broadband wireless access technology developed rapidly in 1990s. The wireless technology, represented by Local Multipoint Distribution System (LMDS) and Multichannel Multipoint Distribution Service (MMDS), found its position in the market oriented to the users of solo, medium/small companies, urban commercial centers and so on.[1] However, beyond the expectation of all, this industry did not boom and expand further. The main reason is the lack of globally uniform standard for broadband wireless access.

In 1999, IEEE organized the 802.16 workgroup to specialize in the technical specifications for broadband wireless access, aiming to establish a globally uniform standard for broadband wireless access. At present, IEEE 802.16 mainly comes down to two standards: the 802.16-2004, i.e., the 802.16d standard for fixed broadband wireless access, and the 802.16e standard supporting mobile broadband wireless access. Issued on

October 1st, 2004, the IEEE 802.16d standard specifies the air interface between the user terminal and base station system in fixed access, and mainly defines the physical layer and MAC layer of air interface. The main feature of 802.16e standard is the support to mobility. This standard specifies a system supporting both fixed and mobile broadband wireless access, which works in a permitted frequency range less than 6GHz suitable for mobility and supports the user terminal moving in the speed of vehicle. Meanwhile, the user capacity of fixed wireless access specified by 802.16d will not be affected.

The IEEE 802.16 workgroup established the specification and standard specifically to the physical layer and MAC layer of the wireless MAN. To compose an operational network, IEEE 802.16 technology requires the support of other components. As a result, the WiMax Forum emerges because of demand. The WiMax Forum was established in April, 2001. At the beginning, the organization intended to offer certification service for conformity and interoperability of broadband wireless access products based on the IEEE 802.16 standard and the ETSI Hiper MAN standard. The product certificated by WiMax is identified by the mark of "WiMax Certified". Along with the development of 802.16e technology and specification, the purpose of the organization expands gradually. It not only intends to establish a whole set of certification system based on the 802.16 standard and the ETSI Hiper MAN standard, but also turns to the research on broadband wireless access system, analysis of demands, exploration of application modes, expansion of market, which greatly promote the development of broadband wireless access market. It is generally agreed that the IEEE 802.16 workgroup is the constitutor of the IEEE 802.16 WiMax air interface specification, while WiMax Forum is the propellant of technology and industry chain. Nowadays, WiMax is nearly another name of IEEE 802.16 WiMax technology, with the air interface specification covering IEEE 802.16d/e standards. Further many researcher do thw work on the wireless system. Abdulrahman Yarali, Saifur Rahman in 2008 [6] describes the overview of the forthcoming most promising wireless system WiMAX-Worldwide Interoperability for Microwave Access.

Mai Tran, George Zaggoulos, Andrew Nix and Angela Doufexi [7] describes the current demand of wireless communication system is to achieve highest capacity with lowest requirement of bandwidth and improved error rate Liangshan Ma, Dongyan Jia [8] analyses both the competitive and cooperative relationships between WiMAX, WLAN and 3G from various aspects such as technical standards, current status and future trends, etc. Abdulrahman Yarali Bwanga Mbula Ajay Tumula [9] identifies the cost effective, flexible 4th generation standard of IEEE i.e. WiMAX system which is becoming the perfect solution to meet the current demands of the future wireless networks thereby providing the tough competition to the existing 3G standards. Sassan Ahmadi, Intel Corporation [10] presents the thorough analysis of IEEE 802.16 architecture which is becoming the most popular 4G standard for the different mobile communication applications. The growing demand for mobile Internet and wireless multimedia applications has motivated the development of broadband wireless access technologies in recent years. Mobile WiMAX has enabled convergence of mobile and fixed broadband networks through a common wide-area radio-access technology and flexible network architecture. Hicham Yehia and Hany Kamal [11] discusses the effect of interference in the WiMAX network thereby analyzing the effect of the same on the capacity of the network. Due to imperfections at both the ends of the system i.e. at transmitter and at the receiver, the interference can occur which limits the system performance.

Raj Jain, Chakchai So-In, And Abdel-Karim Al Tamimi [12] basically deals with the analysis of one to one layer of the WiMAX network which is the very important issue from the view point of service providers and network developers. Nedeljko Cvejic and Seppanen, Tapio [13] illustrate that for the efficient and fruitful wireless communication, the virtual channel i.e. radio channel of propagation should be modeled properly.

Daniele Lo Iacono, Marco Ronchi, Luigi Della Torre, and Fabio Osnato[14] discuss that in today's world, the main goal of any system is to achieve highest system capacity with lowest error rate which is not possible with single transmitter and single receiving antenna because it can't overcome the effects of fading. Onsy Abdel Alim, Hiba S. Abdallah and Azza M. Elaskary [15] discuss two main issues. The first one presents models for simulating OFDM WiMAX system in Simulink including channel estimation and equalization subsystems in MATLAB functions. Next, the effect of channel estimation error on the performance of MIMO VBLAST receivers in uncorrelated Rayleigh flat fading channels is investigated.

Mohab Shalash, Tallal El Shabrawy and Waleed Diab [16] cover a thorough study of wideband frequency selective channels from the perspective of multi-carrier modulation system. Wideband communications systems suffer from frequency selective channels. Accordingly, 3G/4G systems have endorsed the concept of multi-carrier modulation such as OFDM and MC-CDMA, where the wideband channel is sub-divided into numerous subcarriers. Muhammad Nadeem Khan, Sabir Ghauri [17] discusses the model building of the WiMAX Physical layer using Simulink in MATLAB. This model is a useful tool for performance evaluation of the WiMAX standards 802.16e under the various parameters like carrier frequency, frequency bands, bandwidth, radio technology etc which have been mentioned. For this research work, this IEEE transaction will be the mile stone. Vahid Tarokh, Nambi Seshadr and A. R. Calderbank [18] basically includes the characterization of wide band wireless channel for the future wireless technologies along with the feature of antenna diversity

Tao Jiang and Weidong Xiang [19] describe Multimedia Multicast and Broadcast service (MBS) over wireless links, such as mobile TV and IP radio broadcasting. As one of the most promising enabling technologies, mobile WiMAX can offer scalability in both radio access and network architecture, thus providing important flexibility in terms of network services and deployment options.

Kamran Etemad [20] discusses the brief of Mobile WiMAX technology with the layered architecture and evolution. Mobile WiMAX combines OFDMA and advanced MIMO schemes along with flexible bandwidth and fast link adaptation, creating a highly efficient air interface that exceeds the capacity of existing and evolving 3G radio access networks.

Chengshan Xiao, Jingxian Wu, Sang-Yuck Leong and Yahong Rosa Zheng [21] presents a new discrete-time channel model for MIMO systems over space-selective (or spatially correlated), time-selective (or time-varying), and frequency-selective Rayleigh fading channels, which are referred to as triply selective Rayleigh fading channels. MIMO is the current trends in the modern cellular system towards achieving high data rate with low error rate.

Zakhia Abichar, Yanlin Peng and J. Morris Chang [22] include the brief of WiMAX and its layered architecture i.e. physical layer and MAC layer. The theoretical aspects presented in this chapter define the functioning as well features of MAC layer and Physical layer. The MAC layer of the WiMAX technology decides the quality of service and the algorithms related to error control while physical layer is responsible for data transfer with high capacity and low error rate.

H. Farhat, G. Grunfelder, A. Carcelen and G. El Zein [23] Illustrate that to improve data rates and to enhance the quality of the system for the future generation wireless systems, the most prominent solution is antenna diversity techniques i.e. MIMO. The referred reference paper gives the design of MIMO channel sounder utilized for the WiMAX technology. Onsy Abdel Alim, Nemat Elboghdadly, Mahmoud M. Ashour, Azza M. Elaskary [24] has building a System level model for a WiMAX Orthogonal Frequency Division Multiplexing based transceiver. OFDM technique theoretically saves the bandwidth about 50%. Modeling irradiation noise as an external effect added to the Additive White Gaussian noise (AWGN).

Mikko Majanen, Pekka H. J. Perala and Thomas Casey [25] describes that the demand for mobile internet access is continuing its growth at increasing speed. New wireless access technologies compete with each other at the global market and it is still unsure which one will be the winner. One of the most promising ones is WiMAX which is based on IEEE 802.16 air interface standard. Ibrahim A.Z. Qatawneh [26] represents the bit error rate performance comparison of AWGN channel and Rician fading channels by considering their application in multi carrier DE-APSK and single carrier DE-APSK system. Frequency flat Rayleigh fading is a typical channel model found in land mobile radio situations. Alireza Seyedi, Vasanth Gaddam, and Dagnachew Birru [27] represent performance analysis of OFDM UWB system with two antennas at the receiver side. Different antenna selection and combining methods, such as simple antenna selection, antenna selection per sub-carrier, equal gain combining and maximal ratio combining are considered. Shigenobu Sasaki Hisakazu Kikuchi Jinkang ZHU [28] discussed the performance of system over the type of frequency non-selective Rayleigh fading scenario. Fading and interferences are the two phenomenons that make the problem domain of modern wireless communication system most challenging and interesting. Koon Hoo Teo, Zhifeng Tao, and Jinyun Zhang [29] discussed the IEEE 802.16e Standards for Mobile WiMAX. This paper illustrates the implementation of frequency diversity technique for the high speech mobile service perspective. Also the comparison of WiMAX standards with WLANs and cellular is mentioned. More specifically this paper focused on the exploitation of technology in Mobile WiMAX standards. Rick S. Blum, *Senior*, Jack H. Winters and Nelson R. Sollenberger [30] discussed the benefits of transmitting the information through the multiple antennas over the fading channels. It also describes that the mutual information of a single, isolated, multiple transmit and receive antenna array link is exploited by transmitting the maximum number of independent data streams for a flat fading channel with independent fading coefficients for each path.

III DIVERSITY TECHNIQUES

In wireless communication radio waves traveling along different paths arrive at the receiver at different times with random phases and combine constructively or destructively as shown in Figure-1. Some of the signal components travel directly from transmitter to receiver in LOS path while the others will get obstructed by certain objects and then reach to the destination. According to their direction of arrival they form the various angles at the receiver and due to that the amount of received power is going to be altered.

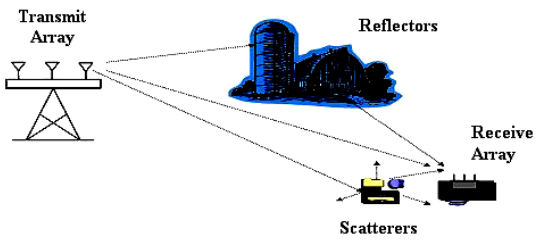

Figure-1: Wave propagations mechanism.

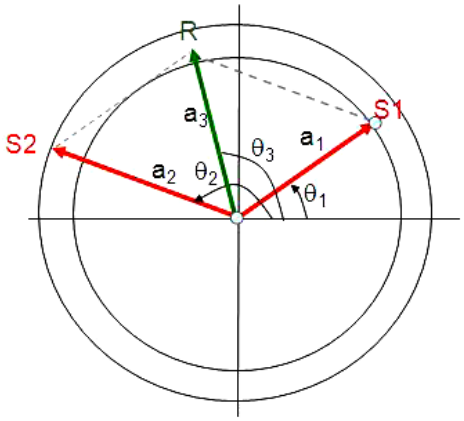

Figure-2: Multipath Components.

When two or more multipath components are with the same access delay bin arrive at the same time, the received signal is

the vector addition of two multipath signals. Let's assume that two signals S_1 and S_2 are arrived at the same time at the receiver and R is the combined signal at receiver.

$$S_1 = a_1 e^{j\theta_i} \quad \& \quad S_2 = a_2 e^{j\theta_2}$$

$$R = S_1 + S_2$$

$$R = a_1 e^{j\theta_1} + a_2 e^{j\theta_2} = a_3 e^{j\theta_3} \qquad [1]$$

The net result is a rapid fluctuation in the amplitude of the received signal in a short period of time or distance travelled known as fading. However, the large scale average path loss remains constant. Multipath propagation had previously been considered a problem, but now it is exploited to achieve higher capacity which is the central idea behind the development of diversity phenomenon.

In practice, diversity techniques can be applied in the space, frequency or time domains. Diversity over time can be obtained via coding and interleaving: information is coded and the coded symbols are dispersed over time in different coherence periods so that different parts of the code-words experience independent fades. Analogously, one can also exploit diversity over frequency if the channel is frequency-selective. In a channel with multiple transmit or receive antennas spaced sufficiently far enough, diversity can be obtained over space as well. In a cellular network, macro-diversity can be exploited by the fact that the signal from a mobile can be received at two base-stations. Since diversity is such an important resource, a wireless system typically uses several types of diversity. The following section illustrates the various types of diversity techniques.

1. Time Diversity

Time diversity means transmitting identical messages in different time slots as shown in Figure-3. This yields two uncorrelated signals at the receiving end. The same information symbol is repeatedly transmitted at different time slots with the hope that they will suffer independent fading and the receiver will combine them properly.

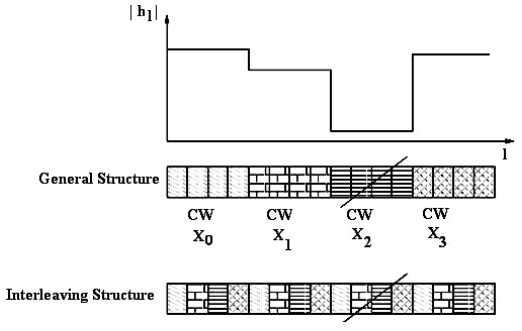

Figure-3: Transmission of code word: An example of time diversity

2. Frequency Diversity

To discuss about the concept of frequency diversity, consider first the one-shot communication situation when one symbol x[0] is sent at time 0, and no symbols are transmitted after that.

The receiver observes

$$y[1] = h_l[1]x[0] + w[1] \qquad l=1,2\ldots\ldots \qquad [2]$$

Let's assume that the channel response has a finite number of taps L, then the delayed replicas of the signal are providing L branches of diversity in detecting x[0], since the tap gains $h_l[1]$ are assumed to be independent. This diversity is achieved by the ability of resolving the multi-paths at the receiver due to the wideband nature of the channel, and is thus known as frequency diversity.

3. Antenna Diversity

Antenna diversity, or spatial diversity, can be obtained by placing multiple antennas at the transmitter and/or the receiver. If the antennas are placed sufficiently far apart, the channel gains between different antenna pairs fade more or less independently, and independent signal paths are created. The required antenna separation depends on the local scattering environment as well as on the carrier frequency. For a mobile which is near the ground with many scatters around, the channel de-correlates over shorter spatial distances, and typical antenna separation of half to one carrier wavelength is sufficient. For base stations on high towers, larger antenna separation of several to 10's of wavelengths may be required.

IV SIMULATION AND RESULT

How to deal with fading and with interference is central aim to the design of wireless communication systems, and by taking the advantage of multi-path fading and improving the system capacity and bit rate of 4G modern wireless system will be the fundamental objective of this research work**.** So in 4G transmission system, link reliability and maximum data throughput is the need for transmitting voice as well as image at high speed. Implementation of antenna diversity techniques along with OFDM technique is one of the promising solutions for this. But very few resources are available in which the modeling and critical comparative analysis of WiMAX system with antenna diversity such as Single Input Single Output, Single Input Multiple Output, Multiple Input Single Output and Multiple Input Multiple Output along with Alamouti coding has been done. Very few results for simulating and modeling of WiMAX system are available for real time data transmission (such as image and speech) to achieve the lower Bit Error Rates, higher Signal to Noise Ratio and higher system Capacity. The basic OFDM technique along with advanced antenna structure i.e. MIMO principle is used to increase the system capacity by reducing the effects of ISI. First of all, the simulation and performance analysis of OFDM technique will be carried out for the physical layer functioning of WiMAX system.

This section discuss the simulation model implemented by use in MATLAB environment to evaluate the BER and also

the analysis based on the eye diagram is presented here showing the characteristic of the inter symbol interference. Figure 5 shows the complete simulink model of the proposed WiMAX physical layer structure with MIMO scheme. Figure 5 shows the eye diagram of the Transmitter side and figure 6 shows the eye diagram at receiver side. The test is performing in 10MHz bandwidth with ¼ cyclic prefix for OFDM.

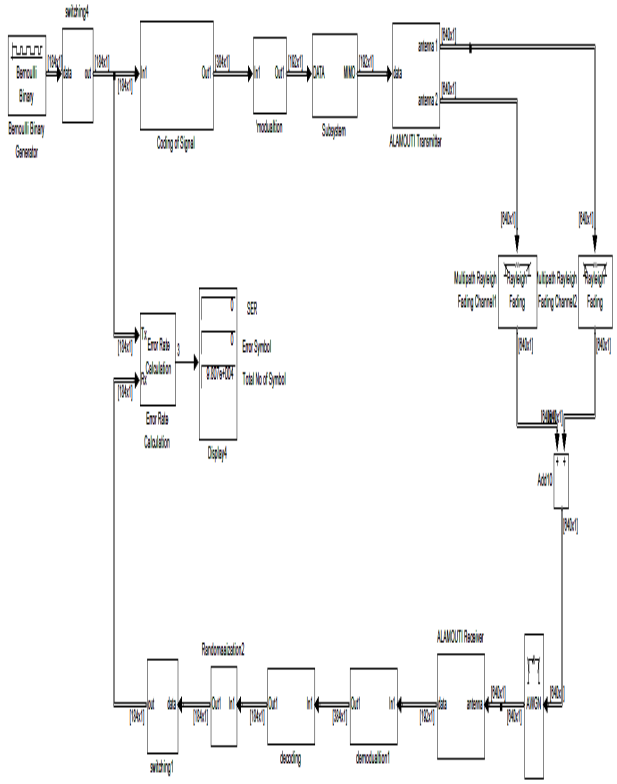

Figure-4: SIMULINK model of Proposed WiMAX System with MIMO.

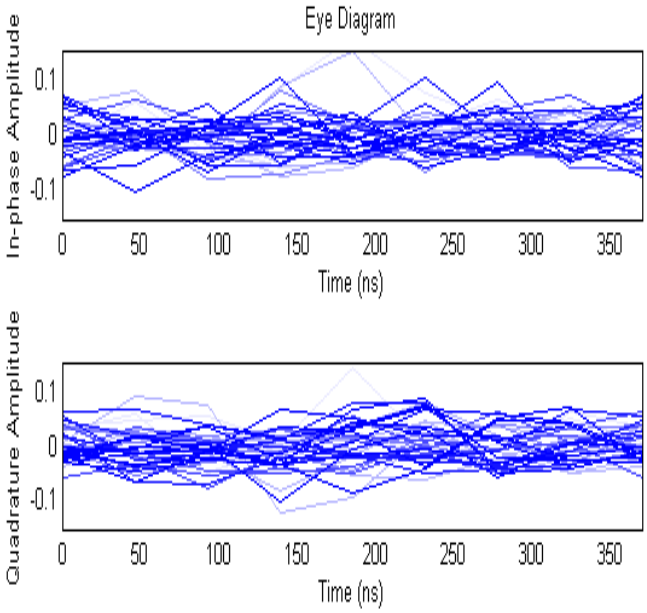

Figure-5: Eye Diagram of Transmitted signal.

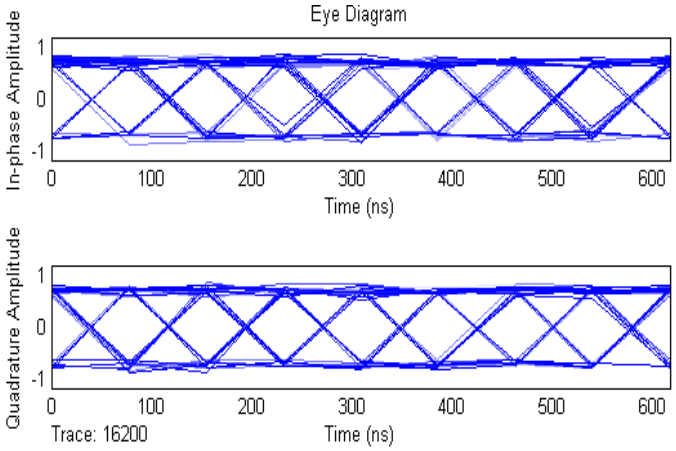

Figure-6: Eye Diagram of Received signal

V CONCLUSION

With the further development of the communication network, WiMax has major realistic significance and strategic value as a standard facing to "the last kilometer" access, especially when no globally uniform standard is established for broadband wireless access. This paper deals with the analysis of the most recent wireless networking technique. Despite being a nearly 50-year-old concept, it is only in the last decade that OFDM becomes the modem of choice in wireless applications. One of the biggest advantages of an OFDM modem is the ability to convert dispersive broadband channels into parallel narrowband sub channels, thus significantly simplifying equalization at the receiver end [4].

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