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BER Performance Analysis of WiMax MIMO System Under Different Channel Conditions

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Abstract— High speed and high quality communication is the requirement of users in the public environment for transmission of different forms of data. WiMax technology is able to provide the data at high communication rate and with higher bandwidth. The incorporation of MIMO technique in WiMax system not only provide robust platform to fading but boost up the system performance. In this paper, 2×2 WiMax MIMO architecture is simulated with specification of different modulation techniques (64-QAM,BPSK) and for different fading channels (Rayleigh, AWGN) by using MATLAB. The analysis results are generated in terms of BER rate. The simulation results identified that the communication in WiMax MIMO is achieved at lower BER rate.

Keywords— WiMax, MIMO, Rayleigh, AWGN, Modulation Scheme, BER

I. INTRODUCTION

WiMAX, an acronym of Worldwide Interoperability for Microwave Access , is a emerging technology 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. 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.

WiMax Network

WiMax network is one of the most adaptive network reference model defined to provide textual, voice and video communication. The network is deployed with placement of base stations and antenna to control the communication. These controllers are defined with relative characterization, load strength and the communication characterization. The network architecture is illustrated with specification of IP address and with the specification of various associated components. The components of this communication architecture and the architectural description of the network is defined in this section. The generalized communication architecture of WiMax technology is shown in figure 1. It consists of mobile station,base station, Access Service Network,ASN Gateway and Connectivity service network.ASN forms the radio access network at the edge and consists of one or more BS and ASN-GW.CSN is maintain by network service provider and support IP connectivity .

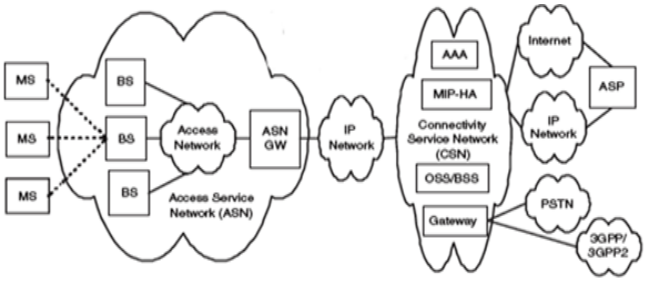

Figure 1. WiMax Architecture

The architectural formulation of WiMax network is defined with flexible decomposition and specification of fix road side units. These road side units and the associated base stations are defined with specific coverage to enable the effective communication in the region. These physical entities are responsible to provide the seamless communication with adaption to different data forms. Each of the associated WiMax components or units are defined with functional description. The decomposition of these components is defined in terms of actual base station controllers (BSC), base station Transceivers (BTS) and the Access service network gateways (ASN-GW). The communication architecture is also able to provide the effective communication between mobile nodes of same region as well as inter-region. The gateway components and features are described as integrated form or as separate elements to provide the effective communication. Serving GPRS Support Node (SGSN) is defined to provide the intermediate support for any component. The coverage enhancement, single strength improvement and the clustered communication can be improved using these support nodes.

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.

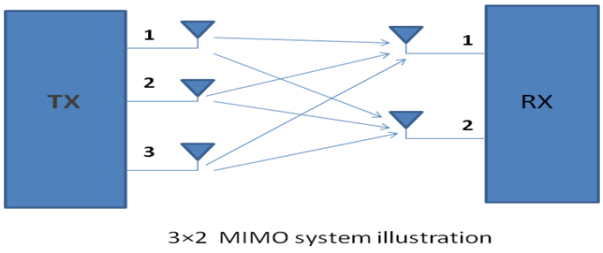

Figure 2. MIMO System Illustration

MIMO systems can be employed in various ways , such as BLAST ,described by [5,6], space time coding [7,8] and many more. In 1998,Siavansh Alamouti described Alamouti space time block code [9] 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[8]. 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 maintenance of isolation characteristics between antennas.

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 [10].

The overlay of this paper is : Section 1 gives brief introduction to WiMax system, its network architecture and MIMO techniques, Section 2 contains the literature review, Section 3 explains the methodology used, Section 4 describes the results and discussion and Section 5 contains the conclusion.

II. LITERATURE REVIEW

Author [11] has defined a mathematical model to polarize the orthogonal signal for WiMax MIMO system. The simulation work is performed on multipath fading channels based on IEEE 802.16 channel models. The polarization of orthogonal antennas was provided to control the polarization decoupling in limited capacity. The mathematical model was defined to control the transmission and retrieval through antennas. The effect of channel degradation was also observed by the author.

Author [12] has provided a physical layer based simulation system for WiMax MIMO-OFDM system. The control through physical layer and combination of data rate and coverage were observed by the author. The physical layer modifications were provided in terms of Space Time block codes and the spatial fading.

Author [13] has analyzed the performance of MIMO for mobile WiMax respective to QoS (Quality of Service) aspects. Author observed various applications and services of mobile WiMax communication. The paper has provided

the analysis for TCP application in terms of throughput, operating range and performance ratio. The cross layer interaction and the scheduling behaviour of the MAC layer were also discussed by the author

Author [14] has defined the WiMax measurement for Line-of-Sight characterization of communication over the channel. The performance of physical layer was addressed by the author respective to the MIMO measurement. The spatial multiplexing and home environment based communication control architecture was discussed in this paper.

Author [15] has observed the performance of mobile WiMax MIMO for both uplink and downlink communication. The broadband wireless access (BWA) was defined to control the cost and to provide the flexible communication in the network. The mobile WiMax system is defined with relative problem and recent issues.

Author [16] has defined the LDPC channel encoding based ICI (Intercarrier Interference) cancellation in MIMO OFDM WiMax system. The potential cause of deterioration of service quality was observed for high speed data communication and encoding. The interactive parallel interference with channel interference analysis were observed to improve the data correction rate and to reduce the error occurence in the system.

Author [17] has proposed the cooperative Multiple Input Multiple Output (MIMO) system to use the amplify and forward relaying strategy in the communication architecture. The simultaneous and cooperative diversity of the system was observed under the interoperability of the microwave access of the system.

Author [18] has analyzed the performance of Multiuser-MIMO for mobile WiMax system. The system was defined for effective downlink and transmission with specification of 6 antennas and receivers with 2 antenna. The block based diagonalization algorithm was defined to reduce the number of interferences in the system.

Author [19] has defined an applied MIMO based Hadamard transform model for WiMax system. The model was defined at two points of constellation to control the transmission and to reduce the error rate in the system. The analysis was conducted in terms of BER ratio which identified the significant reduction in error rate for 64-QAM based modulated communication

Author [20] has used the LDPC coding for MIMO system under Rayleigh channel. The mobile WiMax system was defined with support of high data rate and capacity constraints. The robust platform was provided under different selective fading conditions to increase the data rate and performance of communication system. The Rayleigh channel based communication technique was defined to improve the communication for WiMax network.

Author [21] has generated the encoded signal code for MIMO system for mobile WiMax network. The signals were encoded using Orthogonal space time block coding method. The paper has investigated the channel specific communication using STBC-MIMO system.

Author [22] has defined a performance analysis system for uplink MIMO system for 2x2 mobile WiMax system. The frequency domain based access method was analyzed under the real time fading channel specification. The broadband access with mobility support was discussed to defined the constraints for 4G requirements of the WiMax network. The MIMO technique was defined for different link forms and availability of the channel features.

Author [23] has defined a virtual MIMO system for WiMax relay system to improve the communication. The single antenna based relay system was defined to get the benefit of diversity gain. As the number of relay nodes were increased in the system, the effect and performance of the system was observed in this paper.

III. METHODOLOGY USED

In today's scenario, high speed data delivery and quality communication are the major requirements of any network. There are various real time networks and critical scenarios where such requirements are more challenging. WiMax is one such network technology that is capable to provide the higher bandwidth, high capacity communication at higher data rate. The MIMO (Multiple Input Multiple Output) with WiMax is capable to share the available bandwidth and channel with large number of users. This architecture is able to provide the better and reliable communication as per user requirement. In real environment, this kind of communication also suffers from different kind of noise and channel fading. The stages and the work exploration with specification of structural features and stages are provided in figure 3.

The presented work is defined to define a high speed and high quality communication system for multiple users in the architecture. The MIMO system is defined to utilize and distribute the available channel among available number of users with specification of different communication and channel features. The model is defined with specification of network system, channel specific and signal specific components and process stages. The channel is also affected by noise and the fading vector. The effectiveness of the data quality is observed under the existence of these fading vectors. The stages and the work exploration with specification of structural features and stages are provided in figure 3.

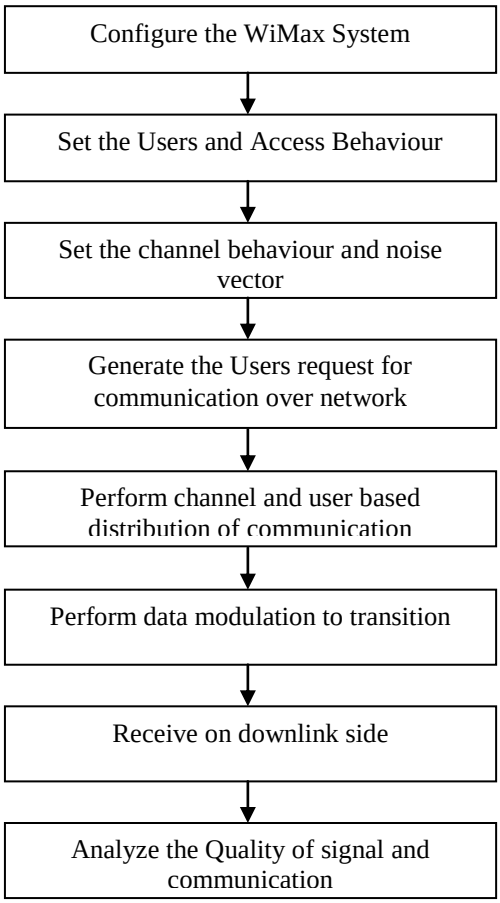

Figure 3. WiMax MIMO Architecture Set Up

Figure 3 has defined the communication architecture for WiMax MIMO system in existence of noise and channel fading. The model is able to provide the effective channel sharing to improve the downlink rate by utilizing the communication and channel features in effective way. Figure 3 has provided complete specification of the communication behaviour considered in this work. At the earlier stage of this model, the configuration of WiMax system is provided with specification of communication rate, antenna features etc. After setting up high level features, the channel features are also defined including the number of carriers, subcarriers, channel etc. The fading type and modulation type features are also defined. The number of users are defined to observe the parallel access of the system in the environment. Now as the request is performed, the architectural behaviour is performed in sequence to perform the data access and downlink in the environment.

Once all the configuration is done at network level, channel level and communication level and data request is generated, the communication is performed by following the subsequent process stages. At the earlier stage, the data is divided in smaller blocks. The adaptive modulation and encoding is performed during the data uplink. In this work, BPSK and QAM modulations are performed for modulation. The work stages for signal generation and communication control are also defined in this section. The communication is performed on the noise and fading affected channel. As the downlink is performed at the receiver side, the received data is compared with actual to observe the error rate.

In this research, four different models are generated for WiMax MIMO system with modulation and fading channel variations which are shown in figure 4,5,6,7. These models are defined with the following associated parameters:-

Table 1. Parameters of model design

Parameters	Values
Sample Time	4e-6/144
Samples Per Frame	144
Modulation	64-QAM ,BPSK
FFT Size	1024
Simulation Time	1S
Buffer Size	80
Channel	Rayleigh, AWGN

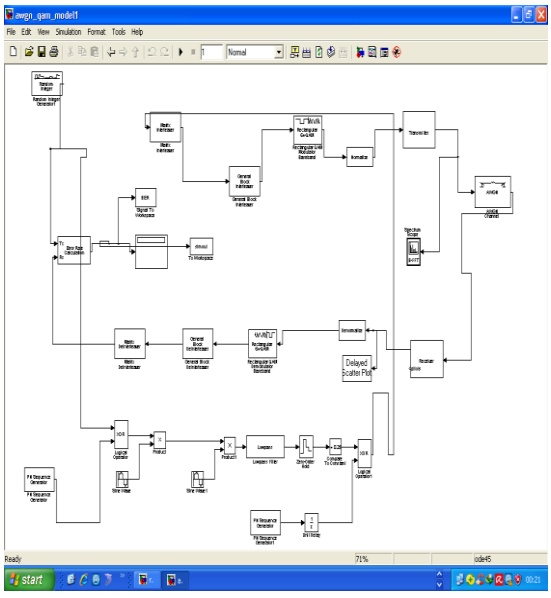

Figure 4. QAM Modulated WiMax MIMO Architecture (AWGN)

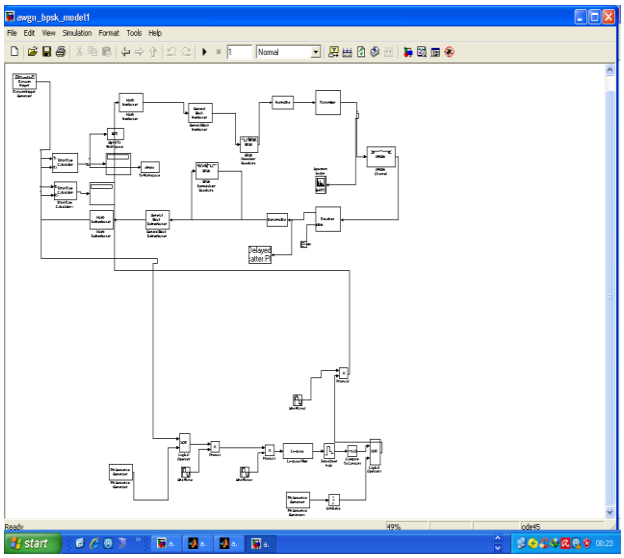

Figure 5. BPSK Modulated WiMax MIMO Architecture (AWGN)

The architecture is having the two main splits of transmitter and receiver phase. Each of the integrated architectural stage to the system are defined in the form of separate blocks. The transmitter block goes through the series of stages including the padding, IFFT and cyclic prefix stages. The transmitter phase is common for each modulation and fading channel. The transmission in this work is performed on the multi-carrier system. The integrated stages of the receiver side are in reverse order to that of the transmitter side.

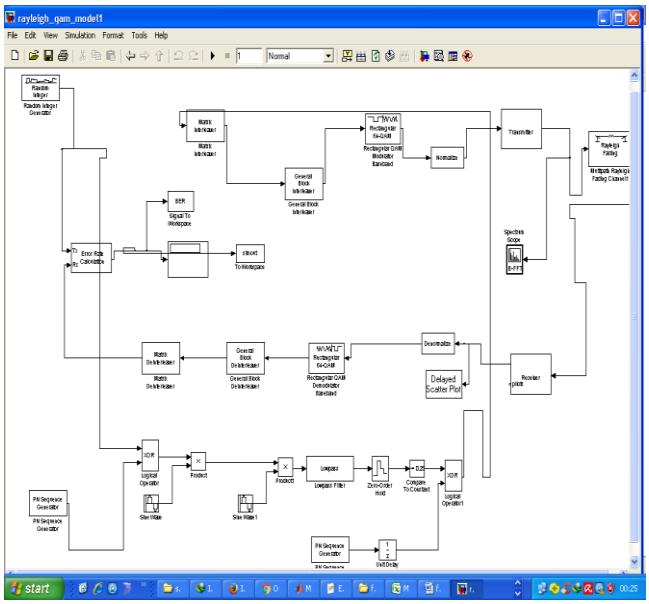

Figure 6. QAM Modulated WiMax MIMO Architecture (Rayleigh Fading)

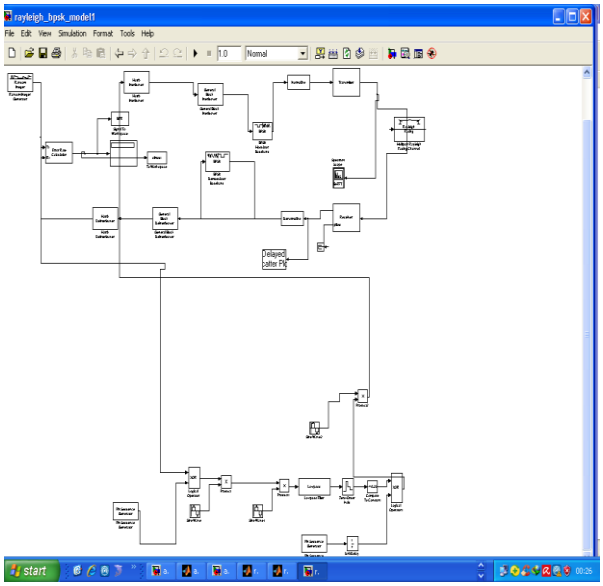

Figure 7. BPSK Modulated WiMax MIMO (Rayleigh Fading)

IV. RESULTS AND DISCUSSION

In this present work, an analytical observation of MIMO communication system is provided for different modulations and fading channels. The communication system is here defined for 2x2 users and with specific modulation. The fading channel considered in this communication system are AWGN and Rayleigh affected. The evaluation is performed in terms of BER rate analysis for SNR values between 2 to 10 . The results for BER rate analysis for AWGN with QAM modulation scheme are provided in figure 8.

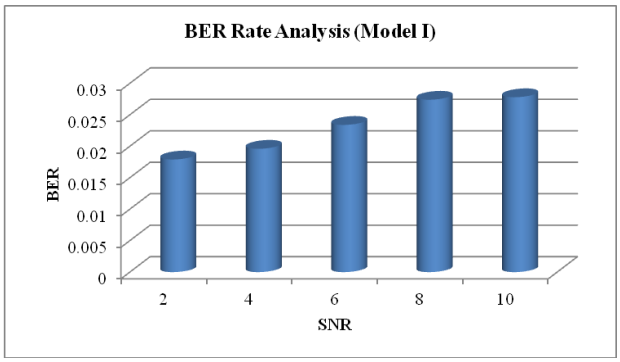

Figure 8. BER Rate Analysis (AWGN)

Figure 8 is showing the analytical results for BER evaluation for different SNR values under AWGN channel with 64- QAM modulation scheme. With SNR=10 , BER obtained is much more than that with SNR=6. Also, the results identified that the maximum BER ratio is even less than 0.03.It shows that the model has achieved the higher

accuracy. The results for Rayleigh fading channel with QAM modulation are provided in figure 9.

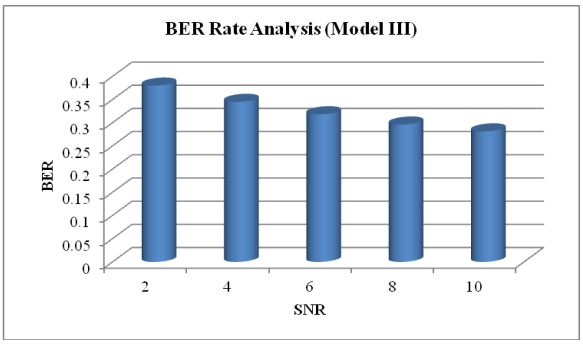

Figure 9. BER Rate Analysis (Rayleigh)

Figure 9 is showing the analytical results for BER evaluation for different SNR values under Rayleigh fading channel with QAM modulation scheme. The results identified the maximum BER ratio is approximately 0.35 which shows that model has achieved higher accuracy.

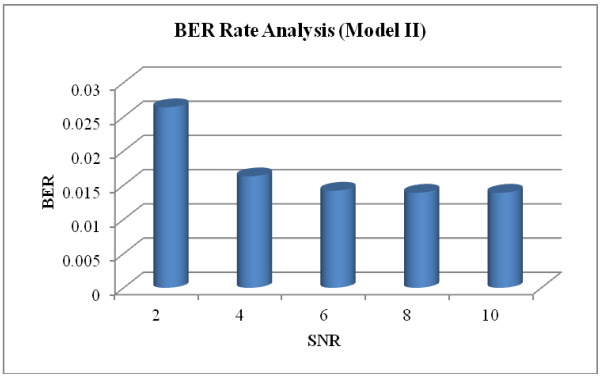

Figure 10. BER Rate analysis (AWGN)

Figure 10 shows the analytical results for BER evaluation for different SNR values under AWGN channel with BPSK modulation scheme. As SNR value increases BER ratio decreases for model II. The results identified the maximum BER ratio is even less than 0.03 which shows that the model has achieved much higher accuracy.

The results for Rayleigh channel with BPSK modulation scheme is provided in figure 11. The results obtained shows that maximum BER ratio is approximately 0.35 for model IV which shows that model has achieved higher accuracy.

For both 64-QAM and BPSK modulation scheme, the maximum BER ratio obtained with Rayleigh channel is much higher than that obtained with AWGN channel. This shows that WiMax MIMO system has better BER performance with AWGN channel as compared to Rayleigh channel.

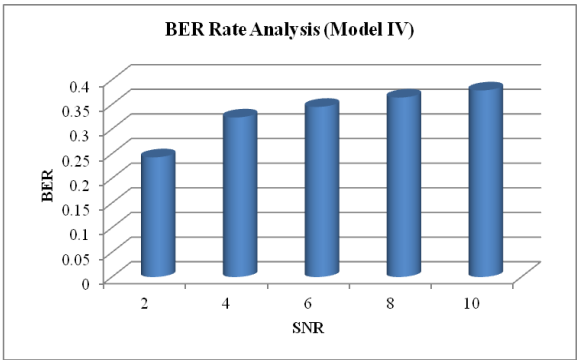

Figure 11. BER Rate analysis (Rayleigh)

V. CONCLUSION

WiMax MIMO system is one such communication architecture that can fulfil the user requirement upto some extent. The architecture is able to provide better utilization of available network resources and channel capabilities and reduce the error rate in noisy and fading channel. The model is simulated in this work in simulink environment to explore each of the communication stages. The architecture is defined with specification of users, channel type, modulation type and channel fading. The results identified that the significant BER occur when the configuration is provided in effective way for WiMax MIMO system. Also it is identified that WiMax MIMO system has better BER performance with AWGN channel as compared to Rayleigh channel.

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