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WiMAX model Performance Analysis and Design in Fading Channel

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Abstract: Transmit Antenna Selection (TAS) is vital piece of future remote frameworks to lessen the unpredictability of various antenna procedures and to fulfill the need of higher information rates. In this paper, we show TAS method in light of Maximal Ratio Combining (MRC) plan with different antenna choice. The imperfect antenna determination is completed for selecting more than one subset of recieving antenna which minimizes the upper bound of pair astute blunder likelihood. The objective of the paper to study the Rayleigh and Nakagami-m fading channel to determine the single user multi-antenna and multi-user antenna selection and also to find the average signal to noise ratio (SNR) and outage probability through Nakagami-m fading channel as to vary L (selection), y^{th} (Threshold) and y (SNR) or constant y^{th} (Threshold) and to determine the error performance(bit error rate performance) of BPSK,QPSK and 8PSK (Through RAYLEIGH AND Nakagami-m fading channel)

Keyword: Fading Channel, Nakagami, SNR, and TAS.

1. Introduction:

Worldwide Interoperability for Microwave Access (WiMAX) is an emerging global broadband wireless system based on IEEE 802.16 standard. It is a new wireless OFDM-based technology that provides high quality broadband services long distances based on IEEE.802.16 wireless (Metropolitan Area Network) MAN air interface standard to fixed, portable and mobile users [1,2]. WiMAX promises to combine high data rate services with wide area coverage (in frequency range of 10 – 66 GHz (Line of sight) and 2 -11 GHz (Non-Line of Sight)) and large user densities with a variety of Quality of Service (QoS) requirements. WiMAX can provide broadband wireless access (BWA) up to 30 miles (50 km) for fixed station and 3 to 10 miles (5-15 km) for mobile stations with theoretical data rates between 1.5 and 75 Mbps per channel. The new standards for WiMAX are being developed for expanding the mobility further with enhanced coverage, performance and higher data rates (of the order of 100 Mb/s) in a WiMAX Network. The WiMAX standard air interface includes the definition of both the medium access control (MAC) and the physical (PHY) layers for the subscriber station and base station while the access network operability is defined by the WiMAX Forum, an organization consisting of operators and component and equipment manufacturers. As the primary function of WiMAX PHY layer is the actual physical transportation of data. The main performance becomes more challenging when mobile environments are encountered in wireless channel. In order to achieve maximum performance at low BER, high data rate transmission (both in fixed and mobile environments) and high spectral efficiency with variety of QoS needs IEEE 802.16d/e standard supports variety of PHY layer mechanisms with a variety of features. The flexibility of the PHY enables the system designers to tailor their system according to their requirements.

WiMAX is next generation broadband wireless technology it provides high speed, secure, sophisticate broadband services .The evolution of WiMAX began with the requirement of having a wireless Internet access and other broadband services which can work well in rural areas or in areas where it is hard to establish wired infrastructure and economically not feasible. IEEE 802.16, also known as IEEE Wireless-MAN is standard of fixed wireless broadband and included mobile broadband application. WiMAX forum, established in 2001 to coordinate the components and develop the equipment those will be compatible and inter operable. In 2007, Mobile WiMAX equipment developed with the standard IEEE 802 16e [5] got the certification and released the product in 2008, providing mobility and nomadic access. The IEEE 802.16e was based on Orthogonal Frequency Division Multiple Access (OFDMA) can give better performance in non-line-of-sight environments. IEEE 802.16e introduced scalable channel bandwidth up to 20 MHz, Multiple Input Multiple Output (MIMO) and AMC enabled 802.16e technology to support peak Downlink (DL) data rates up to 63 Mbps in a 20 MHz channel through Scalable OFDMA (S-OFDMA) system [2]. It has strong security architecture as it uses Extensible Authentication Protocol (EAP) for mutual authentication, a series of strong encryption algorithms, CMAC or HMAC based message protection and reduced key lifetime [4].

The goal of this thesis is to implement and MIMO system Physical layer specification by following IEEE 802.16e-2005 Using Adaptive decision control techniques we analyse the performance of MIMO system physical layer in mobile WiMAX based on the simulation results of Bit-

Error-Rate (BER), Signal to Noise Ratio (SNR) and Probability of Error (Pe).

The objective of the project to study the Rayleigh and Nakagami-m fading channel to determine the single user multi-antenna and multi-user antenna selection and also to find the average signal to noise ratio (SNR) and outage probability through Nakagami-m fading channel as to vary L (selection), y^{th} (Threshold) and y (SNR) or constant y^{th} (Threshold) and to determine the error performance(bit error rate performance) of BPSK,QPSK and 8PSK (Through RAYLEIGH AND Nakagami-m fading channel).

2. Literature Review:

The WiMAX forum is based on 802.16d/e Orthogonal Frequency Division Multiplexing (OFDM) based adaptive Physical Layer (PHY) layer. In this paper, the performance of WiMAX PHY layer is investigated for two PHY layer modifications, link adaption algorithm (Adaptive Modulation and coding, AMC) and MCCDMA (hybrid OFDM system with multiple access technology, Code Division Multiple Access) to provide high suppression against multipath fading , provide high bandwidth efficiency, high throughput with high data rates for mobile environments. The results obtained for these modifications show that these mechanisms enhance the performance of the PHY layer in mobile environments with lower BER and high spectral efficiency.

Here, performance evaluation of WiMAX system is discussed with channel estimation in flat fading condition. Modulation technique used are BPSK (Binary Phase Shift Keying), QPSK (Quadrature Phase Shift Keying), 16QAM (Quadrature Amplitude Modulation) and 64 QAM.

Channel estimation based on fuzzy logic system is discussed which finds the type of channel and type of fading, e.g. slow/fast and flat/frequency selective fading channel. The speed of the mobile unit determines the channel fading rate and the Doppler spread, which is directly related to coherence time of the channel [11]. To minimize the multipath fading effect we have designed WiMAX models with different IQ mapping schemes. The preferred IQ mapping schemes are BPSK1/2, QPSK1/2, QPSK3/4 and QAM 16.For each IQ mapping simulink models are designed along with channel estimation subsystem.

WiMAX is introduced by the Institute of Electrical and Electronic Engineers (IEEE) which is standard designated 802.16d-2004 (used in fixed wireless applications) and 802.16e-2005 (mobile wireless) to provide a worldwide interoperability for microwave access. At present, telecommunication industries are highly concerned with the wireless transmission of data which can use various transmission modes, from point- to-multipoint links. It contains full mobile internet access. Various applications have already been applied so far using WiMAX, as alternative to 3G mobile systems in developing countries, Wireless Digital Subscriber Line (WDSL), Wireless Local Loop (WLL). IEEE 802.16e-2005 has been developed for mobile wireless communication which is based on OFDM technology and this enables going towards the 4G mobile in the future. In this thesis work, we built a simulation model based on 802.16e OFDM-PHY baseband and demonstrated in different simulation scenarios with different modulation techniques such as BPSK, QPSK and QAM (Both 16 and 64) to find out the best performance of physical layer for WiMAX Mobile. All the necessary conditions were implemented in the simulation according to the 802.16e OFDMA-PHY specification. The noise channel AWGN, Rayleigh fading, SUI, data randomization techniques, FFT and IFFT, and Adaptive modulation is used for the whole simulation procedure. The performance has been concluded based on BER, SNR and Pe output through MATLAB Simulation.

The channel estimation subsystem extracts the pilot data inserted before transmission and compare with original pilot data. In course of comparison the estimator calculates the change in gain and phases of pilot symbols and from these estimated values the gain and phase of data is adjusted.

Mehboob Ul Amin et al (2013) worked on Multiple-Input Multiple-Output Orthogonal Frequency Division Multiplexing (MIMO-OFDM) which is an attractive air-interface solution for next generation wireless local area networks (WLANs), wireless metropolitan area networks (WMANs), and fourth generation mobile cellular wireless systems. However one of the main disadvantage associated with MIMO-OFDM systems is the high peak-to-average power ratio (PAPR) of the transmitter's output signal on different antennas. High Peak to Average Power Ratio (PAPR) for MIMO-OFDM system is still a demanding area and difficult issue. So far numerous techniques based on PAPR reduction have been proposed. In this work a new technique based on the combination of Orthogonal Space Time Block Code (OSTBC) Encoder and Discrete Cosine Transform based Selective Level Mapping as method of PAPR reduction technique has been proposed and simulated. The results have been verified in terms of various graphs and plots and are compared with earlier results of embedded transform techniques. Simulations show that better results are obtained in the proposed technique [19]

Mr. Apoorva Pandey et al (2013) proposed an algorithm for wireless communication fading of channels is the serious cause of the received degraded signals. The effect of fading can be minimized by using various time and space domain techniques. However, space domain techniques are preferred over the others due to its advantages. In this work, comparison of the wireless MIMO system under Almouti‘s and maximum ratio combining schemes is presented. Basic idea in these schemes is to transmit and receive more than one copy of the original signals. Using two transmitter antennas and one receiver antenna, the scheme provides the nearly same diversity order as the maximal-ratio receiver combining (MRRC) with one transmitter antenna, and two receiver antennas. Results for one transmitter and four receivers under MRRC is also presented and compared. Finally, results are presented while varying the average transmitted power [20].

3. Methodology:

Some decades ago, both the sources and transmission system were on analog format but the advancement of technology made it possible to transmit data in digital form. The data payload capacity and transmission rate increased from kilobit to gigabit due to increase in speed of computers [3]. From wire to wireless concept emerged and researchers get success to invent wireless transmitter to transmit data. Applications like voice, internet access, instant messaging, SMS, paging, file transferring, video conferencing, gaming and entertainment etc became a part of life. Wireless technology provided higher throughput, immense mobility, longer range, robust backbone to thereat. The vision extended a bit more to provide smooth transmission of multimedia anywhere with variety at low cost and flexibility even in odd environment.

Wireless Broadband Access (WBA) via DSL, T1-line or cable infrastructure is not available in rural areas. The DSL can covers only up to near about 18,000 feet (3 miles), that is why many urban, suburban, and rural areas cannot be served by WBA. The Wi-Fi standard broadband connection may solve this problem a bit but it has coverage limitations. But the Metropolitan-Area Wireless standard which is called WiMAX can solve these limitations [4].

3.1 Diversity Concept:

As mentioned above, diversity combining consists of receiving redundantly the same information-bearing signal over two or more fading channels, then combining these multiple replicas at the receiver in order to increase the overall received SNR. The intuition behind this concept is to exploit the low probability of concurrence of deep fades in all the diversity channels to lower the probability of error and of outage. These multiple replicas can be obtained by extracting the signals via different radio paths:

- In space by using multiple-receiver antennas (antenna or site diversity)
- In frequency by using multiple-frequency channels separated by at least the coherence bandwidth of the channel (frequency hopping or multicarrier systems)
- In time by using multiple time slots separated by at least the coherence time of the channel (coded systems)
- Via multipath by resolving multipath components at different delays (direct sequence spread-spectrum systems with RAKE reception)

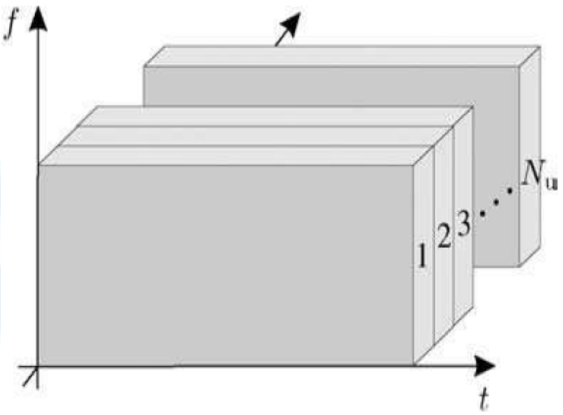

Fig 1: Space Diversity

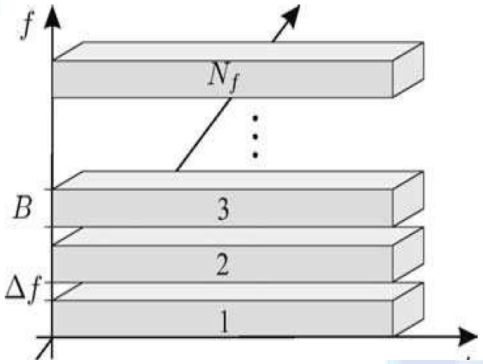

Fig 2: Frequency Diversity

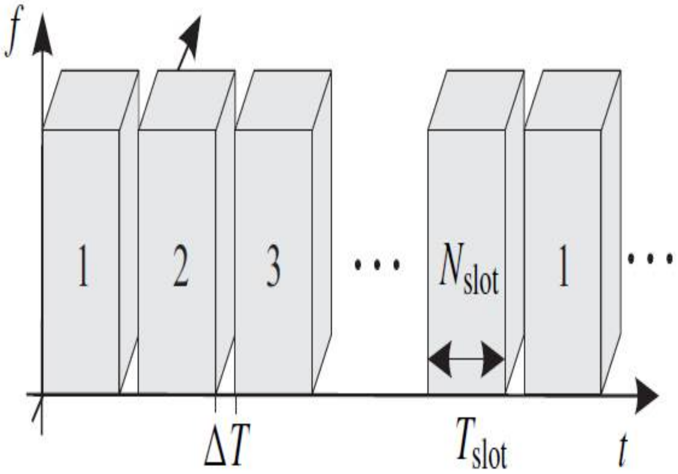

Fig. 3: Time Diversity

3.1.1 Brief Survey of Diversity Combining Techniques

Diversity techniques can be first classified according to the nature of the fading that they are intended to mitigate. For instance, micro diversity schemes are designed to combat short-term multipath fading whereas macro diversity techniques mitigate the effect of long-term shadowing caused by obstructions such as buildings, trees, and hills. Diversity schemes can also be classified according to the type of combining employed at the receiver. At this point, we should distinguish the classical “pure” combining schemes [1] from the more recently proposed “hybrid” techniques.

3.1.1.1 Pure Combining Techniques:

There are four principal types of combining techniques that depend essentially on the (1) complexity restrictions put on the communication system and (2) amount of channel state information (CSI) available at the receiver.

Maximal-Ratio Combining (MRC)

In the absence of interference, MRC is the optimal combining scheme (regardless of fading statistics) but comes at the expense of complexity since MRC requires knowledge of all channel fading parameters. Since knowledge of channel fading amplitudes is needed for MRC, this scheme can be used in conjunction with unequal energy signals, such as M-QAM or any other amplitude/phase modulations. Furthermore, since knowledge of channel phases is also needed for MRC, this scheme is not practical for differentially coherent and noncoherent detection. Indeed, if channel phase estimates are obtained, then the designer might as well go for coherent detection, thus achieving better performance.

Equal Gain Combining (EGC)

Although suboptimal, EGC with coherent detection is often an attractive solution since it does not require estimation of the fading amplitudes and hence results in a reduced complexity relative to the optimum MRC scheme. However, EGC is often limited in practice to coherent modulations with equal energy symbols (M-ary PSK signals). Indeed, for signals with unequal energy symbols such as M-QAM, estimation of the path amplitudes is needed anyway for automatic gain control (AGC) purposes, and thus for these modulations MRC should be used to achieve better performance [3].

Selection Combining (SC)

The two former combining techniques (MRC and EGC) require all or some of the CSI (fading amplitude, phase, and delay) from all the received signals. In addition, a separate receiver chain is needed for each diversity branch that adds to the overall receiver complexity. On the other hand, SC-type systems only process one of the diversity branches. Specifically, in its conventional form, the SC combiner chooses the branch with the highest SNR. In addition, since the output of the SC combiner is equal to the signal on only one of the branches, the coherent sum of the individual branch signals is not required. Therefore, the SC scheme can be used in conjunction with differentially coherent and noncoherent modulation techniques since it does not require knowledge of the signal phases on each branch as would be needed to implement MRC or EGC in a coherent system.

Switched Combining

For systems that use uninterrupted transmission, such as frequency-division multiple-access systems, SC in its conventional from may still be impractical since it requires the simultaneous and continuous monitoring of all the diversity branches. Hence SC is often implemented in the form of switched or scanning diversity, in which, rather than continually picking the best branch, the receiver selects a particular branch until its SNR drops below a predetermined threshold. When this happens the receiver switches to another branch. There are different variants of switched combining [8], but in its simplest form the switch-and-stay combining (SSC) receiver switches to, and stays with, the other branch regardless of whether the SNR of that branch is above or below the predetermined threshold [9,10]. SSC diversity is obviously the least complex diversity scheme to implement and can be used in conjunction with coherent modulations as well as noncoherent and differentially coherent ones.

3.1.1.2 Hybrid Combining Techniques:

Because of additional complexity constraints or because of the potential of a higher diversity gain with more sophisticated diversity schemes, newly proposed hybrid techniques have been receiving a great deal of attention in view of their promising offer to meet the specifications of emerging wideband communication systems. These schemes can be categorized into two groups: (1) generalized diversity schemes and (2) multidimensional diversity techniques.

Generalized Diversity Techniques

The complexity of MRC and EGC receivers depends on the number of diversity paths available, which can be quite high, especially for multipath diversity of wideband CDMA signals. In addition, MRC is sensitive to channel estimation errors, and these errors tend to be more important when the instantaneous SNR is low. On the other hand, SC (or switched combining) uses only one path out of the L available multipaths and hence does not fully exploit the amount of diversity offered by the channel. As a tradeoff, a wave of papers have been published bridging the gap between these two extremes (MRC/EGC and SC) by proposing GSC that adaptively combines (as per the rules of MRC or EGC) the Lc strongest (highest SNR) paths among the L available ones. We denote such hybrid schemes as SC/MRC or SC/EGC-Lc/L. In the context of coherent wideband CDMA systems, these schemes offer less complex receivers than do the conventional MRC RAKE receivers since they have a fixed number of fingers independent of the number of multipaths. More importantly, SC/MRC was shown to approach the performance of MRC, while SC/EGC was shown to outperform in certain cases conventional post-detection EGC since it is less sensitive to the "combining loss" of the very noisy (low-SNR) paths [11].

Multidimensional Diversity Techniques

Multidimensional diversity schemes involving the combination of two or more conventional means of realizing diversity (e.g., space and multipath) to provide better performance have received a great deal of attention. For example, in the context of wideband CDMA they are implemented in the form of two-dimensional (2D) RAKE receivers consisting of an array of

antennas, each one followed by a conventional RAKE receiver. Furthermore, these schemes can take advantage of diversity from frequency and multipath as is the case in multicarrier RAKE CDMA systems [12] or from Doppler and multipath as proposed recently by Sayeed and Aazhang [13]. Composite microscopic–macroscopic diversity can also be viewed as a two-dimensional diversity scheme. This type of diversity is used is systems originally proposed by Cox et al. [14] in conjunction with universal digital portable communications. These systems consist of several access ports (base stations) that continually track a mobile terminal. Each access port contains a multielement antenna array that employs microdiversity to reduce the effects of multipath fading. Macrodiversity is then performed at the output of the different access ports to mitigate the effects of shadowing. Two dimensional diversity can be generalized to multidimensional diversity by simultaneous exploitation of, for example, space, frequency, and multipath diversity.

3.2 Multiple Antenna Technique:

we dealt mainly with receiver diversity systems such as the ones consisting of a single antenna at the transmitter and multiple antennas at the receiver. However, applications in more recent years have become increasingly sophisticated, thereby relying on the more general multiple-input/multipleoutput (MIMO) antenna diversity systems, which promise significant increases in system performance and capacity. In this context, Tse et al. derived the joint MRC weights at both mobile unit and base station over fading channels, and the performance of the resulting MIMO MRC system was analyzed over Rayleigh and Rician fading. In what follows, we first briefly describe MIMO MRC systems, then summarize the analytical approach developed, which extends the Khatri distribution of the largest eigenvalue of central complex Wishart matrices to the noncentral case, and finally apply this new result to the performance analysis of MIMO MRC systems over Rician fading channels. The resulting expressions are obtained in terms of generalized hypergeometric functions, generalized Marcum Q-functions, modified Bessel functions, or incomplete gamma functions. These expressions are also compared to the special cases dealing with the outage probability of MIMO MRC systems over Rayleigh fading channels and traditional single-input/multiple-output (SIMO) MRC systems.

Whereas initial work on optimum combining in the presence of co-channel interference dealt mainly with a single antenna at the transmitter and multiple antennas at the receiver, applications in more recent years have become increasingly sophisticated thereby relying on the more general multiple-input/multiple-output (MIMO) antenna systems, which promise significant increases in system performance and capacity. In this context, Wong et al. derived the joint optimal antenna weights at both mobile unit and base station over interference-limited fading channels and evaluated the average BER performance of the resulting optimized MIMO system by Monte Carlo simulations. In this section, we summarize work on an interesting connection between results in the statistical literature dealing with the distribution of the largest eigenvalue of certain quadratic forms in complex Gaussian vectors and the performance analysis of the optimized MIMO system proposed by Wong et al. We adopt the following assumptions: (1) both the desired and interfering signals are subject to Rayleigh fading, (2) the interferers have equal average power, and (3) the effect of thermal noise is neglected, which is reasonable for interference-limited systems in which the number of antenna elements Lr at the receiver is less than or equal to the number of interferers NI . Extensions of the work presented here to Rician fading for the desired user, unequal power interferers, and the presence of interferers is available

4. Result and Discussion:

In this section we have discussed the results that are obtained by our analysis over the simulation results related to fading channels at different parametric values. We have developed Matlab based simulations for Rayleigh and Nakagami – m channel for considering their performance measures on the terms of probability distribution function, bit error rate performance power and outage probability and selection at single and multiple antenna at the receive antenna.

We have considered Rayleigh and Nakagami –m fading channel under different scenarios for analyzing their performance in terms BER and outage probability at various combinations of modulation scheme and single/multi antenna systems. For the Nakagami – m fading channel Matlab simulation are used to develop mathematical model of fading channel for computer channel performance.

In the figure 4 we have shown the BER vs. SNR performance of Rayleigh fading channel for considering 1 bit symbol and at the SNR varying from 1 to 10dB.

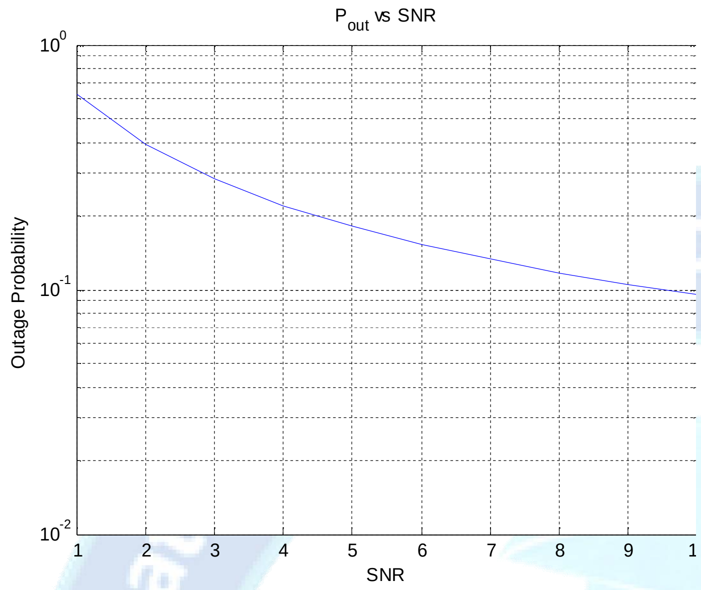

Fig. 4: BER vs. SNR curve at 1 bit per symbol for Rayleigh fading channel.

In the figure 4 we can see that as the SNR is increased the noise power is reduced at as the noise decreases the error is also reduced hence the P_{out} is also reducing. At the SNR=10 the P_{out} reduces to 0.1.Similarly we have also kept the SNR fixed at 1 dB and vary the bit per symbol to find the effect of modulation scheme at different M-PSK methods. The bit per symbol is taken as 1 (BPSK), 2(QPSK), 3(8PSK) etc. In the figure 2 (a)we can see that as the bit per symbol is increased the BER increases.

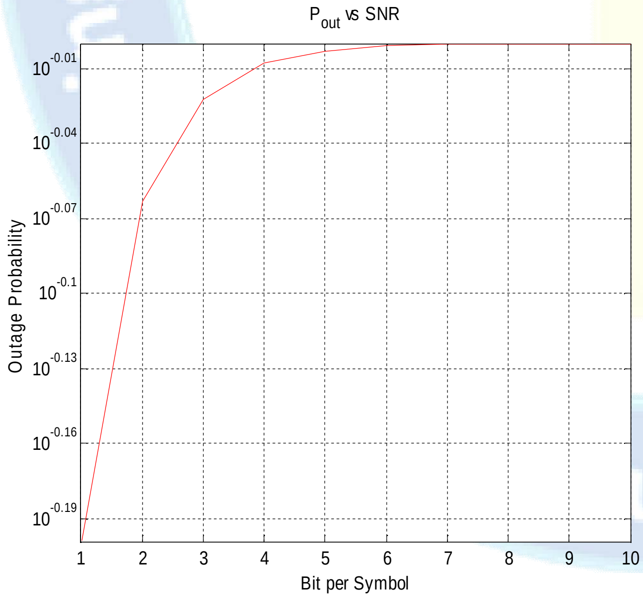

Fig 5. P_{out} performance of Rayleigh fading channel at different bits per symbols.

Table 1: BER performance for 8PSK at m=1,2,3 for Nakagami – m fading.

8PSK			
EbNo(dB)	m=1	m=2	m=3
1	0.3027	0.2882	0.283
2	0.283	0.2665	0.2605
3	0.2622	0.2436	0.2368
4	0.2407	0.2197	0.212
5	0.2187	0.1952	0.1865
6	0.1966	0.1705	0.1608
7	0.1747	0.1462	0.1356
8	0.1535	0.1228	0.1114
9	0.1333	0.1009	0.089
10	0.1146	0.0811	0.0689

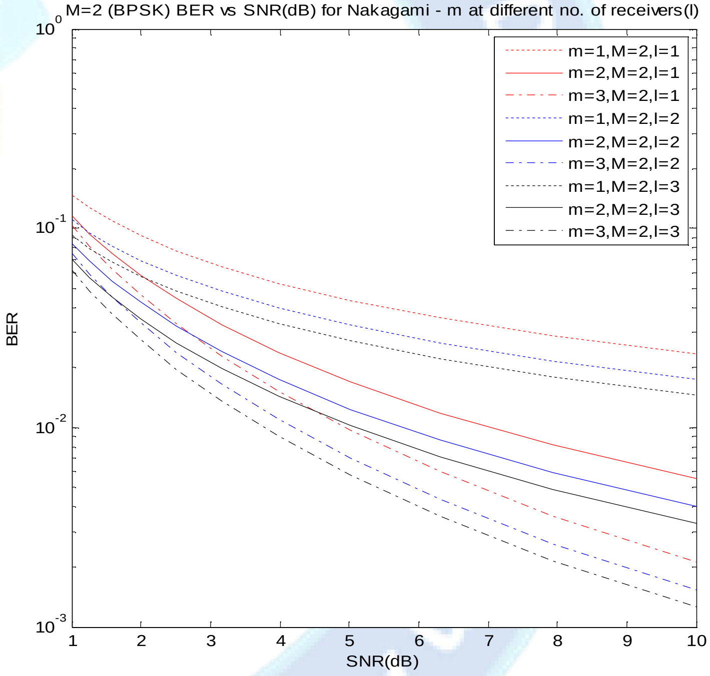

Fig. 6. BER vs SNR for l=1,2 ,3 at different fading parameter m.

From figure 6 we can observe that as the '*l*' is increased the value BER is decreased for all values of m hence higher the no. of received channels lower the BER. Thus MIMO systems with multiple receiving channels are more suitable than single receiver. As the m of fading channels are increased the BER is also reducing and lowest BER is observed at m=3 and l=3.

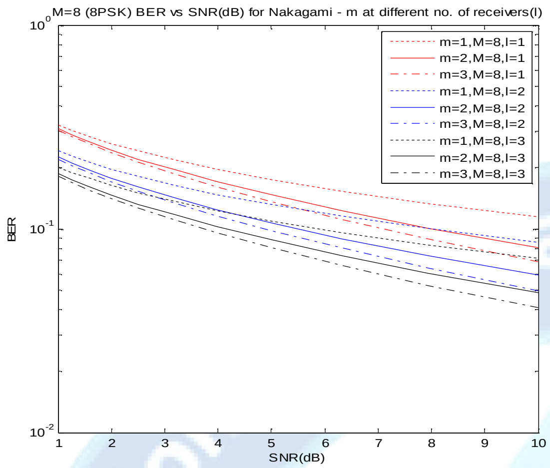

Fig. 7. BER vs SNR for l=1, 2, 3 at different fading parameter m.

From figure 7 we can observe that as the *'l'* is increased the value BER is decreased for m=1,2 and 3 hence higher the no. of received channels lower the BER but there is no such significant difference in BER for 8PSK as compared to BPSK and QPSK. Thus MIMO systems with multiple receiving channels are more suitable than single receiver. As the m of fading channels are increased the BER is also reducing and lowest BER is observed at m=3 and l=3.We can draw the conclusions that higher the value of m we get lower the BER in the signal for all the modulation scheme. BPSK gives best performance as compared to the QPSK and 8PSK.

5. Conclusion:

This work focus on the performance analysis of fading channels in respect of SISO and MIMO systems for this purpose we have developed communication models of Rayleigh and Nakagami-m fading channels. The fading channel performance is observed for BPSK, QPSK and 8PSK schemes for the issues with multiple numbers of receiver channels. The outage probability and BER are evaluated and analyzed in terms of different SNR and threshold value of SNR. We have worked for MIMO system related fading because it unwanted effects over the received data in a multipath channel includes motion due to the frequency offset known as Doppler shift of the carrier and the time delay of the envelope. Because of the shifted and abruptly delayed waves interference works destructively and cause very severe losses. We have considered each receiving channel path characterized by our fading model.

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