FADING ANALYSIS OF MIMO BASED MOBILE AD-HOC NETWORKS

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ABSTRACT

MIMO technologies are beneficial for Mobile ad-hoc networks by providing the diversity and capacity advantage as well as spatial degree of freedom in designing MAC protocol. The integration of MIMO technology in the area of mobile ad-hoc network has great attenuation in commercial and military application. Most important event in wireless communication is the advent of MIMO technologies which uses multiple antennas to coherently resolve more information than single antenna [1,2,3]. The use of multiple antennas increases the data rate in wireless network. The use of multiple antennas causes the amplitude and phase fluctuation and time delay in the received signal, which causes fading of the signal [4,5]. Again the nodes are moving randomly that leads to a frequency shift of the arriving signal. We have studied the MIMO mobile ad-hoc network's received signal assuming the flat Raleigh fading and considering the Doppler shift due to the continuous movement of the mobile nodes. Some parameters will come into consideration when we studied about MIMO Mobile ad-hoc network i.e. Average Fade Duration (AFD), Level Crossing Rate (LCR). In this paper we shall discuss the different fading channels and show some simulated results for Doppler spectrum at variation of Doppler shift (i.e. direction of motion of the antenna) with respect to Power Spectral Density. And some comparison study of AFD and LCR is done with MIMO Mobile ad-hoc network and ordinary ad-hoc network.

KEYWORDS

Ad hoc networks, Multi Input Multi Output (MIMO), Fading, Doppler shift, Scattering.

1. INTRODUCTION

The use of multiple antennas in transmitting and receiving nodes enhance the data rate in wireless networks. Multi-input and Multi-output (MIMO) technology takes the advantage in propagation environment that is rich in multiple paths and has traditionally been a challenge in wireless communication [9,10]. In wireless communications, fading is deviation of the attenuation that a carrier-modulated telecommunication signal experience over certain propagation media. The fading will vary with time, geographical position and/or radio frequency and modeled as a random process. In wireless communication system fading may either be due to multipath propagation called as multipath fading or due to be shadowing from obstacles affected by the wave propagation, sometimes referred to as shadow fading. Multipath consist of different length for MIMO mobile ad-hoc network model; that is reason for creating multiple copies of signal at different time of arrival and phase shift, with the varying phase shift the Doppler spectrum will changes. In this paper we shall discuss the different fading channels and show some simulated results for Doppler spectrum at variation of Doppler shift (i.e. direction of motion of the antenna) angle with respect to Power Spectral Density. Finally some

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simulated result is shown for comparison of MIMO Mobile ad-hoc network and ordinary ad-hoc network.

2. MIMO AD-HOC NETWORK CHANNEL MODEL

In a generic MIMO ad hoc network's each node is equipped with multiple antennas. There are several peer to peer communication links in the network. Each link consists of one transmitter with N_t antennas and one receiver in N_r antennas. We assume that all the channels are flat fading, and received signal are corrupted by additive white Gaussian noise (AWGN). The mobile node in the ad-hoc networks has no base station and peer-to-peer communication will form logical link via its intermediate nodes. The signal being transmitted from the source node and transmit via different paths and goes to the destination due reflection, diffraction and scattering. The different paths have lengths which causes the destination to see multiple copies of signal at different links of arrival. These multiple copies of signal will cause the small scale fading. As the antenna move through space, it will experience the peaks as well as valleys of the signal strengths due to the interfering wavelengths added and subtracted at the receiver. We consider one link connected peer-to-peer network is shown Figure 1.

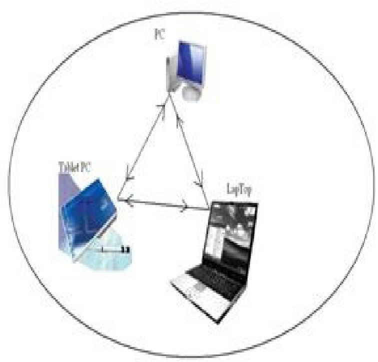

Figure1: Network Model

Mathematically, fading is usually modeled as a time-varying random change in the amplitude and phase of the transmitted signal. In adhoc networks fading occur due to many reasons i.e. the node **a**re moving randomly that leads to a frequency shift of the arriving waves, signal being transmitted from the source node transmit via different paths and goes to the destination due reflection, diffraction and scattering. To modeling the MIMO based mobile ad-hoc network some important issues take into consideration that affect propagation within the channel like variation in time, multipath phenomena and Doppler shifts, angle of arrival of the received signals, Average Fade Duration, Level Crossing Rate and also the effects of using multiple carrier frequencies [6,7,8]. We assume that all the channels are flat fading that can be incorporated in the signal while modeling it mathematically. Lets the received signal r(t), and it is obtained by adding transmitting signal s(t) multiplied by time varying attenuation α(t) and noise contribution n(t),

$$\text{i.e. } r(t)= \alpha(t)\, s(t)+n(t) \text{--------(i)}$$

The time varying attenuation is known as fading which depends upon the channel environment. If there are many statistically independent scatters and no single scatter makes a dominant contribution, then α follows a Rayleigh distribution and its pdf is given by,

$$pdf(\alpha)= (\alpha/\sigma^2)\exp(-\alpha/2\sigma^2) \quad \text{for } 0< \alpha <\infty \text{----------(ii)}$$

The multipath propagation also contributes a phase shift (distributed 0 to 2Π). For Rayleigh fading amplitude, phase shift is statistically independent Simultaneous transmission of data between different nodes creates multiple copies of signal, which causes the fading effect on MIMO based mobile Ad-Hoc network. And in the subsequent section we have shown the simulated results.

3. SIMULATED RESULT

The fading of a MIMO channel happens due to the scattering of the reflected waves and these are basically the Raleigh and Rican scattering. We have simulated a model network and fading due to Raleigh scattering for the channel are shown in Figure1. As the nodes of the networks are moving randomly so the Doppler shift also occur. For the different angles of the moving nodes a simulated effect of Doppler shift is shown in Figure 2a, Figure 2b and Figure 2c are shown. Some Comparative study of AFD and LCR is done for single channel and multiple channels in Figure 4a, 4b, 5a, 5b.

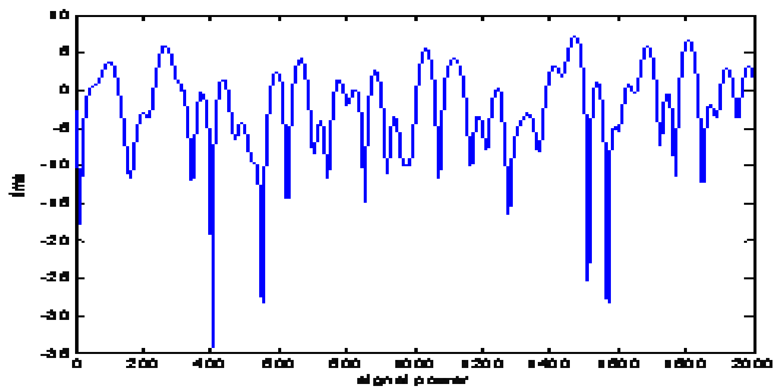

Fig1 : Signal in Rayleigh fading MIMO channel

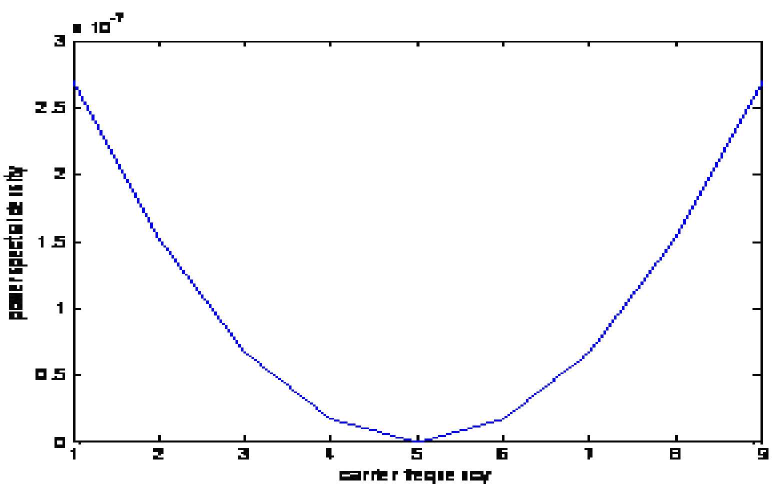

Fig2a: Doppler shift vs. Power Spectral Density with phase angle (pi/6).

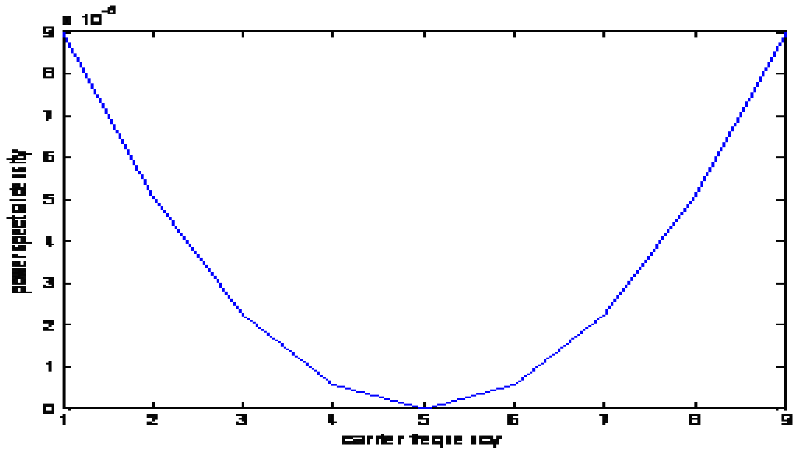

Fig2b: Doppler shift vs. Power Spectral Density with phase angle (pi/3).

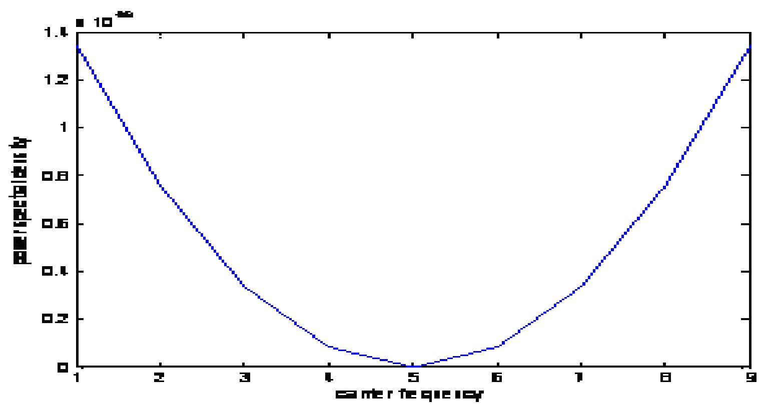

Fig2c: Doppler shift vs. Power Spectral Density with phase angle (pi).

Table1: Comparative Study of Spectral Efficiency

Different Phase Angel (in Degree)	**Spectral Efficiency**
0	**3.6*10^(-7)**
30	**2.7*10^(-7)**
60	**9*10^(-8)**
90	**3.6*10^(-7)**
120	**9*10^(-8)**
150	**2.7*10^(-7)**
180	**3.6*10^(-7)**
360	**3.6*10^(-7)**

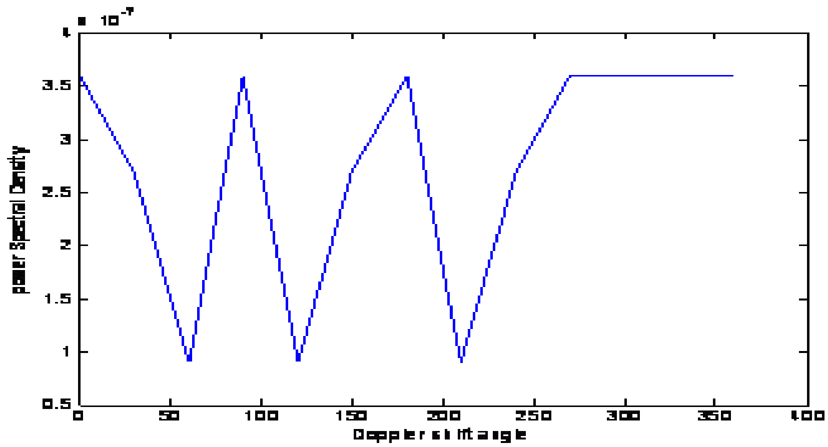

Fig 3:PSD vs Doppler Shift Angle

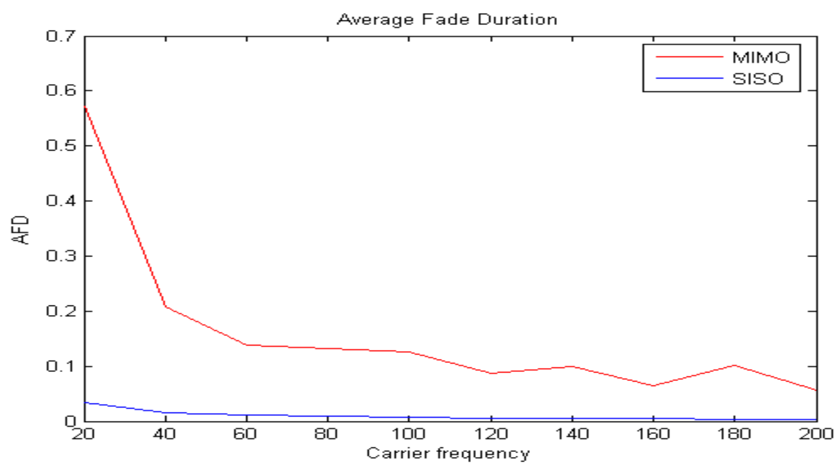

Fig 4a: AFD vs Carrier frequency with different channel practically

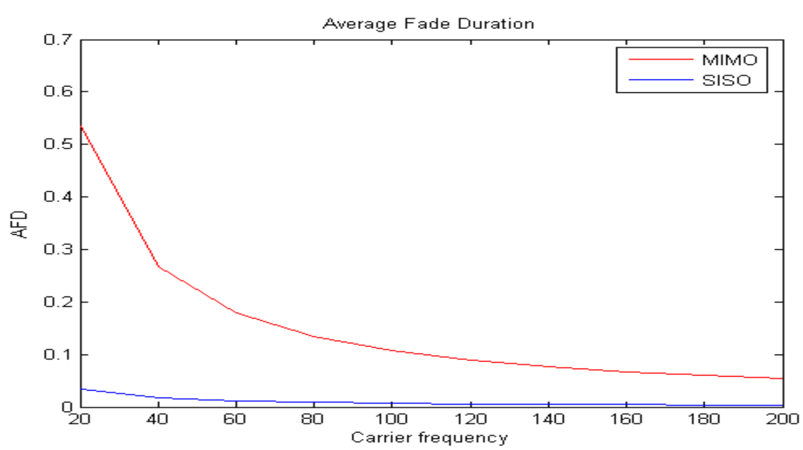

Fig4b:AFD vs Carrier Frequency with different channel theoretically

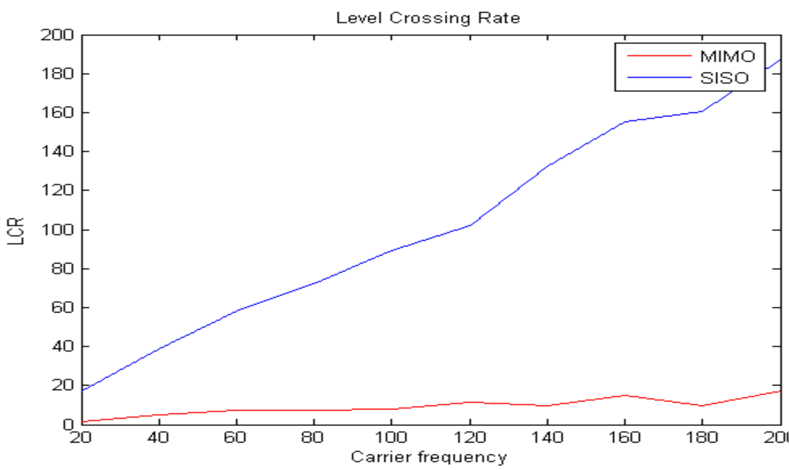

Fig 5a: LCR vs Carrier frequency with differnt channel practically

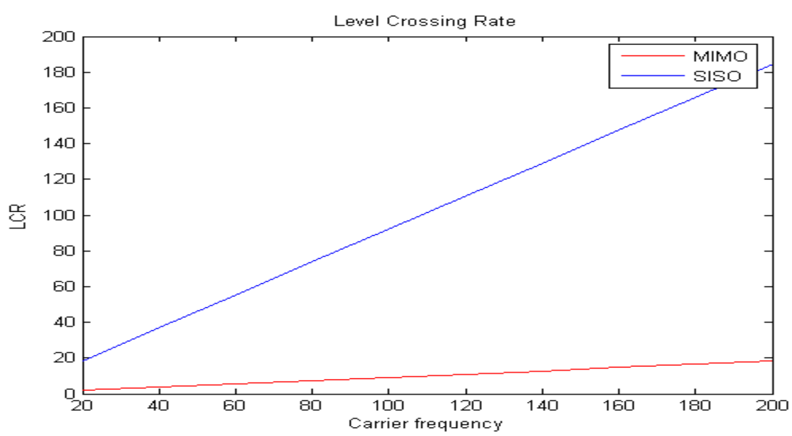

Fig 5b: LCR vs Carrier frequency with different channel theoretically

4. CONCLUSION

We have simulated various MIMO ad-hoc networks with different values of Doppler shift and Spectral efficiencies. From the simulated result it is found that the spectral efficiency of the MIMO based ad-hoc networks increase by a factor of Doppler Shift angle. It is found that the spectral efficiency of the MIMO based ad-hoc network increases up to a certain limit. The value of Spectral Efficiency will remain constant for each (Π /2) phase difference of Doppler shift angle. When consider AFD and LCR for MIMO based ad-hoc network and Single input ad-hoc network, it has been found that AFD is greater for MIMO based ad-hoc network and LCR is lower with respect to Single channel ad-hoc network.

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