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EFFECT OF IMPLEMENTING ALAMOUTI DIVERSITY SCHEME IN MULTI-USER DS-CDMA WIRELESS COMMUNICATION SYSTEM

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Abstract:-

The communication system under present study utilizing ½ rated convolutional encoding and interleaving schemes over an Additive White Gaussian Noise (AWGN) and other fading (Rayleigh and Rican) channels with deployment of Alamouti scheme. The simulation study is made with the development of a computer program written in MATLAB source code. Computer simulation results on BERs demonstrate that the multi transmit antenna supported DS-CDMA system outperforms in retrieving synthetically generated bit stream of the individual user. The system is highly effective to combat inherent interferences under fading channels. It is anticipated from the study that the performance of the communication system degrades with the increasing of noise power.

Keywords: - DS-CDMA, Alamouti, Fading channel, Convolution code, Interleaving.

1. INTRODUCTION

With the technological development in wireless communications, it has become a challenging task to design robust wireless networks (fixed and/ or mobile infrastructure based) to ensure high speed Internet connectivity. Over the last few years, it is being observed that the people are using their personal wireless enabled devices such as cell phones, laptops and PDAs to communicate with others residing in different parts of the world [1]. Modern mobile communication systems adopt the digital modulation scheme instead of previously used analog modulation. Digital modulation is very much advantageous in noise immunity and robustness to channel impairments. Code division multiple access (CDMA) is a multiple access technique where different users share the same physical medium, that is, the same frequency band, at the same time [2]. The main ingredient of CDMA is the spread spectrum technique which uses high rate signature pulses to enhance the signal bandwidth far beyond what is necessary for a given data rate. In a CDMA system,

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the different users can be identified and hopefully separated at the receiver by means of their characteristic individual signature pulses (sometimes called the signature waveforms) that is by their individual codes. Nowadays, the most prominent applications of CDMA are mobile communication systems like cdmaOne (IS-95), UMTS or cdma2000. To apply CDMA in a mobile radio environment, specific additional methods are required to be implemented in all these systems. Methods such as power control and soft handover have to be applied to control the interference by other users and to be able to separate the users by their respective codes [3]**.** DS/SS is perhaps the most common form of spread spectrum in use today. DS/SS accomplishes bandwidth spreading through the use of a high rate symbol sequence (termed a chip sequence) that directly multiplies the information symbol stream. Since the chip sequence has a rate much higher than the data rate, the bandwidth is increased [4]. Arunarasi *et. al* [5] already reported about DS-CDMA and Md. Matiqul *et. al* [6] already reported about MC-CDMA. Although several research papers come out every day but still this topic may be of an interest.

2. ALAMOUTI SCHEME

In 1998, Alamouti has presented a simple two-branch transmit diversity scheme. Using two transmit antennas and one receive antenna the scheme provides the same diversity order as maximal-ratio receiver combining (MRRC) with one transmit antenna and two receive antennas [7], [8]. Figure 1 shows the block diagram of base band representation of the Alamouti's two branch transmit diversity scheme. The scheme is defined by the three functions such as encoding and transmission sequence of information symbols at the transmitter, combining scheme at the receiver and decision rule for maximum likelihood detection. In encoding and transmission sequence, two signals are simultaneously transmitted from the two antennas at a given symbol period. The signal transmitted from antenna zero is denoted by $\mathbf{s_o}$ and from antenna one by $\mathbf{s_1}$. During the next symbol period, signal (- $\mathbf{s_1^*}$) is transmitted from antenna zero and signal $\mathbf{s_o^*}$ is transmitted from antenna one where ***** is the complex conjugate operation. In Alamouti scheme, the encoding is done in space and time (space–time coding) and such encoding may also be done in space and frequency.

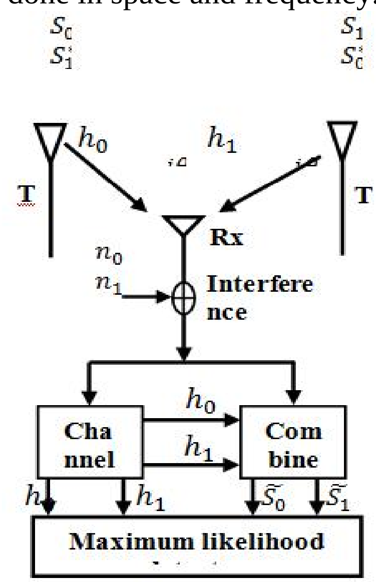

Figure 1: Transmitter and receiver structures for Alamouti's transmission scheme.

The channel at time t may be modeled by a complex multiplicative distortion $\mathbf{h_o(t)}$ for transmit antenna zero and $\mathbf{h_1(t)}$for transmit antenna one. Assuming that fading is constant across two consecutive symbols, we can write

$$h_o(t) = h_o(t+T) = h_o = \alpha_o e^{j\theta_o}$$

$$h_1(t) = h_1(t+T) = h_1 = \alpha_1 e^{j\theta_1}$$

(1)

Where, T is the symbol duration. The received signals can then be expressed as

$$r_o = r(t) = h_o s_o + h_1 s_1 + n_o$$

$$r_1 = r(t+T) = -h_o s_1^* + h_1 s_o^* + n_1$$

(2)

Where $\mathbf{r_0}$ and $\mathbf{r_1}$ are the received signals at time t and t+ **T** and are $\mathbf{n_0}$ and $\mathbf{n_1}$ complex random variables representing receiver noise and interference. The combiner shown in Figure 1 builds the following two combined signals that are sent to the maximum likelihood detector:

$$\tilde{s}_0 = h_0^* r_0 + h_1 r_1^*$$

$$\tilde{s}_0 = h_0^* r_0 + h_1 r_1^*$$

$$\tilde{s}_1 = h_1^* r_0 - h_0 r_1^*$$

(3)

Substituting (1) and (2) into (3) , we get

$$\tilde{s}_0 = (\boldsymbol{\alpha}_0^2 + \boldsymbol{\alpha}_1^2)\mathbf{s}_0 + \mathbf{h}_0^*\mathbf{n}_0 + \mathbf{h}_1\mathbf{n}_1^*$$

$$\tilde{s}_1 = (\boldsymbol{\alpha}_0^2 + \boldsymbol{\alpha}_1^2)\mathbf{s}_1 - \mathbf{h}_0\mathbf{n}_1^* + \mathbf{h}_1^*\mathbf{n}_0$$

(4)

These combined signals are then sent to the Maximum likelihood detector.

3. SYSTEM MODEL AND DESCRIPTION

The proposed simulated DS-CDMA system with implementation of various coding and alamouti diversity schemes is depicted in Figure 2**.**

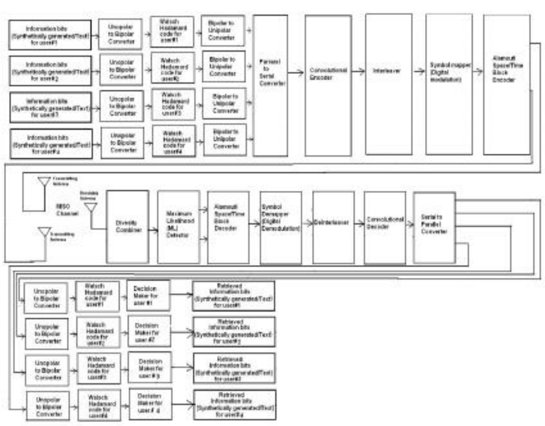

Figure 2: Block diagram of Alamouti encoded model for multi-user DS-CDMA system

The synthetically generated binary random data for multi-users have been considered. The individually generated random data and messages are then encoded with ½ convolution encoder. The encoder output is converted into bipolar NRZ format and subsequently generated data fed into digital modulator. The digitally modulated signal .is then multiplied with generated pseudo random noise for each user. The pseudo randomly noise contaminated modulated signals for users are then added up and Alamouti encoded and transmitted through two transmitters and passed through AWGN, Rician and Reyleigh fading channel. At the receiving end the channel output is then received by single antenna and multiplied with the generated pseudo random noise and demodulated. The demodulated signal for each user is processed. The processed output is sent up to the decision making device and eventually, the information bits and messages transmitted for each user are recovered.

4. RESULTS AND DISCUSSIONS

Simulation parameters for the proposed system model are shown in Table 1. The performance of the proposed system was tested in different channels.

Parameters	**Types**
No. of bits used for synthetic data	1000
Message Length	Variable
Modulation	QPSK, 4QAM
SNR in dB	0-10
Channel	AWGN, Rayleigh, Rician
Channel coding	½- rated Convolution coding
No. of samples in each bit	10
Diversity scheme	Alamouti (two transmitting and one receiving antenna)

Table 1. Simulation parameters for the system model

Figure 3 shows the BER performance of multi-user DS-CDMA wireless communication system under QPSK digital modulation techniques with and without implementing of Alamouti encoding for wide range of SNR from 0 dB to 10 dB. It can be seen from this Figure 3 that bit error rate can be reduced rapidly with using Alamouti diversity technique in the proposed communication system.

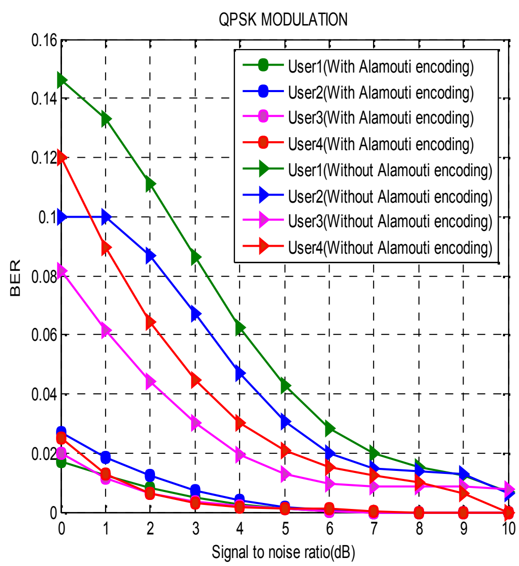

Figure 3: Performance evaluation of Alamouti encoded and without Alamouti encoded multi-user DS-CDMA under QPSK modulation.

Figure 4 shows the BER performance of multi-user DS-CDMA wireless communication system under QAM digital modulation techniques with and without implementing of Alamouti encoding for wide range of SNR from 0 dB to 10 dB. Figure 4 also shows that bit error rate increases without using Alamouti diversity technique while decreases with implementing Alamouti's transmission scheme. As compared Figure 3 and Figure 4, another point is clear that bit error rate is higher for both cases in QPSK modulation which indicates QAM may be a preferable modulation scheme for this proposed communication system. On the other hand, Figure 6 compares the BER performance of the investigated communication system under 4QAM modulation in Rayleigh fading channel for the same three cases as shown in Figure 5. For a typical selected value of SNR 4 dB,

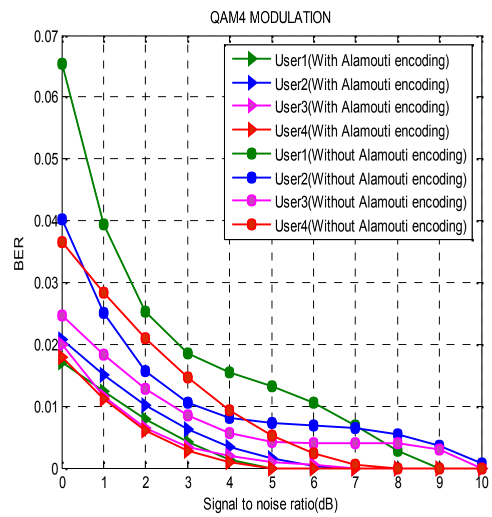

Figure 4: Performance of Alamouti encoded and without Alamouti encoded multi-user DS-CDMA system under 4QAM modulation.

Figure 5 evaluates the BER performance of the investigated communication model under 4QAM modulation in AWGN channel with and without Alamouti diversity as well as with interleaving plus Alamouti technique where SNR range was 0 to 10 dB. It is evident from this Figure 5 that system performance increases significantly with deploying Alamouti diversity technique and best result comes while deploying Alamouti with interleaving. For a typically chosen value of SNR 4 dB with 4QAM modulation, it is observed that bit error rates are 0.1870 and 0.0042 for without Alamouti diversity and with Alamouti plus interleaving schemes, respectively. It means that a gain of 16.49 dB can be achieved by the proposed wireless communication model under AWGN channel. However, Alamouti scheme itself reduces the bit error rate drastically.

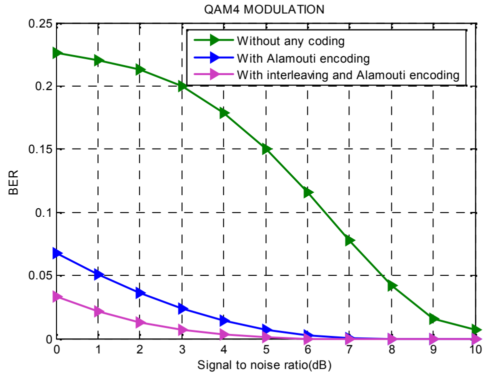

Figure 5: Performance of without encoding, with Alamouti encoding and with interleaving plus Alamouti scheme under AWGN channel.

it is observed from Figure 6 that bit error rates are 0.1970 and 0.0378 for without Alamouti diversity and with Alamouti plus interleaving schemes, respectively. It means that a gain of 7.17 dB can be achieved under Rayleigh channel by this proposed model while using Alamouti with interleaving scheme.

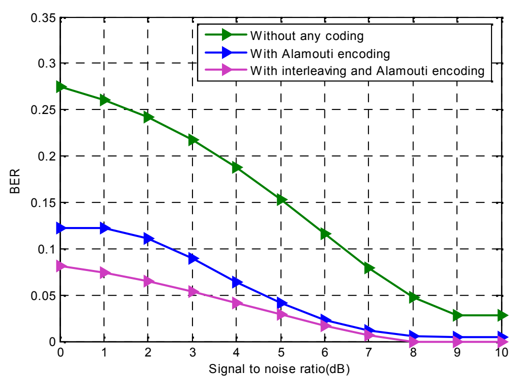

Figure 6: Performance of Alamouti encoded and without Alamouti encoded DS-CDMA under Rayleigh channels.

Finally, Figure 7 depicts the BER performance with similar modulation technique in Rician fading channel. Here for the same value of SNR 4 dB, bit error rates are 0.1892 and 0.0194 for without Alamouti diversity and with Alamouti plus interleaving schemes, respectively which implies that system performance can be improved by 9.89 dB under Rician fading channel by this proposed model if Alamouti with interleaving scheme is used.

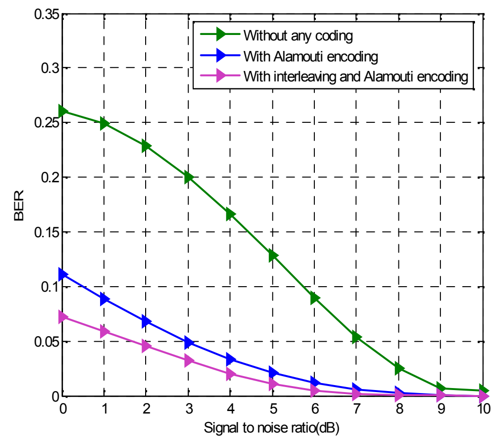

Figure 7: Performance evaluations of Alamouti encoded and without Alamouti encoding under Rician channel.

CONCLUSION

The effect of implementing Alamouti diversity in multi-user DS-CDMA wireless communication system has been studied in this paper. Simulation results show that the system performance is improved by using Alamouti scheme under AWGN channel as well as under fading channels. However, in this case, Rician fading channel shows a little bit better performance than Rayleigh fading channel.

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