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Improved Performance of Multiuser System Using Combined Diversity with Nagakami Fading Channel

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Abstract - **In wireless communication security, Signal to Noise Ratio (SNR) and Bit Error Rate (BER) are the important parameters to be improved. Frequency Hopping Spread Spectrum (FHSS) combined with Nagakami Fading Channel (NFC) and combined diversity techniques have been proposed to improve the performance of multi-user system. Combined diversity is nothing but a combination of Maximal Ratio Combining (MRC) and RAKE Receiver. Nagakami fading channel supports both line of sight and multipath communication so that it can tolerate both weak and severe fading. FHSS is used to enhance security in areas where secured communication is needed. Combined diversity technique is used to avoid fading (i.e random fluctuations in signal) and to increase the SNR. By combining these techniques one can provide secured communication with improved SNR and BER. It can be used in military areas, satellite communication. The software used to simulate the proposed method is MATLAB.**

***Keywords* –Signal to Noise Ratio (SNR), Maximal Ratio Combiner (MRC), RAKE receiver, Nagakami Fading Channel (NFC), Bit Error Rate (BER)**

I. INTRODUCTION

Spread spectrum technique has been initially proposed for antijamming, secured communication and multi-Path fading, which has acquired increased importance as they are used in areas where secured communication is needed, through code division multiple access. Direct Sequence Spread Spectrum (DSSS) and Frequency Hopping Spread Spectrum (FHSS) are the two common forms of spread spectrum communication. In previous papers they have used DSSS along with fading channels to provide secured communication. In this paper we have proposed FHSS along with NFC to provide secured communication than DSSS.

Frequency hopping spread spectrum (FHSS) is one of the well known techniques which provides multi access capability and potential resilience against hostile environment. In FHSS system the available channel bandwidth is subdivided into large number of contiguous frequency slots. In the signaling interval the transmitted signal occupies one or more of the available frequency slots. FHSS allows multiple users to share the same frequency band with minimum interference by assigning distinct frequency hopping pattern to different users. So FHSS is used for transmitting and receiving the signal. The channel used is Nagakami Fading Channel which covers both weak and severe fading condition. NFC is most widely used as a model of wireless fading channel because of its good fit to different fading scenario as well as its analytical versatility At the receiver side combined diversity technique has been used to increase the signal to noise ratio and to decrease the bit error rate. Combined diversity techniques are MRC and RAKE receiver.

Multipath path fading channel provides multiple replicas of transmitted signal which arrives with different phase and amplitude. NFC supports both line of sight (LOS) and multipath signals. At the receiver side combined diversity technique is employed which combines the multiple replicas of the received signal in a way such that fading of the resultant signal has been reduced. The optimum linear combining technique (MRC) is used for coherent reception with independent fading at each antenna element in the presence of spatially white Gaussian noise. MRC mitigates the effect of fading; however, it ignores co channel interference (CCI). CCI is collision of data between different channels. MRC is used to increase the SNR and another advantage is that it does not require the knowledge about the channel. A RAKE receiver is a radio receiver designed to counter the effects of multipath fading and combines the delayed version of received signal. It employs number of correlators to separately detect the strongest multipath component. RAKE receiver is used to remove intersymbol interference by providing guard time between signals.

This paper is organized as follows: In section 2, system model described. In section 3 mathematical models to generate nagakami fading channel is described. In section 4 simulation results is discussed. Finally section5 concludes the paper.

2. SYSTEM AND CHANNEL MODEL

Let us consider a multi-user environment with N users uniformly distributed. The N user's information is encoded using convolutional encoder and is multiplexed using time division multiplexing (TDM). The multiplexed signal is transmitted by means of FHSS transmitter. In FHSS the modulation technique used is FSK. The transmitted signal is passed through nagakami fading channel. At the receiver side the signals are combined using diversity technique (MRC+RAKE receiver). Finally the combined signal is demodulated and the estimate of original signal is obtained.

Fig2.1 Overall block diagram

2.1 TRANSRECEIVER MODEL

In this paper spread spectrum is used to provide secured communication in multiuser environment. Although bandwidth is an important parameter which has to be minimized, sometimes increasing the bandwidth improves the performance of the system. Spread spectrum technique increase the bandwidth of the signal beyond the minimum necessary for transmitting the signal. There are various types of multiple access method such as frequency division multiple access (FDMA), time division multiple access (TDMA) and code division multiple access (CDMA). FDMA and TDMA include only orthogonal signals. CDMA is a type of spread spectrum which includes both orthogonal and non orthogonal signals. In CDMA there are two common methods: DSSS and FHSS.

In FHSS information signal is sent in different hop frequencies and each user is assigned to different frequency. In DSSS the information signal is modulated at different carrier frequency. Instead of modulating the information signal using pseudorandom noise sequence (PN), we are modulating the carrier which in turn modulates the information signal. PN sequences are generated by linear combination of shift registers. A block diagram of transmitter and receiver is shown in Fig2.2 and Fig2.3.

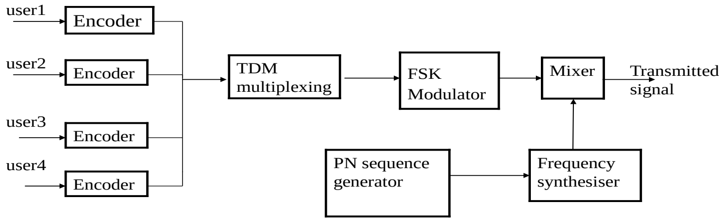

Fig 2.2 FHSS transmitter

In our proposed method we have considered four users. The information signals from the users is encoded and then multiplexed. The modulation used is M-ary Frequency shift keying (FSK). The resulting FSK signal is translated in frequency by an amount which is determined by the PN sequence generator. The frequency synthesizer output is multiplied with FSK signal and is transmitted through the channel. Frequency synthesizer is used to generate a carrier based on the frequency of the PN sequence. Frequency synthesizers are used in all high frequency applications such as communications, radar, digital communications, electronic imaging and spectroscopy.

At the receiver side an identical PN sequence generator synchronized with the received signal is used to control the output of the frequency synthesizer. Thus the PN frequency translation is removed at the receiver by mixing the synthesizer output with the received signal.

The resultant signal is demodulated by means of FSK demodulator. The demodulated output is demultiplexed in order to obtain the individual user signal. The demultiplexed signal is decoded using viterbi decoder to obtain the estimate of original signal.

The primary advantage of FHSS over DSSS is as follows: In FHSS near far problem is not critical, it provides immune to multipath interference and robust multi access capability, FHSS does not require contiguous band of frequency, the aggregate number of users is more (i.e) in 2.4 Ghz band up to 12 systems can be collacted providing an overall aggregate rate of 36 Mhz and overall efficiency is 0.43 bits/Hz.

2.2. FSK MODULATOR AND DEMODULATOR

During long haul transmission, the high frequency part of the digital signal will easily attenuate and cause distortion. Therefore, the signal has to be modulated before transmission, and one of the methods is the frequency-shift keying (FSK) modulation. FSK technique is to modulate the data signal to two different frequencies to achieve effective transmission. At the receiver, the data signal will be recovered based on the two different frequencies of the received signal. This is because the correlation of both signals is low; therefore, the effect of transmitting and receiving will be better. However, the required bandwidth must be increased. At the receiver side FSK demodulator is used to demodulate the received signal.

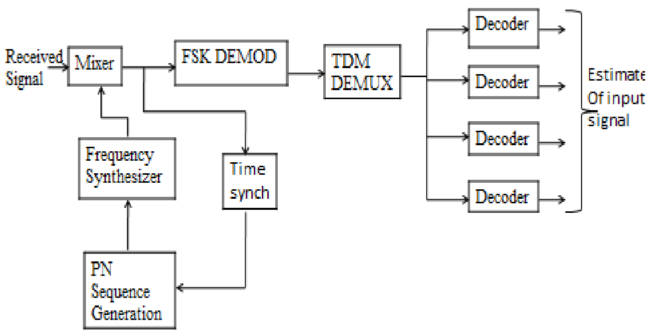

Fig2.3 FHSS RECEIVER

2.3 CHANNEL MODEL

In digital communication the signal received by the user may consist of large number of multipath component due to reflection, diffraction and scattering between transmitter and receiver. The randomly distributed phase, amplitude and angle of arrivals of multipath component combine at the receiver give a resultant signal which can change rapidly over a small travel distance. If there is LOS between transmitter and receiver Rician fading channel can be used. If there is no LOS between transmitter and receiver, Rayleigh channel can be used. Rayleigh fading models are frequently used in simulating high frequency signals propagating in ionospheric medium. However Rayleigh fading channel fall short in describing long distance fading effects with sufficient accuracy.

The channel used in our proposed system is nagakami fading channel (NFC). NFC is a time variant flat fading channel and can be applied to wide variety of empirical measurements.NFC follows gamma distribution. NFC is capable of receiving diffracted, reflected and scattered information. NFC is a two parameter distribution m and second parameter Ω=E (R^2). This distribution provides more flexibility and accuracy in matching the observed signal statistics.NFC can be used to model fading channel conditions that are either more or less severe than Rayleigh distribution, and it includes Rayleigh distribution as a special case when m=1. NFC is the best fit for data signals received in urban radio multipath channel.

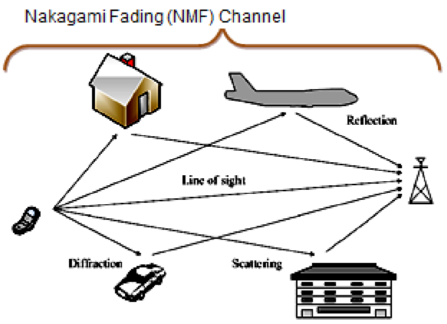

FIG 2.4 Nagakami Channel

2.4 COMBINED DIVERSITY

Combined diversity technique is used to improve the SNR at the receiver side. Combined diversity is a combination of MRC and RAKE receiver which is explained as follows

2.4.1 MAXIMAL RATIO COMBINING

Diversity combining technique is used to mitigate the effect of fading. The idea behind diversity technique is to send same data over independent fading path. These independent paths are combined in such a way that it reduces the effect of fading. MRC is one of the diversity techniques the output is the sum of all branches.

The gain of each channel is made proportional to the rms signal level and inversely proportional to the mean square noise level in that channel. Different proportionality constants are used for each channel.MRC provides maximal output SNR and consequently maximal performance gain under white noise assumption. At high SNR, the diversity order of MRC is M, and so the MRC achieves full diversity order. The hardware complexity is less in case of MRC.

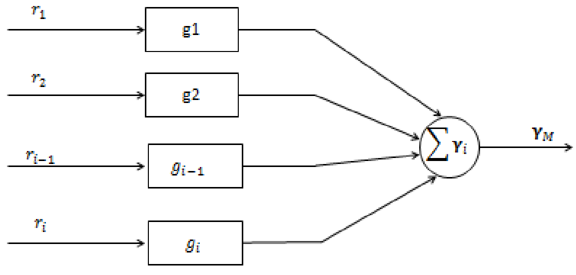

Fig 2.5 MRC combining

2.4.2 RAKE Receiver

Rake receivers are common used in a wide variety of CDMA and radio devices such as mobile phones and wireless equipment. Rake receivers are also used in Radio Astronomy. The RAKE receiver is another form of diversity combining, since the spreading code induces path diversity on the transmitted signal so that independent multipath component seperated by more than one chiptime can be resolved. RAKE receiver employs number of correlators .The outputs of each correlator are weighted to provide better estimate of the transmitted signal than is provided by a single component. A RAKE receiver combines the information from several correlators, each one tuned to a different path delay, producing the strongest version of the simple receiver with a single correlator tuned to the path delay of the strongest signal. The diversity combiner combines the demodulator output.

3. MATHEMATICAL MODEL FOR NFC

Nagakami fading channel is used to characterize the statistics of signals transmitted through multipath fading channel. The PDF for this distribution is

$$P_{\propto}(\propto) = \frac{2m^m \propto^{2m-1}}{\Omega^m \Gamma(m)} \exp\left(-\frac{m \propto^2}{\Omega}\right)$$

α ≥ 0, the SNR then follows the distribution :

$$P_{\gamma}(\gamma) = \frac{1}{\Gamma(m)} \left(\frac{m}{\gamma}\right)^m \gamma^{m-1} \exp\left(-\frac{m\gamma}{\gamma}\right)$$

Where α is attenuation constant
γ is signal to noise ratio
m is fading parameter

γ ≥ 0, which is gamma distributed. The problem of estimating parameters is more complicated in this case

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4. SIMULATION RESULTS

The parameters are listed below

Data rate	8bits/sec
Sampling frequency	32KHz
Frequency seperation	8
Length of PN sequence	255

Tab 4.1 Parameters for SImulation

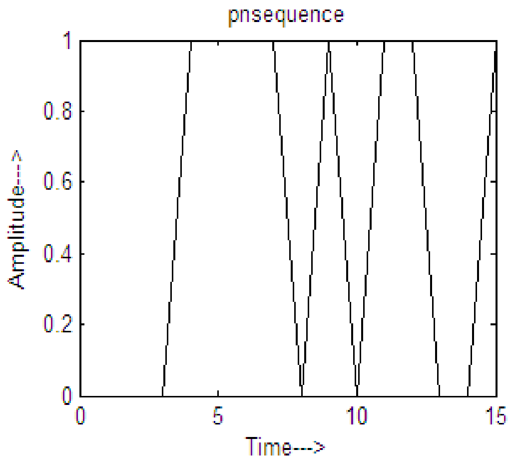

Fig 4.1 PN Sequence

The length of PN sequence generated is 255.

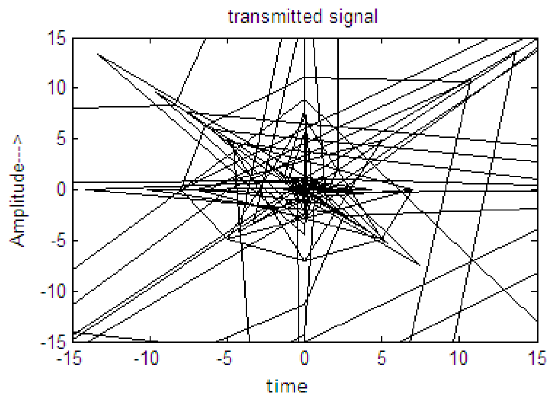

Fig 4.2 Transmitted Signal

Transmitted signal is multiplication of input signal and PN sequence.

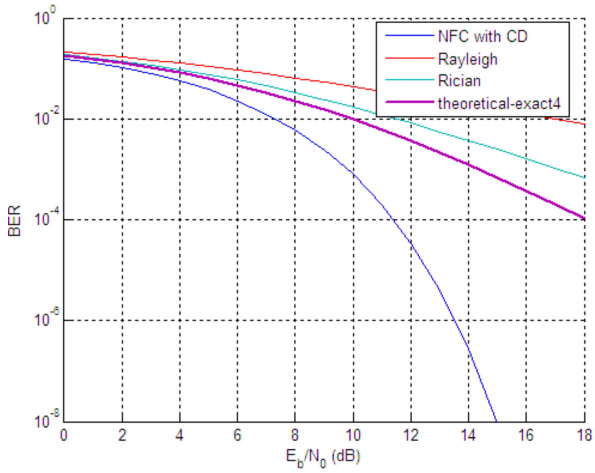

Fig 4.3 BER Comparision

From this graph we came to know that NFC has less BER. Where CD is Combined Diversity

5. .CONCLUSION

In this paper we have analysed the performance of multiuser system over NFC with combined diversity technique. When Rayleigh and Rician is used along with MRC the BER decreases at 18 to 20 dB. By using our proposed method the BER decreases at 15 dB itself. Expressions has been derived for nagakami fading channel and probability of error has been calculated. By combining the above techniques the security has been improved and probability of error has been decreased and signal to noise ratio has been increased

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