

Location Based Spectrum Sensing For Rayleigh Fading

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Abstract

Spectrum sensing is one of the main research issues under wireless communication for dynamic spectrum sharing .there are many spectrum sensing algorithm proposed in literature each of them has its own advantages and disadvantages. Among the algorithms energy detector based spectrum sensing is less complex and adapted in wireless standard. The issues in the energy detector is the poor performance in fading environment and correct threshold selection for the given environment. Here in this paper a location based threshold selection in the Rayleigh fading environment is used for the analysis and the probability of detection, probability of false alarms are calculated for the performance evolution. Here a cooperative spectrum sensing is carried out by taking various like indoor environment and relay network of the case amplify and forward .the energy of received signal is usually function of distant from the transmitter, so under location based threshold selection more threshold value is used if the sensing node is near to primary transmitter or less value is used if it is far away from the transmitter .under this work it is assumed that all the node in the network is assumed that they are all known the location of them and the primary user

Keywords:

1. Introduction

Spectrum sensing has become increasingly important because of the high demand on spectrum and underutilization of the spectrum. As Cognitive Radio technology is being used to provide a method of using the spectrum more efficiently, spectrum sensing is the main application of cognitive radio

One of the main thing in spectrum sensing is that Cognitive Radio systems has to access empty sections of the radio spectrum, and to keep monitoring the spectrum to ensure that the Cognitive Radio system does not cause any undue interference relies totally on the spectrum sensing elements of the system.

For the overall system to operate effectively and to provide the required improvement in spectrum

efficiency, the Cognitive Radio spectrum sensing system must be able to effectively detect any other transmissions, identify what they are and inform the central processing

unit within the Cognitive Radio so that the required action can be taken.

Cognitive radio systems coexist with other radio systems, using the same spectrum but without causing interference. The spectrum sensing algorithm should be continuously sense the spectrum occupancy and will utilize the spectrum on a non-interference basis to the primary user. There are two major methods in which cognitive radio spectrum sensing can be performed Non-cooperative spectrum sensing and Cooperative spectrum sensing. In Non-cooperative spectrum sensing a cognitive radio acts on its own. But in Cooperative spectrum sensing will be undertaken by a number of different radios within a cognitive radio network. Typically a central station will receive reports of signals from a variety of radios in the network and adjust the overall cognitive radio network to suit. It reduces problems of interference where a single cognitive radio cannot hear a primary user because of issues such as shading from the primary user all the sensing algorithm assumes that the channel will be flat and the performance is studied with the flat fading .but in the cooperative sensing scenario some cognitive radio undergo fading ,some may be flat .so in this paper we analysis cooperative spectrum sensing using energy detector on Rayleigh fading.

This paper is organized as bellow that section II discuss about the system model of the energy detector based spectrum detection algorithm on Rayleigh fading. Section 3 presents the results of the simulation study, section 4 concludes the paper

2. System Model

The energy detector system consist of a wireless receiver which gives the digital version of the received signal, then the energy of the received signal is calculated .the calculated energy is fed to the decision device which perform the decision of spectrum sensing and gives the output of whether the sensing spectral frequency is free or occupied by some primary user .the entire operation is given in the fig.1

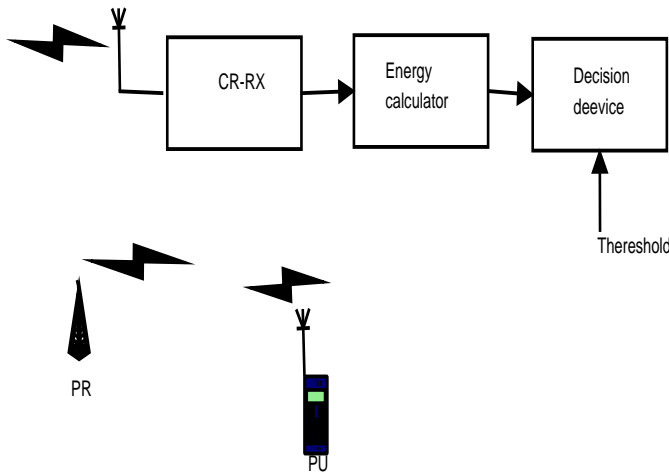


Fig.1 Cr Energy Detector System Block Diagram

The received signal under AWGN is

$$Y(n) = s(n) + n(n) \quad (1)$$

$S(n)$ is the transmitted signal, $n(n)$ is the additive Gaussian noise

The output that comes out of the energy calculator is energy of the received signal over the time interval T and this output is considered as the test statistic to test the two hypotheses H_0 and H_1 [1]. H_0 : corresponds to the absence of the signal and presence of only noise. H_1 : corresponds to the presence of both signal and noise.

Thus for the two state hypotheses numbers of important cases are

R1) H_1 turns out to be TRUE in case of presence of primary user i.e. $P(H_1 / H_1)$ is known as Probability of Detection (P_d).

R2) H_0 turns out to be TRUE in case of presence of primary user i.e. $P(H_0 / H_1)$ is known as Probability of Missed-Detection (P_m).

R3) H_1 turns out to be FALSE in case of absence of primary user i.e. $P(H_1 / H_0)$ is known as Probability of False Alarm (P_f).

Under AWGN channel case the Probability of detection is [2],

$$P_d = P(Y > \frac{E_s}{N}) \quad (2)$$

The probability of false alarm P_f can be evaluated

$$P_f = P(Y > \frac{E_s}{N_0}) \quad (3)$$

By analytically we can derive the P_d for the AWGN channel as below

$$P_d = Q_d(\sqrt{2\alpha} / \sqrt{1+\alpha}) \quad (4)$$

Where

$$\alpha = E_s / N = \beta / 2 \quad (5)$$

Where β is the effective SNR in terms of non-centrality parameter

Where, $Q_d(\dots)$ is the generalized Marcum-Q function For the case of the Rayleigh Channel.

The received signal is

$$Y(n) = s(n)h(n) + n(n) \quad (6)$$

Probability density function for Rayleigh channel is

$$f(h) = 1/h e^{-\alpha/h^2}, h \geq 0 \quad (7)$$

Probability of detection for Rayleigh Channel is obtained by averaging their probability density function over Probability of detection for AWGN Channel [2] that is

$$P_{d,ray} = \int_0^{\infty} P_d f(h) dh \quad (8)$$

By analytically, we can derive the probability of the detection for the Rayleigh Channel

$$P_{d,ray} = e^{-\frac{\alpha}{2}} \sum_{n=0}^{\infty} \frac{(\frac{\alpha}{2})^n}{n!} + (1 + \frac{\alpha}{2}) [e^{-\frac{\alpha}{2(1+\alpha)}} - e^{-\frac{\alpha}{2}} \sum_{n=0}^{\infty} \frac{(\frac{\alpha}{2})^n}{n!} (\frac{1+\alpha}{2(1+\alpha)^2})^n] \quad (9)$$

3. Result and discussion

The energy detector algorithm is simulated with 100 cooperative node and the AND rule based final decision is made to find out the spectral occupancy. The Rayleigh fading channel is simulated and the output of the channel is taken as received signal. Fig.2 shows the distance between the node kept for the simulation in the cooperative network

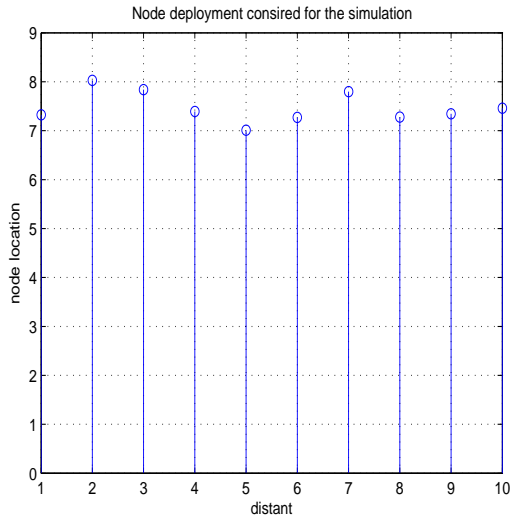


Fig.2 node deployment scenario with some distant between them

Fig.3 shows the Rayleigh channel coefficient that are used for realization of the Rayleigh channel.

The threshold values for the local detection is calculated by using inverse incomplete gamma function .the computed threshold values are plotted in the fig.4.the plot shows that based on the distant of the node location the threshold values are selected ,more the distant less the threshold value. The performance of the algorithm in Rayleigh fading is compared with AWGN channel and plotted in the fig.5

.the fig.5 shows that the performance of the energy detector is actually improved in Rayleigh fading.

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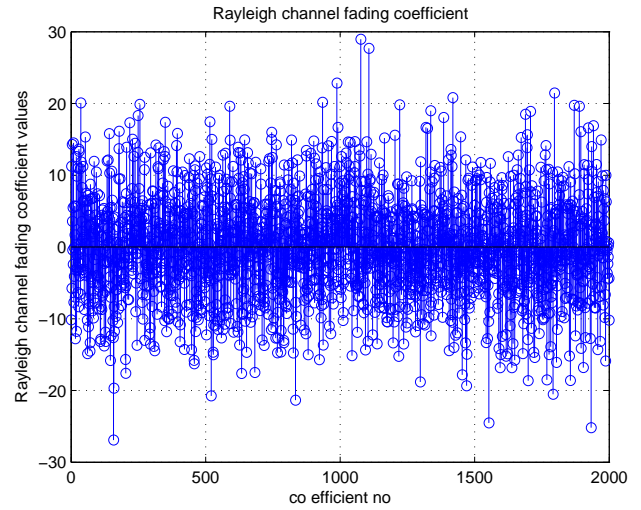


Fig.3 Rayleigh Fading Channel Coefficients

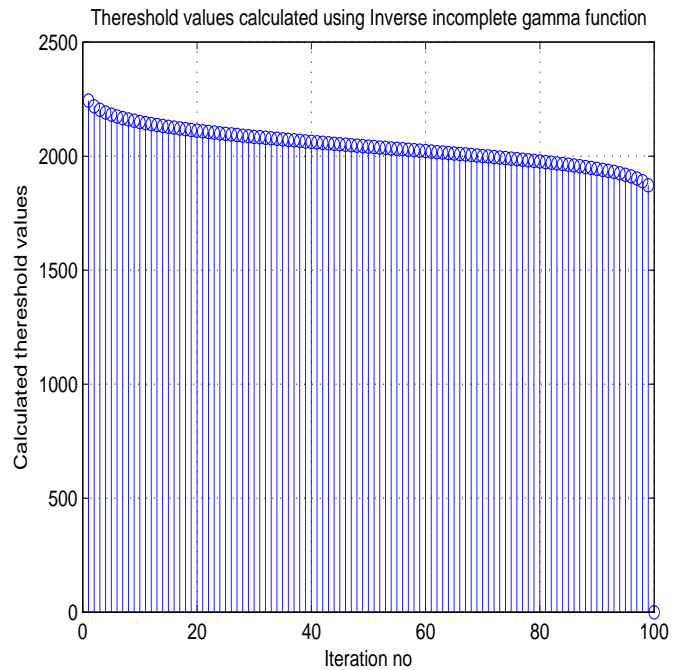


Fig.4 Computed Threshold Values For 100 Nodes

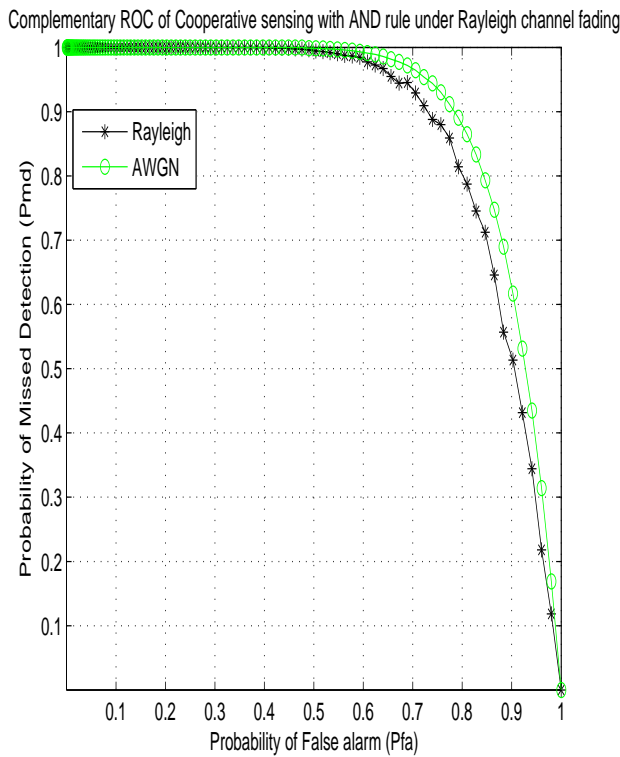


Fig.5 ROC Curve For AWGN And Rayleigh Fading Channels

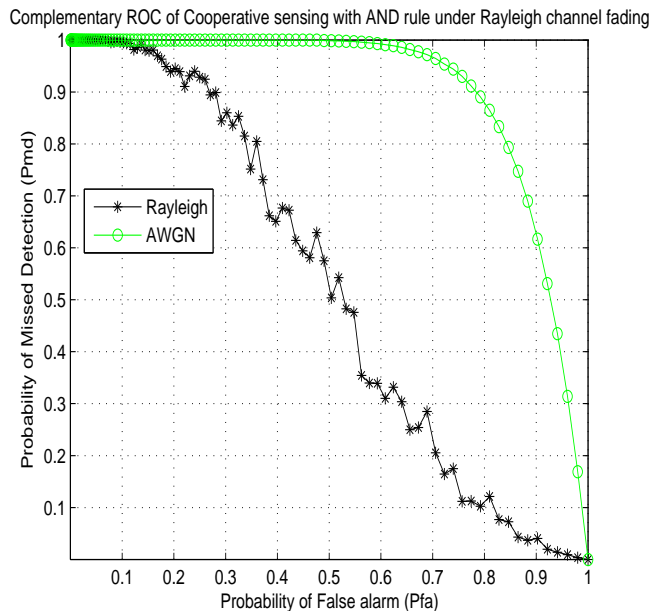


Fig.6 ROC curve for Amplify and forward cooperative network

In the cooperative case the amplify and forward relay network case is simulated and the performance is plotted in the ROC curve. Since the signal loss is avoided and the fading effect is reduced by the amplification

process there is a drastic improvement in the energy detector under this case. Fig.6 shows the improved performance of the energy detector. But there is some up and down the curve because of the incomplete inverse gamma function based threshold. The performance of the algorithm is evaluated by using indoor path loss model where we absorb from Fig.7 that the performance is more or less same for both AWGN and Rayleigh channel.

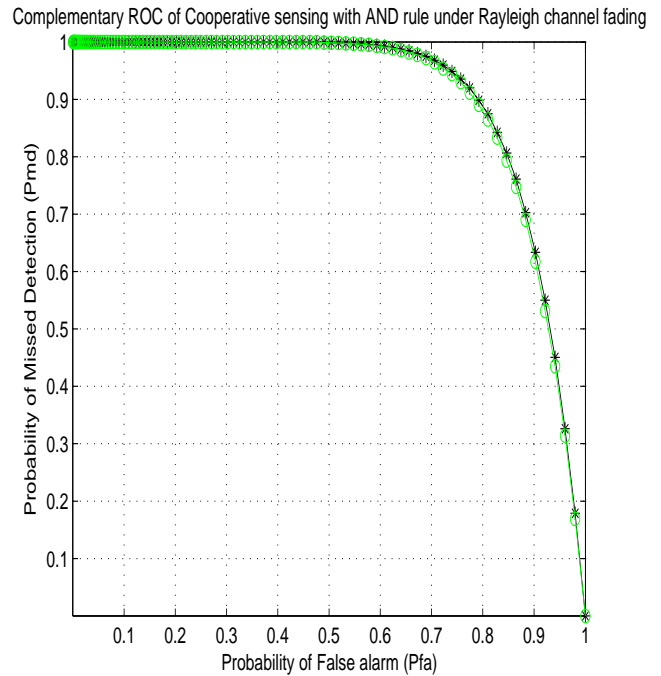


Fig.7 indoor scenario the AWGN channel and Rayleigh channel performance

4 Conclusion

This paper analyzed the performance of the energy detector spectrum sensing algorithm in Rayleigh fading environment and the result is compared with AWGN channel. The cooperative sensing based on the AND rule based decision is simulated and the performance is evaluated for the cases of indoor and amplify and forward cooperative networks. From the result we can conclude that Rayleigh fading supports the energy detection based algorithm comparing AWGN case but in the indoor scenario the performance is same for both AWGN and Rayleigh case. The energy detection algorithm performance is very good in the amplify and forward based relay cooperative networks but we observe some kind of small oscillation because of the incomplete inverse gamma function based threshold.

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