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Performance Analysis of Fading Channels on Cooperative Mode Spectrum Sensing Technique for Cognitive Radio

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ABSTRACT

Spectrum sensing is the main feature of cognitive radio technology. Spectrum sensing gives an idea of detecting the presence of the primary users in a licensed spectrum. The sensing of radio spectrum is an essential problem in cognitive radio (CR) networks, where secondary users (SUs) need to detect the presence of primary users (PUs) before they use the spectrum allocated to PUs. The detection of primary user status and the spectrum sensing are the major issues in cognitive radio systems. We employ one of the simplest and most efficient Spectrum Sensing technique, the cooperative spectrum sensing with three different digital modulation techniques BPSK, QPSK, 16-QAM. In this paper, we analyze the performance of the cooperative spectrum sensing technique with BPSK, QPSK, 16-QAM modulation techniques over Rayleigh fading Channel. Further, we analyze the performance and BER (Bit Error Rate) of cooperative spectrum sensing under Rayleigh fading and AWGN channels. The investigation and analysis on cooperative spectrum sensing with above digital modulation techniques can be utilized for future reference of spectrum sensing in the CR networks over AWGN and Rayleigh fading channels.

***KEYWORDS:** Cognitive Radio, Spectrum Sensing, AWGN, Rayleigh Fading Channel*

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INTRODUCTION

The radio spectrum is turning out to be scarcer with the growing number of spectrum-hungry applications, then again, the report from the Federal Communications Commission uncovered that most of the licensed spectrum is severely underutilized [1]. Cognitive radio (CR) [2], [3] is therefore proposed, to manage the difficulty between spectrum scarcity and spectrum underutilization. CR permits unlicensed users or secondary users (SUs) to access licensed spectrum to such an extent that the induced interference to the licensed users or primary users (PUs) is within the acceptable level.

In CR, an Unlicensed User or Secondary User senses for idle licensed user's bands, and if located, SU can exploit these bands for its own data transmissions. The SU however, performs spectrum sensing (SS) while transmitting its own to check the return of PU, and if PU has reappeared, SU needs to empty the band right away to maintain a strategic distance from harmful interferences. Among the current spectrum sensing methods, energy detection has been utilized comprehensively as it does not depend on licensed user signal characteristics and it is also the simplest to implement when compared to other techniques [3]. In Energy Detection, the detected signal energy is compared with a predetermined value of threshold (cooperative spectrum sensing) to detect the presence of a primary user signal. The performance of cooperative spectrum sensing worsens in a fading environment.

The authors in [4] have analyzed cooperative spectrum sensing performance under Nakagami fading channel, and Rayleigh-fading-channel. The authors in [5] researched the cooperative spectrum sensing performance under various channel conditions. The authors have demonstrated that the fading and shadowing parameters have directly affected the detection probability. S. Jindal et al. in [9] have studied detector based on wavelets with respect to channel fading. The authors in [7] have examined the cooperative spectrum sensing performance under various noise uncertainties and its consequences on cooperative spectrum sensing. B. Zhao et al. [10] have proposed an cooperative spectrum sensing based spectrum sensing scheme. The authors in [6] have studied Spectrum sensing using different methods with known and unknown noise levels. Three distinct types of signals are considered in our work are BPSK, QPSK, and 16-QAM. This paper evaluates the performance of energy detector in Rayleigh fading channel with signals from three different modulation schemes discussed above. Accordingly, we analyze and measure the enhancement in the capability of detection of cooperative spectrum sensing under various signal provisions in which the various parameters like the signal to noise ratio (SNR), detection threshold, Number of samples(N) can be optimized.

Although distinctive research has been conducted on the Performance of cooperative spectrum sensing using a specific signal in different channel conditions, very few have studied to analyze different signal provisions in single platform. The study conducted in this paper was to investigate three distinct signal provisions concurrently under Rayleigh fading and to measure signal to noise ratio, N and Pf.

System Model and Basic Spectrum Sensing:
Cooperative spectrum sensing is the conventional method to perform the spectrum sensing with least sensing time and least computational complexity. The cooperative spectrum sensing detects the presence of the Primary User by estimating the energy of the detected signal. It contains four major functional blocks. They are the Filter, Squarer, Integrator and decision device. The energy of the detected signal acquired from filtered squared and integrated output is quantified as the test statistics. The energy of all these filtered received signals is compared with a known threshold. Then afterward numerous probabilities like missed detection, false alarm and detection probabilities are evaluated.

H_0: y (n) = w (n) Primary User absent
H_1: y (n) = s (n) + w (n) Primary User Present

Where w (n) is Additive White Gaussian noise (AWGN), is the signal transmitted by primary user y(n), is the signal that has been captured by the Cognitive radio. The matrix is evaluated from the energy of all filtered received signals. The energy of all these filtered received signals is compared with a known threshold. Then afterward numerous probabilities like missed detection, false alarm and detection probabilities are evaluated.

Fig.1.1. Implementation of Energy detector with square law device

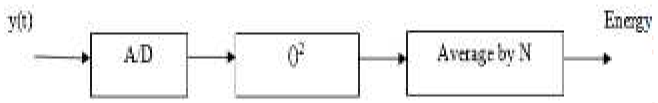
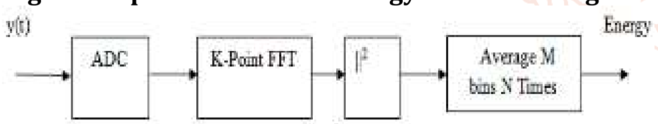


Fig.1.2. Implementation of Energy detector using FFT



In the cooperative mode, selection combining has been used and total error rate has been established in terms of false and missed detection over binary symmetrical channel. Curves has been plotted in terms of total error rate in the cooperative mode with respect to amplitude's power (*p*) of samples of primary users and with respect to SNR. In the end, performance has been analyzed in terms of error detection probability over Hyper-Rayleigh fading with respect to SNR and is compared with threshold optimization and CFAR method in which energy detector is used using MATLAB.

Result & Analysis:
In this paper, performance analysis of spectrum sensing employing improved energy detector over TWDP channel has been analyzed & evaluated and compared with threshold optimization and CFAR methods.

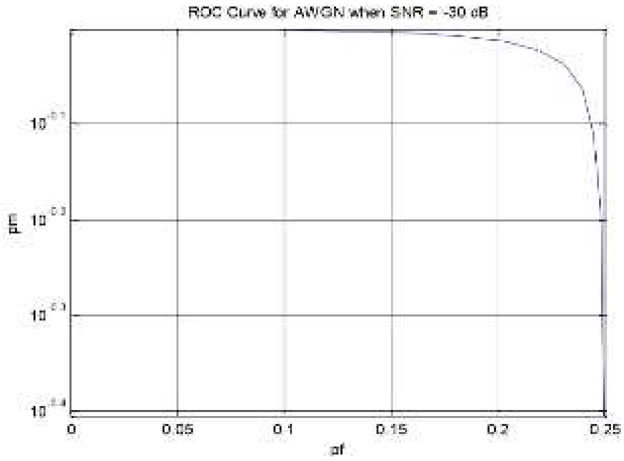


Fig.1.3 AWGN Fading Channel

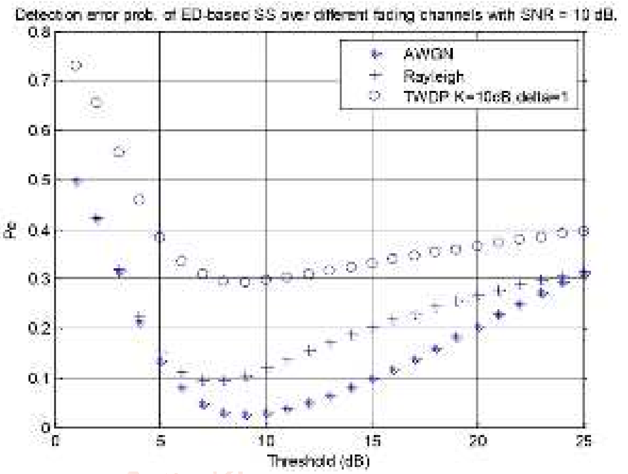


Fig.1.4 Detection Error Prob. of Diff. Fading Channels

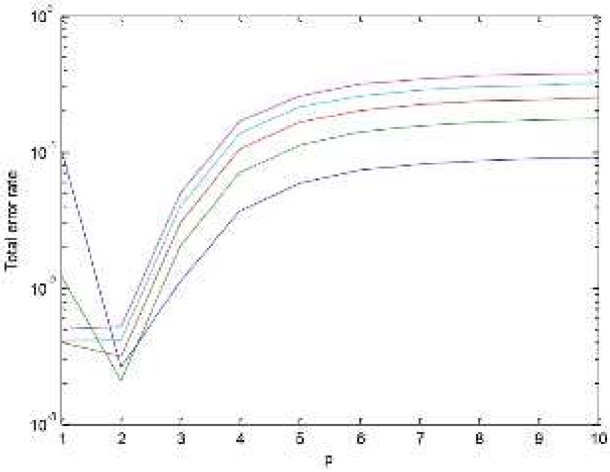


Fig.1.5. Total Error Rate Vs p Plot

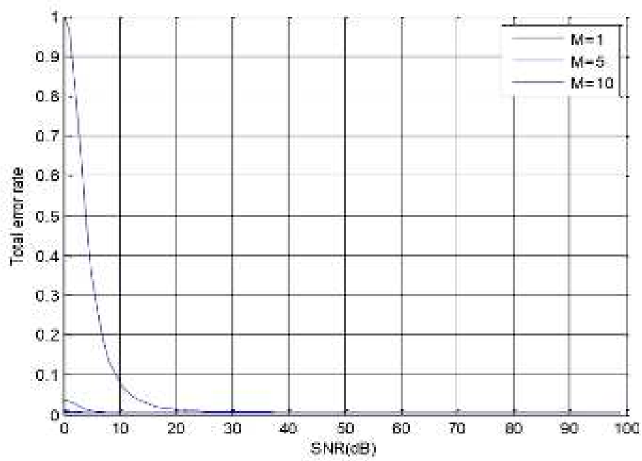


Fig.1.6. Total error rate Vs SNR Plot

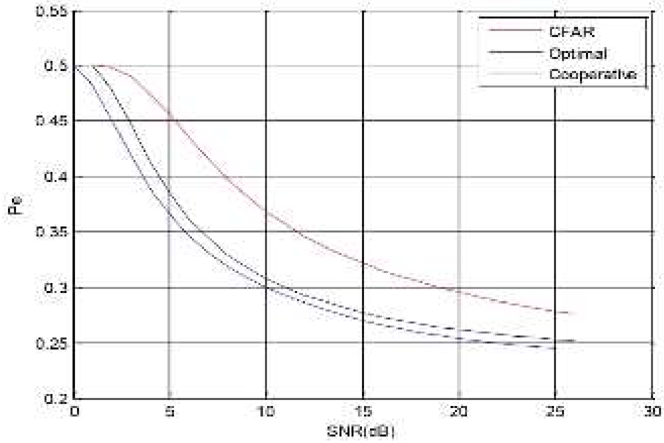


Fig.1.7. Detection Error Probability Vs SNR Plot over TWDP

TABLE1.1. Comparison P_e of Vs SNR

SNR in dB	Value of in CSS	Value of in OTM	Value of in CFAR
0	0.5	0.5	0.5
5	0.37	0.39	0.45
10	0.3	0.31	0.37
15	0.27	0.28	0.32
20	0.25	0.27	0.29
25	0.24	0.26	0.28

Conclusion:

In cooperative spectrum sensing, at each cognitive radio different antennas has been used.. In CFAR, the performance curves are obtained. Simulation results of Complementary Receiver Operating Curves (ROC) have been evaluated for AWGN Channel and for Rayleigh Channel with the help of MATLAB and following results have been concluded

- False Alarm detection probability is reduced when cooperative spectrum sensing is used in comparison to energy detection based spectrum sensing.
- SNR gain is archived in case of cooperative spectrum sensing.
- Efficiency has been enhanced of cognitive M2M wireless nodes.
- In cooperation mode, the number of cognitive radios and value of *p* are exceptional for which minimum error rate exhibits.
- In low SNR regions, less error rate is achieved if at each CR various antennas are used.

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