IJISET - International Journal of Innovative Science, Engineering & Technology, Vol. 2 Issue 12, December 2015.
www.ijiset.com
ISSN 2348 – 7968

Performance Evaluation of Relay based Cooperative Spectrum Sensing in Cognitive Radio Network Using Decode and Forward Relaying Technique

Mr.Lokesh Mehta[1], Mr. Mukesh Saini[2] and Mr. Geetesh Wagdre[3]

[1]MTech Student Electronics & communication Department, RGTU/PIES
Bhopal, Bhopal 462044, India

[2] Asst Prof. Electronics & communication Department, RGTU/PCST,
Bhopal, Bhopal 462044, India

[3]Asst Prof. Electronics & communication Department, RGTU/PCST
Bhopal, Bhopal 462044, India

Abstract

Rapid growth of wireless networks has increased the demand for radio spectrum which is a finite resource. However; the studies have shown that the licensed spectrum is not utilized most of the time. Cognitive radio is a technology that promises to bring a solution to this inefficient spectrum utilization .In cognitive radio networks generally consist of two types of wireless users: primary and secondary users primary users have highest priority in accessing a band of spectrum, secondary users equipped with cognitive radios exploit the same band of spectrum given that their transmissions do not harm the primary user's transmission. In this Paper, we develop performance modeling and evaluation of cognitive radio networks. This Paper shows the performance analysis of relay based CR networks and presents decode and forward relaying technique for cooperative spectrum sensing. Compared with amplify and forward technique, decode and forward techniques improves the detection accuracy.

Keywords: - **Amplify and forward, Decode and Forward, Cooperative Spectrum Sensing, cognitive radio, MRC, Energy Detection.**

1. Introduction

The term cognitive radio was first introduced by Joseph Mitola [1]. The cognitive radio is a radio that adapts to the conditions of the environment by analyzing, observing and learning. The cognitive network makes use of these adaptations for future decisions [2].Other definitions of CR were provided in [3 & 4] as follows-

FCC in [3]: CR is a radio that can change its parameters based on interaction with the environment in which it operates.

Jondral in [4]: CR is an SDR that additionally senses its environment, tracks changes, and reacts upon its findings. A CR is an autonomous unit in a communication environment that frequently exchanges information with the networks it is able to access as well as with other CRs**.**

A reliable cognitive radio system with high data rates is achievable by using cooperative relays for both the spectrum sensing and secondary transmissions. However, the two individual designs of spectrum sensing and secondary transmissions cannot be optimized separately, since they affect each other [5, 6]. For example, when an available spectrum hole is not detected by spectrum sensing during a certain observation window, the spectrum hole utilization would decrease. Cooperative relay communication or cooperative diversity techniques like amplify-and-forward (AF) and decode- and- forward (DF) has been discussed in [7-8].

In this paper, we have investigated the performance of spectrum sensing for a CR node which is far from PU. To improve the spectrum sensing efficiency; we propose a cooperative network based on relay nodes. The performance has been investigated in terms of BER, throughput, and Probability of detection.

2. System Model.

A centralized CR network with *active* secondary users is considered. The cooperative decision is assumed to be made by a fusion center. The secondary users share the same spectrum band which is originally allocated to the primary user.

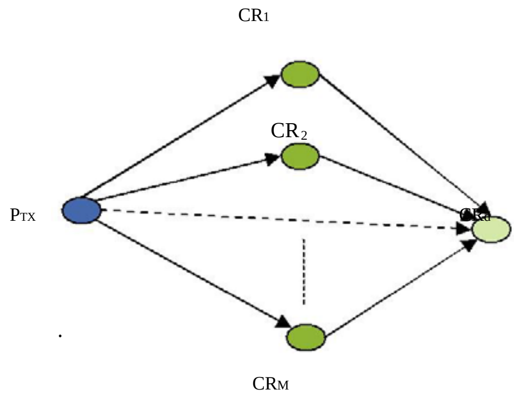

Fig. 1 System model for the cooperative communication

Fig.1 shows the system model for the cooperative communication. In this model, CR1, CR2…..CRM are within effective transmission radius (*rp*) of primary transmitter (*PTX*). Hence, the detection probabilities of CR1, CR2….CRM will be high. But CRd is beyond *rp*. Hence, it is hard for CRd to take decision about the presence or absence of PU. To improve the performance of spectrum sensing of CRd, we consider that CR1, CR2…CRM sense the activity of the PU individually and radius of each CR is *rc*. CR1, CR2….CRM and CRd are within each other's communication area. In our model, PTX is the source node; CR1, CR2...CRM are the relay nodes and they work on time division mode; CRd is the destination node. The time frame of each relay CR is divided in to two slots. In the first time slot, each relay CR received the signal of PU. In the second time slot the relay CRs decode the received signals and send the decoded signals to the destination CR. Signal from relays and signal of direct link is combined by MRC.

3. Spectrum Sensing Techniques

Spectrum sensing must be perform first before permitting the secondary user to access the vacant licensed band as it is key element in CR communication. Secondary Users are allowed to utilize the licensed band only in the case when they do not create any type of interference for the primary users.

The ED based approach also known as radiometry, is the most common way of spectrum sensing in high SNR conditions since it does not require prior knowledge of primary signals and has much lower computational and implementation complexity [9-10].In this energy detection approach, in order to determine whether the channel is occupied or not, the received signal strength or radio frequency energy in the channel is measured. This detector has a simply analytical model hence low computational complexity and can be easily implemented in hardware or software.

Energy Detection: The received signal at an energy detector will be filtered by an ideal band pass filter with bandwidth W. Then using a magnitude squaring device, the received energy, Y , is measured over an observation time of T, and compared with a predetermined threshold, λ, to decide whether the signal is present or not.

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4. Cooperative Sensing Techniques

Cooperation sensing is a proposed solution to the problems that arise during spectrum sensing like fading, shadowing and noise uncertainty [11]. Cooperative sensing has decreased the miss detection and false alarm problem up to a satisfactory level. In addition cooperative sensing can solve one of the most critical issues of spectrum, hidden terminal problem. This problem occurs when the CR is shadowed or in severe multipath fading [11].

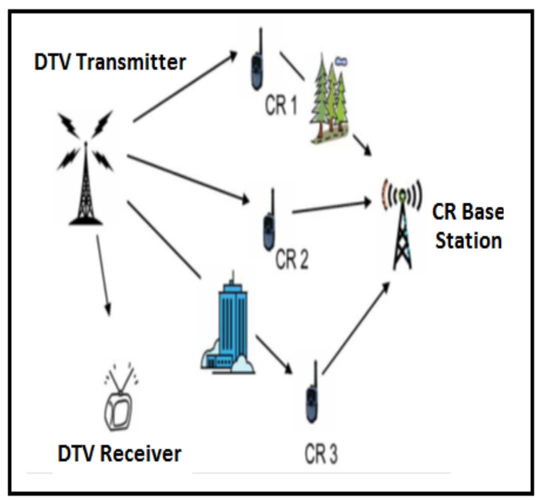

Fig.2 Co-Operative Spectrum Sensing in CR Networks.

5. Simulation Result

In this section we provide extensive simulation results to investigate the performance of spectrum sensing with energy detection method. The performance is investigated with different cooperative diversity technique, at different *SNR*.

In Fig.3&4, we estimate the BER performance of the CR user under different scenarios. BER is shown as a function of sensing channel *SNR*. The performance is investigated under DF cooperative diversity for different number of relay CRs. The BER reduces with increasing *SNR*.

ISSN 2348 – 7968

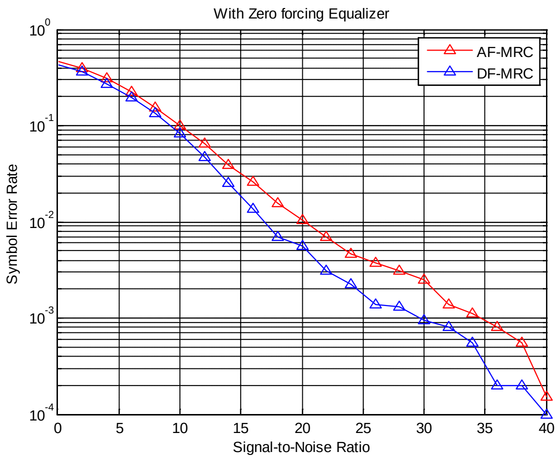

Fig.3 BER vs SNR with ZF Equalizer

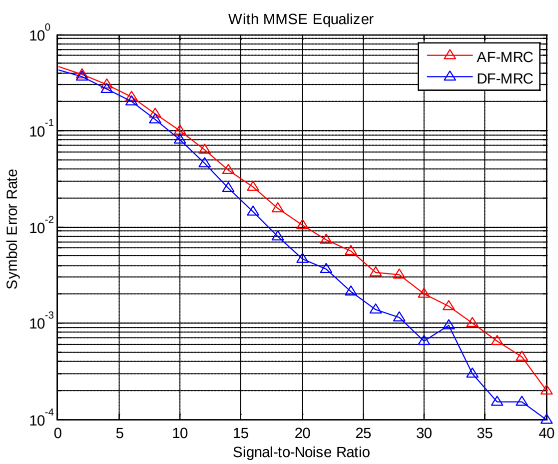

Fig.4 BER vs SNR with MMSE Equalizer

In Fig.5&6, we estimate the Probability of detection performance under different scenarios.

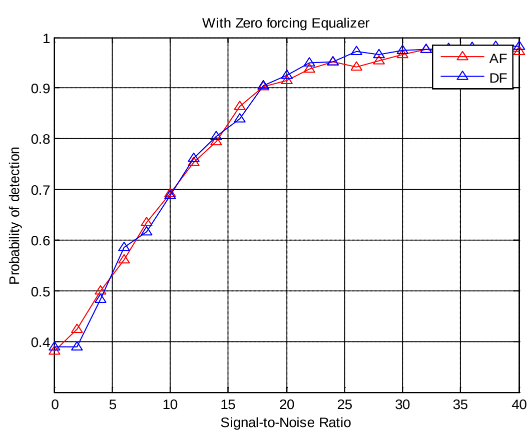

Fig.5 Probability of detection vs SNR with ZF Equalizer

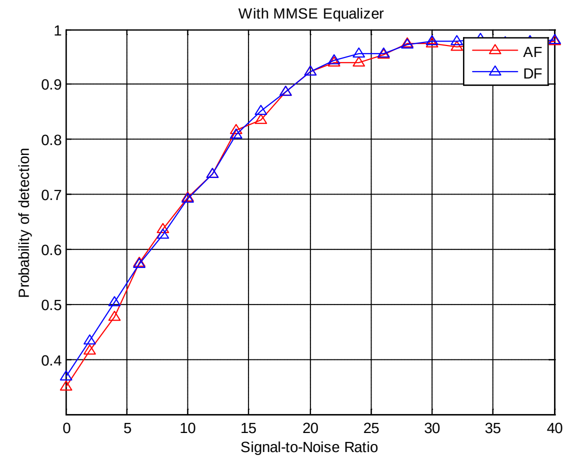

Fig..6 Probability of detection vs SNR with MMSE Equalizer.

In Fig.7&8, we estimate the throughput performance under different scenarios.

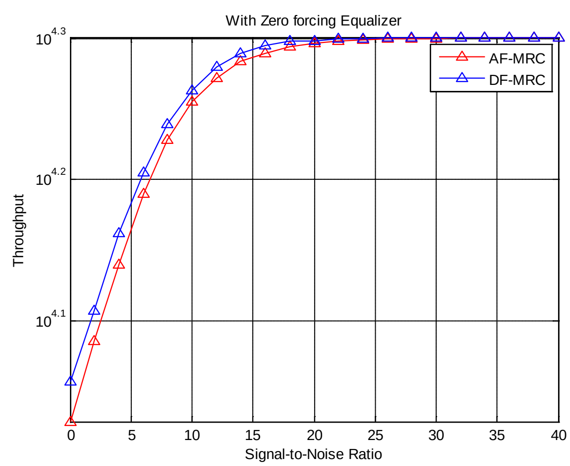

Fig.7 Throughput vs SNR with ZF Equalizer.

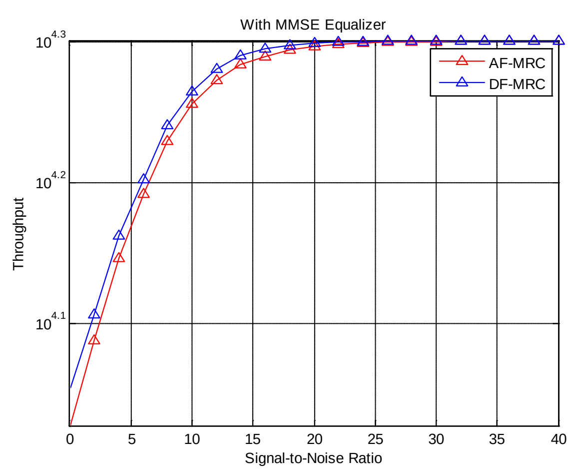

Fig.8 Throughput vs SNR with MMSE Equalizer.

TABLE 1
BER vs SNR for AF & DF with ZF Equalizer

S.No	*SNR*	*BER AF case with ZF Equalizer*	*BER DF case with ZF Equalizer*
1	*2*	*0.3904*	*0.3599*
2	*4*	*0.3096*	*0.2744*
3	*6*	*0.2255*	*0.1986*

TABLE 2
BER vs SNR for AF & DF with MMSE Equalizer

S.No	*SNR*	*BER AF case with MMSE Equalizer*	*BER DF case with MMSE Equalizer*
1	*2*	*0.3881*	*0.3610*
2	*4*	*0.2994*	*0.2738*
3	*6*	*0.2228*	*0.2032*

6. Conclusion

This Paper present a selective-relay-based cooperative sensing scheme without a dedicated channel to report initial detection results for fusion and show its advantage over traditional cooperative sensing. Based on two relaying strategies, namely, the amplify-and-forward strategy and the detect-amplify-and-forward strategy, We analyzed the way the detection accuracy varies with the number of cooperative users we show the importance of including the relaying channel propagation characteristics to the analysis and design of cognitive radio Networks. Compared with amplify and forward technique, decode and forward techniques improves the detection accuracy.

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