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Performance Evaluation of Energy Detection based Blind Spectrum Sensing

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Abstract –**Cognitive radio (CR) emerges as a novel wireless communications technology with the potential to change the inefficient way in which the radio spectrum is currently used. The techniques of dynamic access to the spectrum are a key element in the implementation of radio cognitive technology. This paper implements a blind spectrum sensing framework in cognitive radio networks using Energy Detection technique in Rician fading channel**

Keywords – **ADC, CR, Rician Fading Channel.**

I. Introduction

At present, the exploitation of much of the radio spectrum allocated under license is inefficiently performed due to the fixed allocation policies of the frequency bands. The inefficient use of spectrum, when examined as a function of frequency, time and space, has been demonstrated by recent studies [1]. The constraints imposed by current regulatory policies are the main constraints on the efficient use of spectrum. As a result, some frequency bands are used intensively and are congested, while other regions of the spectrum are partially or totally unoccupied most of the time. To support the increasing demands of new wireless communications technologies and services, more efficient spectrum management schemes are needed. On the other hand, the success of the services in the bands of free access has motivated the development of novel technologies that allow the use of the spectrum in an intelligent, coordinated and opportunistic way, without harming the existing services. Cognitive radio (CR) is a technology with the potential to dramatically change the way the radio spectrum is currently used and at the same time increase its availability for new wireless communications services [2].

The original idea of cognitive radio was introduced by Mitola in [3], where it was defined as "the point at which wireless PDAs and related networks are, in computational terms, sufficiently intelligent with respect to radio and The corresponding terminal-to-terminal communications to detect the eventual communication needs of the user as a function of the context of use and to provide the radio resources and wireless services best suited to their needs. The research highlights the potential of radio cognitive technology to increase the flexibility of current wireless communications services through a knowledge representation language called RKRL (Radio Knowledge Representation Language).

The concept of cognitive radio originally formulated by Mitola has been reviewed and reformulated by several authors. According to Haykin, "Cognitive radio is an intelligent wireless communications system that is aware of its surroundings and uses the understanding-by-building methodology to learn from its environment and adapt its internal state to statistical variations in radio frequency stimuli (Eg, transmission power, carrier frequency and modulation type) in real time, with two fundamental objectives: to make efficient use of the spectrum and to provide highly reliable communication [4].

Cognitive radio differs from conventional radio in three fundamental aspects: 1) cognitive ability; 2) ability to learn and adapt; 3) self-reconfiguration capability [4]. Cognitive ability refers to the ability to obtain information from the environment and the internal state of the system through multiple sensors. The ability to learn and adapt allows the use of this information to dynamically and autonomously adjust the operating parameters through the ability to auto-reconfigure, in order to optimize system performance. Note that the use of the term system implies that the above three capabilities may be distributed across multiple layers of protocols and devices in a network. Figure 1a shows the minimum functional components that the ideal cognitive radio architecture should have: 1) user interface functions, 2) environment sensors, 3) system applications, 4) reconfigurable radio interface, 5) Cognitive functions and 6) output functions for interaction

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with the user. Between each of the functional components several interfaces are established through which data exchange and control signals are produced that define the operation of the system.
The main objective of this paper is to implement a blind spectrum sensing framework in cognitive radio networks using Energy Detection technique in Rician fading channel.

II. Proposed Method

Energy detection is transmitter detection technique for spectrum sensing. It is used to detect the primary signal is exist or not in the frequency spectrum which is being sensed. The concept for energy detection of unknown signals is developed by Urkowitz in 1967. Although, in which the signal is actually unknown in detail, it's considered deterministic. Deterministic signal is assumed as the input with signal present is Gaussian but not zero mean. The spectral region is known and the noise is assumed to be Gaussian and additive with zero mean [6]. Energy detection method [5] is, also, known as periodogram (PE) [7]. Basically, Energy detection is most common method of spectrum sensing is due to two reasons:

a) Receiver do not require any knowledge about primary user's signal
b) it have very low computation complexity

The energy detection can be performed in two ways, Time domain and frequency domain. There is no difference in evaluated result any domain can be used. Figure 1 shows the time domain representation of the energy detection method. To measure signal power in specific frequency band in time domain, bandpass filter of bandwidth W is used at input signal. ADC is used to convert one form to another for samples. A square and average device is used to obtain the receiver signal energy, and it compared with threshold to decide whether the signal is present or not.

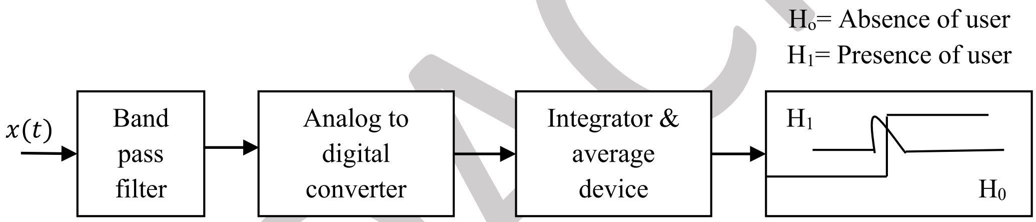

Figure 1: Block diagram of Energy Detection

For system model, a system is considered of one cognitive radio (CR), one primary user (PU) and fusion center (FC). When a signal from PU is transmitted, the received signal by the CR for the detection of PU can be modeled under two hypotheses (H_0 & H_1), is gives as follows

$$H_0:\ y(k) = n(k): \text{PU is absent} \quad (1)$$

$$H_1:\ y(k) = h * s(k) + n(k): \text{PU is present} \quad (2)$$

Where y(k) the received signal by secondary users is, s(k) is the transmitted signal of the primary user, h is the channel coefficient and n(k) is AWGN with zero mean and σ^2 variance (i.e. N $(0,\sigma^2)$). H_0 & H_1 are the sensing states for absence and presence of signal respectively.
The decision statics D, to check about the presence or absence is made by making the test on the received signal at Cognitive radio receiver,
The decision statics for energy detection is,

$$T = \sum_{k=0}^{L} |y(k)|^2 \quad (3)$$

Therefore, T is the summation of energy of y (k) over L samples via energy detection statics.

Probability of detection P_d is used is defined as follows:

$$P_d = Pr\ \{T > \gamma | H_1\} \quad (4)$$

Probability of false alarm P_f is used is defined as follows:

$$P_f = Pr\ \{T > \gamma | H_0\} \quad (5)$$

Rician Fading Channel

Rician Fading occur when signal received through both direct path (LOS-line of sight) and indirect path (non-LOS). Here direct signal is much stronger than indirect signal. In Rician fading channel model direct or LOS path signal represent by X which is called specular component and indirect or non LOS path signal is represented by Y which is called scatter component. Specular component X have non-zero mean (m) while scatter component have non zero mean (m) but both have equal variance (σ^2).

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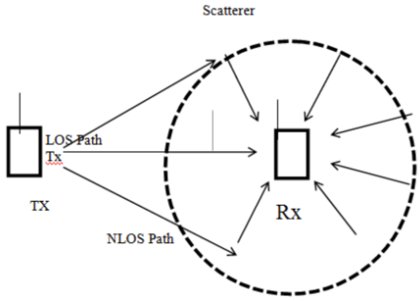

Figure 2: Rician fading model [8]

Here,

$$Z = \sqrt{X^2 + Y^2} \quad (6)$$

Where, Z is Rician distribution.

Rician fading channel is define by Rician factor "K" which is the ratio of power of direct path to power of all indirect path signal:

$$K = \frac{m^2}{\sigma^2} \quad (7)$$

Then the probability density function is given as:

$$p(Z) = \frac{Z}{\sigma^2} e^{-\frac{Z^2+m^2}{2\sigma^2}} . I_0\left(\frac{ZM}{\sigma^2}\right); \quad Z \geq 0 \quad (8)$$

Where, I_0 is zeroth order Bessel function of first kind.

III. Simulation And Results

The performance of proposed algorithms has been studied by means of MATLAB simulation.

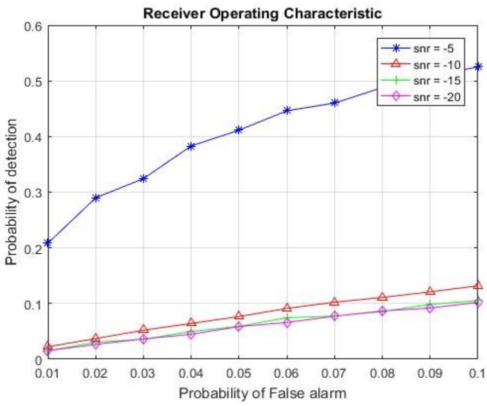

Figure 3: P_f v/s P_d graph at different values of SNR in Energy detection

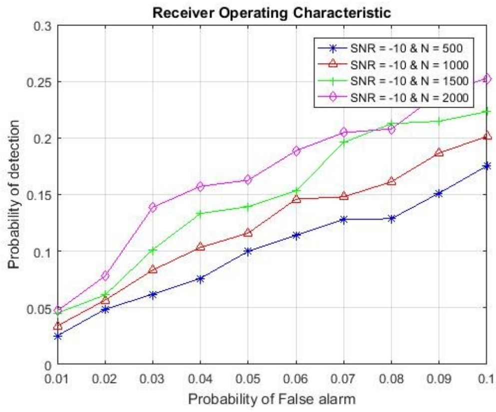

Figure 4: P_f v/s P_d graph at different value of Number of samples (N) in Energy detection

IV. Conclusion

Spectrum is a very valuable resource in wireless communication systems and it has been a major research topic from last several decades. Sensing provides awareness regarding the radio environment so that the spectrum opportunities can be efficiently reused while limiting the interference to the primary user. Simulation results show the performance of Energy Detection technique of spectrum sensing in Rician fading channel.

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