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Techniques for Energy Detection in Cognitive Radio for Spectrum Sensing: A Case Study

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Abstract: Cognitive radio is believed to be the future wireless communication system. In the existing wireless communication systems, the static allocation of spectrum is employed and it had led to the problem of spectrum scarcity. Spectrum sensing is the basic and necessary mechanisms of the Cognitive Radio to seek out the unused spectrum allotted to the primary users. This paper presents an outline of CR design, discusses the characteristics and advantages of various spectrum sensing techniques of CR .One of the techniques of spectrum detection called Energy detection does not requires signal properties, channel data, a sort of modulation of the transmitted signals so it is used extensively. A survey of different spectrum sensing and energy detection techniques is presented.

Keywords: Wireless communication technologies, Energy detection techniques, cognitive Radio, Dynamic Spectrum access.

I.INTRODUCTION

Nowadays cognitive Radio is a topic of great interest for the technologists because utilization of spectrum efficiency is increasing widely .This is a recent and interesting analysis topic , that's why many technical analysis queries still ought to be answered. A dynamic Spectrum Access Scheme can be employed to tackle the problem of spectrum scarcity. As a single user can never use whole of the spectrum provided to him. So cognitive radio has the ability to find out the unused bands in the radio environment. So CR can mould the transmission parameters according to the requirement. That's why spectrum sensing is the main thing for a CR user that let him know about the unused bandwidths.

II. SENSING THE SPECTRUM FOR SPECTRUM SHARING

Wireless communication systems have grown considerably in two decades. This domain has restrictions to the growth because radio spectrum is a limited resource. Recent data shows that spectrum exploitation is increasing exponentially. So inferring this inefficient usage of spectrum, CR and Dynamic Spectrum Access (DSA) propose an expedient spectrum usage approach [1]. The fundamental plan of DSA is that frequency bands that don't seem to be being used by their authorized users, (Primary Users (PU)), area unit utilized by CRs, (Secondary Users (SUs) as long as they are not doing harmful interference to PUs[2].Hence, the fundamental technology of DSA techniques is that of CR .So CR allows the exploitation of temporally unused spectrum bands called Holes. The CR holes of spectrum are classified in two types i.e. Spatial Spectrum Holes and Temporal Spectrum Holes. During the time of sensing a temporal hole is not used by the primary user so it can be used by the secondary user in that time slot. A spatial spectrum hole is a band which is not used by the Primary Users at some spatial areas; and thus can be employed by the Secondary Users.

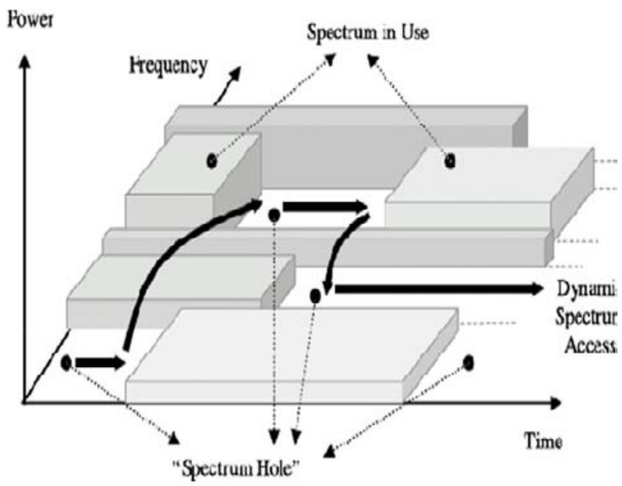


Fig.1 Different types of spectrum holes

III.CHARACTERISTICS

CR has two crucial characteristics that are need to be stated [3]:

Cognitive Efficiency

The cognitive efficiency of a CR is a method of analyzing the outer radio environment so as to find out the unused radio-frequency spectrum and find out the acceptable communication parameter to adapt with the dynamic radio environment .To justify the capability of a CR in term of cognitive cycle Metola[1] stated "a Cognitive radio regularly observes the environment, orients itself, creates plans, decides, and so acts", as shown in figure two.

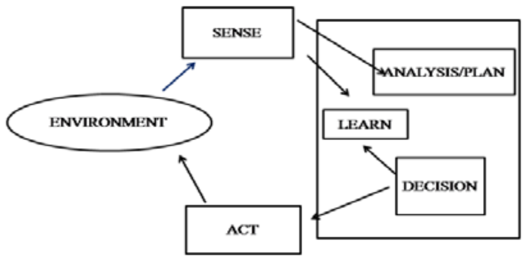


Fig.2 Cognitive cycle

The process of sensing the outside environment finds out the presence of a spectrum hole. The observations taken by the sensing are provided into plan cycle processes within which further used, however they are additionally provided to learn module to learn and remember. The learning permits the system to become skilled from the experiences. The analysis method is liable for generating and analyzing work streams i.e. determines rate, bandwidth, frequency, power, modulation, etc. At the decision stage of the cycle, the CR has selected acceptable spectrum band for transmission of the signal .The analysis, decision and learn modules compose the inner part of the system, the intelligence that governs the complete CR called the cognitive Engine. Cognitive engine is considered a similar to human brain that enables intelligence within the radio device.

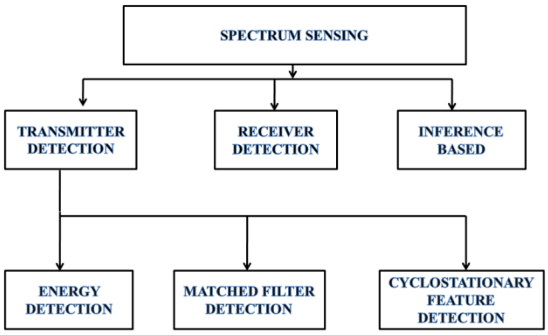
Finally the choice is place into action and therefore the operation of the cognitive radio is really influenced .The sensing (observation) and action modules represent the interfaces of Cognitive Radio with the real world. Similar cycles describe the operation of CR by [4],[5]and][6]

Reconfigurability

Reconfigurability shows the radio efficiency to vary the functions i.e. cognitive radio can vary the radio frequency, transmission power, modulation theme, communication protocol as to accomplish the optimum functioning [4], [7].

IV. SPECTRUM SENSING

Spectrum sensing is the most important task in CR cycle so therefore the main aim to the Cognitive radio users. In spectrum sensing analyzing the spectrum and searching out the unutilized bands and sharing it as well as preventing the use of the spectrum that is already occupied by a primary user is done. It is outlined as [8] "action of a radio measure signal feature". For increasing the probability of sensing various techniques for spectrum detection techniques can be employed as shown in Figure.



Fig,3 Techniques for spectrum sensing

A. Transmitter Sensing OR Non-cooperative Detection

In this technique every CR has the capability to sense the existence or the non existence of the PU in the specified spectrum .A mathematical representation for transmitter detection is

: (H1:y(t)) = (w(t))

: (H)2y(t) = h.x (t) +w t()

Where H1 represents "no signal transmitted",

H2= "signal transmitted", y(t) =signal received,

x (t) = signal transmitted, w(t) = associate Additive White Gaussian Noise (AWGN) with zero mean and variance

h= amplitude of gain of channel gain (channel coefficient).

Various ways are presented, like matched filter sensing, energy detection, and cyclostationary feature detection[9], [10].

B. Matched Filter Detection

The matched filter sensing using CR was 1st presented in [11].The matched filter (also stated as coherent detector), can be inferred as the best sensing technique if Cognitive Radio has information of Primary User waveform. It is accurate as this maximizes the received signal-to-noise ratio.

C. Cyclostationary Feature Detection

A signal is called as cyclostationary if its autocorrelation and mean are periodic functions. Feature detection means obtaining features from the received signal and employing the detection task on the obtained features. This technique can differentiate PU noise and PU signal, and it can also be used at significantly low Signal to Noise ratio (SNR).

D. Energy Detection

Energy detection or non-coherent detection, is the detection method that uses energy detector (referred to as radiometer) to denote whether the signal is present or not within the band. This is very important and typical method of sensing the spectrum since it has fair computational complexities, and may be used in time as well as frequency both domains. Energy detector needs information regarding the noise within band to regulate the detection function. .As compared to the energy detection technique, matched filter and cyclostationary techniques needs a prior data of the PU to work efficiently, since it is complicated to realize in practical because PUs take issue in various scenario .This type of detection is not much optimal but it is easy to implement, therefore it has been adopted extensively. Detection is done by doing the comparison of output of energy detector with threshold that depends on the noise factor.

D.Receiver Detection (Cooperative Detection)

The information which CR gain for PU is shared among different networks. It provides a more accurate spectrum sensing for the areas wherever the CRs are situated.

There are two methods for cooperative spectrum sensing [10], [12]:

1. Centralized approach: In this approach to CR it has a central CR called fusion centre (FC) in the network. It gathers the sensing data from every sense CRs existing in the network. For collecting the data, every CR is tuned with a control channel called Report Channel having a physical point-to-point link between every cooperating CR and the FC for sending the sensing results. After this FC analyses the sent information and determines the spectrum bands which may or may not be used.

2. Distributed approach: Like the centralized approach, distributed cooperative sensing is not dependent on the FC for making a cooperative decision .In the distributed approach of the CR cooperative spectrum sensing, a single CR has not the full control. Every CR sends their specific data related to sensing to all other CRs and then merges its information with that of the received information and then decides if there is any primary user is present or not. But it needs every independent CR to have a much greater level of independency and set them to make an ad hoc network.

For the detection of signals, techniques of sensing are classified into two types: Coherent and Non-coherent spectrum sensing.

Coherent detection: PU signal is coherently detected by making comparison of the received signal characteristics with a prior information of PU signals.

A different approach for classifying the sensing techniques relies on bandwidth of the spectrum of interest for narrowband fig 3 [13]

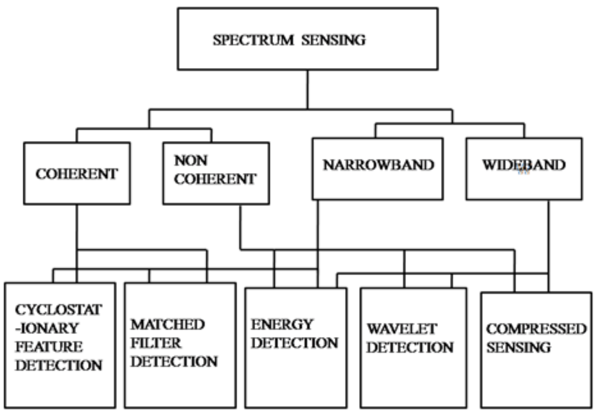


Fig.4 A different classification for spectrum sensing techniques.

V.DETECTION OF ENERGY UNDER AWGN CHANNELS

Energy detection is the preferred detection methodology because of its simple and easy circuit in practical implementation. The main aim of energy detector is to calculate the energy of received signals and then compare it with a threshold .In journalism, we encounter numerous algorithms that shows energy detection is enforced each in time as well as frequency domain by making use of Fourier Transform(FFT).

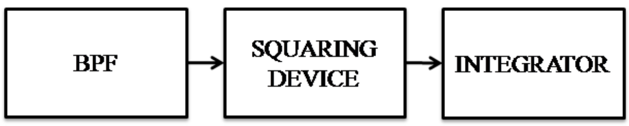


Fig.5 Time Domain Representation of Energy Detection

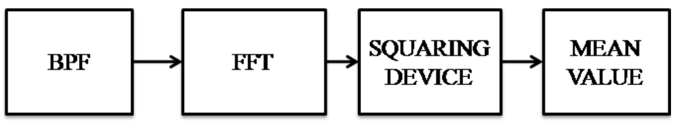


Fig.6 Frequency Domain Representation of Energy Detection

VI. TIME DOMAIN ENERGY DETECTION

Kostylev [16], analysis of a signal with random (Rayleigh, Rice, and Nakagami) Amplitude. The analysis is based on no diversity case below Rice, Nakagami, and Rayleigh fading channels, and quantify the advance within the likelihood of detection when multiple antennas (diversity) ways for energy detection based mostly systems like Equal gain combining (EGC), Switch and Stay (SSC) and selective combining (SC), is used. Digham et al. [14] the main focus is on different multiple antenna process based energy detector receptions like Selection Combining(SC), Maximal Ratio Combining (MRC), Switch-and-Stay combining (SSC), square law Selection(SLS) and square-law Combining (SLC) under Rayleigh Fading Channels .The likelihood of detection over, Nakagami, Riciean and Rayleigh fading channels has been derived.

The technique of Energy Detection uses a device for squaring after that an integrator, and in output we get the decision variable. After this the comparison of Decision variable is done with a threshold and if it is greater than the edge, then the results of the detector will be a PU present. Sensing using Energy detection method is incredibly practical as it needs no data regarding the signal required to detect.

VII. FREQUENCY DOMAIN ENERGY DETECTION

The technique of energy detection is the most general detection method which is nowadays used in cooperative spectrum sensing [10].The reason behind this is performance degradation of it because the noise uncertainty could be mitigated by using the diversity gain that results from cooperation. At Apattuet al. [15], The performance of the energy detector used in cooperative spectrum detection is measured over channels having multipath fading as well as shadowing.

VII. CONCLUSION

A review of the CR technology and the spectrum sensing techniques is presented through this paper .Energy detection is presented as a figure of benefit on which quantitative assessment of a radiometer’s design as well as its standardization design and algorithmic rule are based. The spectrum detection scheme called Energy detection in the domains of time and frequency is discussed with both its merits and demerits. Energy detection has been used as another spectrum detection methodology for CRs due to easy circuit in practical implementation and data regarding the signal that is to be detected is not needed. Sensing using Energy detection method is incredibly practical as it needs no data regarding the signal required to detect.

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