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SURVEY ON PERFORMANCE ANALYSIS OF SPECTRUM SENSING TECHNIQUES FOR COGNITIVE RADIO SYSTEM

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Abstract: In the development of future wireless system the spectrum utilization functionalities will play a key role due to the scarcity of unallocated spectrum. Moreover, the trend in wireless communication system is going from fully centralized system into the direction of self-organizing system where individual nodes can instantaneously establish ad hoc networks whose structure can change over time. Cognitive radio, with the capabilities to sense the operating environment, learn and adapt in real time according to environment creating a form of mesh network, are seen as a promising technology. The research work presents an overview of cognitive radio, various spectrum sensing technique used in CR and also describe the state-of-the-art in cognitive radio standards and regulation. In this project we have implemented and analyzed the energy detection technique for spectrum sensing in CR.
Keywords: Cognitive radio, spectrum sensing, energy detection.

I. INTRODUCTION

Communication reliability in Wireless Sensor Networks (WSNs) is challenged by narrow-band interference (Wi-Fi, Bluetooth, etc.) and persistent multi-channel fading. Low reliability often manifests itself in needless packet retransmissions, and thus higher energy consumption. This problem can be mitigated through diversity in the routing protocol, by intelligently routing packets to mitigate areas of low connectivity [1]. This, however, may often not be enough, and further methods to improve overall connectivity are desired. Another option to mitigate communication difficulties is offered through frequency diversity. Wireless sensor networks (WSN) are being used in many industrial and application areas, including industrial process monitoring, healthcare applications, home automation, and traffic control [1]. In last decade, various communication systems use industrial, scientific, and medical (ISM) band for exchanging information due to its license-free nature [1, 2]. As a result, the ISM band becomes more congested. The concept of Cognitive Radio (CR) has recently initiated great interest to get full potential of the radio spectrum [3]. If a Primary User (PU) is currently not using the band, the secondary user changes its transmission parameters to take advantage of the band. After detecting the vacant frequency bands, a CR user selects the best available spectrum hole for opportunistic communications and it vacates the channel when the PUs returns. It also applies the same phenomenon to a control channel. Hence, a particular channel cannot be fixed as a control channel forever and the control channel can vary from time to time. CR networks involve extensive exchange of control messages to coordinate critical network functions, which are broadcasted on a pre-assigned Common Control Channel [4]. However, not only is a static control channel allocation contrary to the opportunistic access paradigm, but also the implementation of a CCC for all the CR users is a challenging task [4]. Furthermore, the sudden appearance of a PU may lead to loss of connectivity among SUs [4, 5].

II. METHODOLOGY

Cognitive radio mainly does four functions.-

- It continuously looks for the unused spectrum which is known as the spectrum hole or white space as is shown in the Figure 1 This property of cognitive radio is termed as spectrum sensing.
- Once the spectrum holes or white spaces are found, cognitive radio selects the available white space or channel. This property of cognitive radio is termed as spectrum management.
- It allocates this channel to the secondary (cognitive) user as long as primary user does not need it. This property of cognitive radio is termed as spectrum sharing.
- Cognitive radio vacates the channel when a licensed user is detected. This property of cognitive radio is termed as the spectrum mobility

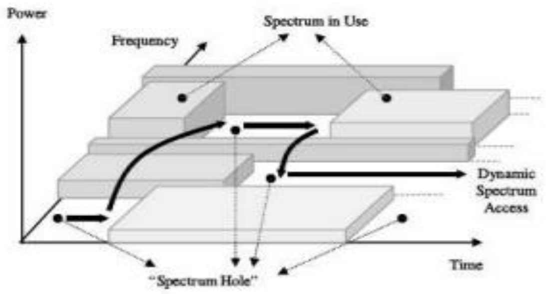

Figure 1: Spectrum hole concept [2]

All these methods are good and each has its own advantages and disadvantages. The method used in this research work is energy detection method because of its simplicity and ability with which it can be applied in almost all the cases. Moreover, it has low computational and implementation complexities and optimal under no knowledge of primary signal. We have used energy detection method for building the cognitive radio network.

III. ENERGY DETECTION

Energy detector based approach is the most common way of spectrum sensing because of its low computational and

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implementation complexities. When the primary user signal is unknown or the receiver cannot gather sufficient information about the primary user signal, the energy detection method is used. About the primary user signal, the energy detection method is used. This method is optimal for detecting any unknown zero-mean constellation signals and can be applied to cognitive radios (CRs) [6]. The decision metric for the energy detector can be written as:-

The energy of an averaged signal is subjected to two hypothetical test functions.

H1 (PU is in operation)

Under H0

X[n] = w[n]; (occurrence of noise only)

Under H1

X[n] = s[n] + w[n]; (occurrence of signal with noise)

Here n = 0,1,2….,N-1,N shows the index of sample, w[n] designate the noise and s[n] is the primary signal to detect.

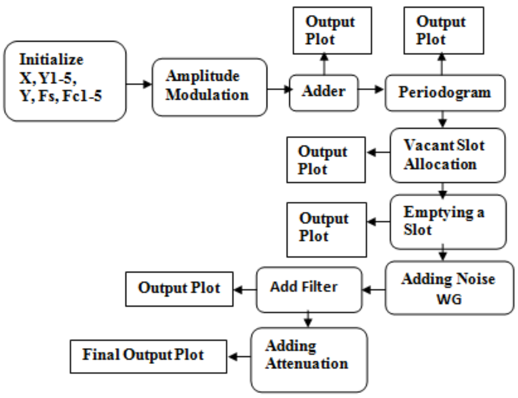

Figure2: Energy Detection Block Diagram [2]

Brief definitions of system model components:

- Initialization- 5 Carrier Frequency Bands for Users, Message Frequency and the
- Sampling Frequency is initialized.
- Modulation- Modulates user data over the respective frequency band by amplitude modulation
- Adder- Addition of all the modulated signals to produce a transmitting signal
- Periodogram- To estimate the power spectral density of received signal.
- Vacant Slot Allocation- New User is allotted to the first spectral hole when he arrives.
- Emptying a slot- Asked user to empty a specific slot if all the slots are engaged.
- Addition of noise- Amount of Noise to be added
- Addition of Filter – Filteration of added noise
- Attenuation- Percentage of Attenuation is introduced

IV. SIMULATION RESULT

The proposed scheme will work following steps:

Energy Detection If the secondary user cannot gather sufficient information about the PU signal; the optimal detector is an energy detector, also called as a radiometer. It is common method for detection of unknown signals. The block diagram of the energy detector is shown in Figure 3.

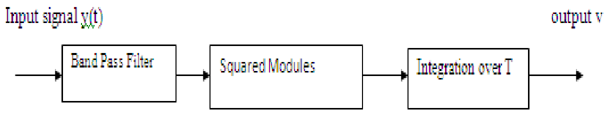

Figure 3: Energy detection

First, the input signal y(t) is filtered with a band pass filter (BPF) in order to limit the noise and to select the bandwidth of interest. The noise in the output of the filter has a band limited, flat spectral density. Next, in the figure there is the energy detector consisting of a squaring device and a finite time integrator. Finally, this output signal V is compared to the threshold n in order to decide whether a signal is present or not. The threshold is set according to statistical properties of the output V when only noise is present. The probability of detection Pd and false alarm Pf are given as follows.

$$\boldsymbol{pd} = \boldsymbol{p}\ \{\boldsymbol{y} > \lambda \backslash H\mathbf{1}\}$$

$$\boldsymbol{pf} = \boldsymbol{p}\ \{\boldsymbol{y} > \lambda \backslash Ho\}$$

From the above functions, while a low Pd would result in missing the presence of the primary user with high probability which in turn increases the interference to the primary user, a high Pf would result in low spectrum utilization since false alarm increase the number of missed opportunities. Since it is easy to implement, the recent work on detection of the primary user has generally adopted the energy detector. However, the performance of energy detector is susceptible to uncertainty in noise power. In order to solve this problem, a pilot tone from the primary transmitter is used to help improve the accuracy of the energy detector. The energy detector is prone to the false detection triggered by the unintended signals.A simple energy detector works poorly for frequency hopping spread spectrum signals. The channelized radiometer is multichannel receiver that has several energy detectors that integrate energy in many frequency bands simultaneously. It is especially useful detecting frequency hopping spread signals. An analysis of the effects of frequency sweeping on a channelized radiometer is presented in. It is assumed that the signal to be detected uses slow frequency hopping and that sweeping is faster than hop dwell time. In a practical signal detection system, the instantaneous bandwidth may be limited. In frequency sweeping, the centre frequency is changed as a function of time to cover a wider bandwidth. Numerical examples in demonstrate that if the number of hops observed per decision is small, sweeping can be necessary to get the desired performance. When the channel is fading, the best performance s obtained using fast sweeping. The drawback of channelized radiometer approach compared to a simple energy detector is the increased complexity.

V. SIMULATION RESULT

This paper presents the cognitive radio system using MATLAB (R2013a) v.8.1.0.604. We have used the digital implementation of energy detector using FFT. It is assumed that there are 5 primary users in the spectrum. The cognitive radio system continuously looks for the spectrum hole where primary user is not present which is determined by the

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energy detection method and as soon as it finds out the spectrum hole, it allots it immediately to the Secondary user and whenever primary user wants to occupy the slot, secondary user immediately vacates it. The carrier frequencies used for 5 signals are 1MHz, 2MHz, 3MHz, 4MHz, 5MHz and sampling frequency is 12MHz. Power spectrum density of signal is calculated and it is compared with the predefined threshold value to determine the presence of primary user signal [1]. Here, we have assumed that 1st, 2nd, 4th and 5th primary users are present and 3rd primary user is not present. Further secondary user is added at the vacant slot of 3rd carrier band. Here, Signal to noise ratio (SNR) is taken as 3dB, 6dB, 10dB and filtered with the help of digital filters respectively. Also the signal is added with 10%, 15%, 20% attenuation respectively. Then, the following results are obtained which are shown in the Figure 4, Figure 5, Figure 6 and Figure 7.

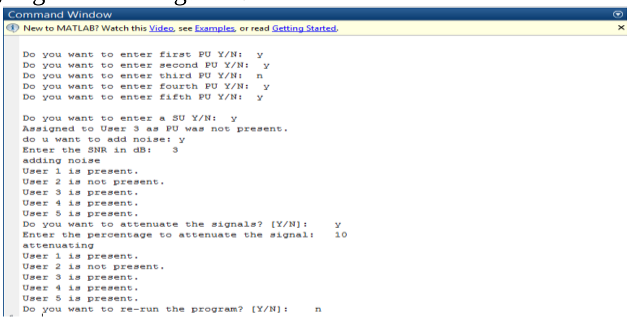

Figure 4: SNR and Attenuation selection to get graph results

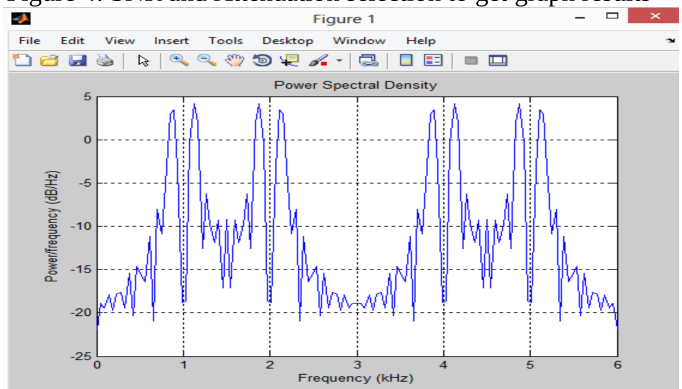

Figure 5: Graph showing the power distribution over different frequencies as power spectral density for carrier band. User 1, 2, 4, 5 present and user 3 is absent.

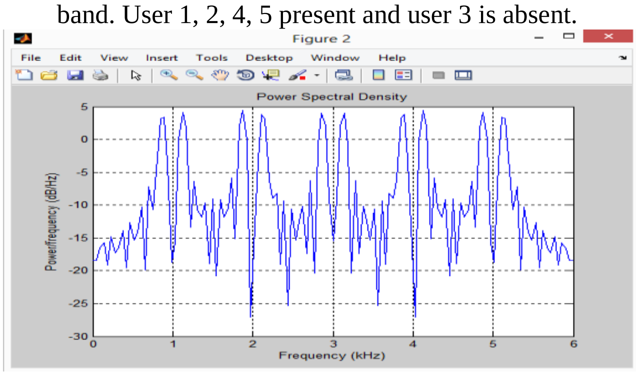

Figure 6: Graph showing the power distribution over different frequencies after adding secondary user at carrier band 3, where primary user is absent initially.

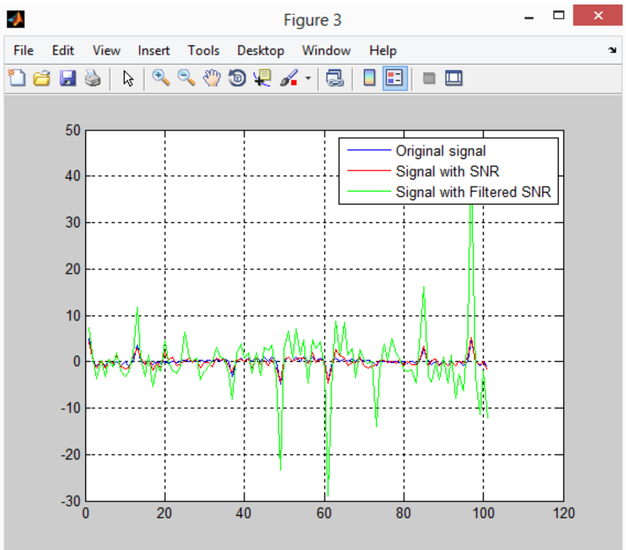

Figure 7: Graph showing the filtered SNR with respect to signal with SNR and original signal, SNR = 3 db

VI. CONCLUSION

In this research work a survey on existing techniques was presented which provides a methodology to analyze the cognitive radio networks to achieve rendezvous to establish communication. It also prevents the multi-users involved in rendezvous from taking greedy decisions by the use of a cut-off time period. The frequency prediction algorithm assures first attempt rendezvous with a high degree of occurrence. It was observed that the first time rendezvous is increased when the motivation to perform rendezvous is not frequent between the SUs. This research work investigated different spectrum sensing techniques in cognitive radio network. Cognitive Radio (CR) has emerged as a leading technology because it can intelligently sense an unused spectrum without creating any harmful interference to authorized users. It is a novel approach to fulfill increasing demand of bandwidth for effective and healthy communication. Varying SNR in radio environment may affect performance of spectrum sensing techniques. Spectrum sensing is a multifaceted problem demanding coordinated efforts of the regulatory and technical sides. In this research work a comparative analysis of spectrum sensing capability of matched filtering, Energy detection and cyclostationary feature detection technique was carried out in terms of decision accuracy vs. SNR under varying channel conditions including AWGN.

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