Spectrum Sensing in Cognitive Radio

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Abstract*—Cognitive Radio directs at amplifying the use of the limited radio bandwidth while accommodating the increasing number of services and applications in wireless networks. For cognitive radio networks to operate efficiently. Secondary users (SU) should be able to exploit the radio spectrum that is unused by the primary network. A censorious component of cognitive radio is thus spectrum sensing. In this report, we propose a simulation methodology for the spectrum sensing technique to meet the requirements of the IEEE 802.22 standard. The sensing performance is described through extensive simulation using MATLAB simulation tool. In most of the existing work. The simulation scenario of the CSS algorithm has been based on common theoretical assumptions rather than to meet the operational requirements of the WRAN standards. Further, it can be found that spectrum sensing and sharing have been designed separately. This research paper discusses the algorithm framework of local sensing using energy detection and cooperative sensing based on machine learning to meet the functional requirement of the IEEE 802.22 WRAN standard. The simulation results of the proposed spectrum sensing algorithm lead to formulating effective coalition formation games in order to make effective strategic interaction among secondary users.

Keywords—Cognitive radio; wireless network; secondary user; spectrum sensing; energy detection

I. INTRODUCTION

As expressed earlier there has been a rapid growth in wireless communication technologies and thus there has been increased pressure in both the licensed and unlicensed frequency spectra. Since the fixed spectrum assignment will fail to cater to the needs of media. Utilizing the existing spectrum for holes as transmission media seems a viable alternative. As mentioned above, every secondary user has a mechanism devised to estimate the frequency bands that are not occupied. However, there is a huge challenge when the number of secondary users is very high. Every secondary user will the presence of white space at different frequencies owing to the different energy levels that they receive from the primary user. In such a case, the accuracy of an individual secondary user is questionable and we need a central station that can decide as to which of the frequency bandwidths are actually available for detection. This role is performed by the fusion center, which based upon a predefined algorithm utilizes the results from the individual secondary users and determines the available frequency bands. Also, cooperative spectrum sensing in essence refers to the understanding between the different secondary users to utilize a particular frequency. Once the fusion center has detected a white space and communicates that to the secondary users, not all can utilize the frequency for data transmission at one instant. There needs to be cooperation among the secondary users to utilize the available bandwidths at different instances and allow the other secondary users to use while it itself is idle. Thus, cooperation is essential in any spectrum sensing module.

II. SPECRTUM SENSING TECHNIQUES

First Spectrum Sensing becomes a challenging task in practice because the channel from the first transmitter to the secondary user is often bad due to shadowing and time-varying multipath fading. As a result, detecting the primary user based on the observation of a single secondary user may not be enough especially under low SNR conditions.

Spectrum sensing can be done using the following methods

1) Cooperative detection

2) Non-cooperative detection

3) Interference temperature detection under the transmitter detection.

4) Matched filter detection: Matched filter detection means applying the matching filter to the signal to get the high processing gain and better detection performance.

5) Energy detection: Decision static follows chi-square distribution by a false alarm and detection probability.

6) Cyclostationary detection methods: Modulating the signals and coupling with the sine wave carriers. Hopping sequences and cyclic prefixes.

III. ENERGY DETECTION

The Energy detection may be a spectrum sensing method that detects the presence/absence of a sign just by measuring the received signal power. This detection approach is sort of easy and convenient for practical implementation. The energy detector is the most widely used technique in radiometry.

The energy detector detects the received signals' energy to compare with the threshold and then deduce the status of the primary signals. The disadvantage is that a threshold we used are going to be easily influenced by unknown or changing nose levels, therefore the energy detectors are going to be confused by the presence of any in-band interference.

Another disadvantage of the energy detector is that perfect noise variance information is required. When there is noise uncertainty, there is an SNR threshold below which the energy detector cannot reliably detect any transmitted signal.

This disadvantage can be overcome by estimating the noise variance as accurately as possible. Different algorithms exist

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that can be used to estimate the noise variance, which when combined with input signal information can give the signal strength at that point. The noise is generally estimated to be "Additive White Gaussian Noise" or AWGN. Three main algorithms are required for this job. They are Periodogram, threshold detection and channel availability detection.

$$s(\omega) = \frac{1}{N} \left| \sum_{n=1}^{N} x(t) e^{-j\omega t} \right|^2$$

A. Periodogram

The Fast Fourier Transform (FFT) is an efficient method for transforming signals from the time domain to the frequency domain. The Periodogram is based on the Fourier transform — and most often the Fast Fourier Transform (FFT), which is an efficient way of calculating the Discrete Fourier Transform. The difference between the two is that the Periodogram takes the FFT of evenly spaced segments of the data rather than the entire data at once. The equation for a Periodogram is given as the following:

$$s(\omega) = \frac{1}{N} \left| \sum_{n=1}^{N} x(t) e^{-j\omega t} \right|^2$$

In this, the processing gain is proportional to FFT size N and therefore the averaging time (t). An increase within the size of FFT improves the frequency resolution which is useful in detecting narrowband signals. If we reduce the average time it improves the SNR by reducing the noise power. In the application of spectrum sensing, the Periodogram method is superior because it provides a better variance for the set of input data. Periodogram will generally produce a smoother graph and enables the system to detect and display signals in the presence of noise.

B. Process of Energy Detection

The process of energy detection can be briefly described as follows:

1. The frequency range over which the secondary user is to transmit is decided (r1—r2).

2. The spectrum is scanned to find any holes in the given range

3. Energy detection is done at every frequency in the range by using a Periodogram as described below

4. The decision metric is calculated from the received signal.

5. The decision metric is compared with a calculated threshold based on probabilities of detection and false alarm to come to a decision whether the PU is present or not.

The decision of the energy detector is based on the statistical inference of a hypothesis regarding a signal‘s presence. The below equation represents the hypotheses described above the received signal- ‘RS' can be either only noise win) or signal together with noise {s{n)+w{n)}.

$$RS(n) = \begin{cases} w(n) \\ w(n) + s(n) \end{cases}$$

After the signal (RS) is received at the secondary user. each secondary user calculates the decision metric (M) based on which the presence of the primary user is decided. The equation for finding the decision metric is as given below

$$M = \sum_{n=0}^{N} |RS(n)|^2$$

'N' is the observation vector.

The performance of the energy detector is often evaluated by using two probabilities:

Probability of detection Pd and Probability of warning Pf. The probability of detection is to decide the presence of the primary user. In contrary. the Pf is to make a decision the presence of PU when it's actually not present. It can be formulated as.

$$P_d = (M > \lambda / H_1)$$
$$P_f = (M > \lambda / H_0)$$

' is decision threshold which can be selected for finding the optimum balance Pd and Pf. H0: is the hypothesis that the signal is not present. H1 is the hypothesis that the signal is present.

By setting the desired probability of false alarm and calculating the variance of a data set, the system sets a threshold to indicate signals above the noise level. However. It requires the knowledge of noise and received signal power. Since it is difficult to estimate the received signal power as it changes based on the transmission characteristics and the distance between the cognitive radio and primary user. Hence. The knowledge of noise power estimation is sufficient for the selection of a threshold. Each SU processes its received energy and compares it with the local threshold. The received signal strength of every SU varies supported its distance from the Primary transmitter.

IV. SIMULATION

- The frequency range is considered between 50-950MHz where 1 the channel is equal to 10 Mhz.
- Range and Channel width can be altered for different ranges and outputs.
- The sampling frequency that is considered is 1400mhz.
- There are 10 secondary users, 1 primary user, and 1 fusion center present in our simulation.
- We have considered a total grid of 120*120km.

- The location of all the users and fusion center is generated by a rand function that changes with each cycle.
- Primary user frequency is generated on the basis of a range with random noise added to it using a rand function.
- A random message signal is generated using the rand function which is to be transmitted.
- Primary user signal is generated using Amplitude modulation using ammo func which modulates primary user frequency with respect to sampling frequency and message signal.
- The periodogram function is used to find the power spectral the density of the primary user signal.
- The distance between the nodes is calculated by distance=sqrt((X(i)-PX)^2 + (Y(i)-PY)^2) where x and y are location of the nodes.
- The signal at the node is generated using awgn function which adds noise to the primary user signal with the random signal to noise ratio.
- The periodogram function is used to find the power spectral of the density of the signal at the node.
- The value of the threshold is found out by calculating the average power spectral density of all the 10 nodes.
- Threshold and power spectral density of all the nodes is sent to the fusion center which works on the basis of the centralized fusion the center algorithm which determines the free and occupied slots in the range on the basis of comparison between threshold and power spectral density of all nodes.
- By varying the value of t in the program number of times the program is executed can be changed.

V. RESULTS

Results:

Program execution values in 1st cycle:

Location of Fusion Center , Primary User and Secondary Users :

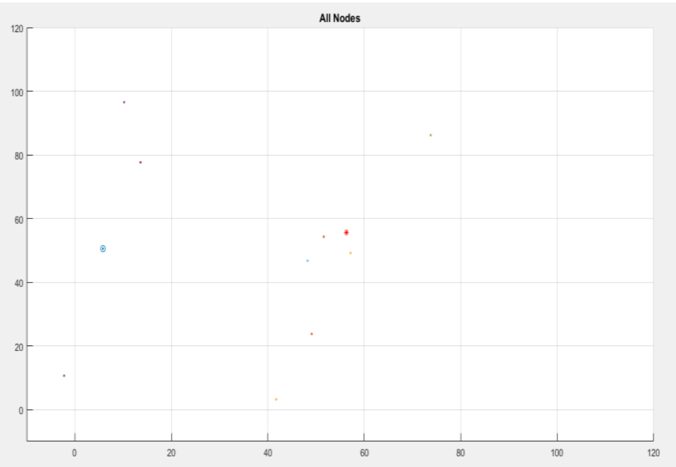

Fig. 5.1

Primary User Power Spectral Density:

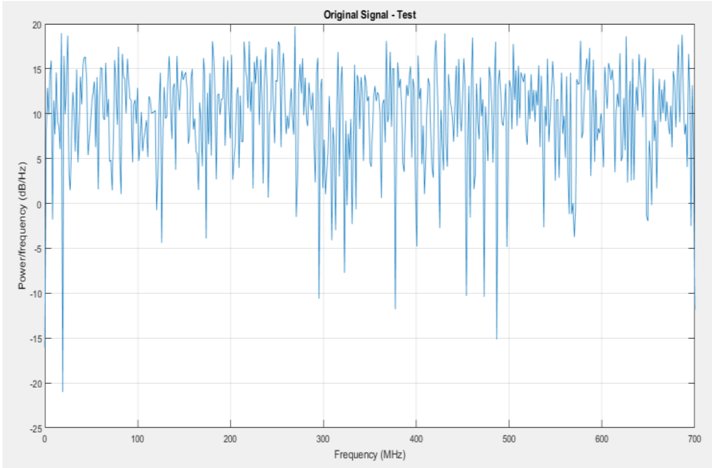

Fig. 5.2

Power Spectral Density of Secondary Nodes:

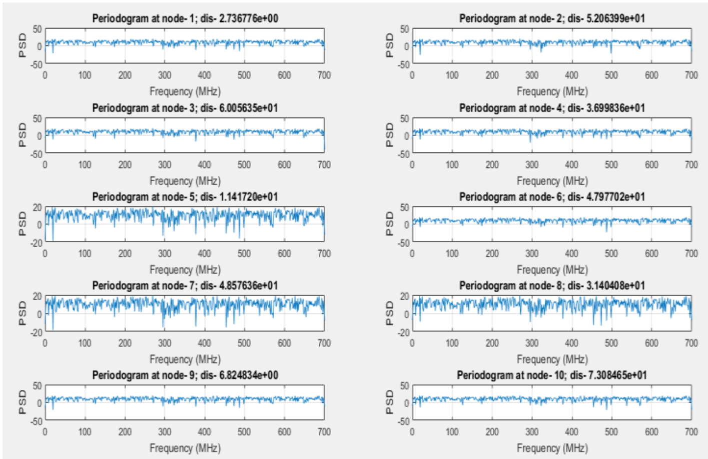

Fig. 5.3

Decision:

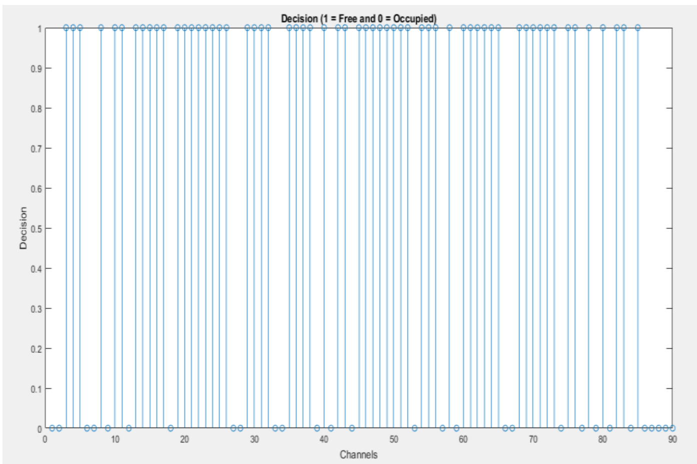

Fig. 5.4

Program execution values in 2nd Cycle:

Location of Fusion Center, Primary User and Secondary Users

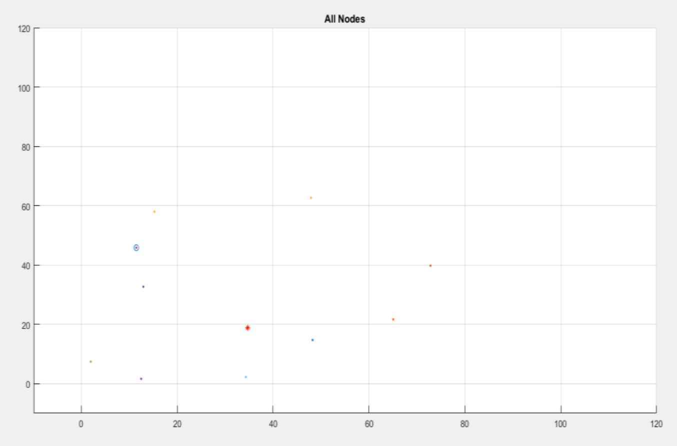

Fig. 5.5

Primary User Power Spectral Density:

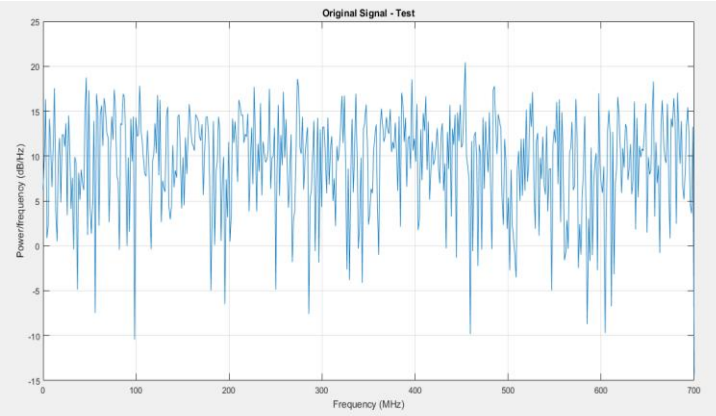

Fig. 5.6

Power Spectral Density of Secondary Nodes:

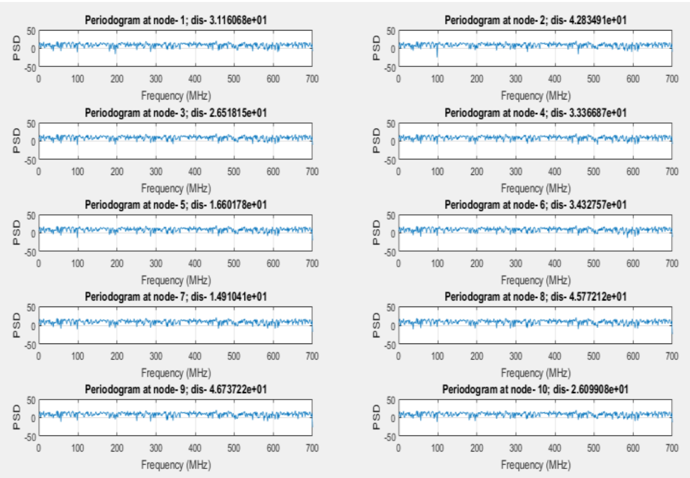

Fig. 5.7

Decision:

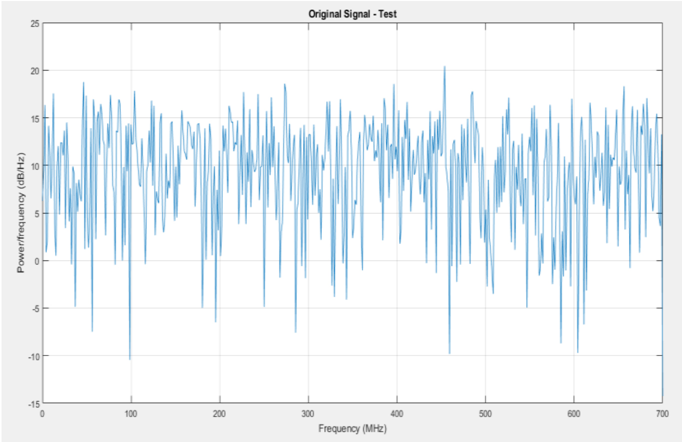

Fig. 5.8

VI. FUTURE SCOPE

- Spectrum Sensing within the wireless sensor technology- the essential concept for wireless technology today depends on the cognitive features.
- Practical Implementation-In this the utilization of a very wideband antenna might be a search challenge. Because in future the utilization of 28 and 38 GHz frequency signals are often potentially used with an overall band of roughly 1GHz.
- Researching Scope- one among the foremost future scope of cognitive radio is within the application of mobile communication and internet technologies using fast spectrum sensing features to reduces the time and therefore the traffic jam. WLAN's are connected to FC that has a very high signal level.
- Direction for a replacement invention- Femtocells over TV wide spaces, the cognitive radio within the 5th Generation(5G), LTE over TV wide spaces, multimedia services over cognitive radio networks.

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CONCLUSION

Cooperative sensing is an effective technique to improve detection performance by exploring spatial diversity at the

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expense of cooperation overhead. There are various methods we can use for spectrum sensing .In this paper, we used energy detection method for spectrum sensing and found that energy detection is one of the efficient method of spectrum sensing in cognitive radio. Energy detection is a spectrum sensing method that detects the presence/absence of a signal by measuring the power of received signal.

REFERENCES

[1] S. Haykin, "Cognitive Radio: brain empowered wireless communication," IEEE Journal on Some Areas in Communication, vol 23, no.2, pp.201-220, February 2005.

[2] I.J. Mitola," Software Radio: the survey, critical evaluation, and future directions," IEEE Aerospace and Electronics Systems Magazine, vol 8,no.4,pp.25-36, in April 1993.

[3] FCC, "Spectrum policy task force report, "Tech. Rep.02-135, Federal Communications, Commission, November 2002,

[4] Available: http://hraunfoss.fcc.gov/edocs public/attachmatch/DOC-228542A1.pdf.

[5] M. A. McHenry, "NSF spectrum occupancy measurements project summary," Tech Rep., SSC, August 2005, Available: http://www.sharedspectrum.com/.

[6] E. Larson and M. Skoglund, "The Cognitive Radio during a frequency planned environment with some of the basic limits," IEEE Transactions on the Wireless Communications, vol no. 7, no. 12,pp. 4800-4806,December 2008.

[7] A. Sahai, N. Hoven, and R. tundra, in "Some fundamental limits on cognitive radio, "in Proc. of The Allerton Conference on Communication, Control, and Computing, October 2004, pp. 1662-1