International Journal of Research Publication and Reviews

Journal homepage: www.ijrpr.com ISSN 2582-7421

Design of Spectrum Sensing method in Cognitive Radio System using Energy and variance estimation in 5G communication System

Rahul Saini, Divyanshu Rao and Ravi Mohan

Department of Electronics and Communication
SRIT, Jabalpur, India

Abstract-One key component in CR usefulness is having the option to perform real time spectrum use authority, as it has the opportunities for unlicensed clients (Secondary user) to get to empty authorized frequency bands. For Cognitive radio systems to work effectively, auxiliary clients (secondary users) ought to have the option to find the closer primary clients (primary users), in this way a basic capacity that a Cognitive Radio hardware (Microcontroller) have to first perform spectrum sensing. Spectrum sensing is an essential need of 5th generation based cognitive radio systems. Analysis of Variance, Eigen, and Energy based Sensing Method for Cognitive Radio Network, A new method of sensing developed in this work. Sensing of spectrum hole with sole methods may results in a miss or sometime spectrum hole though it was in use by the primary user. This work is a design of an affine combinational sensing method that can sense the spectrum holes with high accuracy in the radio channel and it must be only when the primary user is not using it. Spectrum sensing with ANOVEE detection method with Rayleigh fading channel and additive white Gaussian noise (AWGN) channel has been implemented in this work and comparative analysis done between the probability of detection (PD) and the probability of false alarm (PFA). MATLAB simulator is used for the designing of a cognitive radio transmitter, receiver, and channels, Monte Carlo simulation has been performed for spectrum analysis over the channel.

Keywords-Spectrum Sensing, Cognitive radio, MATLAB, OFDM, LTE, 5G communication

I. INTRODUCTION

Over the years from the beginning of wireless communications, many aspects of the personal mobile phone and wireless communications have changed and evolved in order to cope with ever-increasing high demands and popularity. These aspects are such as the move from analog to digital communications, from voice-centric to datacentric systems [1]. Especially in recent decades, there has been rapid growing need for the anytime, anywhere and always-connected communication [2]. With the number of mobile subscribers grows exponentially from less than a hundred million subscribers in 1996 to more than five billion in 2010 [3], wireless networks have evolved over the year since the first-generation Advanced mobile phone system (AMPS) to the current fourth generation Long Term Evolution (LTE) [4]. For each generation of wireless and mobile communications, many technologies have been improved and enabled higher data rates, better spectral efficiency. The move from analog to digital communication occurs in the transition from first generation (1G) to second generation (2G). With spread spectrum technologies, Wideband Code Division Multiple Access (WCDMA) becomes dominant in the third generation (3G) mobile communication. With Orthogonal Frequency Division Multiple Access (OFDMA), current 4G system supports higher data rates and better spectral efficiency over existing 3G system. In order to further cope with an increasing demand, a new paradigm and technologies that can enhance spectral efficiency and improve spectrum utilization are needed for the next generation beyond 4G mobile networks.

II.PROPOSED SPECTRUM SENSING TECHNIQUE

The principal step of spectrum sensing is that it decides the presence of primary user on a band. The cognitive radio has the capacity to impart the result of its detection with other cognitive radios in the wake of sensing the spectrum. The main objective of spectrum sensing is to discover the spectrum status and activity by periodically sensing the target frequency band.

Spectrum Management: Provides the reasonable spectrum scheduling technique among coexisting users. The available white space or channel is quickly chosen by cognitive radio if once found. This property of cognitive radio is described as spectrum management.

Spectrum Sharing: Cognitive Radio doles out the unused (spectrum hole) to the secondary user (SU) as long as primary user (PU) does not utilize it. This property of cognitive radio is described as spectrum sharing.

Spectrum Mobility: When an authorized (Primary) user is detected, the Cognitive Radio (CR) empties the channel. This property of cognitive radio is depicted as the spectrum mobility, also called handoff.

Energy Detection: The aim of the spectrum sensing is to decide between two hypotheses which are

x (t) = w(t), H_0 (Primary User absent)

x (t) = h * n(t) + w(t), H_1 (Primary User present)

Where x(t) is the signal received by the CR user, n(t) is the transmitted signal of the primary user, w(t) is the AWGN band, h is the amplitude gain of the channel. H0 is a null hypopaper, which states that there is no licensed user signal.Energy Detection is a simple detection method. The energy detection is said to be a blind signal detector in light of the fact that it overlooks the structure of the signal. Energy detection is based on the rule that, at the receiving end, the energy of the signal to be detected is computed. It estimates the presence of a signal by comparing the energy received and a known threshold λ derived from the statistics of the noise.

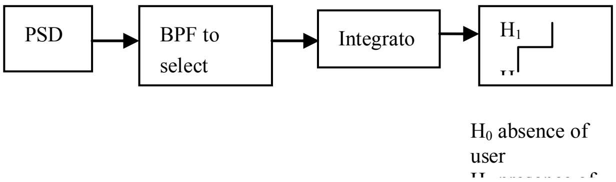

Figure 1 Energy Detector Block Diagram

Matched Filter Detection: The best sensing technique in AWGN environment without ant prior information about the signal is ED technique. If we considered the signal structure, then we can get best performance by using matched filter method. Matched filter is a linear filter which used to maximize signal to noise ratio in presence of additive noise. It provides coherent detection. A coherent detector uses the knowledge of the phase of the carrier wave to demodulate the signal.

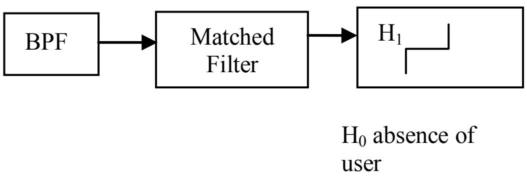

Figure 2 Matched filter Block diagram

Cyclisation Feature Detection: Cyclo-stationary feature detection taking into account introduction of periodic redundancy into a signal by sampling and modulation. The periodicity in the received primary signal to recognize the presence of Primary Users (PU) is misused by Cyclo-stationary feature detector which measures property of a signal specifically Spectral Correlation Function (SCF) given by

$$S_x^{\infty}(f) = \int_{-\infty}^{\infty} R_x^{\infty} e^{-j2\pi f t} \, d\tau$$

Where $Rx\ (\tau)$ is cyclic autocorrelation function (CAF).

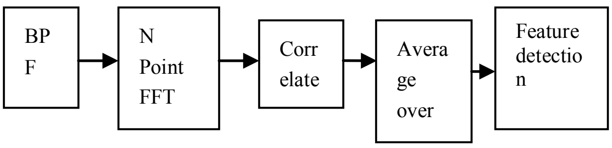

Figure 3 Cyclo-stationary feature detection block diagram

III. PROPOSED SPECTRUM SENSING

Spectrum sensing is the ability to measure, sense and be aware of the parameters related to the radio channel characteristics, availability of spectrum and transmit power, interference and noise, radio's operating environment, user requirements and applications, available networks (infrastructures) and nodes, local policies and other operating restrictions. It is done across Frequency, Time, Geographical Space, Code and Phase.

A number of different methods are proposed for identifying the presence of signal transmission all of which are in early development stage. They are:

1. Energy – Detection Based
2. Waveform Based
3. Cyclostationary – Based
4. Radio Identification Based
5. Matched filtering Based

We will be dealing with Energy detection Wavelet Packet based spectrum sensing.As a secondary-tier user, CR user needs to vacate the spectrum whenever PU retransmits again. CR is defined as a radio that can change its transmission parameters based on interaction with the environment in which it operates [7]. CR enables its users to

1. Determine which portion of the spectrum is available and detect the presence of licensed users when a user operates in a licensed band.
2. Select the best available channel.
3. Coordinate access to this channel with others.
4. Vacate the channel when PU is detected.

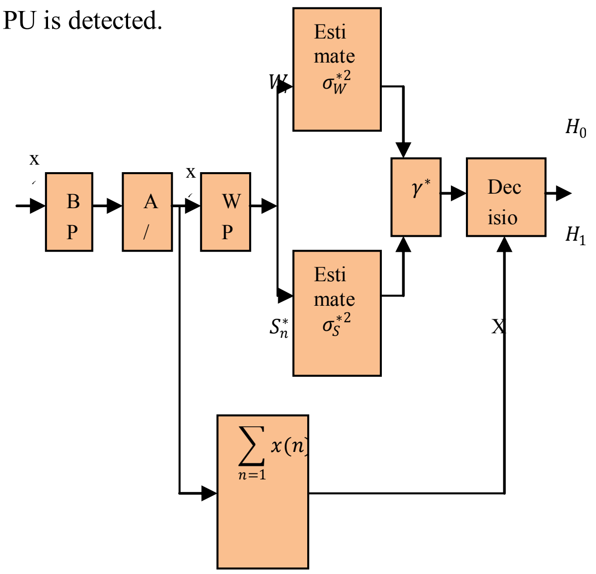

Figure 4 – Proposed Block diagram of Energy Detection Model based on WPT

The block diagram is similar to the simplest energy-based detector but most importantly a Wavelet Packet Transform (WPT) block has been introduced which estimates the current noise and signal power, which is very important for settling threshold. The analog signal x(t) after being converted into digital signal x(n) is decomposed for a certain level related to the resolution required and then is reconstructed by wavelet packet decomposition coefficients. And hence the noise power and reconstructed signal power is estimated.

Cognitive radio system implementation using MATLAB:

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

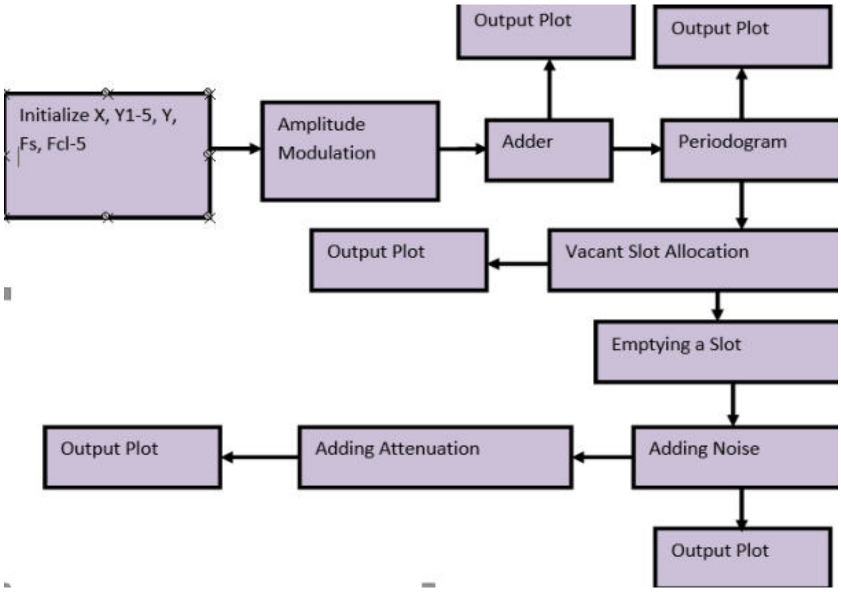

Figure 5 Methodology/Block diagram of set up

IV.SIMULATION RESULTS

The cognitive radio framework ceaselessly looks for the spectrum hole where primary user is not present and is determined by the technique for energy detection. When it figures out the spectrum hole, promptly it allots to the Secondary User (SU) and at whatever point Primary User (PU) wants to possess the slot, Secondary User instantly leaves it. Wavelet Packet Transform (WPT) method were in match with the values and graph plotted with the traditional Energy Detection method when the noise was known. Hence WPT is quite a robust method for CR applications when the noise is unknown.

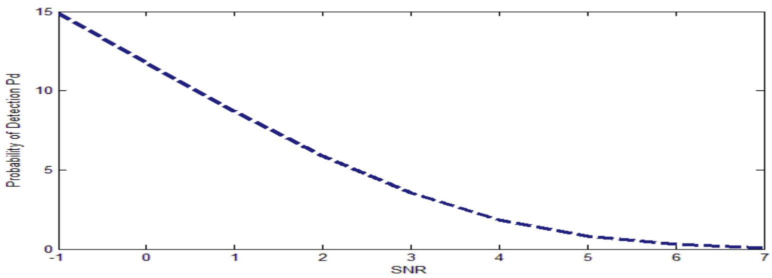

Figure 6 - Simulation of PD vs SNR

SNR's for -1, 4 and 7 dB, respectively. (i) At SNR = -1 dB: The probability of missed detection vs. probability of false alarm is plotted in Fig.7. The three curves are compared. We found that the obtained results matched with what was obtained in reference [1] such that in both of them the deviation of simulated result values from the approximated and theoretical values are very less. The results show that as the probability of false alarm increases, the probability of miss detection decreases. The theoretical and the simulated results are nearly same for Probability of false alarm between 0.1 to 1.

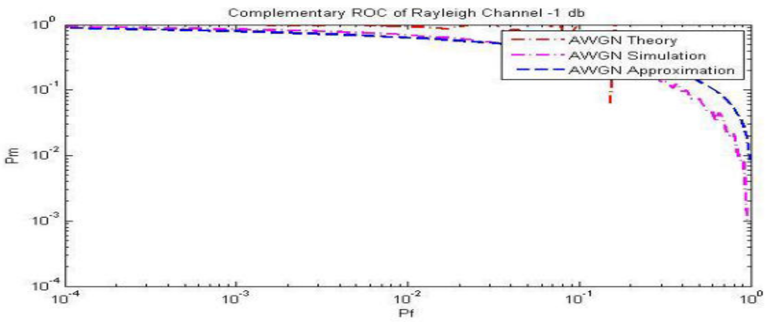

Figure 7. The probability of missed detection vs. probability of false alarm for SNR = -1dB

(ii) At SNR = 4 dB: The probability of missed detection vs. probability of false alarm is plotted in Fig.8. The three curves are compared. .We found that the obtained results matched with what was obtained in reference [1] such that in both of them the deviation of the simulated curve with the theoretical and approximated curve is increase.

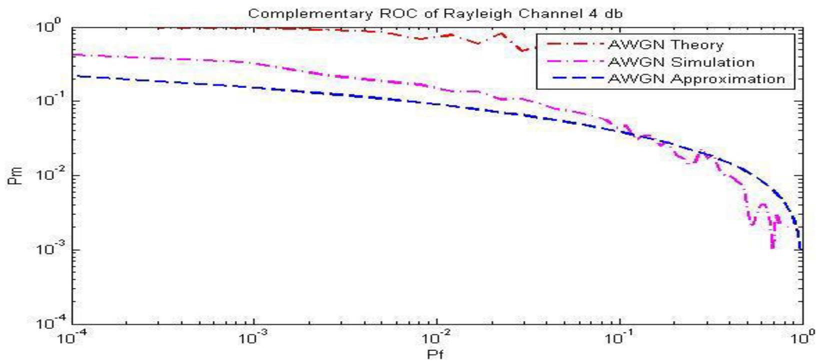

Figure 8. The probability of missed detection vs. probability of false alarm for SNR = 4 dB

(iii) At SNR= 7 dB: The probability of missed detection vs. probability of false alarm is plotted in Fig.9. The three curves are compared. We find that the obtained results matched the results obtained in reference [1], such that in both of them, the Receiver fails to get satisfactory results. So, the values of the SNRs are depending on other factors.

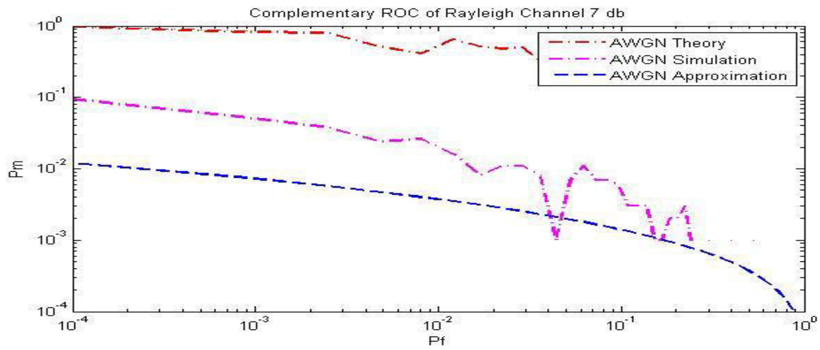

Figure 9 The probability of missed detection vs. probability of false alarm for SNR = 7 dB

(IV) At SNR = -1 dB: The probability of missed detection vs. probability of false alarm is plotted in Fig.10. showing comparison between the simulated curves and theoretical curves over AWGN channel and Rayleigh fading channel.

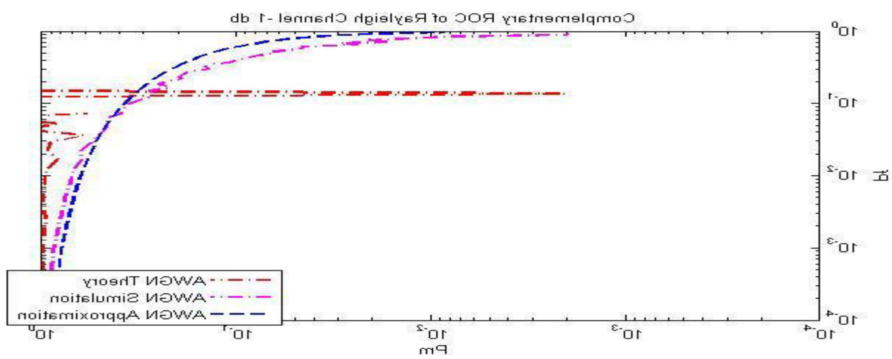

Figure 10. The probability of missed detection vs. probability of false alarm for SNR= -1 dB

(V) At SNR = 4 dB: The probability of missed detection vs. probability of false alarm is plotted in Fig.11.showing comparison between the simulated curves and theoretical curves over AWGN channel and Rayleigh fading channel.

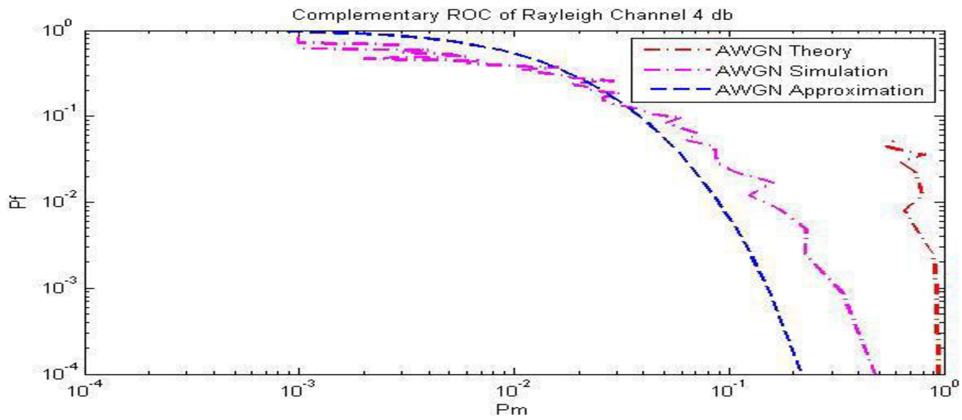

Figure 11. The probability of missed detection vs. probability of false alarm for SNR= 4 dB

(VI) At SNR = 7 dB: The probability of missed detection vs. probability of false alarm is plotted in Fig.12.showing comparison between the simulated curves and theoretical curves over AWGN channel and Rayleigh fading channel.

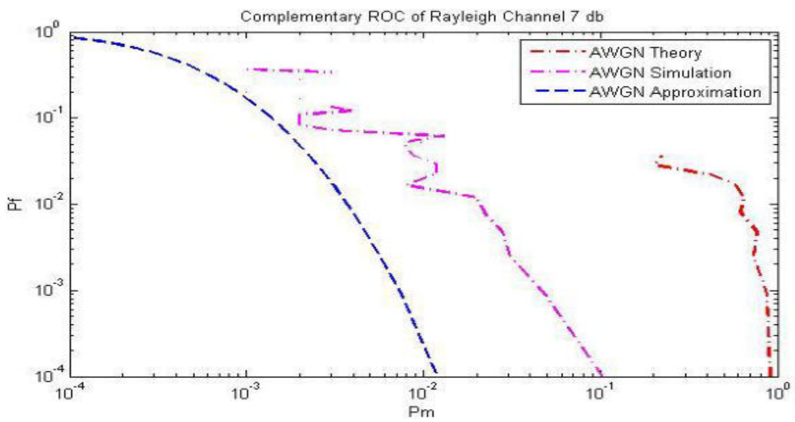

Figure 12. The probability of missed detection vs. probability of false alarm for SNR= 7 dB

Table 1 Comparative Results for Pf (False Alarm)

Work by	**Pf at -1 db**	**Pf at 4 db**	**Pf at 7 db**
Roshdy Abdelrassoul et al [1]	0.24	0.91	0.56
Proposed	0.1	0.67	0.37

Table 2 Comparative Results for Pm (probability of missed detection)

Work by	Pm at -1 db	Pm at 4 db	Pm at 7 db
Roshdy Abdelrassoul et al [1]	0.21	0.87	0.61
Proposed	0.13	0.62	0.39

From the table-1 and table-2 we can easily analyze that proposed work probability of missed detection (Pm) is less as compare to the work by Roshdy Abdelrassoul et al[1] also the probability of false alarm (Pf) is less as compare with Roshdy Abdelrassoul et al[1]. Table 1 and table 2 shows the comparative results with obtain values at the SNR values of -1 db, 4db and 7 db respectively.

V. CONCLUSION

This paper gives some idea regarding cognitive radio technology, its diverse classifications and distinctive spectrum sensing methods. The work of this paper contributes toward energy detection procedure and finally method executed using MATLAB code. All the works in this paper are based on MATLAB and MATLAB simulation. The simulation results are taken for different number of samples to study energy detection performances. This paper has been completed in the final year of B. Tech and hence the hardware implementation could not be carried out in the tenure. Thus, it can be carried out in future.

REFERENCES

[1] E. O. Kandaurova and D. S. Chirov, "Algorithm and Software for Intelligent Analysis of the Frequency Spectrum for Cognitive Radio Systems," 2020 Systems of Signal Synchronization, Generating and Processing in Telecommunications (SYNCHROINFO), 2020, pp. 1-5, doi: 10.1109/SYNCHROINFO49631.2020.9166031.

[2] P.T Sivagurunathan, P Ramakrishnan and N. Sathishkumar, Recent Paradigms for Efficient Spectrum Sensing in Cognitive Radio Networks: Issues and Challenges, IOP Publishing Ltd.*J. Phys.: Conf. Ser.* 1717 012057

[3] H. M. El Misilmani, M. Y. Abou-Shahine, Y. Nasser, and K. Y. Kabalan, Recent Advances on Radio-Frequency Design in Cognitive Radio, Hindawi Publishing Corporation, International Journal of Antennas and Propagation, Volume 2016, Article ID 9878475, http://dx.doi.org/10.1155/2016/9878475

[4] E. Raeisidehkordi, M. Kafami and H. Bakhshi, "A New Wide Spread Spectrum Model in Cognitive Radio Networks," 2019 5th Conference on Knowledge-Based Engineering and Innovation (KBEI), 2019, pp. 449-453, doi: 10.1109/KBEI.2019.8734922.

[5] R. L. Peterson, R. E. Ziemer and D. E. Borth, Introduction to spread-spectrum communications, New Jersey: Prentice-Hall, vol. 995, 1995.

[6] R. W. Middlestead, "Digital Communications with Emphasis on Data Modems: Theory" in Analysis Design Simulation Testing and Applications, John Wiley & Sons, 2017.

[7] A. E. Azhar, A. L. Yusof, A. Idris and N. Ya'acob, "An enhancement of direct sequence spread spectrum (DSSS) technique in LTE and Wi-Fi coexistence technologies", *2017 IEEE 8th Control and System Graduate Research Colloquium (ICSGRC)*, pp. 257-261, 2017.

[8] D.S. Chirov and E.O. Kandaurova, "Identification of available trunking communication systems in heterogeneous cognitive radio access networks", *2019 Systems of Signal Synchronization Generating and Processing in Telecommunications SYNCHROINFO 2019*, pp. 1-6

[9] M. López-Benítez and F. Casadevall, "Spectrum usage models for the analysis design and simulation of cognitive radio networks" in Cognitive Radio and Its Application for Next Generation Cellular and Wireless Networks, New York: Springer-Verlag, 2012.