Simulative Analysis of Spectrum Sensing In Cognitive Radio with Various Modulations

Er.Harwinderpal Singh[1], Er.Harjitpal Singh[2] ,Anurag sharma[3]

[1] *Assistant Professor , Cem Kapurthala ,Punjab,India*
[2]*Assistant Professor , CTIEMT Shahpur,Punjab,India*
[3] *Assistant Professor , CTITR Maqsuda,Punjab,India*

Abstract - *Cognitive radio are able to sense spectral environment and able to provide opportunistic access. cognitive radio find gap in the spectrum and adjust system parameters to utilize it. So the need of cognitive radio is because unlicensed spectrum is rare and almost none unavailable under 3 GHZ. The first step of cognitive radio is to identify free spectrum and channel sensing is one of the most fundamental part of cognitive radio. The cognitive radio serves the user without causing any interference to the primary user. So the cognitive radio start on sensing the spectrum to detect the appearance of the primary user. The probability of detection and probability of false alarm are the main factors which deals with the performance of the cognitive radio. In this paper energy detection scheme is used for multiuser cognitive radio environment and the performance of the energy detection scheme for various modulation schemes like Qpsk,Qam . Also the BER v/s SNR under different modulation techniques is investigated.*

Key Words: wireless communication, cognitive radio, energy detection, Qpsk,Qam, BER and SNR

1. INTRODUCTION

Cognitive radio is a type of wireless radio communication channel which are able to monitor, sense And detect the conditions of operating environment and dynamically reconfigure their own characteristics. In wireless communication most of the bands that are used for transferring information from one place to another are underutilized means that most of the bands that are not fully used.

To overcome the problem of bands under utilization we use a technique in wireless communication is known as cognitive radio. cognitive radio is an intelligent radio that can be programmed and configured dynamically. Cognitive radio detects wireless channels that are available or free, so that those wireless channels can be used for transferring some data[7]. Networks of cognitive radio could function at licensed portions of the spectrum. In wireless communication their are mainly two types of users: primary user and secondary user. Channels that are allocated to a user are called primary users**[4**]. The channels that a user borrows from the neighbourhood are called secondary users **[4**]. Cognitive radio are reconfigurable, easily accesses the empty bands and do efficient utilization of the radio spectrum. Due to the two fundamental characteristics cognitive capability and reconfigurability **[6],** cognitive radio technology raised new threats and vulnerabilities.

In wireless communication there are many factors affecting wireless communication like under utilization of frequency bands, fading, physical obstructions. So in this one main factor is under utilization of frequency bands. So to overcome this factor we use cognitive radio by the secondary user are called "In band channels".

The cognitive radio networks has two major challenges in wireless comm (1) To protect the primary users against the interference from the secondary users. (2) To have efficient reuse of the frequency spectrum. **M. Farag et al.** [2014] proposed an efficient energy detector which is used for optimal CR performance. In this paper the author has taken two threshold levels and these thresholds evaluations are based upon estimating the noise uncertainty factor which are used to maximize the probability of detection (Pd) and minimize the probability of false alarm (Pfa). **Abdullastar et al.** [2012] proposed a survey based on cognitive radio in which energy detector over Additive White Gaussian Noise (AWGN) under various fading channels for spectrum sensing is used. **Fragkiadakis et al.** [2013] proposed security threats and detection techniques in cognitive radio networks. **Kim et al.** [2012] proposed an optimal in-band sensing scheduling algorithm which optimizes the sensing-time and sensing-frequency of energy and feature detection. **Mariani et al.** [2011] proposed the performance of the ED with estimated noise power (ENP), addressing the threshold design and giving the conditions for the existence of the SNR wall. **Attapattu et al.** [2011] proposed two fusion strategies i.e data fusion and decision fusion and the results are extended to a multihop network. **Kaur et al.** [2014] proposed the comparision between the Wired and Wireless networks on the basis of various parameters such as Reliability, Mobility, Speed, Security . **Hong Im et al.** [2015] proposes an improved spectrum-sharing protocol for multiuser cooperation in cognitive radio (CR) networks. Further more the author analyzed the results on SNR and BER.

2. SPECTRUM SENSING

The method of detecting the license user or primary user is called spectrum sensing. The spectrum sensing technique is mainly divided into three categories: energy detection, matched filter detection, cyclostationary feature detection**[7].** All the three different parameters are described below. The other parameters like probability of detection**[4],** probability of false alarm and probability of miss detection shows the performance of spectrum sensing. The probability of detection means the probability of correctly determining the license primary user presence. The probability of false alarm means the probability of misjudgment of a primary user when the license primary user in actual not present there. The probability of miss detection means the probability of primary user not present in the spectrum and the spectrum is occupied by the secondary user. So all the methods that are dscribed below are dependent on transmitter detection. So the spectrum sensing technique method will help to find the primary user in the spectrum.

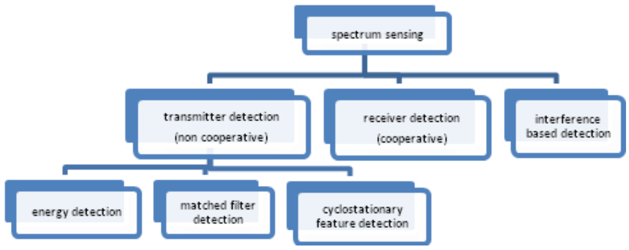

Fig -1 : Spectrum Detection Techniques

Spectrum sensing is the main thing in cognitive cycle whose classification is shown in the above figure.

spectrum sensing technique in cognitive radio enables to utilize the available spectrum efficiently and the need to provide more effective communications. Spectrum sharing detects unused spectrum and share it without harmful interference to other users. In cognitive radio networks the spectrum sharing allow the users to share the spectrum bands of the licensed band users. So the spectrum sensing mainly study the spectrum and find the unused bands.

2.1 ENERGY DETECTION

Energy detection is spectrum sensing method that detects the presence/absence of a signal just by measuring the received signal power. energy detection has a squaring device, after the squaring device we have a integrator. the output of integrator gives us the decision variable**[7].**The variable is compared with the threshold value. If the value of decision variable is more than the threshold, then the energy detector gives the result that a primary user is present. Energy detection is a preferred technique in cognitive radio because of its simplicity and applicability. In energy detector the threshold values depend on noise uncertainty factor. The energy detector can work with small values of probability of false alarm and high probability of detection by using a long observation table.

In the frequency spectrum we have some spectrum holes. The unused bands in the spectrum are known as spectrum holes. The spectrum holes are of two types :

1)temporal spectrum holes: the spectrum holes which are not occupied by the primary user when it is sensing, therefore the secondary user can use this band in the slot which is going on.

2)spatial spectrum holes : the holes which are not occupied by the primary user at some spatial areas, therefore can be occupied by the secondary users as well as outside this area.

3. BIT ERROR RATE (BER)

The Bit Error Rate is a metric which can be employed to characterize the performance of a communication system. Bit error rate or bit error ratio (BER) is defined as the rate at which errors occur in a transmission system during a studied time interval[**2**]**.** In wireless transmission, the number of bit errors is the number of receiving bits of a signal over a channel which changes because of distortion,noise, interference **[3].**BER Performance degrades due to errors like noise. BER is a unit less quantity, often expressed as a percentage or 10 to the negative power. The formula to calculate Bit error rate is :

Average Bit Error Rate = *number of bits in error/ total number of bits transmitted*

BER depends on the power transmitted at the secondary user.

4. SIGNAL TO NOISE RATIO (SNR)

The SNR is the ratio between the wanted signal and the unwanted background noise[**3**]. The SNR is the ratio of the received signal power over the noise power in the frequency range of the process. SNR is inversely prop to BER, that is high BER causes low SNR. the increase in packet loss, enhance in delay and decrease throughput is caused due to high BER. SNR is an indicator usually measures the clarity of the signal in a circuit or a wired/wireless transmission channel and measure in decibel (dB). It measures the overall fidelity of the system.

SNR= Pnoise / Psignal

International Research Journal of Engineering and Technology (IRJET) e-ISSN: 2395 -0056
Volume: 04 Issue: 04 | Apr -2017 www.irjet.net p-ISSN: 2395-0072

5.SYSTEM MODEL

In CR network, there are two users i.e. primary and secondary users and they are denoted as M in the figure shown below Figure.

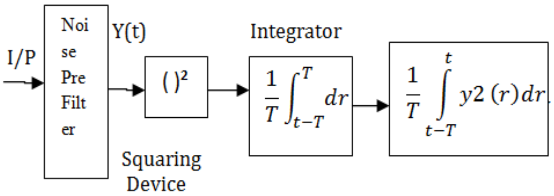

Fig- 2 : System Model

These users are considered with a common receiver. The common receiver receives the Local decisions which can unite all the decisions regarding the absence or presence of the primary users (PU)[**1**]. Let all the spectrum is sensed by the secondary user independently. The essence of spectrum sensing is a binary hypothesis-testing problem. Assume that there are K>1number of antennas are present at the receiver. In Cognitive Radio (CR) the spectrum sensing is considered as in the Eqn 3 [6]. The following two hypothesis is decided by the sensing method .

$Y(t) = [Y_1(t) ....Y_M(t)]^T$

$L(t) = [L_1(t) ....L_M(t)]^T$

$p(k) = [p1(t) : : : p_M(t)]^T$

H_0 : Absent the Primary user
H_1 : Present the Primary user

$$(Y_i t) = \{ (t), \quad H_0 \\ b(t)s(t) + n_i(t), \quad H_1 \qquad (1)$$

where $Y_i(t)$ is the signal received in time slot t at the i_{th} CR, primary user signal is considered as $s(t)$, the additive white Gaussian noise (AWGN) is denoted by $n_i(t)$, and the complex channel gain of the sensing channel between the i_{th} CR and the primary user is denoted by $b_i(t)$. The probability of false alarm P_{fa} means the probability of misjudgment of a primary user when the license primary user in actual not present there. The hypothesis is chosen by the system model to maximize the probability of detection Pd, i.e. the probability of correctly determining the license primary user presence. The Neyman-Pearson theorem derives the optimal receiver. the Neyman-Pearson theorem states that For a given P_{fa}, the probability of detection P_d will be maximized for the following decision statistic, which is basically the likelihood ratio test (LRT):

$$T_{LRT}(x) = \frac{p(Y/H_1)}{p(Y/H_0)}. \qquad (2)$$

Where Y is the aggregation of Y(t); t = 0.......N -1 [7]. It is assumed that distributions of signal and noise are known. Let $s_i(k)$'s are independent over k in which we are dealing with a flat fading channel under the assumptions and we have the following PDFs

$$P((Y|Hi)) = \prod_{k=0}^{N-1} p(Y(k)|Hi) \qquad (3)$$

Assuming Gaussian distributions for noise i.e $n(k) \sim N(0, \sigma_n^2 I)$ and signal samples i.e $s(k) \sim N(0, R_n)$ therefore the LRT reduces to estimator-correlator (EC) detector

$$T_{EC}(x) = \sum_{k=0}^{N-1} x^T(k) R_s (R_s + \sigma_n^2 I)^{-1} x(k)$$

From above equation $R_s(R_s + \sigma_n^2 I)^{-1} x(k)$ is the MMSE estimation of s(k), so that TEC having the correlation of the observed signal x(k) with MMSE estimation of s(k). The assumption that $R_s = \sigma_s^2 I$ reduces T_{EC} to the energy-detector (ED) given by

$$T_{ED}(x) = \sum_{k=0}^{N=1} x^T(k) x(k)$$

also, under the assumption that s(k) is predetermined and known to the receiver, LRT reduces to the matched-filter detector given by

$$T_{MF}(x) = \sum_{k=0}^{N-1} S^T(k) x(k)$$

So, we notice that the LRT reduces to different known detectors under given conditions

If the PU signal is not known earlier, then for detecting zero-mean constellation signals energy detection method is used [7-8]. For the i_{th} CR with the energy detector, , the average probability of detection, the average probability of missed detection, the average probability of false alarm over AWGN channels are given, respectively, by [11]

$$P_{d,i} = Q_u(\sqrt{2\gamma i}, \sqrt{\lambda i}) \qquad (4)$$

$$P_{m,i} = 1 - P_{d,i} \qquad (5)$$

$$P_{f,i} = \frac{\Gamma(u, \frac{\lambda i}{2})}{\Gamma(u)} \qquad (6)$$

In the above equations, λi and γi denote the energy detection threshold and the instantaneous signal-to-noise ratio (SNR) at the i_{th} CR, respectively, u is the time-bandwidth product of the energy detector[**1**].

$$\Gamma(a, x) = \int_x^{\infty} t^{a-1} e^{-t} dt$$

$\Gamma(a, x)$ is the incomplete gamma function. (a) is the generalized Marcum Q function [9-10,12].

6. SIMULATION RESULT AND DISCUSSION

The Simulation has been carried out for cognitive radio network on MATLAB.Under this simulation five primary users and secondary users in the spectrum have been considered. The performance has been detected with the probability of detection, false alarm probability and missed probability under different number of SNR. The Energy detection is used to detect the vacant spectrum in cognitive radio network, where primary users are not present Immediately assigned the vacant spectrum to secondary users as shown in Figure (3) and whenever primary user want to occupy the spectrum, secondary user immediately left this vacant spectrum. The carrier frequencies 1000 Hz to 5000 Hz for five users are used and sampling frequency is 12000 Hz. The Power spectrum density of signals are calculated and compared with the threshold value to determine the availability of primary users. Figure (4) shows that Probability of detection in spectrum sensing for different SNR under AWGN channel. The simulation is carried out for the analysis of detection probability under different number of SNR. Where Pfa=0.01 and time bandwidth factor u=100 were taken for this simulation. SNR was taken -20dB to10dB. It also shows that with the increasing of the SNR (from -13dB to -3dB) the detection also increased and detection probability was almost constant or 1 after -3dB to 10 dB.

Further the performance of the system has been observed with different modulation schemes such as QPSK and QAM in the presence of all primary and secondary users. The simulation results are presented in Figure 5 and Figure 6. It is observed from the results that bit error rate for QPSK is 10^{-4} and for QAM is 10^{-3} as presented in Figures 5 and 6.

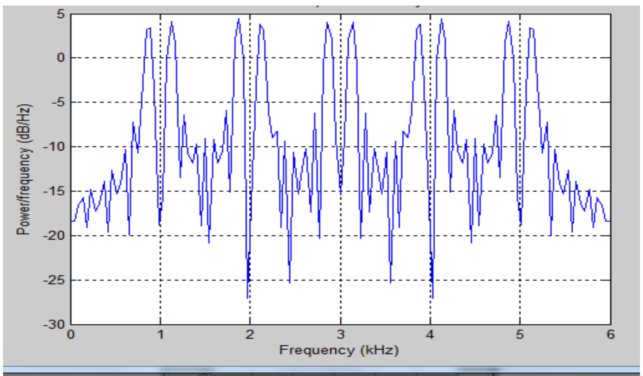

Fig- 3: Spectral Efficiency of Four Primary Users where third user spectrum assigned to Secondary user

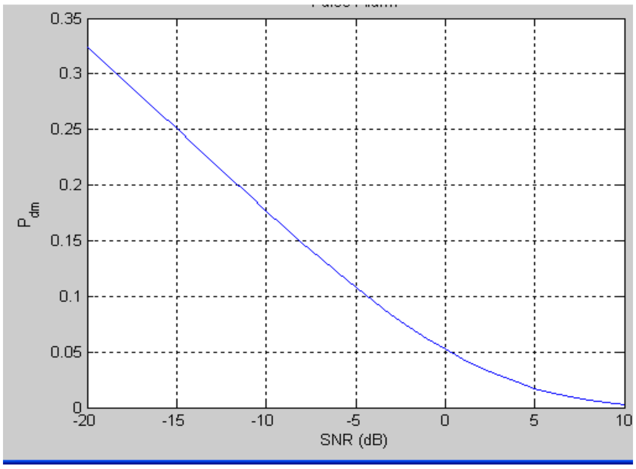

Fig- 4: Probability of False detection of four primary users with single secondary user.

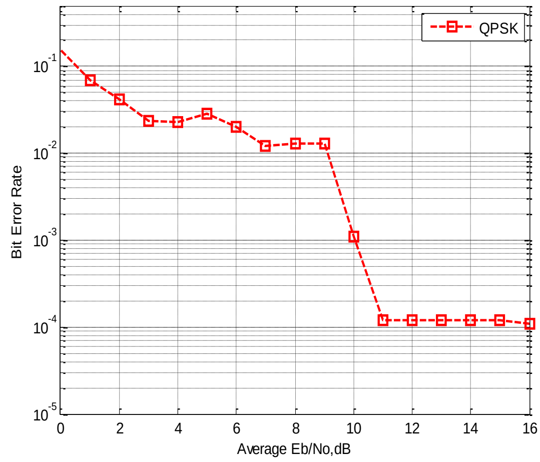

Fig- 5: Bit Error Rate vs. SNR with QPSK Modulation

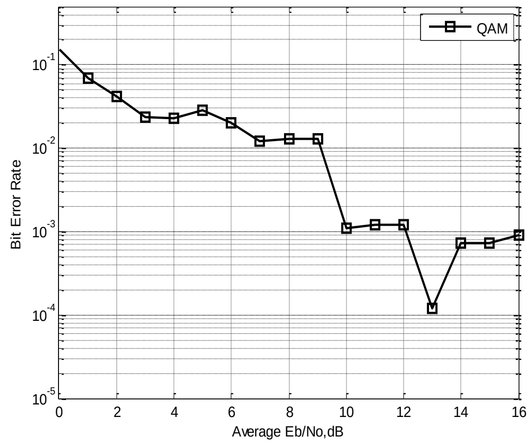

Fig- 6: Bit Error Rate vs. SNR with QAM Modulation

7. CONCLUSIONS

The performance of the cognitive radio system was analyzed in terms of bit error rate along with energy detection. It was observed that the system was with the help of energy detection scheme the wastage of the vacant bandwidth can be avoided and the vacant slot can efficiently be allotted to the secondary user. Further the performance of the system was analyzed in terms of bit error rate and it was found that the system with QPSK modulation worked well. In future, the performance can be enhanced with the implementation of various digital filters and with optimization schemes.

REFERENCES

[1] S A Khan et al, "Spectrum Sensing in Cognitive Radio" ICSETI VOL. 1 2016.

[2] Tae-Kyoung Kim et al, "Improved Spectrum-SharingProtocol for CognitiveRadio Networks With Multiuser Cooperation," IEEE TRANSACTIONS ON COMMUNICATIONS, VOL. 63, NO. 4, APRIL 2015.

[3] ArunKumar Katkoori et al, "A New BNRandSNRcaluculationsforMIMO-OFDM System," International Conference on Recent Advances in Communication, 2014.

[4] Hossam M. Farag et al," Improved Cognitive Radio Energy Detection Algorithm Based upon Noise Uncertainty Estimation", the 31st National Radio Science Conference, April 28 – 30, 2014.

[5]NavpreetKaur, SangeetaMonga,"Comparision of wired and wireless networks", International Journal of Advanced Engineering Technology April-June,2014

[6] Alexandros et al," A Survey on Security Threats and Detection Techniques in Cognitive Radio Networks", the IEEE COMMUNICATIONS SURVEYS & TUTORIALS, VOL. 15, NO. 1, FIRST QUARTER 2013.

[7] Mahmood A. Abdulsattar et al," Energy detection technique for spectrum sensing in cognitive radio", the International Journal of Computer Networks & Communications (IJCNC) Vol.4, No.5, September 2012.

[8] Hyoil Kim and Kang G. Shin," In-band Spectrum Sensing in Cognitive Radio Networks Energy Detection or Feature Detection", 2012.

[9] Andrea Mariani, Andrea Giorgetti, Marco Chiani ,"Effects of Noise Power Estimation on Energy Detection for Cognitive Radio Applications", the IEEE Transactions on Communication, VOL. 59, NO. 12, December 2011.

[10] Samanatapattu et al, " energy detection based cooperative spectrum sensing in cognitive radio networks",IEEE Transactions on Wireless Communications, VOL 10, No. 4, April 2011.

BIOGRAPHIES

Er. Harwinder Pal Singh
AP ECE College of Engineering and Management Kapurthala, Punjab.