An Efficient Spectrum Sensing and Matched Filter Interference Modelling In Cognitive Radio Network

Helen Achankunju¹, Ann Susan Varghese²

¹M .Tech student, Department of Communication Engineering, Mount Zion College of Engineering, Kadammanitta, Kerala, India.

²Assistant Professor, Department of Electronics and Communication Engineering, Mount Zion College of Engineering, Kadammanitta, Kerala, India

Abstract: Cognitive radio is an effective approach for better sharing the underutilized communication spectrum. That underutilized frequency bands have been licensed to the primary users. However due to the uncertainity in detecting the existence of the primary user, the secondary user may interfere with the primary user. When both primary user and secondary users are active simultaneously. Therefore understanding the interference and its consequences on the cognitive network is critical. Unlike statistical models previously reported in the literature minimizing the interference using solid mathematical analysis. We propose an accurate model for describing the interference with amplitude, frequency, mean and variance of the interference suffered by the primary user. The proposed model sense accurately the spectrum using maximum to minimum eigen value technique in the sensing scheme, and we use tracy widom approach. For removing the interference at the receiving section a matched filter is introduced at the output. Simulation results are provided to verify the effectiveness of the model.

Keywords: cognitive radio, cognitive network, interference modeling, primary user, spectrum sensing.

1. Introduction

Cognitive radio is a transceiver system, it is a form of wireless communication, in which transceiver can intelligently detect which communication channel is in use and which is not in use and currently move into the vacant channel while avoiding occupied one. The functions of cognitive radio are, power control, spectrum sensing, wide band spectrum sensing and spectrum management. CR is also a promising technology for the future radio spectrum management. There are two types of cognitive radio network, they are full cognitive radio (mitola radio) and spectrum sensing cognitive radio, in which only the radio frequency spectrum is considered. The licensed users are called primary users and unlicensed users are called secondary users. For opportunistically accessing the spectrum ,the secondary users carry out spectrum sensing and detecting the activities of the primary user to avoid the possible harmful interference on the primary user. However, due to the uncertainty of the number and location of secondary users and imperfect spectrum sensing, primary user receiver suffer from the channel interference from the secondary users. Therefore, an accurate model is of great importance to design cognitive networks in achieving the desired performance goals. Also an interference model is widely used to implement the power control, analyse channel capacity and error performance. The statistical models or interference approximation only show some characteristics of the interference, which is not sufficient to accurately depict the interference due to the errors in evaluating the interference . Thus a more accurate mathematical model is necessary. Interference is the sum of all signal contributions that are neither noise not the wanted signals. Interference is a major factor in the performance of the cellular systems. The existing system takes the account a number of factors such as, spectrum sensing scheme, spatial distribution of secondary users, channel conditioning. The application of this method can evaluating the cognitive network of spatial shape and density of secondary user and the methods of power control. Spectrum sensing used by the secondary users. The sufficient conditions are identified in the existing system including spectrum sensing scheme, spatial distribution of secondary user nodes, geographical dispersion shape of secondary user distribution and position of primary and secondary users.

2. Motivation and Related Woks

From the related reference papers different methods are used to find interference. [1] present interference models for cognitive radio which employs various interference management mechanisms including power control, contention control, hybrid/contention control schemes. For the first case a power control scheme is proposed to govern the transmission power of a CR node. For the second one, a contention control scheme at the media access control(MAC) layer, based on carrier sense multiple access with collision (CSMA/CA), is proposed to coordinate the avoidance operation of CR nodes with transmission requests. For the hybrid case ,when power and contention controls are jointly adopted by a CR node to govern its transmission, from that the interference is analyzed and compared with that of the first two schemes by simulation.[3] introduced that a new statistical interference model for cognitive radio network based on the amplitude aggregate interference, which accounts for the parameters related to the sensing procedure, spatial reuse protocol employed by the secondary users, and environment dependent conditions like channel fading and shadowing. For that derive a characteristic function and the nth cumulant of the cognitive network interference on the primary user. In this paper we compare the proposed system

with the previous method and finalise the output using simulations. The interference occurred during spectrum sensing and that interference can be reduced using a matched filter at the receiver section. Advantages of using this system is less interference, secure communication and efficient utilization of the radio spectrum, improved coverage and improved spectrum sensing.

3.System Model



Figure 1: Flow diagram for the proposed system

The input sequence are taken as random numbers zeros and ones. The input signal is added with the noise or the carrier signal the and the signal is modulated. Modulation is the process of mixing low frequency with high frequency carrier waves. we are using binary phase shift keying The modulated signal passes through the channel . Here we are using AWGN channel. After signal passed through channel, we have to find the sensing parameters. There are two types of sensing parameters, probability of detection and probability of false alarm. Primary transmitter is falsely detected to be absent when primary transmitter is actually present. In this case the secondary transmitter will transmit signal with a transmission probability p_{trans}.

The probability of detection increases SNR also increases. Probability of false alarm means the primary transmitter is detected to be present when primary transmitter is actually absent. In this case the secondary transmitter stops signal transmission and which does not interfere the primary receiver. These terms are used to express the efficiency and reliability of the cognitive radio. After finding the sensing parameter we are using eigen value based spectrum sensing technique and using tracy widom approach. Here we are considering the primary and secondary user parameters. At the receiver section a matched filter is used to reduce the interference level or to find out the amount of interference is received at the output. The matched filter is used to maximize the SNR.

4. Implementation

In the implementation process we use spectrum sensing and interference analysis, the spectrum sensing here we are using maximum to minimum eigen value based spectrum sensing technique.

g a. Maximum To Minimum Eigen Value

It is the ratio of maximum eigen value to the minimum eigen value. There are two types of approaches in this eigen value based technique, they are asymptotic approach and tracy widom approach. In our proposed system we are using tracy widom approach to find the largest and smallest eigen values.

b. Tracy widom approach

Denote K the number of receivers or antennas and with N the number of samples collected by each receiver during sensing time. Let λ max and λ min be the largest and smallest eigen values. Denoting as Y the decision threshold, the detector decides for H0 if T< Y, for H1 otherwise. Where T as the test statistic T= λ max/ λ min. The extreme eigen values are converges to the following asymptotical values as N increases.

$$\lim_{n \to \infty} lmin = a = \left(N^{\frac{1}{2}} - K^{\frac{1}{2}}\right)$$
$$\lim_{n \to \infty} lmin = b = \left(N^{\frac{1}{2}} + K^{\frac{1}{2}}\right)^{2}$$

Three assumptions are used to find the random variable, they are

A1: The entries are iid noise samples.

A2: The number of samles is upto infinite

A3: The ratio lies between zeros and ones.

The maximum eigen value is

$$L_{max} = \frac{l_{max} - b}{v}$$

as N tends to infinity the value converges with probability

one with $v = (N^{\frac{1}{2}} + K^{\frac{1}{2}})^2 (N^{-\frac{1}{2}} + K^{-\frac{1}{2}})^{\frac{1}{3}}$ The minimum eigen value is

$$L_{min} = \frac{l_{min} - a}{\mu}$$

With $\mu = (K^{\frac{1}{2}} - N^{\frac{1}{2}})^2 (K^{\frac{-1}{2}} - N^{\frac{-1}{2}})^{\frac{1}{8}}$

The decision threshold can be calculated using,
$$-z_{i}$$

$$\gamma_1 = \frac{b}{a} \left(1 + \frac{(\sqrt{N} + \sqrt{K})^{-\gamma_3}}{NM^{1/6}} F^{-1} (1 - P_f) \right)$$

In the case of asymptotic approach the limiting values that are approached by the eigen values only for very large N and K. For lower values of N and K the threshold may turn out to be unbalanced, that is it provides good probabilities of detection and poor probabilities of false alarm.

c. Matched filter

The matched filter at the receiver section is used to find how much amount of interference is received at the output. The matched filter is used to maximize the signal to noise ratio. In matched filter design requirement specifically given some signal s(t) and noise signal n(t), we want to find the impulse response h(t) that maximizes SNR at the filter output. We choose matched filter so as to maximize the peak signal power to the average noise power at the output of the matched filter. Then finded interference analysis using the parameters like primary and secondary users.

5. Simulation Results

We first investigate the outage probability F_{out} , Fig. 2 is the outage probability as the function of the ST spatial diversity when Pus and SUs are under different fading channels in the previous method. Here we can see that the interference through the fading channels are high. It is generally known that the outage probability increases as the number of ST nodes lead to increased interference to PR.

Fig.3 is the outage probability as the function of the ST spatial diversity when PUs and SUs are under different fading channels in the proposed system, here also we are considering the different fading channels. By the use of matched filter at the output section we can avoid the interference and error free transmission takes place. The low density of the SUs can reduce the interference at the PRs.

Fig. 4 shows the outage probability as a function of different sensing schemes in the previous method. Comparing these technique, they have interference problem and also overlapping of the signal takes place.

Fig. 5 shows the outage probability as a function of different sensing schemes in the proposed method. Here interference level is reduced compared with previous method.

Fig. 6 shows the outage probability as the function of ST power for different PT power in watts. For different values of PT power, the outage probability and the ST power follow reduced level of interference transmission. Overlapping of signals can be reduced. ST power play an important role in cognitive radio network. As expected, the outage probability increases as the ST power increases or the PT power decreases.

Fig. 7 the effect of PT power on the interference are illustrated in the figure with different values of the interference tolerant threshold. For a fixed threshold, the interference decreases as the PT power increases. For a fixed PT power, a larger threshold leads to a larger outage probability due to the fact that larger threshold means that the PU tolerates less interference.



Figure 2: The outage probability as the function of the ST spatial diversity in the previous method.



Figure 3: The outage probability as the function of the ST spatial diversity in the proposed method.







Figure 5: shows the outage probability as a function of different sensing schemes in the proposed method.



Figure 6: shows the outage probability as the function of ST power for different PT power in watts.



Figure 7: The effect of PT power on the interference.

6. Conclusion

It is challenging to analyze the interference in cognitive radio network with low complexity determined by the primary user parameters and accurate spectrum sensing technique we can easy to analyze the interference using matched filter at the output. ST power is another important parameter to degrade the performance of cognitive radio network. The simulation results are presented for better understanding the interference in cognitive radio and provide a useful reference for network designers.

7. Acknowledgment

I would like to express profound gratitude to our Head of the Department, Prof.Rangit Varghese, for his encouragement and for providing all facilities for my work. We express my highest regard and sincere thanks to my guide, Asst.Prof.Ann Susan Varghese, who provided the necessary guidance and serious advice for my work.

References

- A. Babaei, P. Agrawal, and B. Jabbari, "Statistics of aggregate interference in cognitive wireless adhoc networks," in *Proc. ICNC*, 2012, pp. 397–401.
- [2] A. Ghasemi and E. S. Sousa, "Interference aggregation in spectrumsensing cognitive wireless networks," *IEEE J. Sel. Topics Signal Process.*, vol. 2, no. 1, pp. 41–56, Feb. 2008.
- [3] A. Rabbachin, T. Q. S. Quek, H. Shin, and M. Z.Win, "Cognitive network interference," *IEEE J. Sel. Areas Commun.*, vol. 29, no. 2, pp. 480–493, Feb. 2011.
- [4] P. Madhusudhanan, J. G. Restrepo, Y. J. Liu, T. X. Brown, and K. Baker, "Modeling of interference from cooperative cognitive radios for low power primary users," in *Proc. IEEE GLOBECOM*, 2010, pp. 1–6.
- [5] Z. Chen *et al.*, "Interference modeling for cognitive radio networks with power or contention control," in *Proc. IEEE WCNC*, 2010, pp. 1–6.
- [6] A. Ghasemi, "Interference characteristics in powercontrolled cognitive radio networks," in *Proc. CROWNCOM*, 2010, pp. 1–5.
- [7] Z. M. Chen *et al.*, "Aggregate interference modeling in cognitive radio networks with power and contention control," *IEEE Trans. Commun.*, vol. 60, no. 2, pp. 456– 468, Feb. 2012.
- [8] A. Ghasemi and E. S. Sousa, "Fundamental limits of spectrum-sharing in fading environments," *IEEE Trans. Wireless Commun.*, vol. 6, no. 2, pp. 649–658, Feb. 2007.
- [9] P. C. Pinto and M. Z. Win, "Communication in a Poisson field of interferers—Part II: Channel capacity and interference spectrum," *IEEE Trans. Wireless Commun.*, vol. 9, no. 7, pp. 2187–2195, Jul. 2010.
- [10] M. F. Hanif, P. J. Smith, and M. Shafi, "On the statistics of cognitive radio capacity in shadowing and fast fading environments," in *Proc. CROWNCOM*, 2009, pp. 1–6.

Author Profile



Helen Achankunju received the B.Tech degrees in Electronics and Communication Engineering from M.G University, Kerala at Mount Zion College of Engineering and Technology in 2013. And now she is pursuing her M.Tech degree in Communication

Engineering under the same university in Mount Zion College of Engineering.