International Journal of Innovative Technology and Exploring Engineering (IJITEE)
ISSN: 2278-3075 (Online), Volume-8 Issue-10, August 2019

Performance Analysis of Cooperative Spectrum Sensing In Different Case Scenarios

Amardeep A. Shirolkar, S. V. Sankpal

Abstract*: Cooperative relay based spectrum sensing techniques are primarily available techniques in the field of research in cognitive radio networks. Even such techniques are available there is need to consider fundamental effects on spectrum sensing with various combination of scenarios that lead to false alarm detection. In this paper we have compared the three cases of cooperative spectrum sensing to analyze the effects and to form the direction of further research expectations in the field of cooperative spectrum sensing.

Keywords: cooperative spectrum sensing, path loss exponent, hidden node issue, shadowing effect, probability of detection, threshold of detection.

I. INTRODUCTION

The licensed band service allocation is need of time in dense traffic scenarios where spectrum sensing techniques are used for detection of free channels when primary users are not utilizing them. The detection presence of primary user is most important for the cognitive radio manager before allocating time based access of spectrum to secondary user.In cooperative relay based spectrum sensing for the detection of presence of primary user, the detection is affected by various parameters in which signal power mainly depends on the losses of the channel and gain offered by the channel. The effects of channel vary in accordance with distance between primary users and relay nodes as a function of path loss and fading effects. Also, there is need to consider the presence of obstacles while sensing the spectrum to mitigate the effects of hidden issue and shadowing. The presence of obstacle in particular case gives rise to consider specific performance characteristics. In this paper we are focusing on performance evaluation of cooperative spectrum sensing in which detection probability is estimated with respect to detection thresholds in three different cases.

II. RELATED WORK

Variety of papers are studied with respect to methods used in cooperative relaying. Few of them are addressed in this section to form the platform of the proposed work.Saman Atapattu et al [1], have given the method of cooperative spectrum sensing using energy analysis. The paper provides knowledge of energy based spectrum detection technique and effects of channel on power of signal. The channel impulse response n Rayleigh channel are considered. The detection in terms of missed attempts and probability of detection is analyzed. The paper helps while assuming the effects of channel on signal power. Khaled Ben Letaief et al [2], have given the study of hidden node issue in cognitive radio networks. The paper provides the method of cooperative spectrum sensing using multipath signal power to minimize the false detection. Nagina Zarin, et al [3], have given the performance evaluation of cooperative spectrum sensing by considering path loss effects. The paper is useful for studies of distance based probability of detection in cooperative relaying.Yulong Zou et al [4] have given method of selective relaying in cooperative spectrum sensing. The interference based relay node selection process is given. The performance evaluation is done by comparing the results with traditional dedicated reporting channel scheme. Xuanli Wu et al [5] have given method of channel estimation in relay based spectrum sensing technique. The method is given in which interference to primary user can be reduced because of the simplified time slot structure, and channel capacity can also be improved by removing the separate spectrum sensing process. Liangjun Zhang [6] have given method of optimization in cooperative relay based spectrum sensing mechanism. The BER analysis is shown to prove the optimum performance of the method along with time complexity analysis which shows significant reduction in processing time using method given by author.Dongho Seo et al [7] have given method of configuring cognitive relay nodes topology with respect to demand requests. The performance evaluation is done with respect to members count in particular group of topological arrangement to minimize the detection errors. The throughput analysis is given as parameters of evaluation. Yuanhua FU et al [8], have given method for spectrum sensing at SU using soft decision threshold scheme. The scheme proposal is based on overhead decreasing factor in network thereby decreasing the interference levels.Xiaoxiao Wu et al [9], have proposed phase compensation based spectrum sensing technique. The reference signal and received signal are compared to identify the phase compensation. A threshold based decision is taken for detecting the presence of primary users.Li Wang et al [10], have given method of estimating the reliability of cognitive relays for sensing the spectrum in fusion based approach. The historical values of sensing are considered to estimate the reliability of particular node participating in the fusion of sensing principle. The overall probability of false detection is significantly reduced as per the results shown in the paper.

Manuscript published on 30 August 2019.
*Correspondence Author(s)
Mr. Amardeep A. Shirolkar, Department of Technology, Shivaji University, Kolhapur.
Dr. S. V. Sankpal, D. Y. Patil College of Engineering and Technology, Kolhapur

III. PROPOSED WORK

The proposed work is consist of comparative analysis of effects of path loss exponent, hidden node issue and shadowing effects while sensing the presence of primary user suing cooperative relay scheme for the allocation of services to secondary users on temporary licensed band access.The primary user detection is done in cooperative cognitive relay based network using energy sensing mechanism. In this mechanism, the three paths scenario is considered. The figure 1 shows the three paths, which are available for destination node to detect the presence of primary user.

a. The direct path that directly sends the signal to destination for primary user.
b. The path via relaying node 2 which forwards the signal from primary user to destination.
c. The path via node 3 which forwards the signal from primary user to destination.

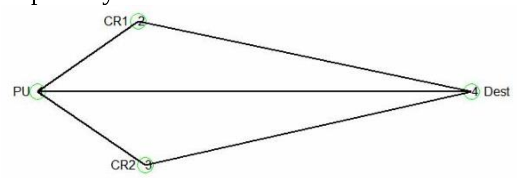

Figure1: The Paths Available For Destination Node To Detect PU

The energy of the signal in wireless networks depends on the path loss exponent. The signal that can be detected from three paths available in the case as shown in figure 1, can be given by the binary hypothesis that, the signal, y(t) is either present or absent. This hypothesis can be represented as,

$$Y(t) = \begin{cases} n(t) & : H_0 \\ hx(t) + n(t) & : H_1 \end{cases}$$

Where, x(t)= is signal sent by primary user,
h = gain of the channel
n(t)= AWGN noise

The received signal is first filtered using band pass filter with specific bandwidth B_w. The received signal power thus depends on channel gain H_0 and SNR. Thus, probability of detection of signal will provide two possibilities, that is, probability of detection and probability of false detection (false alarm). The false alarm is the case where primary user is not detectable even in case of presence and hence concluded to be absent due to false detection. The primary user is said to be present if the signal power is above threshold T_h. Therefore the probability of detection can be given as,

$$P_d = Q_u(\sqrt{2\gamma}, \sqrt{T_h})$$

Where, Q_u is Marcum-Q function, γ is SNR and T_h is threshold of detection.

Mostly, the gain and phase elements of a channel's distortion are conveniently represented as a complex number. In this case, Rayleigh fading is exhibited by the assumption that the real and imaginary parts of the response are modelled by independent and identically distributed zero-mean Gaussian processes so that the amplitude of the response is the sum of two such processes. Thus effect of channel impulse response in terms of path loss exponent in Rayleigh fading channel, the location of the cognitive relay 1 and 2 will be responsible for giving results in terms of probability of detection and probability of false alarm. The simulation experiment is carried out for different locations of the cognitive relays to analyze the probability of detection with respect to threshold and probability of detection with respect to probability of false alarm.

The second case is considered in which there is obstacle in between one of the cognitive relays and primary user such that, effect of shadowing will be the outcome while detecting the presence of primary user. The figure 2 elaborates the case considered.

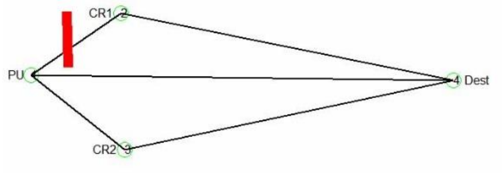

Figure 2: Case Of Obstacle In CR And PU For Shadowing Effect Analysis

The third case is considered in which there is obstacle in between one of the cognitive relays and destination node such that, effect of hidden node will be the outcome while detecting the presence of primary user. The figure 3 elaborates the case considered.

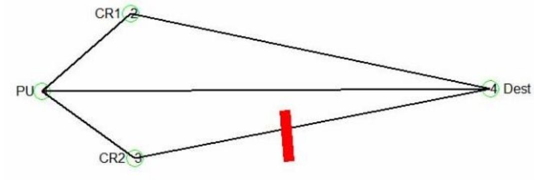

Figure 3: Case Of Hidden Node Issue When Obstacle Is Present

between cognitive relay and destination node.The three cases discussed here collaboratively provide the platform for analysis of probability of detection with respect to threshold.

IV. RESULTS AND ANALYSIS:

The simulation experiment is carried out in matlab. The nodes are considered at specific location at the start of the experiment by fixing up the nodes annotations, viz, primary user, destination node for detecting the presence of primary user, cognitive lay nodes. The nodes are first located as shown in figure 1. The relay nodes are then moved towards destination node in four stages to observe the path loss exponent due to increment in distance of between primary user and cognitive relay node. The final stage of analysis can be understood from the figure 4.

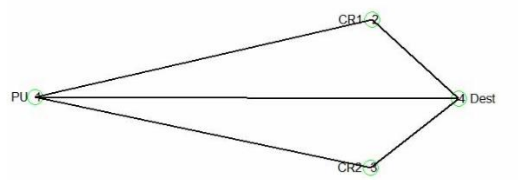

Figure 4: Final Stage Of Cognitive Relay Nodes Movement

The experimental results are analyzed using graphical presentation as shown in figure 5 and 6. Figure 5 shows the graph of probability of detection versus threshold of detection. Figure 6 shows the graph of probability of detection versus probability of false alarm.

Published By:
Blue Eyes Intelligence Engineering
and Sciences Publication (BEIESP)

International Journal of Innovative Technology and Exploring Engineering (IJITEE)
ISSN: 2278-3075 (Online), Volume-8 Issue-10, August 2019

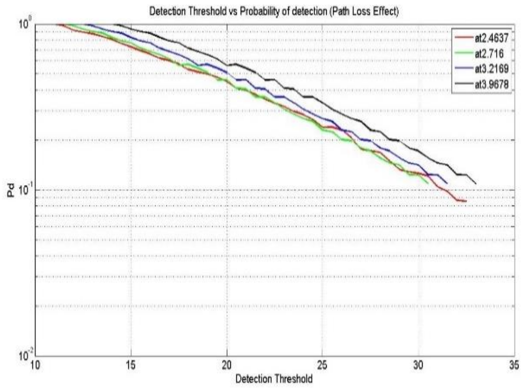

Figure 5: Probability of detection vs Detection Threshold

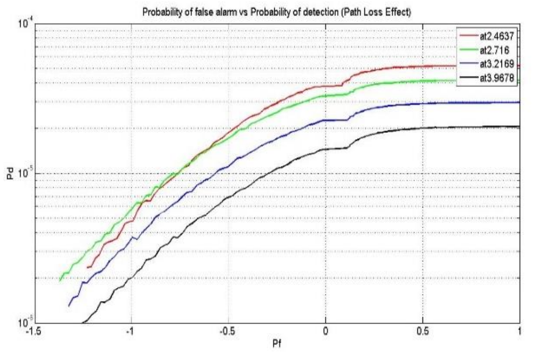

Figure 6: Probability of detection vs Probability of False alarm

Similarly the analysis of cases shown in figure 2 and 3 is done. The graphs obtained are shown in figure 7 to 10.

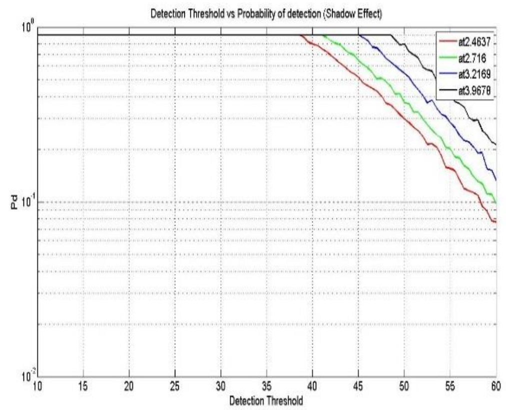

Figure 7: Probability of detection vs Detection Threshold

The comparative analysis of three cases can be understood from table 1.

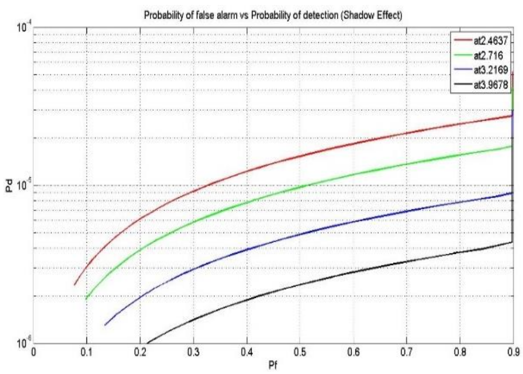

Figure 8: Probability of detection vs Probability of False alarm

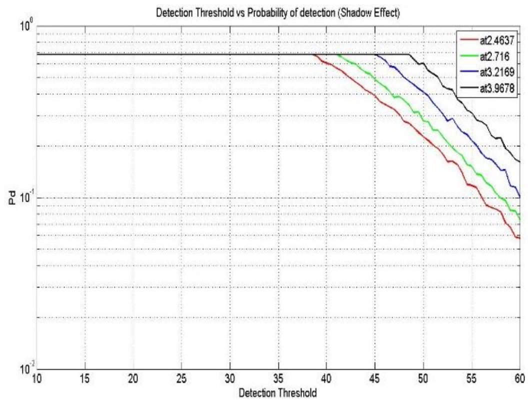

Figure 9: Probability of detection vs Detection Threshold

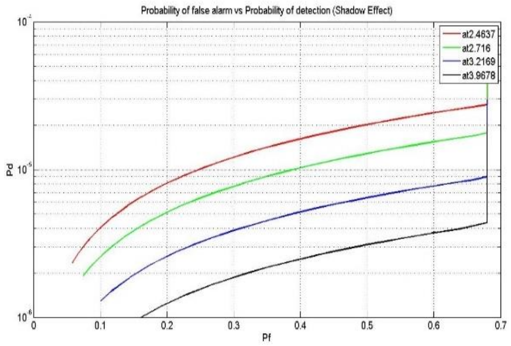

Figure 10: Probability of detection vs Probability of False alarm

The resulting average values of P_d and P_f with respect to distance between primary user and cognitive relay nodes as a function of path loss exponent, shadowing effect and hidden node are shown in table 1.

Table 1: Comparative Analysis

case observed	At a Near location from PU		At a distant location from PU	
	Average Pd	Average Pf	Average Pd	Average Pf
Path loss exponent	0.8	0.2	0.67	0.33
Shadowing Effect	0.6	0.4	0.51	0.49
Hidden Node Issue	0.14	0.86	0.08	0.92

Observations:

From figures 5 to 10 and table 1 following remarks can be done.

1. The probability of detection of primary user depends on path loss exponent and hence distance between primary user and cognitive relays.
2. The probability of detection is maximum with small thresholds when cognitive relay nodes are located nearer to PU.
3. The shadowing issue decreases the performance of detection and hence probability and also degraded with respect to distance between PU and CRs.
4. The hidden node issue decreases the performance of detection and hence probability and also degraded with respect to distance between PU and CRs.

Retrieval Number: J98970881019/19©BEIESP
DOI: 10.35940/ijitee.J9897.0881019
Journal Website: www.ijitee.org

Published By:
Blue Eyes Intelligence Engineering and Sciences Publication (BEIESP)

V. CONCLUSION

In this paper we have successfully evaluated the cases of cognitive relaying. The experimental results are helpful to understand the effects of path loss exponent, shadowing effect and hidden node issues associated with PU detection mechanism while allocating services to secondary users. This paper shows the direction for considering research requirements in cognitive cooperative relaying while service allocation process.

REFERENCES

1. S. Atapattu, C. Tellambura and H. Jiang, "Energy Detection Based Cooperative Spectrum Sensing in Cognitive Radio Networks," in IEEE Transactions on Wireless Communications, vol. 10, no. 4, pp. 1232-1241, April 2011.
2. K. B. Letaief and W. Zhang, "Cooperative Communications for Cognitive Radio Networks," in Proceedings of the IEEE, vol. 97, no. 5, pp. 878-893, May 2009.
3. N. Zarin, S. A. Mahmud and I. Khan, "Relay based cooperative spectrum sensing in cognitive radio networks over rayleigh fading channel with path loss effects," 2012 15th International Multitopic Conference (INMIC), Islamabad, 2012, pp. 291-296.
4. Y. Zou, Y. Yao and B. Zheng, "A Selective-Relay Based Cooperative Spectrum Sensing Scheme without Dedicated Reporting Channels in Cognitive Radio Networks," in IEEE Transactions on Wireless Communications, vol. 10, no. 4, pp. 1188-1198, April 2011.
5. X. Wu, N. Fu and F. Labeau, "Relay-Based Cooperative Spectrum Sensing Framework Under Imperfect Channel Estimation," in IEEE Communications Letters, vol. 19, no. 2, pp. 239-242, Feb. 2015.
6. L. Zhang, J. Yang, H. Zhou and X. Jian, "Optimization of Relay-Based Cooperative Spectrum Sensing in Cognitive Radio Networks," 2011 7th International Conference on Wireless Communications, Networking and Mobile Computing, Wuhan, 2011, pp. 1-4.
7. D. Seo and H. Nam, "A Parallel Multi-Channel Cooperative Spectrum Sensing in Cognitive Radio Networks," 2018 International Symposium on Antennas and Propagation (ISAP), Busan, Korea (South), 2018, pp. 1-2.
8. Smriti and C. Charan, "Double Threshold Based Cooperative Spectrum Sensing with Consideration of History of Sensing Nodes in Cognitive Radio Networks," 2018 2nd International Conference on Power, Energy and Environment: Towards Smart Technology (ICEPE), Shillong, India, 2018, pp. 1-9.
9. Y. Fu, Z. He and F. Yang, "A simple quantization-based multibit cooperative spectrum sensing for cognitive radio networks," 2017 14th International Computer Conference on Wavelet Active Media Technology and Information Processing (ICCWAMTIP), Chengdu, 2017, pp. 220-223.
10. X. Wu, L. Wang, S. Zhang and G. Zhang, "Phase-compensation-based cooperative spectrum sensing algorithm for cognitive cloud networks," 2018 International Conference on Information Networking (ICOIN), Chiang Mai, 2018, pp. 755-759.
11. L. Wang, S. Zhang and L. Gu, "Reliability-based cooperative spectrum sensing algorithm in cognitive radio networks," 2016 24th International Conference on Software, Telecommunications and Computer Networks (SoftCOM), Split, 2016, pp. 1-5.

AUTHORS PROFILE

Mr. Amardeep A. Shirolkar, have completed his Bachelor Degree in Electronics Engineering in the year 1995, M. Tech. in Electronics Technology, in 2010. He is currently Ph.D. scholar at Shivaji University, Kolhapur, Maharashtra. His area of specialization is signal processing and communication.

Dr. Swati V. Sankpal, have completed Bachelor Degree in Electronics Engineering in the year 1984, Master's Degree in Electronics Engineering in the year 1996 from Shivaji University, Kolhapur. She has completed Ph. D. in Electronics Engineering from Shivaji University, Kolhapur in 2012. Her area of specialization is communication and networking, wireless sensor networks.

Retrieval Number: J98970881019/19©BEIESP
DOI: 10.35940/ijitee.J9897.0881019
Journal Website: www.ijitee.org

Published By:
Blue Eyes Intelligence Engineering
and Sciences Publication (BEIESP)