Spectrum Sensing in Cognitive Radio Network Using Fuzzy Logic

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Abstract - Cognitive radio is mostly taken as the disruptive technology which can mostly improves spectrum efficiency as well as utilization to minimize spectrum sensing error. This concept is totally programmable wireless device for sensing the environmental and it can dynamically adapt the transmission waveform, spectrum use, channel access method with network protocols being required for better network and application performance. Sensing information exchange is required before making a final spectrum decision. Hence, it may cause interruption to PUs during the information exchange step. The main application of cognitive radio is that it is more effective, flexible with the access of aggressive dynamic spectrum. Problems like management of cognitive radio, primary and secondary user, minimization of control information, prevention of unwanted information basically occurs in the cognitive radio process. Through the use of the proposed spectrum sensing scheme, the spectrum sensing performance can be improved compared to conventional schemes. Parameters, namely PDR (Packet Delivery Ratio), Throughput, Error rate are used for the reduction of the mentioned affects. In this research, ABC (Artificial Bee Colony) algorithm is used as an optimization tool. The experiment has taken 50 nodes, area of 1000*1000 meters for the evaluation. The results are conducted on with attack by means of cognitive radio and without attack by taking different parameters. The conduction of the results is on the basis of time and energy using MATLAB.

Keywords: Secondary user, Primary user, Spectrum Sensing, Cognitive radio, ABC (Artificial Bee colony), PDR, Throughput and Error rate.

I. INTRODUCTION

COGNITIVE RADIO

Cognitive radio is the emerging technology in the field of wireless. Cognitive radio is the model/system which can change its parameters in accordance to available environment [10]. Cognitive radio (CR) also allows the secondary unlicensed users to utilize the spectrum that is initially allocated to the primary licensed users. There are two types of users primary and secondary: Primary users are those whose radio is not CR enabled radio whereas secondary users are those whose radio is CR enabled radio. To address the problem of scarcity of spectrum, cognitive radio (CR) has emerged as a promising technology to enable the access of the intermittent periods of un-occupied frequency bands, called white space or spectrum holes, and thereby increase the spectral efficiency [1].

SPRECTRUM SENSING

Spectrum sensing, it is desired to minimize spectrum sensing error (i.e., sum of false alarm and miss detection probabilities) since minimizing spectrum sensing error both reduces collision probability with primary user and enhances usage level of vacant spectrum [14]. To provide reliable spectrum sensing performance (i.e., minimize spectrum sensing error) one of the great challenges is determining threshold level since spectrum sensing performance depends on the threshold level [17]. When determining threshold level, besides spectrum sensing error, spectrum sensing constraint which requires false alarm and miss detection probabilities to be below target level should also be considered since it guarantees minimum required protection level of primary user and usage level of vacant spectrum.

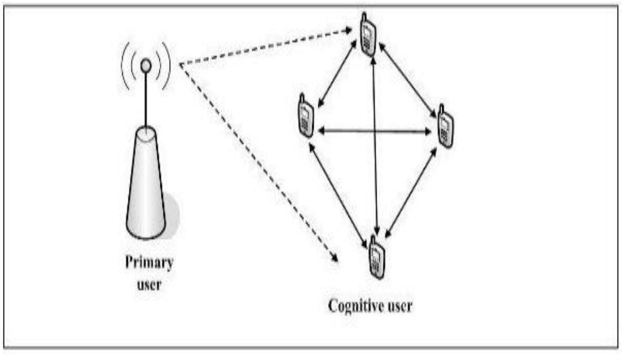

Fig. 1: Spectrum Sensing in Cognitive Radio

CONSTANT DETECTION RATE (CDR)

In addition, the CDR can provide at most constant detection probability even in high SNR region where signal strength is much stronger than noise power to be easily distinguished we consider an optimization of threshold level with energy detection to minimize the spectrum sensing error for a given sensing constraint [14]. The false alarm and miss detection probabilities are monotonically increased and decreased, respectively, as the threshold level increases. Therefore, the spectrum sensing error function has concave or convex properties for certain threshold level duration [17]. To optimize threshold level, besides spectrum sensing error, spectrum sensing constraint which is given by inequality condition should also be considered. Based on properties of spectrum sensing error function and inequality spectrum sensing constraint, we derive an adaptive optimal spectrum sensing threshold level minimizing spectrum sensing error while satisfying spectrum sensing constraint [15].

II. PROPOSED METHODOLOGY

In the research work ABC (Artificial Bee colony) has been used to calculate the different parameters of the proposed work. In ABC system, artificial bees fly around in a multidimensional search space and some (employed and onlooker bees) choose food sources depending on the experience of themselves and their nest mates, and adjust their positions. Some (scouts) fly and choose the food sources randomly without using experience. In this research, ABC (Artificial Bee Colony) algorithm is used as an optimization tool provides a population-based search procedure in which individuals called foods positions are modified by the artificial bees with time and the bee's aim is to discover the places of food sources with high nectar amount and finally the one with the highest nectar for the optimization of the route.

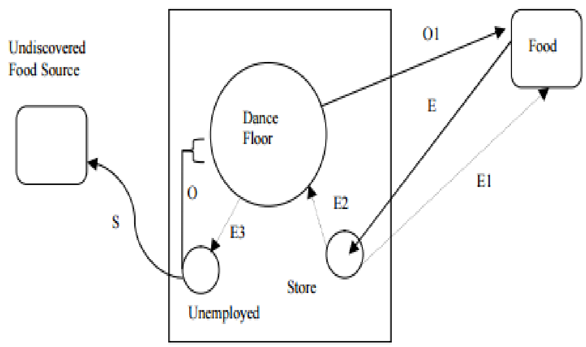

Fig 2: Foraging behaviour of honey bees

Proposed Algorithms

Step 1: Initially a network area having dimension 1000×1000 has been formed.

Step 2: initialize the nodes in the network. That is source node and the destination node in the network area.

Step 3: Now routing options like when we press 1 it will simulate for time based.

If we Press 2 networks will be simulated for energy based.

Step 4: defined transmitter and receiver.

Step5: ABC algorithm is applied for the optimization of the route. The fitness function of the algorithm is used. If fitness function is satisfied then route between source and destination has been created. Otherwise, reject the node and optimized again.

Step 6: Now calculate the performance parameters like Throughput, Error rate and PDR.

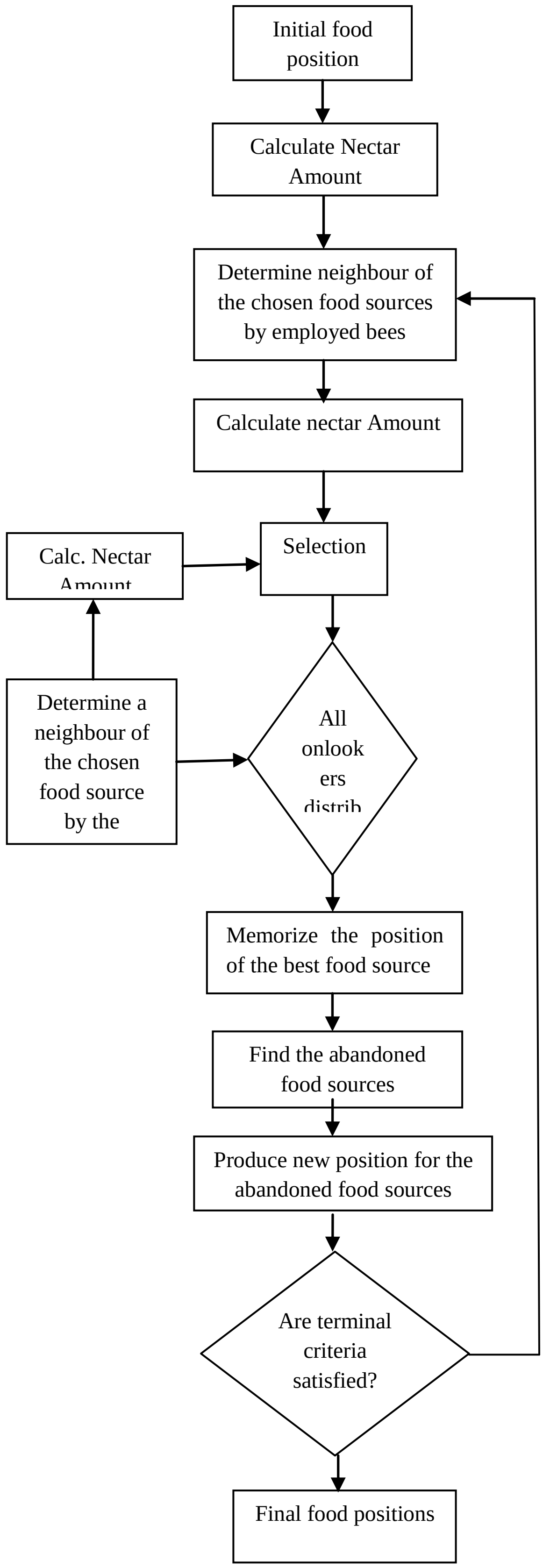

Fig 3: Artificial Bee Colony Algorith

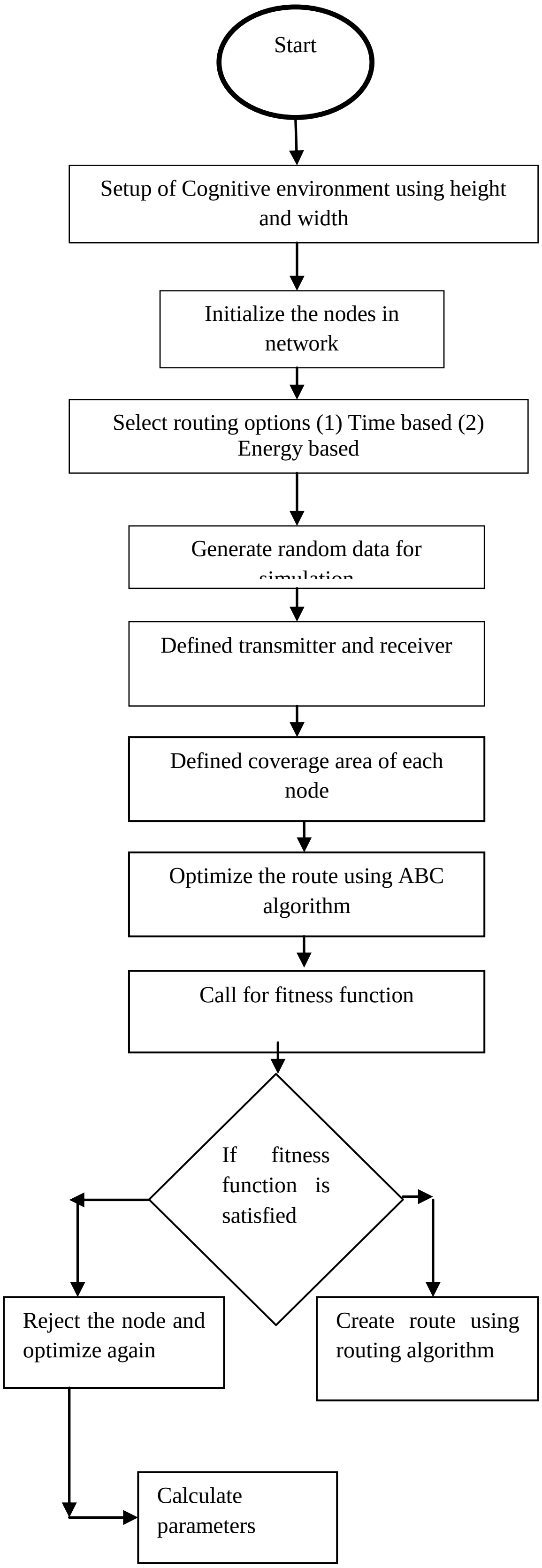

Fig: 4 Flowchart of Proposed Work

III. SIMULATION/EXPERIMENTAL RESULTS

RESULT ANALYSIS

The simulation environment of the proposed work is shown in the table 1

TABLE 1: RESULT SIMULATIONS

Number of nodes	50-100
Area	1000-1000 meters
Simulation Tool	Matlab
Evaluation Parameter	Throughput , Error Rate and PDR

Here, we formulated the following results in MATLAB with 50 nodes.

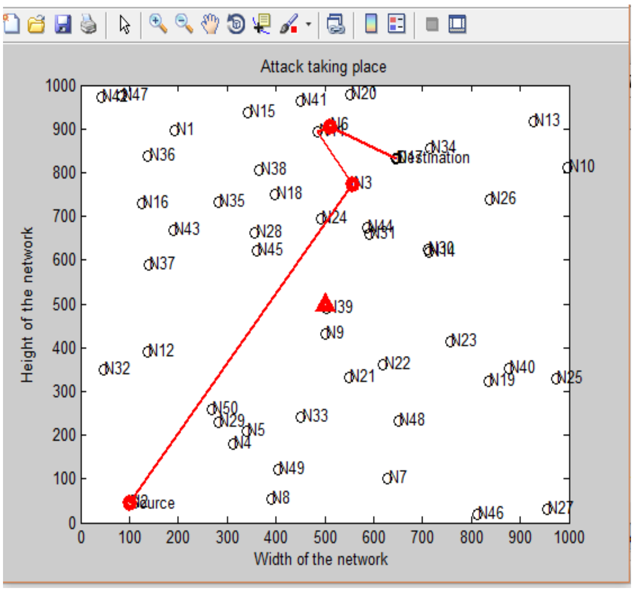

Fig 5: Network Area

In the above figure along the x-axis width of the network, along y-axis there is a height of the network having area 1000×1000. In the above figure node 2 is a source node and node 34 is a destination node. Data transfer follows the path through node 3, node 16 and then reach at the destination.

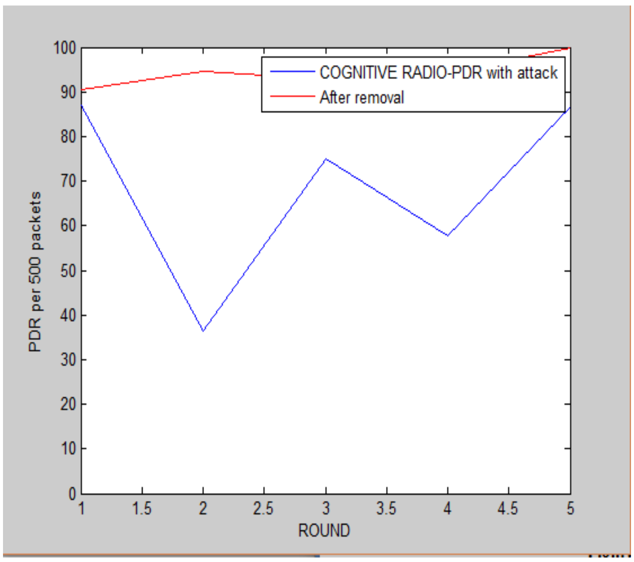

Fig 6: PDR vs Number of rounds

The above figure shows the graph plotted between PDR vs number of rounds. The maximum value of PDR goes upto 100 whereas, number of rounds are 5. There are two lines in the graph which are shown by Red, Blue colour. Blue line indicates the PDR value obtained for Cognitive radio when attack occurred in the network. Red line indicates the PDR values obtained for the Cognitive radio when attack is removed. From the above graph it is clear that the value of PDR without attack is approximately equal to 93.4% whereas with attack the average value of PDR is equal to 68.2%.

TABLE 2: PDR VALUES WITH AND WITHOUT ATTACK

Number of rounds	1	2	3	4	5
PDR values With attack	87	35	72	60	87
PDR values Without attack	91	95	91	90	100

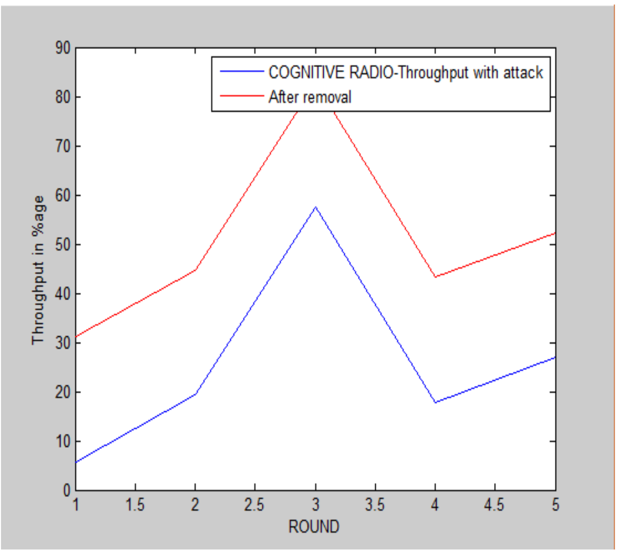

Fig 7: Throughput vs Number of rounds

The above figure shows the graph between throughput and number of rounds. From the above figure it is concluded that the Throughput values obtained for cognitive radio with attack is less than the values obtained without attack. With attack the average value obtained is approximately equal to 22.2 %, whereas, the average throughput values obtained without attack is 52.4 %.

TABLE 3: THROUGHPUT VS NUMBER OF ROUNDS

Number of rounds	1	2	3	4	5
Throughput values With attack	5	16	52	15	23
Throughput values Without attack	31	45	83	50	53

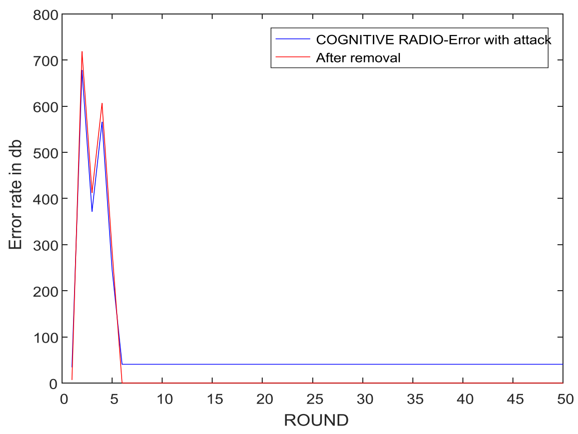

Fig 8: Error rate vs number of rounds

The above figure shows the error rate in db and it is clear from the figure that after a certain amount of time the error becomes approximately zero in without attacker case. Hence the aim to minimize the error rate in search of a secondary node is attained. In the case of attacker, the error rate is around 40 db and in case of without attacker, it is constant.

Result analysis for energy based

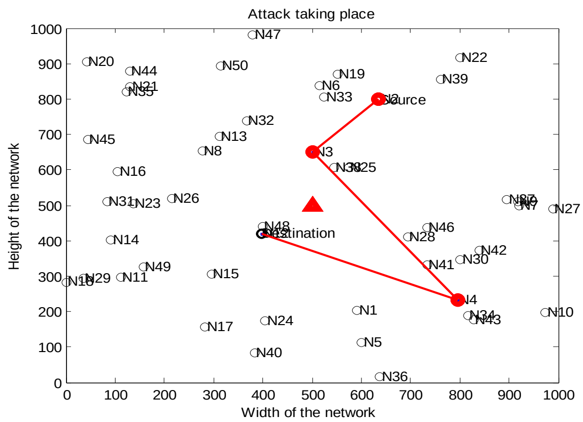

Fig 9: Network area for energy based network

In the above figure node 2 is the most affected node and the area of the network is 1000*1000.

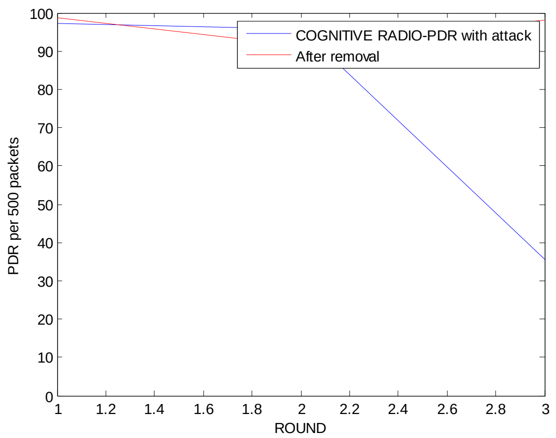

Fig 10: PDR vs number of rounds for energy based

From the above figure it is clear that blue line indicate the PDR value for cognitive radio when attack occurs in the network. Whereas, Red line indicates PDR value, when no attack occurs in the network. It is clear that without attack PDR value is higher than the value obtained with attack in the network.

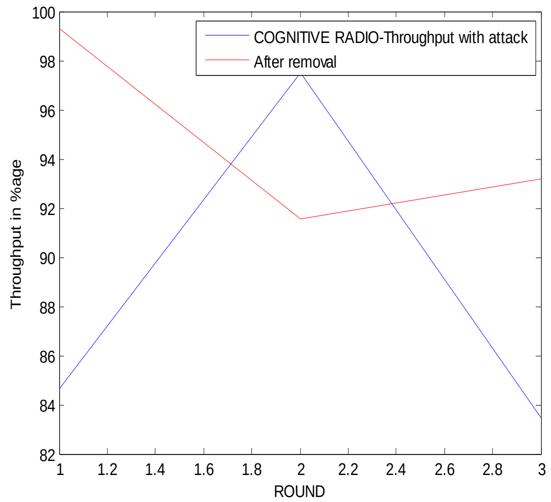

Fig 11: Throughput vs Round in Energy based

The above figure shows the graph between throughput and number of rounds. From the above figure it is concluded that the Throughput values obtained for cognitive radio with attack is less than the values obtained without attack. With attack the average value obtained is approximately equal to 88.6 %, whereas, the average throughput values obtained without attack is 94.6 %.

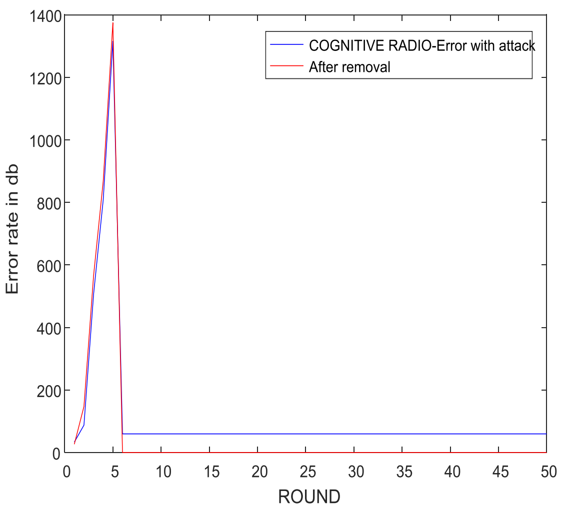

Fig 12: Error rate vs number of rounds

From the above figure, it is clear that initially the bit error rate is high which is approximately near about 1400 db. But as the numbers of rounds are increasing, bit error rate get decreases and become constant. As we can see that in the case of proposed work, the error rate is almost zero.

IV. CONCLUSION

To detect the primary user presence becomes the most difficult are of research. This can only be solved by spectrum sensing in cognitive radio. Spectrum sensing leads to attain high accuracy in the network by using all resources available in network. So, in this research, it has been shown that spectrum sensing performance can be greatly improved with an increase of the number of cooperative partners. CRs, cooperative spectrum sensing may become unfeasible because only one CR should transmit the data to the common receiver So that the decision taken for the data can be easily taken at the receiver end. Due to this, the sensing time has increased intolerably. To address these issues, an efficient sensing algorithm based on ABC algorithm which relies on the transmission of decision in one time slot for one CR but guarantees a target error bound by requiring a few CRs in cooperative spectrum sensing instead of all of them is proposed and the performance of cooperative spectrum sensing with energy detection in cognitive radio networks is studied.

V. FUTURE SCOPES

Conventional scenarios for this seem unrealistic. In order to realize cooperative sensing, a multiplexing scheme and . Conventional scenarios for this seem unrealistic. In order to realize cooperative sensing, a multiplexing scheme. E.g. OFDM (Orthogonal Frequency Division Multiplexing) signals; is used to detect the presence of primary user's signal and is considered to be better than energy detection and matched filter detection as it performs well even in the fading channels. In addition, cooperative detection is used among the secondary users to improve the performance of spectrum sensing. Energy detector based approach, also known as radiometry or period gram, is one of the popular methods for spectrum sensing as it is of non-coherent type and has low implementation complexity. In addition, it is more generic as receivers do not require any prior knowledge about the primary user's signal. In this method, the received signal's energy is measured and compared against a pre-defined threshold to determine the presence or absence of primary user's signal. Moreover, energy detector is widely used in ultra wideband (UWB) communications to borrow an idle channel from licensed user.

REFERENCES

[1] M. T. Islam and M. A. Mahmud, "Multi antenna based cooperative coarse fine sensing for wideband cognitive radio system,"*2017 International Conference on Electrical, Computer and Communication Engineering (ECCE)*, Cox's Bazar, Bangladesh, 2017, pp. 480-485.

[2] H. A. A. Garrido, M. E. Rivero-Angeles and I. Y. O. Flores, "Performance Analysis of a Wireless Sensor Network for

Seism Reporting in an Overlay Cognitive Radio System,”*2016 30th International Conference on Advanced Information Networking and Applications Workshops (WAINA)*, Crans-Montana, 2016, pp. 565-570.

[3] K. Seshukumar, R. Saravanan and M. S. Suraj., “Spectrum sensing review in cognitive radio,” *2013 International Conference on Emerging Trends in VLSI, Embedded System, Nano Electronics and Telecommunication System (ICEVENT)*, Tiruvannamalai, 2013, pp. 1-4.

[4] S. Hussain and X. Fernando, “Spectrum sensing in cognitive radio networks: Up-to-date techniques and future challenges,”*2009 IEEE Toronto International Conference Science and Technology for Humanity (TIC-STH)*, Toronto, ON, 2009, pp. 736-741.

[5] L. N. T Perera and H. M. V. R. Herath, Member, IEEE, “ Review of Spectrum Sensing in Cognitive Radio” 2011 6th International Conference on Industrial and Information Systems, lC11S 2011, Aug. 16-19, 2011, Sri Lanka.

[6] J. Christopher Clement and Kishore V. Krishnan, “Cognitive Radio: Spectrum Sensing Problems in Signal Processing” International Journal o/Computer Applications (0975 - 8887) Volume 40- No. 16, February 2012.

[7] M. Babaei, E. Basar and Ü. Aygölü, “A cooperative spectrum sharing protocol using STBC-SM at secondary user,” *2016 24th Telecommunications Forum (TELFOR)*, Belgrade, 2016, pp. 1-4.

[8] W. Xu, W. Yuan, Q. Shi, X. Wang and Y. Zhang, “Distributed Energy-Efficient Cross-Layer Optimization for Multihop MIMO Cognitive Radio Networks With Primary User Rate Protection,”in *IEEE Transactions on Vehicular Technology*, vol. 66, no. 1, pp. 785-797, Jan. 2017.

[9] S. Das and S. Mukhopadhyay, “SoC FPGA implementation of energy based cooperative spectrum sensing algorithm for Cognitive Radio,”*2015 6th International Conference on Computers and Devices for Communication (CODEC)*, Kolkata, 2015, pp. 1-4.

[10] V. Jamali, M. Ahmadian, S. H. Safavi and M. Ardebilipour, “Cooperative spectrum sensing in cognitive radio networks under primary outage constraint,” *20th Iranian Conference on Electrical Engineering (ICEE2012)*, Tehran, 2012, pp. 1368-1372.

[11] J. Park , “A Fully Integrated UHF-Band CMOS Receiver With Multi-Resolution Spectrum Sensing (MRSS) Functionality for IEEE 802.22 Cognitive Radio Applications,” in *IEEE Journal of Solid-State Circuits*, vol. 44, no. 1, pp. 258-268, Jan. 2009.

[12] X. L. Huang; Y. Xu; J. Wu; W. Zhang, “Non-Cooperative Spectrum Sensing with Historical Sensing Data Mining in Cognitive Radio,” in *IEEE Transactions on Vehicular Technology* , vol.PP, no.99, pp.1-1.

[13] Abdulsattar, Mahmood A., and Zahir A. Hussein, “Energy detection technique for spectrum sensing in cognitive radio: a survey,” *International Journal of Computer Networks & Communications* 4.5 (2012): 223.

[14] G. Caso, L. De Nardis, G. C. Ferrante and M. G. Di Benedetto, “Cooperative spectrum sensing based on Majority decision under CFAR and CDR constraints,” *2013 IEEE 24th International Symposium on Personal, Indoor and Mobile Radio Communications (PIMRC Workshops)*, London, 2013, pp. 51-55.

[15] D. W. Yue, F. C. M. Lau and Q. Wang, “Log-average-SNR ratio and cooperative spectrum sensing,” in *Journal of Communications and Networks*, vol. 18, no. 3, pp. 311-319, June 2016.

[16] S. Das and S. Mukhopadhyay, “SoC FPGA implementation of energy based cooperative spectrum sensing algorithm for Cognitive Radio,” *2015 6th International Conference on Computers and Devices for Communication (CODEC)*, Kolkata, 2015, pp. 1-4.

[17] Oh, Dong-Chan, and Yong-Hwan Lee, “Energy detection based spectrum sensing for sensing error minimization in cognitive radio networks,”*International Journal of Communication Networks and Information Security* 1.1 (2009): 1.