To Enhance the Performance of Relay Based Cooperative Spectrum Sensing In Cognitive Radio Networks over Nakagami-M-Channels

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Abstract: **In wireless communication, a potentially new technology is cognitive networking. This networking is simply a communication system which is very intelligent and consists of connections which are wireless with both external and internal awareness of environment and attain its goals adaptively.**

Keywords: Cognitive Radio Networks, Spectrum Sensing, Decentralized Cognitive Networks, Integrity

1. INTRODUCTION

In modern era, we need a wireless communication which is flexible and robust too. The available spectrum is static and used inefficiently due to licensing and then utilization of electromagnetic spectrum by conventional method. The spectrum is used in an unbalanced way which further leads to scarcity of spectrum because of increased demand and as various technologies needed in it. This problem can be solved if new policies of licensing are introduced and properly coordinated with infrastructure. By this efficiency of spectrum will be increased and radio spectrum is enabled to be used dynamically [1].In many different contexts like communications, cognitive networks and cognitive radio etc. the word 'cognitive' has been used. Example is cognitive network vision. This network should be able to make decision of configuration regarding any vision and particular environment. Cognitive technology is required by the managed networks. The accomplishment of application should be understandable by the network and at a particular moment the work of network should be understandable by the application. So by learning requirements of application, allows network to use new capabilities and these requirements will meet by network protocol which will dynamically chose. If the language is domain specific, users and operators could be enabled for goals description and its requirements [2].

1.2 Cognitive Radio Networks

1.2.1 Spectrum Sensing

The three categories in which techniques of spectrum sensing research falls are –detection of transmitter, detection based on interference and cooperative detection. Three techniques are used mainly for avoiding interference of transmission with primary. Interference temperature at a point is the amount of caused interference at some point in space by the secondary users. When transmission of primary user is occurring, the threshold which is near to primary receiver should be more than interference. But achieving this is not an easy task as secondary users do not know the location of receiver. The scanning of spectrum of secondary user should not confuse with transmission of other secondary network from secondary users with primary transmission when many network are pre-secondary overlap [3].

1.3 Cognitive Network Types

1.3.1 Centralized Cognitive Networks

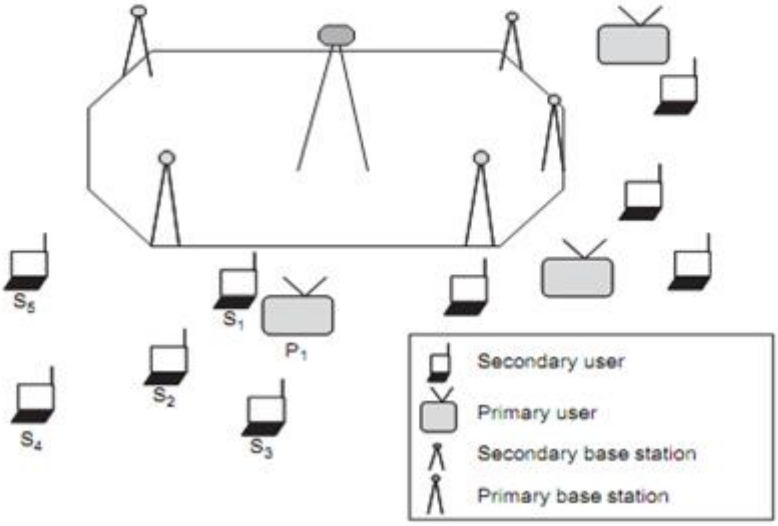

Figure 1.1: Block Diagram of Centralized Cognitive Networks [4]

1.3.2 Decentralized Cognitive Networks

The architecture of decentralized is shown in 1.2 figure. In this the interconnection of secondary users is not done through network which is infrastructure oriented. The ad-hoc manner is followed in this for communication of secondary users. Information can be directly exchanged if the secondary users are in range of communication but if the users are not in communication range, the exchange can be done by multiple hops. In distributed cognitive networks, the decisions on power transmit and spectrum bands etc. by secondary users can be made which is further based on either observation which are local or which are cooperative. This is done by some utility functions so that for all secondary users we can get performance which is nearly optimal. To improve overall detection of primary user in cognitive network, the sharing of information related to secondary user is done. This is highlighted by technique called collaborative sensing. Malicious users are not considered by protocols. The spectrum sharing network is subclass of decentralized network where in unlicensed band the two networks which are wireless coexist [3].

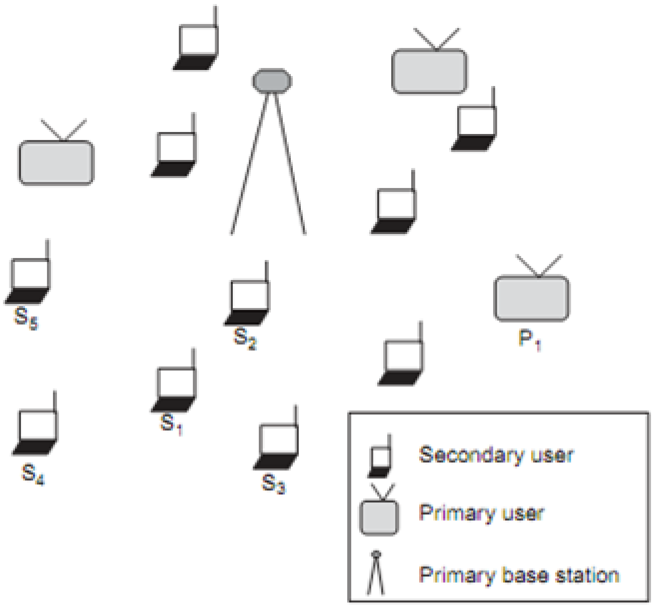

Figure 1.2: Block Diagram of Distributed Cognitive Networks [8]

1.4 Communication Security Building Blocks in Cognitive Radio

Wireless network which are existing like wireless LAN IEEE 802.11 are having common security building blocks in cognitive network, they are very important.

1.4.1 Availability

In terms of cognitive networks, availability means primary and secondary users are able for spectrum access.

The term availability, for primary users means transmission with any secondary user interference in licensed band. If we considered policies of dynamic spectrum access, the guaranty is there for primary user availability. The term availability, for secondary user means chunks are present of spectrum where transmission can be done without any interference caused with primary user. To use an opportunity, the large chunks are available of spectrum. There is no guarantee for secondary user of spectrum availability. In cognitive network which are centralized, availability means appropriate countering of attacks should be ensured by security mechanisms. [5]

1.4.2 Integrity

In wireless network, the integrity is important as violators can easily access the wireless medium. For, the same reason security is added as the additional layer at link layer in wireless LAN's so that it becomes secure. The protocol used for security in this layer is CCMP. To verify the message integrity, MIC is used in this protocol. MIC is message integrity check. In cognitive radio network, these techniques can be used. [13-15]

1.4.3 Identification

For any communication device one basic requirement for security is identification. In this method, a user or a device gets associated with their identity. Example-IMEI i.e. international mobile equipment identifier is provided in cellular networks. This is equipment used for identification. This identifies uniquely identifies the devices of mobile in cellular network similarly. In cognitive network, in the devices of secondary user mechanism of tamper proof identification is built [17].

1.4.4 Confidentiality

This is similar to integrity. The work of integrity scheme is that it ensure that the does not get changed maliciously and the confidentiality scheme works for the assurement of un-accessed data by the way it is transformed. This is possible if the data which is transmitting is encrypted and ciphers are employed there. The encrypted data should have a security key which is known by recipients only. So that the recipients can only decrypt it and data can be read by them [19].

1.4.5 Non-repudiation

Either sender or receiver is prevented from denying message transmitted in this technique. So, if message sent can be proved of having a claimed sender by the receiver and also received message can be proved of having claimed receiver by the sender. In setting of cognitive radio network, if any harmful unauthorised user is identified of violating protocol, then these techniques can be used to give prove of its misbehaviour and can band that user from secondary network. [20]

2. LITERATURE SURVEY

James D. Gadze et al. [6] Researched on the study of performance of detection of energy which is based on sensing of spectrum for networks of cognitive radio. If the environment is noisy and faded then the performance of detection of energy relays of techniques of sensing of spectrum. Investigation is done for both detection of single user and cooperative. Derivation is also performed of solution in closed form for wrong alarm and detection probability. Monte Carlo method of MATLAB is used for verification of analytical results by computing them numerically. Evaluation of performance of detection of energy is also done with use of ROC curves (receiver operating characteristics) over the channel of AWAN and also over Nakagami-m channels.

Jian Li et al. [7] Proposed modeling of interference co-channel in wireless networks of cognitive. The technology called cognitive radio shares the bands of frequency which are underutilized and whose license is with primary users. However, due to problem of uncertainty in primary user detection, the possibility of interference of secondary user with primary user is there when both users are simultaneously active. So, interference consequences are very accurate is proposed by the researchers for the description of this co-channel interference along with .pdf, .cdf variance, mean of the above interference faced by primary users. The model which is proposed keeps many factors into account like scheme of spectrum sensing, secondary users spatial distribution and condition of channel which include fading Nakagami and shadowing. Also mathematical expression of influences which is exact is also given from these factors. Many practical applications are there of this framework like cognitive network evaluation of any shape and secondary users density and also power control methods and spectrum sensing methods used by secondary users. To check the effectiveness of method used, simulation results are provided.

Seema M Hanchate et al. [8] discussed the algorithm of spectrum sensing and its implementation in cognitive radio. The latest advancement in revolution is cognitive radio. The future of wireless world will be governed by it. The main aim of this radio is efficient use of spectrum available and also the usage should be fair, cost effective and it should provide a good communication for all network users. Different techniques of non-cooperative sensing of spectrum are discussed and comparison is done of the implemented algorithm.

Fangjun Zhu et al. [9] investigated efficient formation of beam of Trans receiver in MIMO network of cognitive radio. The MIMO network is very efficient for communication for next generation also as it improves utilization of spectrum and also service in wireless. For protection from interference of PUS and good service quality to SUS, the joint design of beam of trans receiver for SUS is the key. Investigation is done by author of the formation of beam in CR network (MIMO) and also of two problems to be optimized are consider i.e. total power of transmission should be minimized and SINR maximized. Formulation of the problem can be as indefinite programs of quadratic optimization. So, an algorithm is proposed which is based on least, error (means squared) and programming as semi definite. This is to get an optimal beam. This paper finding tells that the algorithm proposed is better than existing ones in terms of power transmission and SINR.

Mikio Hasegawa et al. [10] discussed the centralized network and decentralized network of cognitive radio and their optimization. The usage of radio as a resource is improved in technology of cognitive radio. This is done by reconfiguring connection settings of wireless as per the decisions which are optimum. The decision depends on the information collected related to the context. The algorithm used for the decisions taken is an algorithm which optimizes the usage of radio as a resource in cognitive networks which are heterogeneous in nature. If the network managed is centralized then the algorithm proposed by researchers is that whose solution is optimal. If the network managed is decentralized the algorithm proposed by author is distributed which uses dynamics of minimized distributed energy of tank called Hopfield neural network. This algorithm gives minimized function of objective with no calculation of centralized. For optimization of the whole network rule of decision making is derived. The validity of this is demonstrated by numerical simulations and feasibility by designing and implementation on systems of cognitive network.

Matthew R. Tolson et al. [11] Discussed networks of cognitive radio with multicast reliability and ordered fully with multicasting. Subscription to the broadcasted messages is enabled to nodes group. Reliability takes care of correct receiving of message to all nodes and ordered fully makes messages to be received by all nodes in proper order. The architecture proposed here employs multicasting for CR node so as to exchange mapping of radio environment and performing dynamic access to spectrum. Construction of test beds which are wireless and emulated and also measurement of service quality is done. A software toolkit which is multicast was installed on every node and resulting service quality of this is measured. On emulated test bed, channel effects were applied as of test bed which is wireless. The demonstration of characterization of service quality is feasible over wireless network of CR by using an emulated network equivalent to it.

3. PROPOSED WORK

3.1 Problem Formulation

Popularity is increasing of Meta heuristic algorithms emerging today which are naturally inspired. Almost all meta heuristic has main thing that they have natures best feature especially in the field of biology where evolution over millions of years is form natural selection two terms called intensification and diversification need to be known here, the term intensification means searching of best solution and selection of best solution which the term diversification means to ensure efficient exploring of search space.

3.2 Proposed Work

Cuckoo search algorithm is a new algorithm which is based on breeding behaviour like for efficient performance brood parasitism is done for certain species. This is the sensing algorithm based on optimisation. The comparison of this algorithm and spectrum sensing asynchronous cooperative technique is done. In technique of Meta heuristic optimization, implementation of the optimization technique called cuckoo search is done. The technique uses minimum nodes of energy as subordinate chains. The technique feasibility is checked by the simulated results when compared with traditional techniques.

4. RESULTS AND ANALYSIS

The results are obtained by method of cuckoo optimization technique.

4.1 Results and their Discussion

The algorithm discussed in previous chapter is used in MATLAB implementation and also tested. For simplicity, results are mentioned below:

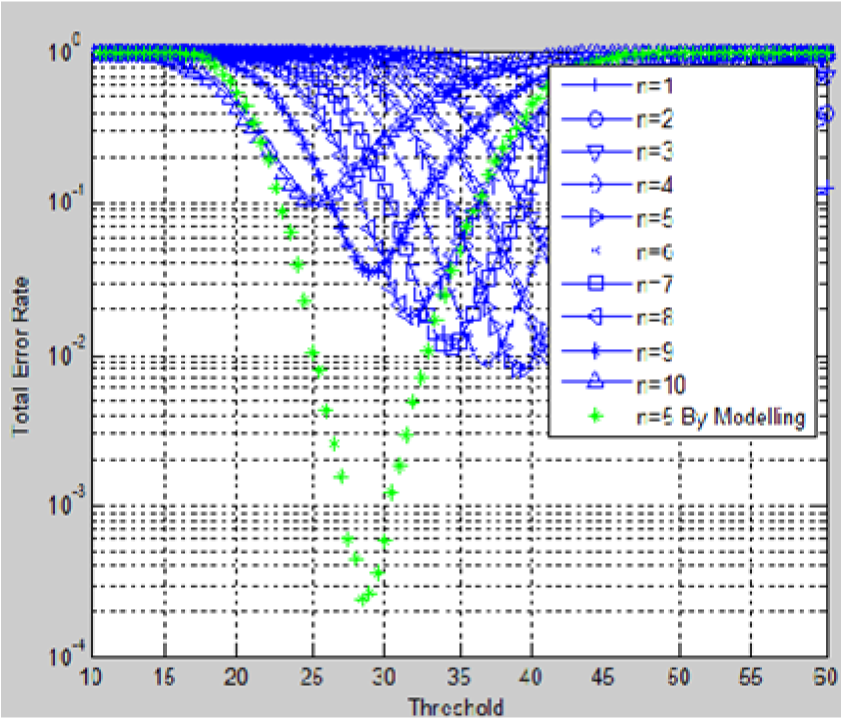

Figure 4.1: Threshold vs Total error rate

Figure shows threshold versus error rate values. 10db is value assumed of SNR here. At n=5 , error rate evaluation for various values of threshold is performed. In actual, error rate is the missed detection probability of the signal. If more number or very few numbers of CRs are used then probability of wrong alarm will be high. As shown by the figure that low error rate is there at n=5 and high at n=10 and n=1. So for achieving low error rate CRS value should be half i.e. 5. So correct cooperative spectrum sensing is done as missed detection probability and wrong alarm probability is low.

The characteristic performance is shown by figure below. The graph shows both detection probability (P_d) and wrong alarm probability (P_f) of the technique called cuckoo search.

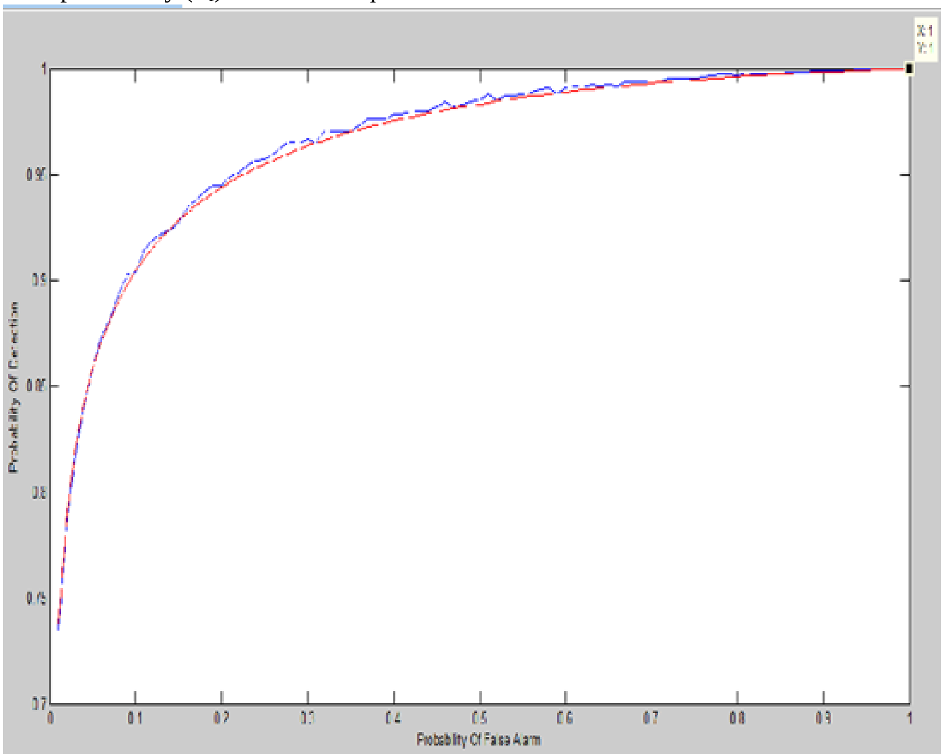

Figure 4.2: Detection vs wrong alarm probability to find values at different points.

Here, red line shows wrong alarm probability and blue line shows detection probability. A simple implementation that says a solution is represented by each egg and the eggs of cuckoo gives a new solution. The technique of cuckoo search can be used for multiple eggs that represent the solution. Nest with a single egg is used in this dissertation. The figure reveals that the detection probability is increased more in comparison to wrong alarm probability; this is due to the cuckoo search scheme applied. So the sensing performance is improved of the spectrum in CRs.

Taken the points between 0 to 1 we find that in cuckoo search technique of optimization the detection probability of the spectrum is more than the sensing technique of asynchronous cooperative spectrum.

Values are taken from different points in graph like detection probability taken is 0.1, 0.2, 0.3, 0.4, and 0.5 and so on. We can take any point's in-between 0 to 1 to compare with asynchronous sensing technique.

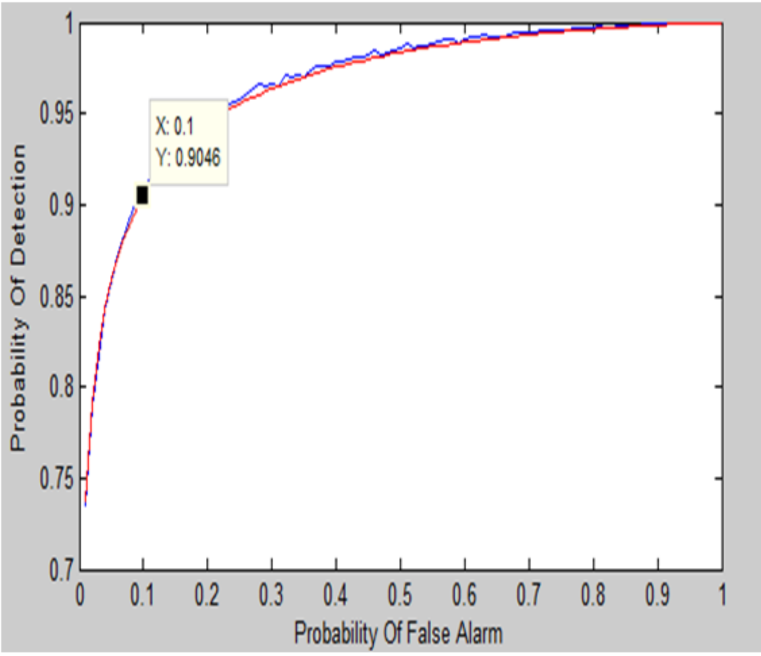

Figure 4.3: Value of P_d at P_f X=0.1

Figure shows the graph of detection probability with wrong alarm probability. The value is taken at P_f X=0.1 is 0.9046.

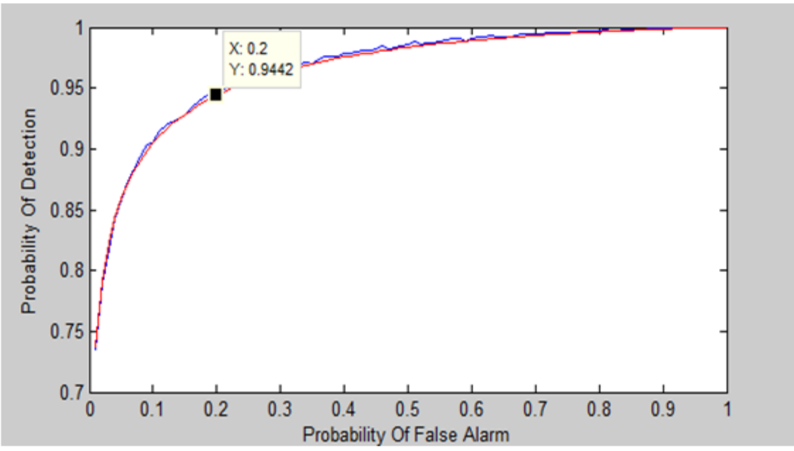

Figure 4.4: Value of P_d at P_f X=0.2

In above figure the value is taken at P_f X=0.2 is 0.9442.

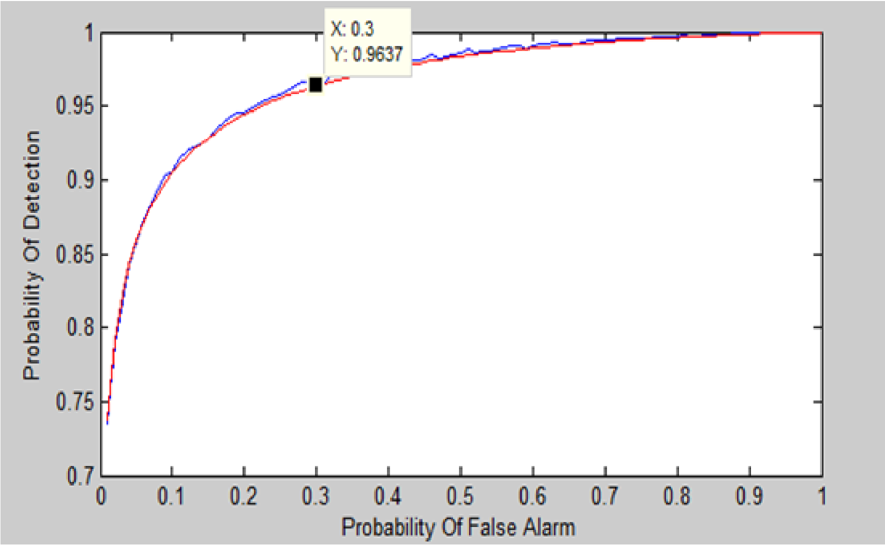

Figure 4.5: Value of P_d at P_f X=0.3

In above figure the value is taken at P_f X=0.3 is 0.9637.

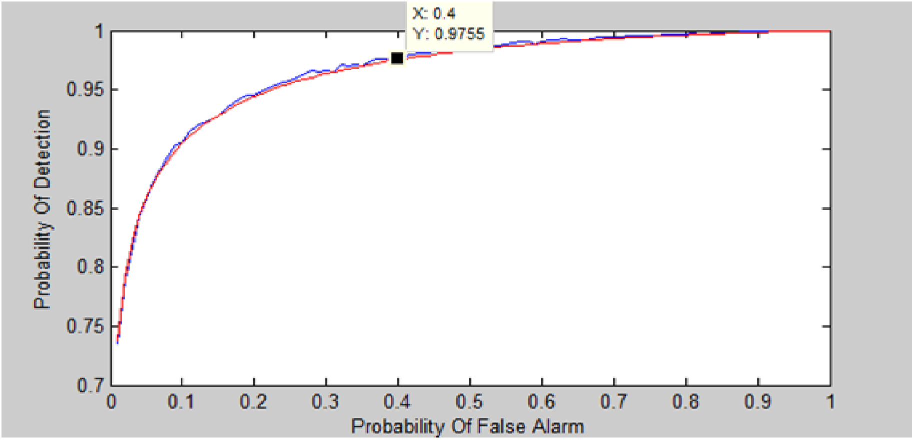

Figure 4.6: Value of P_d at P_f X=0.4

At P_f X= 0.4, the value is 0.9755 of probability of detection of cuckoo search spectrum.

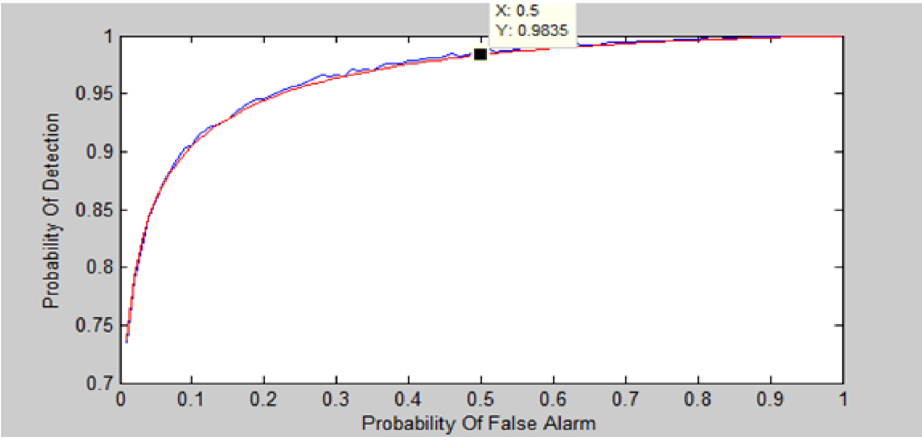

Figure 4.7: Value of P_d at P_f X=0.5

Figure above shows the value is 0.9835 at point 0.5.

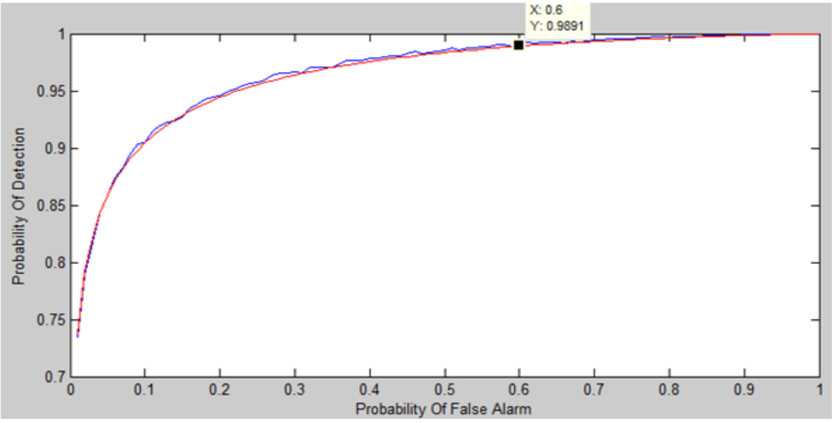

Figure 4.8: Value of P_d at P_f X=0.6

Figure shows graph between P_d and P_f. At point P_f X= 0.6, the value of P_d is 0.9891.

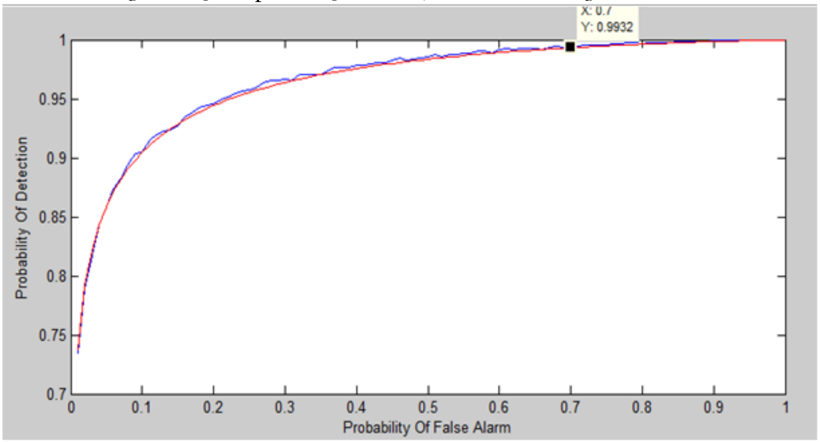

Figure 4.9: Value of P_d at P_f X=0.7

At P_f X= 0.7, the value is 0.9932 of probability of detection of cuckoo search spectrum

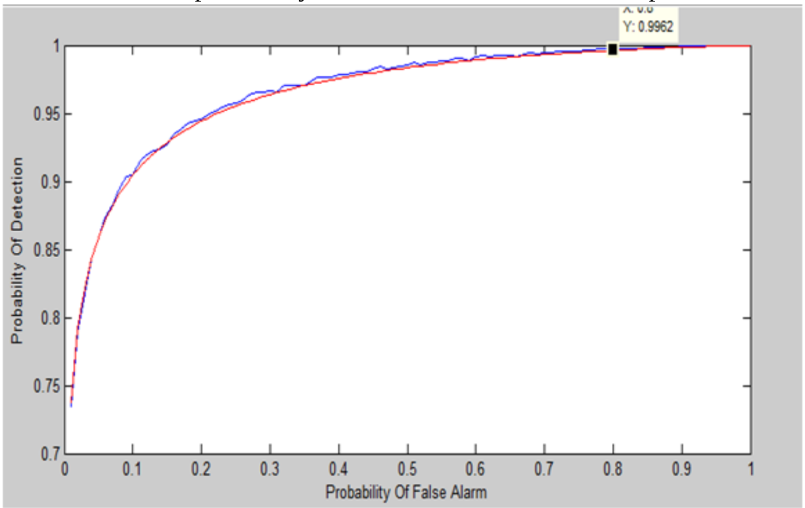

Figure 4.10: Value of P_d at P_f X=0.8

Figure 4.10 shows P_d and P_f graph. It is clear from figure that the value of detection probability of the spectrum is 0.995 at P_f X= 0.8.

From figure 4.11 it is clear that the value of detection probability of spectrum is 0.9984 at point 0.9.

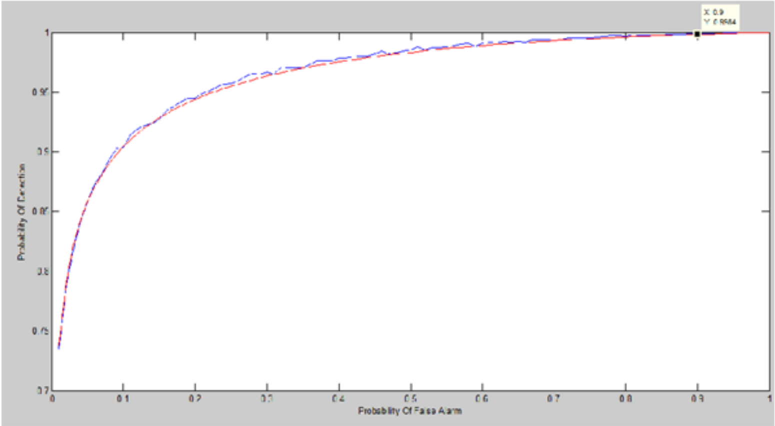

Figure 4.11: Value of P_d at P_f X=0.9

The table shows the different Pd and Pf values.

Wrong alarm probability (X)	Detection probability (Y)
0.1	0.9046
0.2	0.9442
0.3	0.9637
0.4	0.9755
0.5	0.9835
0.6	0.9891
0.7	0.9932
0.8	0.9962
0.9	0.9984
1	1

Table 4.1

The figure below details the ACSS and optimization technique of cuckoo search (CS) compared in terms of spectrum's detection probability. In ACSS, the user with high SNR of cognitive radio performs detection faster that low SNR. The final result depends on who gives local decision earlier and is given by fusion centre. The more generic algorithm is CR used for many problems of optimization.

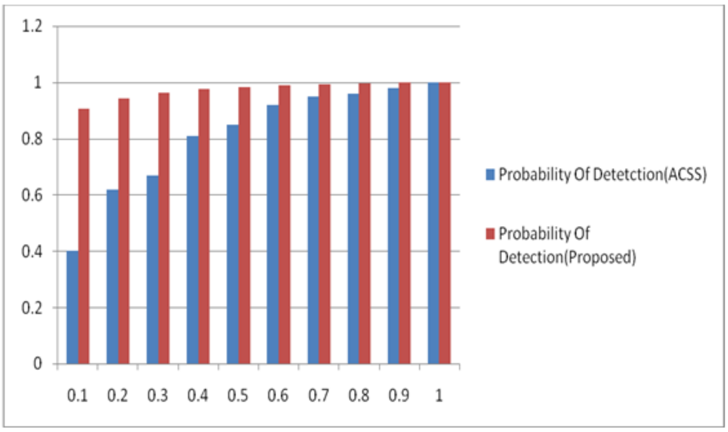

Figure 4.12: Comparison of Probability of detection in ACSS & CS (proposed)

The figure gives the comparison of detection probability of ACSS and CS(proposed) technique. The blue graph is the graph of ACSS detection probability and red colour graph is the graph of proposed detection probability. The graph of both the detections clearly shows that if we move from 0 to 1 detection probability of proposed technique is increasing if comparison is done with technique of ACSS. The major difference in both is shown by points 0.1 to 0.4. At points 0.5 to 0.7 the difference is less and moving to 0.8 and 0,9 point the values are very complex here but the difference is not much between detection probability of ACSS and proposed CS.

The table below reveals the results of comparison done of both detection ACSS and CS:

Table 4.2: Comparison of detection probability (P_d) in ACSS and CS and the importance of P_d in technique of CS

Values	Values of P_d in ACSS	Values of P_d in CS	P_d Improvement in CS Technique
0.1	0.4	0.9046	0.5046
0.2	0.62	0.9442	0.3242
0.3	0.67	0.9637	0.2937
0.4	0.81	0.9755	0.1655
0.5	0.85	0.9835	0.1335
0.6	0.92	0.9891	0.0691
0.7	0.95	0.9932	0.0432
0.8	0.96	0.9962	0.0362
0.9	0.98	0.9984	0.0184
1.0	1.0	1.0	0

This table reveals that moving from 0 to 0.9 the higher value of cuckoo search detection probability is than ACSS detection probability. To have good sensing performance the detection probability of spectrum should be always high. The improvement done in detection probability of CS is also shown in the table above.

5. CONCLUSION AND FUTURE SCOPE

The network which knows and understands about the context and is able to process and work on the knowledge it has, is cognitive network. Today's network of cognitive radio has many technologies for making intelligent wireless system computationally. The increase in communication networks complexity is dealt with a very powerful solution given by networks of cognitive radio. This is done by the emphatically networks with the decision making ability of cognitive networks. In networks of cognitive radio, the spectrum sensing sensitivity is improved by the use of method called ACSS i.e. asynchronous cooperative spectrum sensing. This is done by the application of optimization technique of cuckoo search. Evaluation is also done of wrong alarm probability or of spectrum sensing detection by the use of method called energy detection.

As known that the algorithm if cuckoo not much old and it is in early development phase still and also before comparing it accurately to other matured algorithms, necessity of initial tuning is there. For the improvement and stabilization of the algorithm of cuckoo search, comparison is done with other Meta heuristic algorithms. In future investigation will be done on modified cuckoo search to perform in many other benchmarks and other problems of real life and also optimization problems which are unconstrained are parallelized implemented can be applied in algorithm of CS.

In present situation, there is random replacement of some fraction of nests. Prioritization of poorer solutions can be done for the removal. Also the removal probability can be changed and the correct value can be sought. CS improved version can be used for constraining the problems o optimization so that its performance

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