IJCRT.ORG ISSN : 2320-2882
INTERNATIONAL JOURNAL OF CREATIVE RESEARCH THOUGHTS (IJCRT)
An International Open Access, Peer-reviewed, Refereed Journal

AN OPTIMIZATION OF FUZZY ANT COLONY MODEL BASED ROUTING ALGORITHM FOR IMPROVEMENT OF EFFICIENT ROUTING IN COGNITIVE RADIO NETWORKS

Dr. S.NIVAS
Assistant Professor,
Department of Computer Science
Nift-Tea College of Knitwear Fashion, Tirupur

Dr.N. ULAGANATHAN
HOD, Assistant Professor,
Department of Computer Science
Nift-Tea College of Knitwear Fashion, Tirupur

ABSTRACT

Cognitive radio provides good clarification to spectrum shortage problem to accommodate new wireless applications. The network selection is an important mechanism in cognitive radio heterogeneous network) to provide optimal Quality of Service to both Primary Users and Secondary Users. The aim of this work is to provide optimal QoS to SUs by appropriate network selection and channel assignment. The proposed FACOCRA (Fuzzy Ant Colony optimization based cognitive routing algorithm) selects the best network while maximizing the data rate and minimizing the interference and cost simultaneously. Simulation results show the attractive performance of our proposed algorithm.

Keywords: CRN, ACO,PSO,On-demand routing,Overhead ratio

1. INTRODUCTION

Data transmission over wireless channel has been increased exponentially during the last decade. Due to this heavy load, wireless systems are facing problem of spectrum scarcity. To solve this problem, either expand wireless spectrum or use available spectrum efficiently and intelligently. Fifth-generation (5G) networks are expected to provide high data rates with good QoS. Thus, in the coming years, demand for high data rates will increase manyfold. There are different views about 5G architecture: how to cope with high data rates such as cognitive radios, small cells, light communication, and MIMO communication systems. The 5G networks are considered as a heterogeneous network that consists of different types of primary networks. The small cells deployment can meet the demand of high data rates in 5G networks. Moreover, efficient spectrum sharing temporally and spatially ensures the coverage of 5G networks everywhere and all the time. CRN opportunistically utilized the spectrum of licensed networks (primary network). CRNs are becoming the best choice to use wireless spectrum efficiently [1]. CRNs use the spectrum holes available in existing wireless networks. The unlicensed users of CRN are known as SUs and licensed users of primary networks are known as PUs [2].

2. RELATED WORK

One of the main differences between ad hoc networks and traditional CRNs is frequency distribution, which is static in traditional ad hoc networks but dynamic in CRNs. The frequency distribution in CRNs varies with the PUs working condition. Routing algorithms for CRNs should utilize the flexibility of CRs and deal with the critical challenges that do not exist in the traditional ad hoc networks. Generally, there are two main kinds of routing scenario in CRNs: The CR nodes with full spectrum knowledge and with local spectrum knowledge. In the former case, all the CR nodes have a spectrum occupancy map of the CRNs, or there is a central control entity, which could indicate over time and space the channel availabilities [3].

On the other hand, CR nodes with local knowledge are that nodes locally construct spectrum availability information.

Under local spectrum knowledge scenario, Cheng et al. [4, 5] propose an approach based on local spectrum knowledge and integrating consideration of the switching delay and back off delay along the path. With full consideration of all possible delays during a multihop transmission through Cognitive Radio Network, the authors develop metrics and mechanism of spectrum assignment. Cheng's approach has a good performance and many algorithms compare with it.

Yang et al. [6] analyze and model per node delay and the path delay in multihop Cognitive Radio Network. Then, they propose a framework of local coordination based routing and spectrum assignment, which consists of one protocol for routing path and one scheme for neighborhood region. In brief, the proposals [4–6] are "greedy-like" approaches and have the potential of ending up in a bad locally optimal solution.

The Spectrum Aware Mesh Routing (SAMER) proposal [7] opportunistically routes traffic across paths with higher spectrum availability and quality via a new routing metric. It balances between long-term route stability and short-term opportunistic performance. However, this algorithm assumes that nodes are able to communicate with each other with several possible disjoint channels at the same time. In addition, this routing algorithm works based on link state routing, which requires time to converge and create a network topology map. Thus, this approach may not be suitable to CRNs.

Shiang and van der Schaar [8] propose a distributed resource-management algorithm that allows network nodes to exchange information and that explicitly considers the delays and cost of exchanging the network information over multihop cognitive radio networks. In this algorithm, spectrum sensing plays an essential role in all SUs. If the detection is highly unreliable, the collisions between the SUs and PUs may happen more frequently. As a result, the overall spectral efficiency cannot be improved.

Han et al. [9] present provably good distributed algorithms for simultaneous channel allocation of individual links and packet-scheduling, in Software-Defined Radio (SDR) wireless networks. Unfortunately, this algorithm can only achieve a fraction of the maximum achievable throughput in the worst case.

Cacciapuoti et al. [10] propose CAODV which avoids regions of PU activity during both route formation and packet discovery without requiring any dedicated control channel. However, CAODV broadcast route requests messages to all available channels which increase the protocol overhead and route discovery time.

In [11], by introducing preservation regions around primary receivers, a modified multihop routing protocol is proposed for the cognitive users. Under this protocol, there are possibly some SUs that can never be served. Thus, to design more robust and scalable routing algorithm for CRN and take into account the efficiency of optimization, we propose a more dynamic and more practical ACO-based routing algorithm for CRNs.

3. HETEROGENEOUS NETWORK MODEL

The CRHN consists of N primary networks. Each primary network consists of different number of PUs. Availability of channels to SUs depends on the behavior of PUs. All primary networks are connected to a centralized operating mechanism that knows requirements of SUs and PUs activity. It is assumed that communication environment is slowly varying during spectrum decision time.

The objectives are

(i) Minimizing the cost paid by SU,

(ii) Minimizing the interference provided by SU,

(iii) Maximizing the accumulative data rates by SUs.

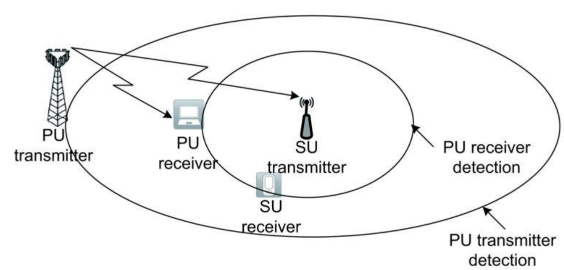

Figure 1: Spectrum sensing concept

3.1 Local Spectrum Sensing Techniques

To identify the SHs and protect PU transmission, different local spectrum sensing techniques have been proposed for individual SUs by applying the hypothesis testing criteria discussed above.

3.1.1 Matched filtering detector

If the SUs know information about the PU signal, the optimal detection method is matched filtering [11], which correlates the known primary signal with the received signal to detect the presence of the PU signal and thus maximize the signal-to-noise ratio (SNR). The matched filtering detector requires short sensing time to achieve good detection performance. However, it needs knowledge of the transmit signal by PU that may not be known at the SUs. Thus, the matched filtering technique is not applicable when transmit signals by the PUS are unknown to the SUs.

3.1.2 Energy detector

Energy detector [11] is the most common spectrum sensing method. The decision statistics of the energy detector are defined as the average energy of the observed samples

$$Y = \frac{1}{N} \sum_{t=1}^{N} |x(t)|^2. \quad \text{… (1)}$$

The decision is made by comparing Y with a threshold, γ. If Y ≥ γ, the SU makes a decision that the PU signal is present (H1); otherwise, it declares that the PU signal is absent (H0).

The energy detector is easy to implement and requires no prior information about the PU signal. However, the uncertainty of noise power imposes fundamental limitations on the performance of the energy detector. Below an SNR threshold, a reliable detection cannot be achieved by increasing the sensing duration. This SNR threshold for the detector is called SNR wall [12]. With the help of the PU signal information, the SNR wall can be mitigated, but it cannot be eliminated. Moreover, the energy detector cannot distinguish the PU signal from the noise and other interference signals, which may lead to a high false-alarm probability.

3.1.3 Feature detector

Cyclostationary detector is one of the feature detectors that utilize the cyclostationary feature of the signals for spectrum sensing. It can be realized by analyzing the cyclic autocorrelation function (CAF) of the received signal x(t), expressed as

$$R_x^{(\beta)}(\tau) = E\left[x(t)\, x^*(t-\tau)\, e^{-j2\pi\beta t}\right], \quad \text{.... (2)}$$

where E[·] is the expectation operation, * denotes complex conjugation, and β is the cyclic frequency. CAF can also be represented by its Fourier series expansion, called cyclic spectrum density (CSD) function, denoted as

$$S(f,\beta) = \sum_{\tau=-\infty}^{+\infty} R_x^{(\beta)}(\tau)\, e^{-j2\pi f\tau}. \quad \text{… (3)}$$

The CSD function exhibits peaks when the cyclic frequency, β, equals the fundamental frequencies of the transmitted signal. Under hypothesis H0, the CSD function does not have any peaks since the noise is, in general, non-cyclostationary.

Generally, feature detector can distinguish noise from the PU signals and can be used for detecting weak signals at a very low SNR region, where the energy detection and matched filtering detection are not applicable. A spectral feature detector (SFD) has been proposed to detect low SNR television broadcasting signals. The basic strategy of the SFD is to correlate the periodogram of the received signal with the selected spectral features of a particular transmission scheme. The proposed SFD is asymptotically optimal according to the NP test, but with lower computational complexity.

4. FUZZY LOGIC ANT COLONY SYSTEM ALGORITHM

The ants have the ability to search the shortest path between nest and food source by releasing a liquid substance called pheromone on their routes. This behavior was first investigated by Dorigo et al. [14-16].

The fuzzy logic (FL) was introduced by Zadeh [17]. Fuzzy systems have been making rapid progress in the recent years. According to fuzzy logic (FL), an object can take any real value between 0 and 1. Fuzzy control can be defined by linguistic sentences called IF-THEN rules instead of mathematical equations. The process of deduction of rules is called inference [18]. Fuzzy logic controlling system stages are as follows:

(a) Fuzzification operation can map mathematical input values into fuzzy membership functions.

(b) In next step, linguistic rules are made to execute fuzzy membership functions.

(c) Defuzzification operation is used to map a fuzzy output into binary form called crisp output values. There are different Defuzzification techniques; for example, the center of gravity and the mean of maxima are mostly used [18, 19].

A colony of ants is considered on each node. In this figure, the interference to networks by SUs is represented by edges. In each journey, a traveler ant collects information of the transited edges and visited nodes. After arriving at a destination, based on the analyses of transited path by the fuzzy system, the ant releases pheromone on each edge. This procedure will be repeated for all ants, noting that the result of the mentioned procedure is a pheromone report, which presents pheromone amount of each node for each route. Different steps of the proposed algorithm are described as in Algorithm 1.

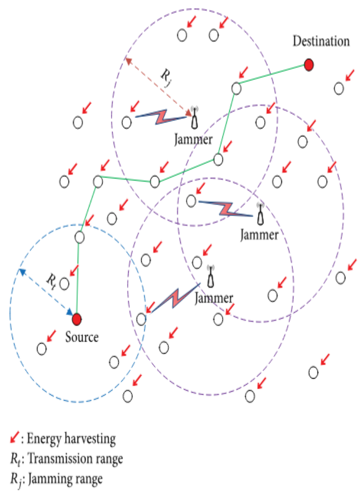

Figure 2: An example of source and destination

SU pair in the multihop and multichannel cognitive radio network under jamming attacks.

4.1 Proposed Algorithm

Procedure FACOCRA
Initialize:
For each iteration
 For each SU
 If SU has available primary network and satisfying constraints
For each active ant
While the ant is active
Network Probability
 Network Selection
 Update Ant Activation
End while
End For
End If
 Local Pheromone
 Updating
End For
 Global Pheromone
 Updating
End For
Result **FACOCRA**
End **FACOCRA**
If
Termination condition is reached
Else
goto Initialize

5. RESULTS AND DISCUSSION

The performances of **FACOCRA** have been evaluated in comparison with PSO and AntHocNet approaches. For the objective function with constraints specified in [20], two scenarios, 1 and 2, are considered. In scenario 1, the price that SUs can pay to buy a network is fixed. In scenario 2, the price to pay by SUs to buy a network is varying.
The following performance metrics are used:

1. Packet Delivery Ratio

2. End to End Delay

3. Overhead Ratio

Table 1:Comparision of Proposed Routing Protocol vs Existing Routing protocol

No. of Nodes	Packet Delivery Ratio			Overhead Ratio			Average End to End Delay		
	FACO CRA	PSO	AntHoc Net	FACO CRA	PSO	AntHoc Net	FACO CRA	PSO	AntHocN et
100	3.5	3.4	3.3	2.4	2.6	2.5	1.5	2.1	2.2
200	4.3	3.9	4.8	3.3	2.9	3.2	2.2	3.1	2.9
300	5.4	4.6	5.3	4.2	3.6	4.1	2.7	3.9	3.4
400	5.9	5.1	5.7	5.0	4.3	4.9	3.2	4.5	4.1
500	7.3	6.3	7.0	5.6	4.7	5.3	3.9	5.3	4.6

Normalized Routing Overhead

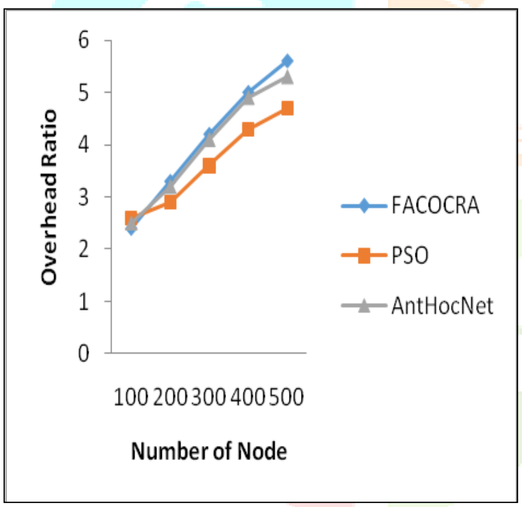

Figure 3: Number of Nodes vs Normalized Routing Overhead

Packet Delivery Ratio

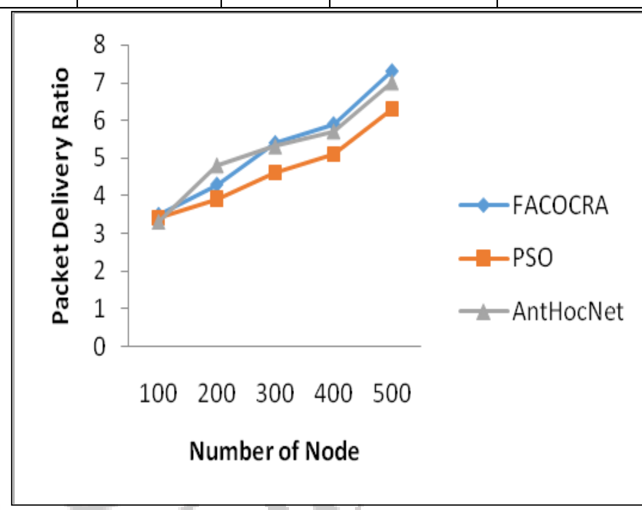

Figure 4: Number of Nodes vs Packet Delivery Ratio

End to End Delay

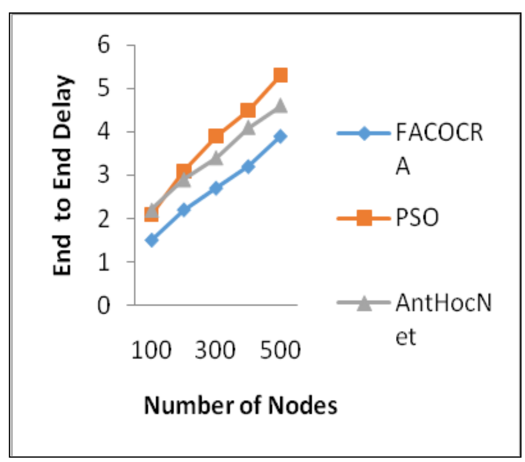

Figure 5: Number of Nodes vs End to End Delay

6. CONCLUSION

The CRHN is a proposed technology for 5G networks. This research work presents fuzzy ants based optimization method to minimize the interference of SUs incurred to primary networks, reduce the cost to buy primary network resources, and maximize the data rates of SUs. The performance of proposed fuzzy logic based ant colony system algorithm (FACOCRA) is evaluated in comparison with other bioinspired algorithms PSO and AntHocNet . Routing is one of the important problems in cognitive radio. In this paper, we propose an ACO-based coginitive routing algorithm to tackle this problem. With the structure of ACO, we implement several operations so as to make ACO capable of routing and channel assignment in multihop CRNs. Our approach together considers the path and channel decisions and thus the end-to-end path latency is reduced. Then, we derive the queuing delay and average queuing length of a cognitive relay node. The validate the efficiency of the algorithm by thorough simulation and find that our approach provides better performance than PSO and AntHocNetin both spectrum distribution varying and channel availability varying environment. The simulation results showed that FACOCRA achieves superior results due to fuzzy logic updating the local pheromone and can enhance the performance of cognitive radio heterogeneous network further.

REFERENCES

1. J. Mitola, "Cognitive radio architecture evolution," Proceedings of the IEEE, vol. 97, no. 4, pp. 626–641, 2009.
2. FCC, FCC 08-260, Unlicensed Operation in the TV Broadcast Bands, 2008.
3. G. Cheng, W. Liu, Y. Li, and W. Cheng, "Spectrum aware on-demand routing in cognitive radio networks," in Proceedings of the 2nd IEEE International Symposium on New Frontiers in Dynamic Spectrum Access Networks (DySPAN '07), pp. 571–574, Dublin, UK, April 2007.
4. G. Cheng, W. Liu, Y. Li, and W. Cheng, "Joint on-demand routing and spectrum assignment in cognitive radio networks," in Proceedings of the IEEE International Conference on Communications (ICC '07), pp. 6499–6503, Glasgow, UK, June 2007.
5. Z. Yang, G. Cheng, W. Liu, W. Yuan, and W. Cheng, "Local coordination based routing and spectrum assignment in multi-hop cognitive radio networks," Mobile Networks and Applications, vol. 13, no. 1-2, pp. 67–81, 2008.
6. Pefkianakis, S. H. Y. Wong, and S. Lu, "SAMER: spectrum aware mesh routing in cognitive radio networks," in Proceedings of the 3rd IEEE Symposium on New Frontiers in Dynamic Spectrum Access Networks (DySPAN '08), pp. 1–5, Chicago, Ill, USA, October 2008.
7. H. P. Shiang and M. van der Schaar, "Distributed resource management in multihop cognitive radio networks for delay-sensitive transmission," IEEE Transactions on Vehicular Technology, vol. 58, no. 2, pp. 941–953, 2009.
8. B. Han, V. S. A. Kumar, M. V. Marathe, S. Parthasarathy, and A. Srinivasan, "Distributed strategies for channel allocation and scheduling in software-defined radio networks," in Proceedings of the 28th Conference on Computer Communications (IEEE INFOCOM '09), pp. 1521–1529, Rio de Janeiro, Brazil, April 2009.
9. S. Cacciapuoti, C. Calcagno, M. Caleffi, and L. Paura, "CAODV: routing in mobile ad-hoc cognitive radio networks," in Proceedings of the IFIP Wireless Days (WD '10), pp. 1–5, Venice, Italy, October 2010.
10. S. W. Jeon, N. Devroye, M. Vu, S. Chung, and V. Tarokh, "Cognitive networks achieve throughput scaling of a homogeneous network," IEEE Transactions on Information Theory, vol. 57, no. 8, pp. 5103–5115, 2011.
11. Sahai A, Hoven N, Tandra R: Some fundamental limits in cognitive radio, in. Proc Allerton Conf Commun Control Comput 2004.
12. Cabric D, Mishra SM, Brodersen RW: Implementation issues in spectrum sensing for cognitive radios, in. Proc Asilomar Conf Signals, Syst Comput 2004.
13. Zhao Q, Sadler B: A survey of dynamic spectrum access. IEEE Signal Process Mag 2007, 24(3):79-89.
14. Clancy T: Achievable capacity under the interference temperature model, in. Proc 26th IEEE Int Conf Comput Commun (INFOCOM) 2007.
15. Bohara VA, Ting SH, Han Y, Pandharipande A: Interference-free overlay cognitive radio network based on cooperative space time coding, in. Proc 5th Int Conf on Cognitive

Radio Oriented Wireless Netw and Commun 2010.
16. Ghozzi M, Dohler M, Marx F, Palicot J: Cognitive radio: methods for the detection of free bands. Comptes Rendus Physique 2006, 7(7):74-81.
17. Ghasemi A, Sousa ES: Impact of user collaboration on the performance of opportunistic spectrum schemes, in. Proc IEEE Veh Technol Conf 2006.
18. HLV Trees In Detection, Estimation and Modulation Theory: Part I. John Wiley & Sons Inc., New York; 2001.
19. Taherpour A, Nasiri-Kenari M, Gazor S: Multiple antenna spectrum sensing in cognitive radios. IEEE Trans Wirel Commun 2010, 9: 814-823.
20. Lei Z-D, Chin FPS: Sensing OFDM systems under frequency-selective fading channels. IEEE Trans Veh Technol2010, 6(4):1960-1968.
21. Axell E, Larsson EG: Optimal and sub-optimal spectrum sensing of OFDM signals in known and unknown noise variance. IEEE J Sel Areas Commun 2011, 29: 290-304.Google Scholar
22. Wald A: Sequential Analysis. John Wiley & Sons Inc., New York; 1947.
23. Sun Z-W, Bradfor GJ, Laneman JN: Sequence detection algorithms for PHY-layer sensing in dynamic spectrum access networks. IEEE J Sel Topics Signal Process 2011, 5(1):97-109.
24. Sonnenschein A, Fishman PM: Radiometric detection of spread-spectrum signals in noise of uncertain power. IEEE J Sel Topics Signal Process 2008, 2(1):4-17.
25. Ghozzi M, Marx F, Dohler M, Palicot J: Cyclostatilonarilty-based test for detection of vacant frequency bands, in. Proc 2nd Int Conf on Cognitive Radio Oriented Wireless Netw and Commun 2006.

26. Sutton PD, Nolan KE, Doyle LE: Cyclostationary signature in practial cognitive radio applications. IEEE J Sel Areas Commun 2008, 26: 13-24.