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Firefly Routing Based Cognitive Radio Network Optimization

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Abstract— Low cost communication is offer by Cognitive radio network and this directly increases the spectrum utilization. Channel sensing and data packet routing among radio network have small time gap to complete communication. This paper has proposed a data routing algorithm for cognitive radio network. Firefly genetic algorithm finds the route between source to destination in dynamic node available network. Out of various possible paths between route one optimal may be best path find by the algorithm. Experimental work perform on MATLAB environment having different number of nodes and position in variable region size. Result shows that proposed work has improved the spectrum utilization by optimizing data routing path.

Keywords— Cognitive radio netwotk, Data Routing protocols, Network Resource Utilization, Spectrum Sensing.

I. Introduction

The rapid expansion of wireless devices has enabled the extensive use of various real-time applications. Some of these applications serve classified information for the military, while others serve the civil defense, fire systems, healthcare, home appliances, and e-commerce transactions. Several applications serve multimedia communications such as video conferencing, Internet telephony, and chatting, while others serve online gaming and entertainment communications [1, 2]. Some of these applications have delay and energy constraints due to the urgency of the carried information and the energy-limited devices used. Users of such applications often seek to avoid service disruption and depletion of their device battery while – at the same time – assuring immediate information transfer at a high delivery rate.

The overwhelming amount of spectrum bands statistically dedicated to primary (licensed) services, which are partially utilized with an average that varies from 15% to 85% [3,]. Cognitive Radio (CR) technology has been introduced to solve the problems of spectrum underutilization and spectrum scarcity caused by improper spectrum management policies. In Cognitive Radio Ad Hoc Networks (CRAHNs), which operate without centralized infrastructure support, data routing encounters various challenges including frequent topology changes, heterogeneous spectrum availability, and intermittent connectivity caused by the activities of Primary Users (PUs) [4].

Routing is the key component of any wireless network which allows to communicate among nodes by finding the optimal routing from source node to destination node. . Several challenging issues present in the development of routing for cognitive radio network. The dynamic channel availability causes variations in PU0s activities resulting in variation of white space, another challenge is raised due to the multiple heterogeneous channels where appropriate channel selection is a crucial task [5]. The dynamic nature of channel availability is a challenging task because dynamic nature of channel degrades the common control information exchange which affects the routing. Similarly, heterogeneous channels and dynamic channel availability results in the frequent channel switching which affects the SU0s performance. Due to these issues development of efficient routing protocol for CRNs becomes a tedious task. On the other hand, several techniques have been introduced to analyze and provide the solution for the efficient resource allocation to serve the increasing demand of users through the fixed spectrum range.

This paper was detailed into few section, in second section paper detailed various authors work proposed for data routing in cognitive radio network. Third section brief proposed FFRCRN (Fire Fly Routing in Cognitive Radio Network) model. To validate proposed model experimental section have comparative parameter values with existing techniques proposed in [7]. Finally whole work is conclude with summarized outcome of model and future aspect in work.

II. Related Work

Bany Salameh et. al. in [5] resolve the issue of multicast interactive media flow in multi-node CR organizations. This work proposed an insightful multicast directing convention for multi-node specially appointed CRNs that can viably uphold interactive media flow. The proposed convention comprises of path determination and channel assignment stages for the diverse multi-cast beneficiaries. It depends on the most shortest route tree that executes the normal transmission metric (ETX). The channel determination depends on the ETX, which is an element of POS (Point of success) over the various channels that relies upon the channel-quality and accessibility.

In [6] author proposed a dispute window based detailing approach with a consecutive fusion system. The proposed algorithm diminishes the reporting time and the correspondence overhead by gathering detecting results from the secondary clients with the most noteworthy quality at a combination community by using Dempster-Shafer proof hypothesis. The combination community communicates the detecting results once a global decision necessity is fulfilled. Through recreations, this work assess the proposed plot as far as level of the quantity of announcing auxiliary clients, mistake likelihood, level of revealing, and spectral proficiency.

Ren Han et. al. in [7] resolve the issue of spectrum distribution as for both spectrum use and organization throughput in the psychological radio-based IoT. On the one side, each connection in a transmission route expects to further develop the transmission execution on the appointed spectrum channel to amplify the start to finish throughput. On the opposite side, these connections share a similar spectrum channel to simultaneously send however much as could reasonably be expected to accomplish the greatest spectrum usage. To tackle the issue, this work propose a simultaneous transmission model in the organization which uncovers the limitations of shared obstruction and asset rivalry in joins simultaneous transmissions. In view of this model, this work define the spectrum assignment plan for joins as the chromosome in hereditary calculations. Then, at that point, this work apply the non-ruled arranging hereditary calculation II to settle the multi-target spectrum assignment issue.

Gaurav Verma et. a; in [8] studied a joined hard choice and delicate information combination plot which gives a shared concession among hard and delicate combination conspire by offering benefits of the two plans. This work initially figure the Minimum Mean Squared Error for all Rayleigh blurred announcing channels utilizing the preparation images. SUs having least MMSE take hard choices, while other excess SUs takes delicate choice. The FC at last chooses presence of PU dependent on the investigation of the got detecting data. This work utilized variety strategies, for example, maximal proportion joining and equivalent addition consolidating to contract the impact of blurring.

A. Ali et. al. in [9] gives a point by point audit of the cutting edge identified with the use of spectrum detecting in CR correspondences. Beginning with the fundamental standards and the principle components of join correspondences, this paper gives an order of the primary methodologies dependent on the radio boundaries. Thusly, this work audit the current spectrum detecting works applied to various classifications, for example, narrowband detecting, narrowband spectrum observing, wideband detecting, helpful detecting, commonsense execution contemplations for different strategies, and the new principles that depend on the join network model. Besides, this work present the most recent advances identified with the execution of the inheritance spectrum detecting draws near.

Nesa Sudha. M et. al. in [10] represents the origination of organizations, their essential objectives (from the very first moment to the present), the progressions it needed to suffer to get to its current structure and the advancements which are in progress and available for additional normalization. The investigation gives more significance to the particulars of the Cognitive Radio Networks, which utilizes the unique spectrum access methods, outlined for better usage of our accessible spectrum assets. The primary calculated hardships and flow research patterns are additionally examined as far as continuous execution.

Muralidharan, A et. al. in [11] proposed a versatile edge location strategy dependent on a picture binarization method. This technique progressively gauges the edge by taking the past choices and certain different boundaries, including the designated probabilities of identification and bogus caution, SNR, and the quantity of tests into account.

Lee, W et. al in [12] proposed a twofold limit method to manage vulnerability where, on the off chance that the energy of the examples is more modest than a specific edge, the band of interest is free, yet assuming the energy of tests is higher than a subsequent edge, the spectrum is involved. Albeit this twofold limit calculation diminishes the impact likelihood, its location execution isn't satisfactory for low SNR esteems, and its affectability to commotion vulnerability is exceptionally high. Moreover, its likelihood of misdetection is higher than with methods that have just a single limit.

III. Proposed Model

This work focus on cognitive network spectrum utilization by identifying the network node position and bandwidth. Nodes were cluster into best suitable path as per sender and receiver network features. This work provide genetic algorithm based solution for identifying the path, as dynamic nature of work best adopt by these kind of soft computing techniques.

Proposed Firefly Explanation

This work utilize firefly genetic algorithm [14] for optimization of spectrum. Work has developed a virtual model for the same where N number of nodes where place in a fix region of area A. As cognitive nodes are moving in nature so each node has its own battery capacity with bandwidth sensing capacity in a range. Genetic algorithm randomly generates set of node path as per source and destination. This path may have one or more number of nodes. Selection of one good path for the source and destination set is objective of the algorithm.

In other words work cluster the nodes into two group one act as path selected nodes and other act as idle nodes. This selection of nodes depends on fitness function adopt by the algorithm.

Generate Path Population

Assume some chromosome set that are the combination of different node as per link starting and ending node. So chromosome have p links where each link has some set of nodes $Ch=\{L_1, L_2, \ldots L_p\}$. All Link in chromosome should have unique set of nodes means $L_1 \cap L_2 \cap L_m$ = Null. Each link is a path for the communication as per requirement [15]. Now population is set of probable solution hence $P=\{Ch_1, Ch_2, Ch_3 \ldots Ch_p\}$.

Pp ßGenerate _path_Population(n, m)

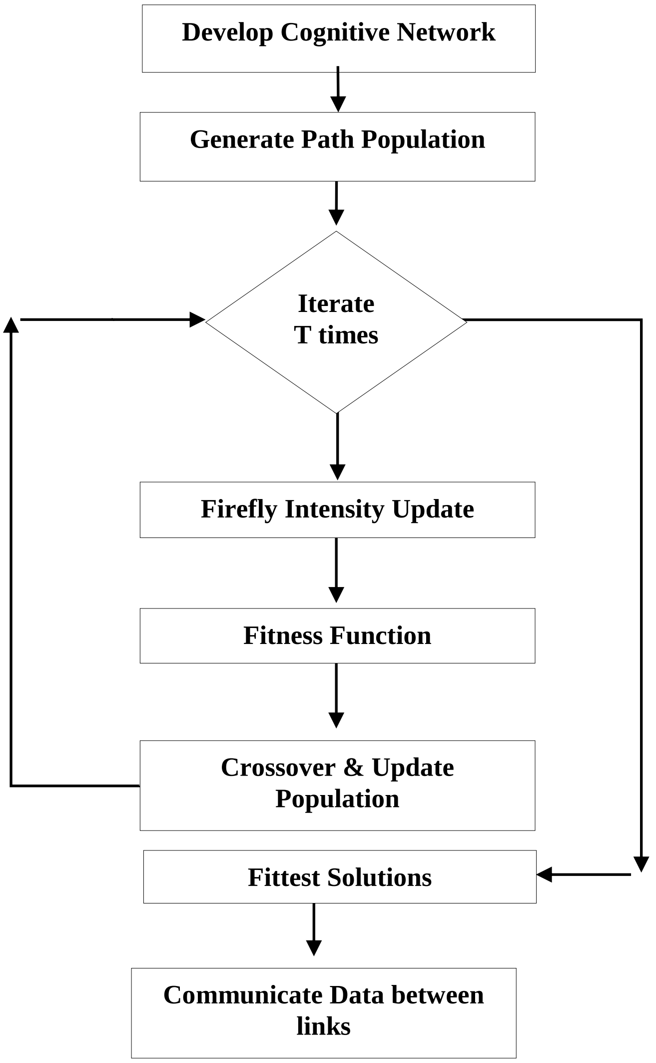

Fig. 1 Proposed firefly based spectrum optimization for cognitive networks.

Fitness Function

In concurrent transmissions, the performance of a link not only depends on its own setup but also the influence factors from other links sharing the same channel. Signal-to interference plus-noise ratio (SINR) is used to measure the

quality of communications [7]. For a link (*i*; *j*) on spectrum channel *m*, its SINR can be calculated as follows:

$$SINR_{ij}(m) = \frac{h_{ij}P_i}{\sigma^2 + \sum_{(a,b)\in I(m)} h_{aj}P_a}$$

where *pi* denotes transmission power of sender *i*. In this paper, assume that the transmission power of all links is at the fixed level. *hij* represents the channel gain between sender *i* and receiver *j*, which can be denoted by k/d_{ij}^{σ} . Here *k* is the path loss constant. *dij* is the distance between *i* and *j*. σ^2 is the path loss exponent. _2 is the thermal noise that can be considered as a constant, and sigma notation presents the aggregate interference at receiver *j*, which is generated by the links transmitting concurrently on the current spectrum channel. Here, *I* (*m*) presents the set of links sharing spectrum channel *m*. To guarantee the effective link transmission, each intended signal should be successfully decoded at the receiver. For the SINR, there exists a desired value denoted by β, which indicates the threshold of successful decoding. So, if link (*i*, *j*) intends to access spectrum channel *m* for its transmission, the constraint is satisfied as follows:

$$SINRij(m) > \beta$$

For link (*i*; *j*), the efficient link transmission opportunity *Tij* is defined as follows:

$$Tij = \min(Ti; Tj)$$

Tij evaluates the transmission opportunities on both sides of link (*i*; *j*). If the link transmits the data of _ow *f* on spectrum channel m, the maximum data rate that the link can maintain is denoted by the following:

$$Rij(m) = Tij \times Cij(m)$$

Thus, due to the constraint of the resource competition, link (*i*; *j*) only applies a portion of its link capacity for the flow transmission.

$$F_{1\_max} = \max(Rf)$$

$$F_{1\_min} = \min(Rf)$$

$$F_{2\_max} = \max(|L|/|M|)$$

$$F_{2\_min} = \min(|L|/|M|)$$

if (F1_max-F1_min)Not Equal 0

$$D = \sum_{k=1}^{2} \frac{R_n + R_{n+1}}{F_{k\_Max} - F_{k\_Min}}$$

EndIf

$$D = D + \sum_{k=1}^{2} \frac{(|L|/|M|)_n + (|L|/|M|)_{n+1}}{F_{k\_Max} - F_{k\_Min}}$$

Fitness ßSort(D)

Light Intensity of Pattern

Calculation of this was done by estimating the total presence of pattern in available dataset [15]. So as per pattern presence in dataset intensity value was set.

$$I_p = N_r \times e^{-\tau r}$$

Where I_p is intensity of N^{th} node. While τ is constant value range between 0-1 and r is random number vary from 0-1 for each pattern.

Crossover

In this work population Pp chromosome values were modified by best chromosome path. As per fitness value best path was select in the population. Best solution change other set of solutions by replacing node in the path randomly. This crossover generate other set of solution which evaluate and compared with previous fitness value to update the population in the model for next iteration.

Now check fitness value of this new solution Ccnew, let its fitness value is better as compared to previous one than this Ccnew is insert into population. In similar fashion if Ccnew fitness value is lower than previous solution exist. Hence new updated population is

In similar fashion other set of chromosomes were modified, here it is possible that modification of chromosome were done at more than one place.

Update Population

Once population get new chromosome than it need to filter with best solution sets. Hence fitness value of each were evaluate and the top p solutions from the new set are filter. Once population get update than as per iteration teacher phase again start. If iteration over than best available solution from the population is consider as final path for required links.

IV. Experiment and Results

This section presents the experimental evaluation of the proposed teacher learning based optimization algorithm for power and subcarrier allocation with MOSOGA Multi Objective Spectrum Optimization Algorithm (MOSOGA) done in [7]. The tests were performed on an 2.27 GHz Intel Core i3 machine, equipped with 4 GB of RAM, and running under Windows 7 Professional.

Results and Analysis

Table 1 Comparison of spectrum utilization.

Network Setup	Nodes x Links	Proposed Work	MOSOGA
80x80	**80x6**	**0.9992**	**0.992**
100x100	**80x6**	**0.9907**	**0.99**
120x120	**80x6**	**0.9991**	**0.9911**
120x120	**100x6**	**0.9991**	**0.9918**
120x120	**100x8**	**0.9992**	**0.9927**

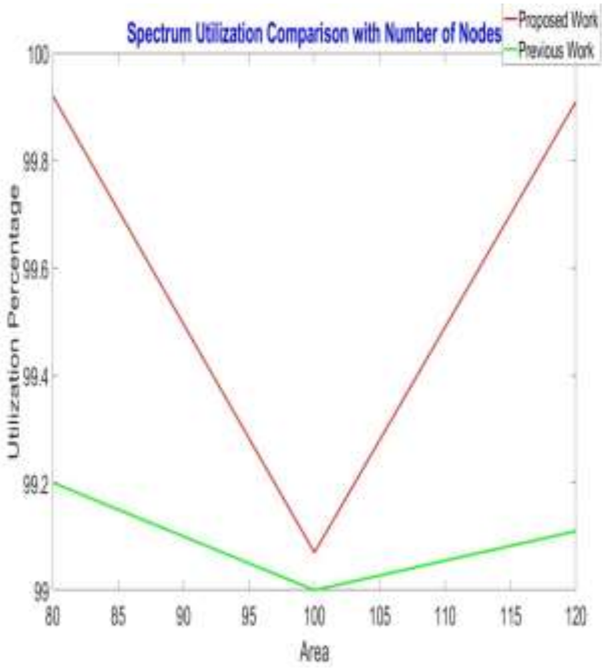

Fig. 2 Spectrum utilization based comparison.

Spectrum utilization Table 1 and fig. 2 shows that proposed firefly based path generation has improved the work performance as compared to existing model proposed in [7]. Light intensity based fitness function has increased the work performance of crossover operation.

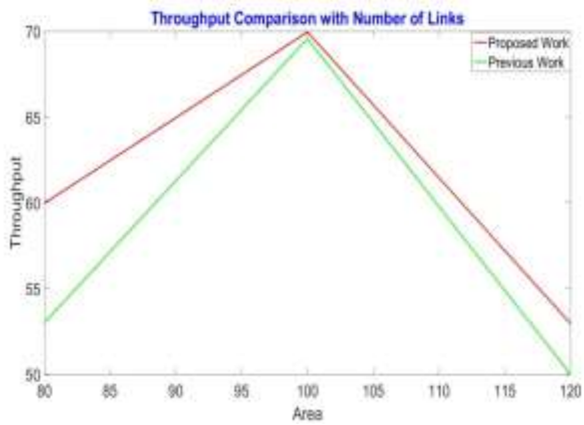

Fig. 3 Troughput based comparison of models.

Table 2 Throughput comparison of Proposed and MOSOGA.

Network Setup	Nodes x Links	Proposed Work	MOSOGA
80x80	80x6	59.9626	52.9852
100x100	80x6	69.9562	69.5705
120x120	80x6	52.9341	49.9641
120x120	100x6	46.6295	42.9938
120x120	100x8	54.9657	54.674

Throughput of the proposed models were shown in table 2 and fig. 3. It was obtained that with increase of throughput vary but this variation of proposed model is always better as compare to previous existing model in [7]. Use of genetic algorithm in dynamic environment of cognitive nodes for path selection is better as most of available bandwidth was utilize by the work.

Table 3 Execution time (Second) comparison of Proposed and MOSOGA.

Network Setup	Nodes x Links	Proposed Work	MOSOGA
80x80	80x6	110.7642	115.6783
100x100	80x6	90.4442	91.5092
120x120	80x6	119.7743	125.9101
120x120	100x6	137.0953	148.2986
120x120	100x8	120.9020	125.8203

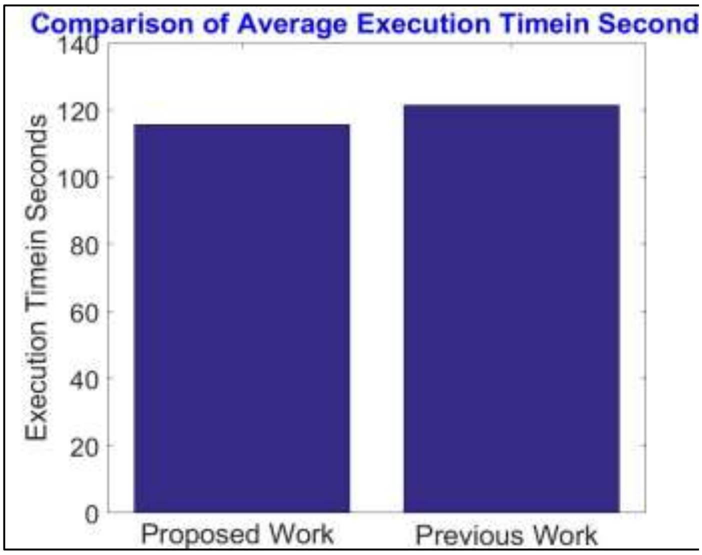

Fig. 4 Execution time based comparison.

Execution time Table 3 and fig. 4 shows that proposed firefly based path generation has improved the work performance by reducing the execution time as compared to exsiting model proposed in [7]. Light intensity based fitness function has increased the work performance of crossover operation. Use of genetic algorithm in dynamic environment of cognitive nodes for path selection is better as most of available bandwidth was utilize by the work.

V. Conclusions

Secondary channel user has very sort time to communicate as sensing a spectrum need to be done and if channel is free then only packet transfer in network. This paper has summarized various techniques adopt by the scholar, to improve the performance of cognitive radio network. Most of scholar work on spectrum sensing by cooperative spectrum sensing. While some of scholars work in direction of packet routing, as channel available for very short duration. Most of tradition routing approach were adopt but dynamic situation based work need lot of improvement. It was found that use of genetic algorithm and machine learning concept handle the dynamic nature of cognitive network for routing. In future scholars can proposed a model that can sense channel accurately and route packet for increasing the channel utilization.

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