



# Comparative Analysis of Distributive Optimized Clustering Techniques in Cognitive Radio Networks

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## Abstract

In this paper we study and compare the performance of Distributed Firefly Optimized Clustering (DFOC) with Distributed Swarm Optimized Clustering (DSOC) optimization techniques used for the dynamic clustering. Proposed Distributed Firefly Optimized Clustering (DFOC) is an optimization algorithm based on the function of attractiveness of firefly behavior. All the cognitive nodes move towards the brighter firefly with random velocity to form an organized cluster with least computation time. In the existing DSOC method each particle's best position and velocity are evaluated according to the objective function until an optimum global best position is reached. The convergence rate of DSOC is similar to Genetic Algorithm (GA). The proposed DFOC, the SU power is reduced to 7.34% for 100 numbers of SUs compared to DSOC.

**Keywords:** Distributed Swarm Optimized Clustering (DSOC), Distributed Firefly Optimized Clustering (DFOC) Primary Users(PUs), Secondary Users(SUs), Dynamic Spectrum Access(DSA)

## 1. Introduction

In Distributed cooperative spectrum sensing clustering is performing the selective Cognitive Radio (CR) users cooperate to detect unused spectrum bands with non cognitive users[1][2]. Cooperative spectrum sensing schemes optimize the cooperation overhead, reporting sensing time and energy consumption[3]. Particle Swarm Optimization (PSO) in a self-organized system with interaction of cooperative distributed behavior[4]. The examples of Group behavior are ant colonies, bird flocking, bacteria molding and fish schooling etc. The optimizing nonlinear function is used to find the best solution in problem space[5]. The movement of user nodes position and velocity depends on the stochastic swarm intelligent optimization technique. The Distributed Swam Optimized Clustering (DSOC) is based on the following three simple rules.

1. Collision avoidance with neighboring nodes.
2. Match the neighboring nodes velocity direction.
3. Stay near neighboring nodes towards the center position.

Each user node move through a multi-dimensional search space to find the best position in the space. The best position could be possible to the maximum or minimum values[6]. But each cluster, checks the fitness function of cluster members and identify the pbest node. In overall nodes, which is having good fitness function is selected as gbest node. Path is selected based on pbest and gbest nodes. The pbest and gbest node selection is dynamic every time as they are generating fitness function at every time[7]. Future wide band spectrum clustering selection is performing the capability of time varying sparsity level to reconstruct spectral estimation[8]. Several open research issues for implementing spectrum sensing clustering

techniques[9]. In the existing DSOC is initialize the each user node with 'K' randomly selected cluster centroids and calculate the distance of each data item from centroid and assign to a cluster[10]. Then the cluster centroid of a particle is updated based on the velocity and position equation and repeated until maximum number of iteration is reached[11]. It tends to incorporate the small categorizes into larger clusters[12]. More optimal solution is considered by the fitness function. A DSOC system combines local search methods with global search methods, attempting to balance exploration and exploitation. A population of user node is uniformly distributed along with their position, velocity in search space[13]. The proposed DFOC performs current space along with self-improving process from previous stages. DFOC sometimes locally searched as well as not able to complete processing stages of them. DFOC can deal with multi-modal optimization problems naturally and very efficiently[14]. The proposed DFOC can't be parallized as all the portions of firefly is determined by the next movement of a firefly. Every firefly is dependent on the current positions. The DFOC is does not require a good initial solution to start its iteration process. It has the high flexibility of integration with other optimization techniques to form hybrid tools[15].

## 2. Proposed Methodology

The proposed Distributed Firefly Optimized Clustering (DFOC) method is used to perform current space along self-improving process from previous stages. Brightness has direct proportionality with attractiveness and considers two fireflies; one of them with less brightness which will be attracted to the greater brightness. If no brighter firefly is found than the given one, the motion will be

random. The objective function has associated with brighter. The light intensity is inversely proportional to the squared distance and directly proportional to the source intensity brightness. After that Fireflies are ranked and obtain the current best cost function. The Base Station (BS) is recognized set of optimal Cluster Heads (CHs) and corresponding to cluster members. The BS transmits CH-ID information to each nodes in the network. Clustering using firefly technique can be categorized into two types: hierarchical and partitioned clustering. Hierarchical approach is the large number of hierarchy cluster into small number of cluster with nearby centroid. It has two methods: (i) the agglomerative method, two or more smaller clusters merged into a large cluster; (ii) the divisive method, divides a longer cluster into two or more smaller clusters. The partitioned clustering tries to divide a set of disjoint clusters from the data set without forming hierarchical structure. The prototype based partitioned clustering is creating cluster centers and advance classify into the data set.

**2.1. Proposed Distributed Firefly Optimized Clustering (DSFOC) Algorithm**

The distributed sensor network involves ‘K’ predetermined number of clusters and ‘N’ number of user nodes practice as follows in figure1:

- Generate the initial population of fireflies in the solution space. Select ‘K’ random selection of CHs from available best cluster head candidates with set of ‘S’ elements.
  - (ii) Evaluation of each user node cost function.
    - a. Calculate the distance (d) between all CHs position and every user node point position from ‘N’ number of node selection.
    - b. Minimum distance selection between CHs and every user node point position .
    - d ( ) = min { d( ) } for k=1,2,...,K
- The BS follows the fitness function of f<sub>1</sub> and f<sub>2</sub>. From the fitness function, selects the minimum cost function and with best CHs.

$$\text{cost} = f_1 \times \beta + f_2 \times (1 - \beta) \tag{1}$$

$$f_1 = \max_{k=1,2,\dots,K} \left\{ \sum_{\forall n_i \in C_{p,k}} d(n_i, CH_{p,k}) / |C_{p,k}| \right\} \tag{2}$$

$$f_2 = \frac{\sum_{i=1}^N E(n_i)}{\sum_{k=1}^K E(CH_{p,k})} \tag{3}$$

(2) Where β is the user-defined constant. Let β=0.5, f<sub>1</sub> is the user nodes associated CHs with maximum average distance and function f<sub>2</sub> is average node energy. n<sub>i</sub> is the cluster particle p.

(iii) In each cluster, checks the fitness function of each user nodes and identify the light intensity associated with fireflies. All the remaining nodes move towards the brighter firefly with random velocity to form an organized cluster.

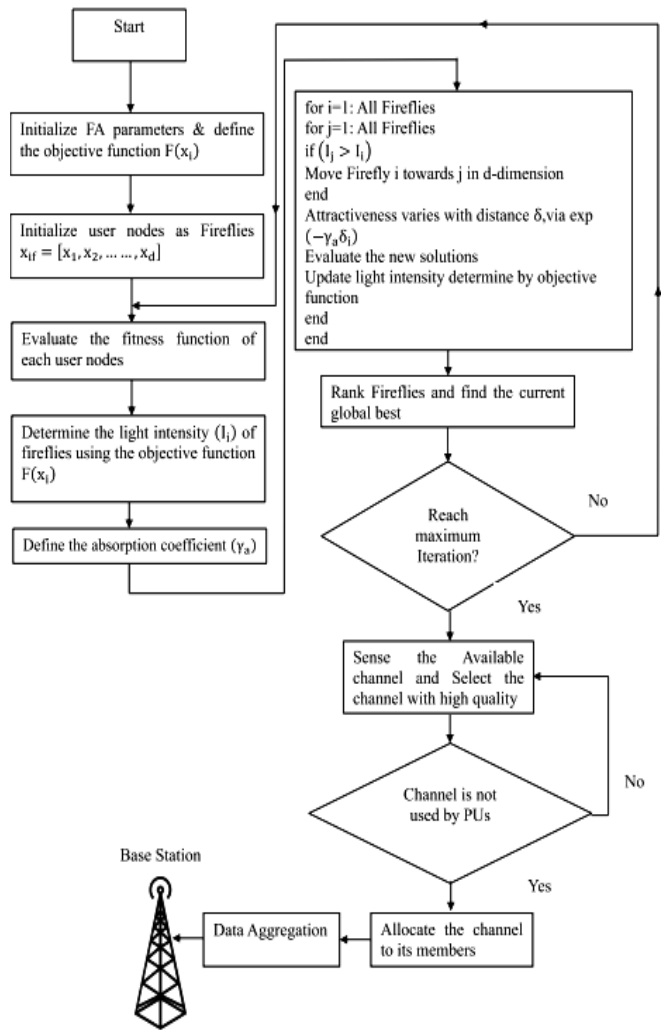


Fig. 1: Flowchart of the DFOC

- (iv) Update the position and light intensity of fireflies from the distance, attractiveness of each firefly with other fireflies for next iteration.
- (v) Rank the fireflies and find the current global best.
- (vi) Go to step iii, and repeat until reached maximum number of swarm iterations for optimization.
- (vii) The selected CH check availability of channel in its location.
- (viii) Choose the channel selection with best suitable condition that the chosen channel should not be nominated by the neighboring PUs.
- (ix) All the cluster members send the collection of data information to CH through the available common channel location. The CH sends the overall collected information to the base station.

**3. Results and Discussion**

The performance evaluation of DFOC with NS2 simulation[16] for CR networks shown in the figure2 with 1 common receiver node, 10 primary and 90 secondary user nodes. The time of simulation is 131.0 sec and constant packet size was 512 bytes. That was considered arbitrarily placed in a 1000 x 1000 meter field by various coloured selection in the Nam window like hot pink, cyan, yellow green, sky blue, yellow, maroon, deep sink, blue, violet red. Each SUs are represented by C0 to C9 and PUs are represented by 0 to 9. Each PUs select any one of 10 common available channels and 20 meters protection range which is remaining CRSN neighbors cannot

occupied the channel selection. Each clustering result illuminate by dash enclosed space. DFOC offering less control overhead and more stability when PUs position altered or SUs dynamic activity.

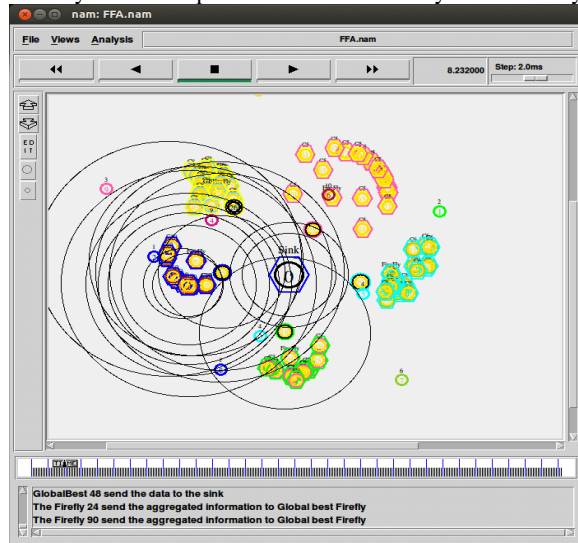


Fig. 2: Channel selection for PUs and SUs.

Figure3 shows the performance evaluation between average node power and cluster number. The graph specifies the different cluster number with power observation. At the cluster number 2, the power is varied for 6506.954W in the existing DSOC method. But in the proposed DFOC is reduced power for 5142.954W which is 20.96% reduced the existing DSOC. As the average node power is reduced when number of cluster is increased. Proposed DFOC of average node power is 21.57% reduced the existing DSOC at cluster number 28. This indicated there is a proposed DFOC power saving of 23.560% compared existing DSOC.

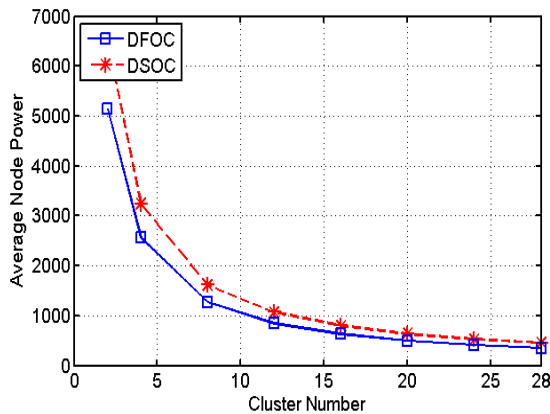


Fig. 3: Cluster number Vs Average Node Power.

Figure4 shows the performance evaluation between average node power and PU index number. As the average node power increased linearly when number of primary users increased. From the primary users 1 to 5, the power is remained constant at 759W in the existing DSOC method. Similarly the power is at 753W for the proposed DFOC, which is 0.79% reduced the existing DSOC method. Then power is linearly increased from 766 to 794W when the PUs 6 to 10 in the existing DSOC. The proposed DFOC power is reduced 0.91% to that of 1.008% for the 6 to 10 PUs and the power is reduced from 759 to 786W than existing DSOC method. This indicates there is a proposed DFOC power saving of 1.005% compared existing DSOC.

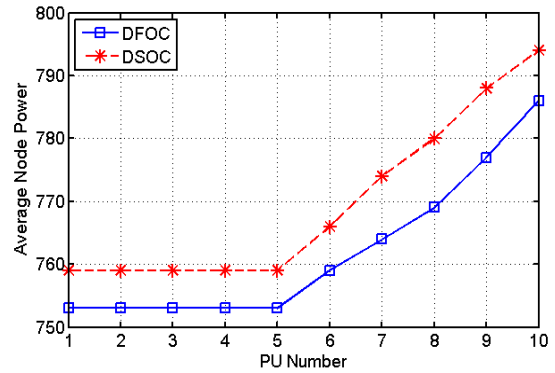


Fig. 4: PU index Number Vs Average Node Power.

Figure5 shows the performance evaluation between average node power and SU index number. As the average node power increased linearly when number of secondary users increased. From the primary users 11 to 15, the power is remained constant in the existing DSOC method. Similarly the power is remained constant for the proposed DFOC, which is 0.79% reduced the existing DSOC method. Then power is linearly increased from 772 to 1829W when the SUs 16 to 100 in the existing DSOC. The proposed DFOC power is reduced 0.77% to that of 10.22% for the 16 to 100 SUs and the power is reduced from 766 to 1642W than existing DSOC method. This indicates there is a proposed DFOC power saving of 7.342% compared existing DSOC.

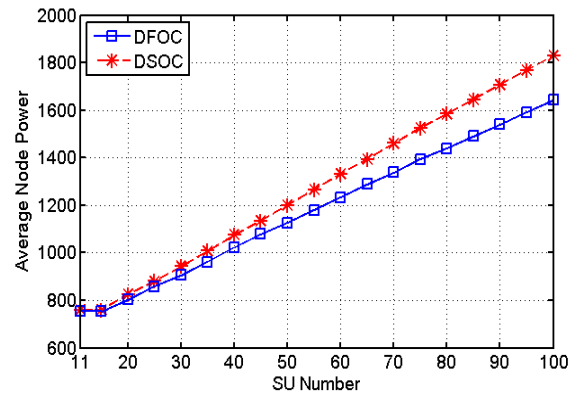


Fig. 5: SU index Number Vs Average Node Power.

## 4. Conclusion

The power saving of proposed DFOC is optimum as cluster number increased the power is decreased as shown in fig.4. . The DFOC performance shows perfect channel detection along with primary users and secondary users in the white space without harmful interference and faster converged group cluster. Moreover the other optimization technique, the DFOC is used to move the random velocity of high attractiveness firefly with least computation time.

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