Cognitive Radio Engine Design using PSO and Firefly Algorithm

Himanshu Sharma[1], Anuj Kumar Goel[2], Ankur Singhal[3], Nemish Dikkala[4]

[1]*Associate Professor, ECE Department, J. B. Institute of Engineering and Technology, Hyderabad, India*

[2]*Professor, ECE Department, University Institute of Engineering, Chandigarh University, Punjab, India*

[3]*Professor, Department of ECE, Chandigarh Engineering College, Landran, India.*

[4]*Student, Department of ECE, J B Institute of Engineering and Technology, Hyderabad, India*

Email: himanshu.zte@gmail.com[1], anuj40b@gmail.com[2], asking2k@gmail.com[3], nemishscience@gmail.com[4]

Abstract – The cognitive radio is the basic cell that makes up the cognitive radio networks. The CRN and its multiple architectures and applications have received extensive attention in the literature. However, a look at the previous work on CR reveals that, in the field of cognitive radio, little is published about the complexities and specificities of the development of its core, the Cognitive Radio Engine (CRE). For proposed Cognitive Radio Engine, this paper discusses two metaheuristics that are Particle Swarm Optimization (PSO) and Firefly Algorithm (FFA) as approximate methods for the optimization of fitness function. For establishing evaluation of performance of CRE according to various criteria's that have been set, like Bit Error Rate (BER), Channel attenuation and Output Power.

Key words – CR, CRE, BER, DSA, FCC, FFA, PDA, PSO, SDR, CE.

1. INTRODUCTION

The increasing communications services and the heterogeneity of the networks have generated the formation of network architectures that respond to this diversity of technologies such as Personal Digital Assistant (PDA), laptops and smartphones that are being designed to make use of wireless standards and take advantage of the services offered by this technology, as in the case of 3G technology, which offers data and voice transmission, and additionally allows video calls to be made.

Cognitive Radio Engine Framework using two metaheuristic approaches; Particle Swarm optimization and Firefly Algorithm has been discussed. Second section presents the theoretical terms related to cognitive radio network. Section three describes the methodology regarding CR engine design implementation. Results are given in fourth section followed by the conclusion in fifth section.

2. COGNITIVE RADIO ENGINE

2.1. Cognitive Radio Engine Architecture

The Cognitive Engine CE of the Cognitive Radio CR consists basically of a programmer block, a core, detection interfaces, user and network (Figure 2.1). In turn, the core consists of a database and blocks of learning, reasoning and optimization.

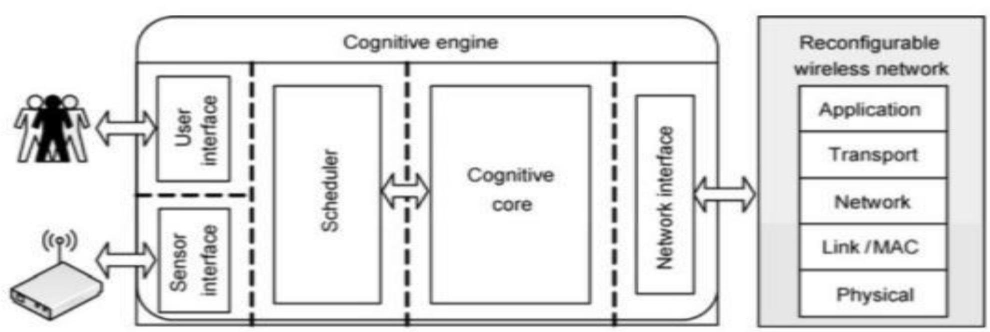

Figure 2.1: Basic block diagram of a CE [12]

3. METHODOLOGY

For its operation, a Cognitive Engine uses metaheuristics**,** so a comparative study between two metaheuristics that are Cuckoo search and Firefly has been done and an exact method called parallel dynamic programming. The main goal is to further develop spectrum management in the CRN framework. So, comparative study has been presented.

3.1. Objective Function (Fitness Function)

This function is to find the optimum result to a combinatorial optimization issue. In this case, to maximise cost is the utility of this function."

Following are the Parameters:

- n: SU numbers.
- m: free channels numbers possessed by PU.
- W: an array of size n. $W[i]$ is the channels numbers requested by SUi.
- C: a size chart n.
- Optimized function is: Max $\sum_{i=0}^{n-1} C[i]$
- The constraint to be respected is: $\sum_{i=0}^{n-1} W[i] \leq m$.

3.2. Particle Swarm Optimization

The PSO depends on a bunch of individuals initially arbitrarily and homogeneously organized, which we call particles from this point forward, which move in the research hyper-space and comprise, every one, a likely arrangement. Every molecule has a memory of its best arrangement visited and the capacity to speak with the particles that encompass it. From this data, the molecule will follow an inclination made, from one perspective, of its will to return towards its ideal arrangement, and then again, of its mimicry contrasted with the arrangements found in its area.

From nearby and observational optima, the arrangement of particles will ordinarily unite to the ideal in general arrangement of the issue being tended to.

Particle swarm is portrayed by [10]:

- The quantity of particles of the swarm is nb.
- The greatest velocity of a particle is $\vec{v}_{max}$.
- Particle inertia is given by Ψ.
- Confidence coefficients, given by ρ_1 and ρ_2,
- Particle is described at time t by:
- $\vec{x}_i(t)$: search space position.
- $\vec{v}_i(t)$: velocity
- $\vec{x}_{pbest_i}(t)$: the place of the best arrangement by which it has passed.
- $\vec{x}_{vbest_i}(t)$: the place of the most popular arrangement of its neighborhood.
- $pbest_i$: best solution fitness value.

3.3. Firefly Algorithm

The latest metaheuristic is Firefly Algorithm. It was created by Yang [13] [14].

Principle of Operation

Given below are the four important points in the firefly algorithm:

Intensity of Light: For simplest case for minimization problems, the luminosity of a firefly at specific location x to chosen as: $I(x)\ \alpha\ 1\ /\ f\ (x)$.

Attractiveness: The core form of this function is represented by any decreasing monotonic function like given:

$$\beta_{i,j} = \beta_0^* e^{-\gamma r_{i,j}^m} \tag{1}$$

Where the distance between two fireflies is r, β_0 at $r = 0$ is attractiveness and γ is constant coefficient for absorption of light.

Distance: The range between two fireflies i and j at x_i and x_j will be the Cartesian distance given:

$$r_{i,j} = \sqrt{\sum_{k=1}^{d} \left(x_{i,k} - x_{j,k}\right)^2} \tag{2}$$

Where $x_{i,k}$ will be the k^{th} component of i^{th} firefly.

Movement: Displacement of a firefly i attracted by more luminous firefly j, is given by:

$$x_i = \left(1 - \beta_{i,j}\right)x_i + \beta_{i,j}x_j + \alpha\left(rand - \frac{1}{2}\right) \tag{3}$$

Where the attraction refers as the first term and second term. Randomization is the third term. Random parameter is α and can be constant. "$rand$" is a random number generator distributed uniformly among [0, 1].

4. RESULTS OF SIMULATION

Graphs beneath address the results obtained:

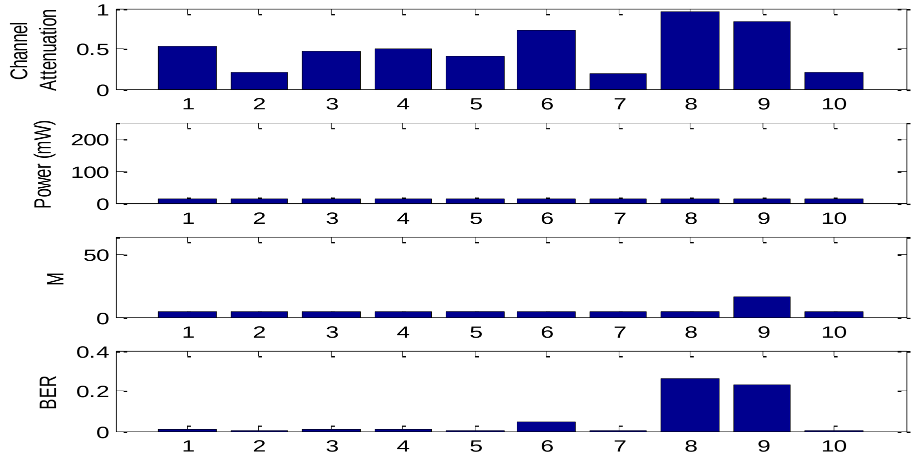

Figure 4.1. Result of low power mode using firefly algorithm

Figure 4.1 shows output of BER, modulation type, power, and channel attenuation for low power mode using firefly algorithm. It is found that the power consumption is minimized in low power mode while the BER is slightly high.

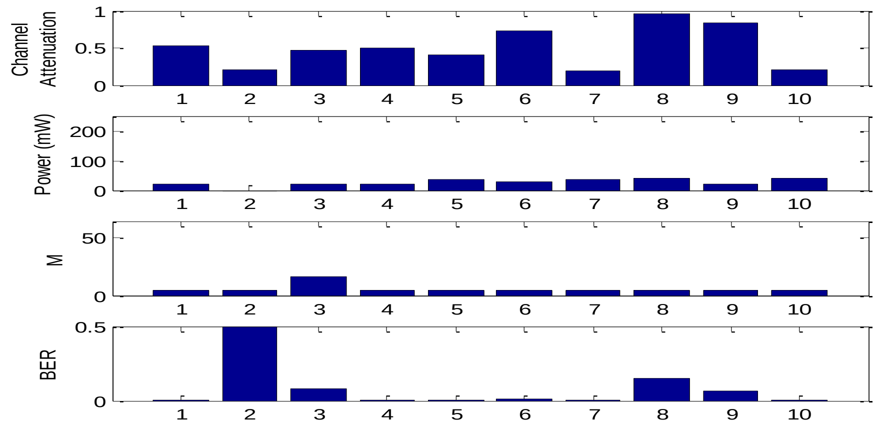

Figure 4.2. Result of emergency mode using firefly algorithm

Figure 4.2 shows output of BER, modulation type, power, and channel attenuation for emergency mode using firefly algorithm. This mode should minimize the BER for each channel. It was noticed that each channel BER was very low driven by the CE offered by the higher attenuation on each channel.

Figure 4.3 shows output of BER, modulation type, power, and channel attenuation for multimedia mode using firefly algorithm. It is under multimedia mode, therefore it is observed that the throughput is maximized at the cost of large power transmitted by proposed cognitive engine.

Figure 4.4 shows output of BER, modulation type, power, and channel attenuation for balanced mode using firefly algorithm. In balanced mode, weights of the three performance evaluation metrics are the same while BER and transmit power are relatively more.

Figure 4.5 shows a comparative analysis of BER, modulation type, power, and channel attenuation between PSO and firefly algorithm for low power mode. The power consumption is minimized while the BER is slightly high during low power mode. Here the firefly algorithm outperforms the PSO algorithm.

Figure 4.6 shows a comparative analysis of BER, modulation type, power, and channel attenuation between PSO and firefly algorithm for emergency mode. This mode should minimize the BER for each channel. It was noticed that for the firefly algorithm, the each channel BER was very low driven by the CE offered by the higher attenuation on each channel.

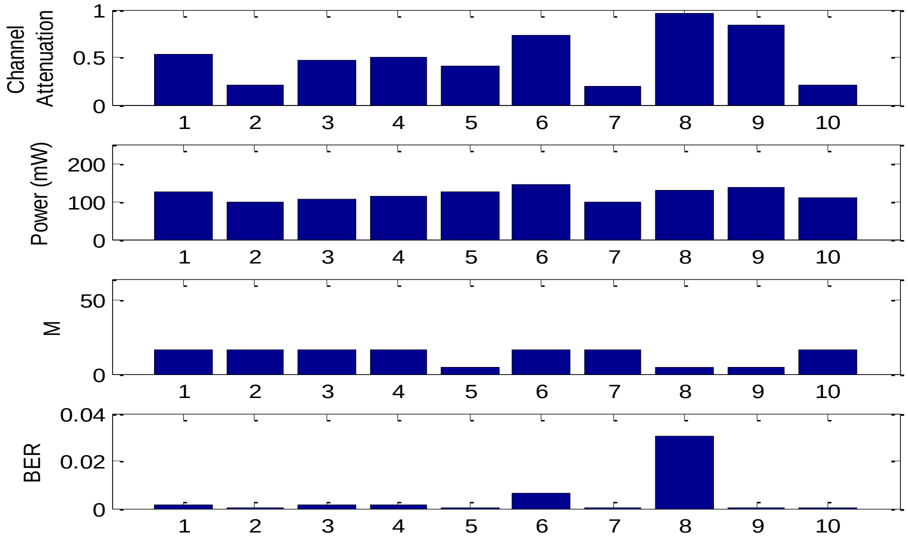

Figure 4.3. Result of multimedia mode using firefly algorithm

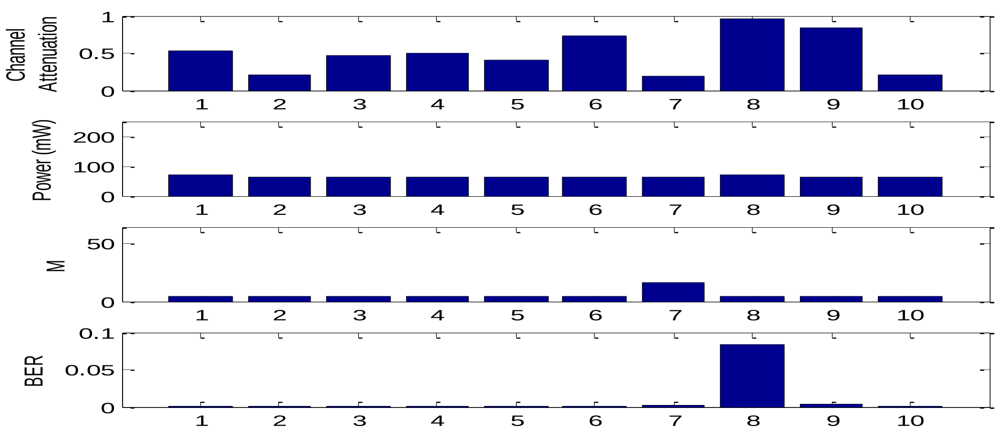

Figure 4.4. Result of balanced mode using firefly algorithm

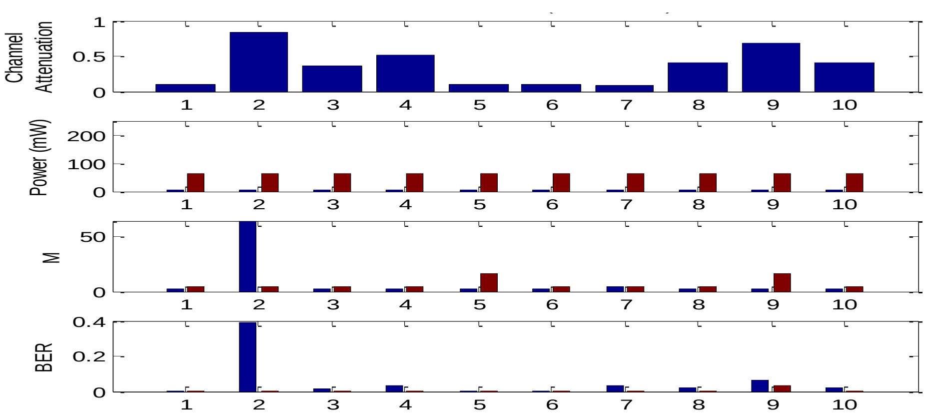

Figure 4.5. Comparative result of PSO and firefly algorithm in low power mode

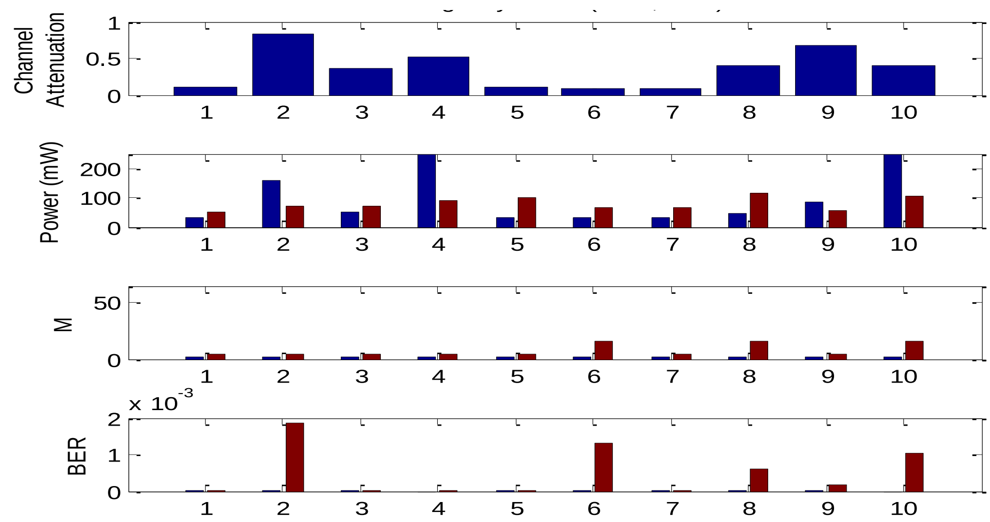

Figure 4.6. Comparative result of PSO and firefly algorithm in emergency mode

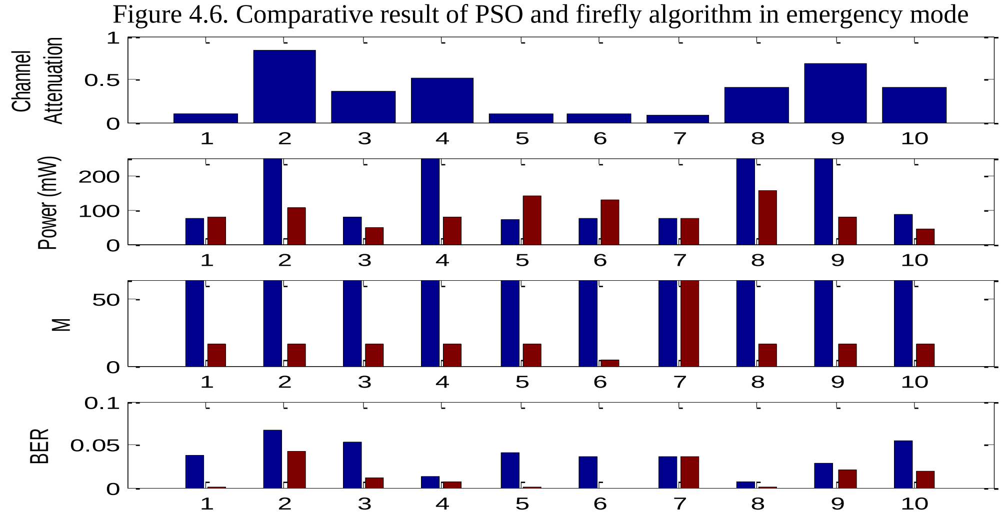

Figure 4.7. Comparative result of PSO and firefly algorithm in multimedia mode

Figure 4.7 shows a comparative analysis of BER, modulation type, power, and channel attenuation between PSO and firefly algorithm for multimedia mode. It is under multimedia mode, therefore it is observed that the throughput is maximized at the cost of large power transmitted by firefly algorithm based cognitive engine. Therefore, the firefly algorithm outperforms the PSO based approach.

5. CONCLUSION

Cognitive Radio is significant methodology which take care of access clashes and saturation of spectrum issues. The trades made in a range access arrangement among primary clients and secondary clients are seen as a sensitive activity and furthermore as conjugative optimization problem. Therefore in this review, we concentrated on a result that will nevertheless provides good pursuance to this negotiation, our work is based on metaheuristics that presents quick results. Two metaheuristic PSO and firefly algorithms that represent the optimization methods are presented. Simulation results clearly shows that the firefly algorithm provides better results as compared to PSO optimization.

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Biography

Himanshu Sharma received his B.Tech in ECE from Kurukshetra University, Kurukshetra, M.E in ECE from Thapar Institute of Engineering and Technology, Patiala, Punjab and Ph.D. from Maharishi Markandeshwar (Deemed to be University), Mullana. He has more than 12 years of teaching experience. Currently he is serving as Associate Professor in Department of ECE at J. B. Institute of Engineering & Technology, Hyderabad. He has published more than 45 research papers in various reputed conferences and journals and supervised more than 20 M.Tech. Thesis. His area of research is Wireless Communication and Networks and currently he is working on Security mechanisms for Cognitive Radio Networks.