Snake Optimization Technique for Spectrum Handoff in Cluster based Cognitive Radio Network

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Abstract

In Cognitive Radio (CR) networks, the use of Secondary Users (SU) in the spectrum has an undesirable effect on spectrum handoff, which causes a handoff delay. The handoff procedure can result in service outages and considerable transmission quality delays, making it a regular source of concern for the SU. An effective spectrum handoff strategy that utilizes the Spectrum Binary Snake Optimization (SBSO) algorithm and the M/G/1 queuing model has been proposed in this study. The use of Cluster Based Cooperative Spectrum Sensing improves SU performance and reduces channel congestion. In order to report the active and inactive channels in the spectrum, the cluster head is connected to the SU base station, and a decision report is subsequently generated by the fusion center. With the use of a bitwise and mutation operator format, SBSO reduces the overall service time required for handoff in the approach that is being proposed. The proposed methodology also provides a framework for observing how primary user activity and spectrum handoff delays behave in the presence of potential interruptions in a CR network. The simulation model of the proposed work optimizes the packet delivery ratio with the three benchmark functions, and provides optimal handoff, and is compared to SBSO and other models that offer a better trade off over delay achievement.

Keywords: Cognitive Radio network, Spectrum Binary Snake Optimization (SBSO), M/G/1 queuing model, Secondary user, Handoff delay

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1. Introduction

The need for spectrum bandwidth has surged recently due to the development of wireless networking technology. The secondary user must purchase the energy from either the nearby main user or the RF energy source in order to finish the transfer without any intervention [1]. To ensure a seamless transmission, the Secondary User (SU) regularly seeks for open channels and waits for the licenced user to arrive [2]. In order to efficiently increase the spectrum bandwidth, the SU monitors the behaviour of the Primary User (PU) [3]. The SU is chosen using reinforcement learning and resource sensing techniques [4]. The intelligent network learns the environment's behaviours through the act ofcognitive radio progressed by 135tilizatio information and choice [5].

A wireless communication network called a Cognitive Radio Network (CRN) has communication nodes or devices that have Cognitive Radio (CR) capabilities. A technique known as cognitive radio enables wireless devices to automatically and dynamically perceive and adapt to their working environment, including changes in the spectrum 135tilization and interference situations, and update their operational settings as necessary. [6]

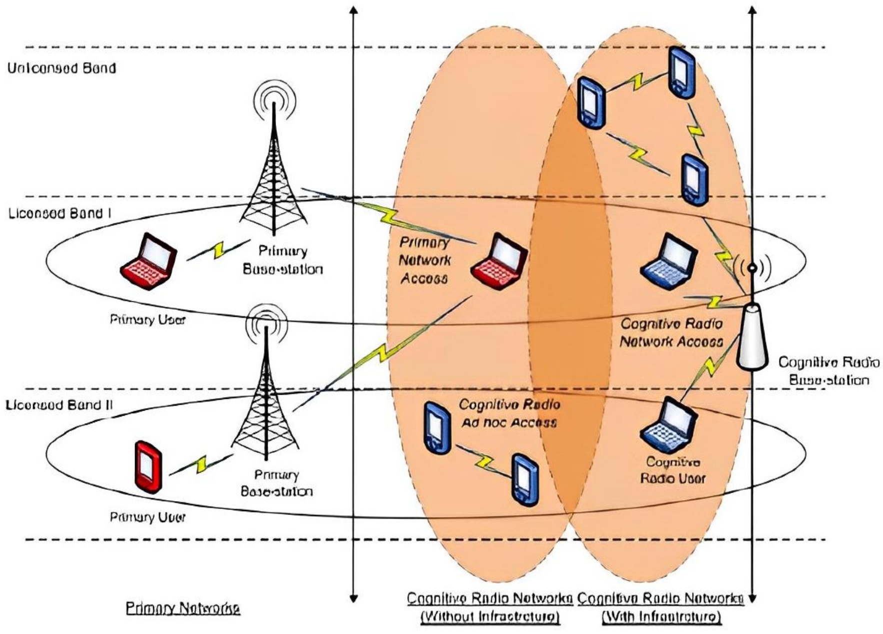

Figure 1. Cognitive Radio Network Architecture [8]

The study strives to improve the SU transmission in order to enhance the Quality of Service (QoS) and to reduce a handoff delay and energy consumption by applying optimization.

2. Related Works

P. V. Naveen Kumar et al., (2020) simulated the likelihood maintenance as well as failure of link while taking into account the threshold time for waiting for a CU. When compared to a negotiated situation, the proposed approach gives a better likelihood of connection maintenance in opportunistic circumstances.

A. Shakeel et al., (2020) used a shared control channel allowing secondary users to meet on the channel taking into account the time delay of the handoff in the network. The outcomes were obtained using a preemptive resume priority M/M/1 queuing network, taking into account a range of secondary users, their typical arrival times, and the service times themselves.

M. Kalpana Devi and K. Umamaheswari (2021) suggested that a preferred SU is chosen from among the groups of various numbers of Sus that have been grouped in order to broadcast the information in the cluster head. FC collects data from the cluster head and uses it to make the right choice. In SpecBPSO, the mutation operation was used to discover the best optimum and global channel, which is more comparable to BPSO. In order to shorten the overall service time, the M/G/1 queuing model was used to accomplish the spectrum handoff.

A. Divya et al., (2020) proposed that the optimum network for spectrum handoff is efficiently selected using the suggested MADM approaches. The research provided evidence that the combined performance of the suggested spectrum sensing, and handoff techniques improves the CRN.

3. Proposed Methodology

The delay in handoff of the proposed work depends on the rate of transmission from the waiting period until the restart of the transmission of SU. The handoff approach involves following two potential scenarios. First scenario: A channel in the spectrum is available for data transmission with a secondary user. In the second scenario, if the channel is already full, transmission must wait until the next channel is free.

3.1 M/G/1 Queueing Priority Network Model

The SU is typically queued up for gearbox using the M/G/1 queueing paradigm. First Come First Serve scheduling is used to fill the queue, where uninterrupted SU is also present. [7]. Even though the uninterrupted SU is in the first position, the interrupted SU is assigned a higher priority.

3.2 Snake Optimization

Numerous metaheuristic algorithms have been proposed recently in the scientific and engineering disciplines to address practical optimization issues. In this research, a brand-new snake-inspired metaheuristics algorithm i.e., Snake Optimization (SO) is suggested to handle a variety of optimization challenges that mimic snakes' unique mating behavior. If there is adequate food and the temperature is low, each snake—male and female—competes to have the best mate.

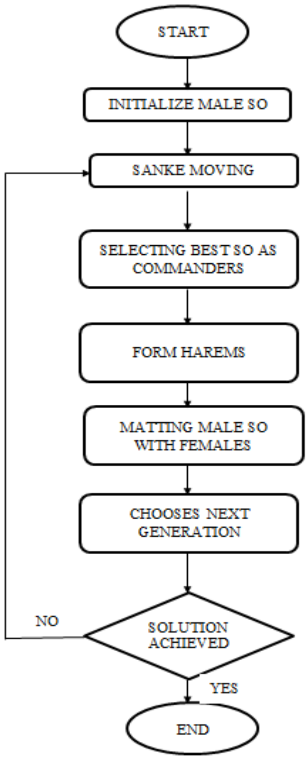

Figure 2. Workflow of Snake Optimization

The entire process is divided into five main phases:

Generate an initial snake

→ Male snakes

→ Appoint the top c% of the male SO as male commanders.

→ Fight between stags and male commanders.

→ Establish harems.

→ The commander mating with the closest hind in his harem.

3.3 Overall Architecture

The secondary users are framed as clusters with a cluster head. The active primary users as sensed by the cluster head; new cluster with cluster head are formed when the existing clusters are full. The FC in charge of monitoring the idle channels gathers all the reports from the cluster heads. The Spectrum Binary Snake Optimization (SBSO) put forth identifies the optimal channel and stores in queue using the queuing algorithm as well as the secondary user handoff is improved in the primary user arrival. Finally, an appropriate channel for completing the incomplete transmission of SU is selected from the queue.

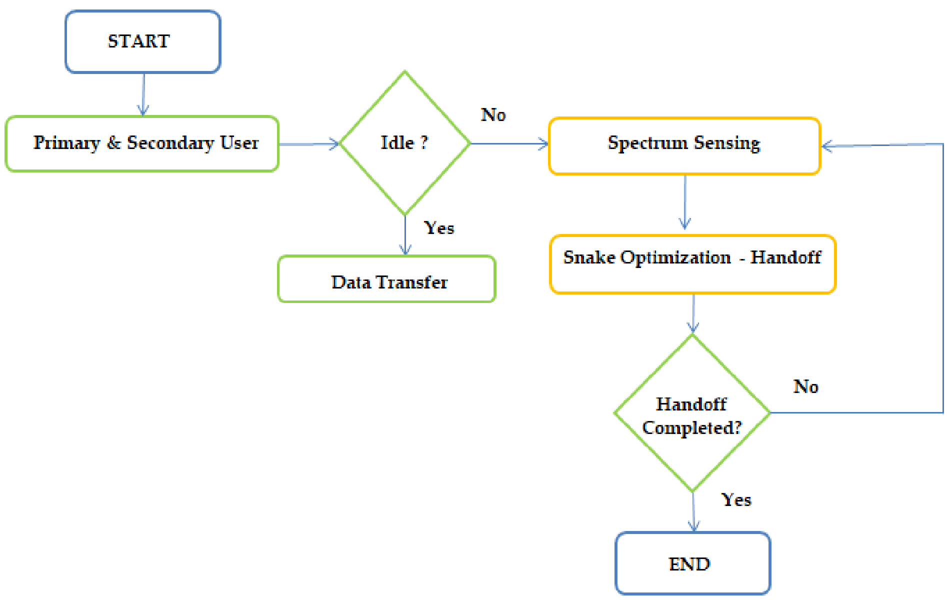

Figure 3. Block Diagram of the Proposed System

Table 3.3.1. Parameter Setup

Parameter Description	**Assigned Value**
Population Size P	100
Maximum inertia weight factor ωmx	0.9
Minimum interia weight factor ωmn	0.4
Accelaration factor/learning factor c1,c2	2.0
Random values rand1 and rand2	0.5
No of Iteration	500
No of secondary users	10 ~40
No of Primary users	4 ~12
Probability of False alarm probfa	0.1 to 1
Probability of detection probd	0.99
Power transmission Ptran	3 W
Signal to Noise Ratio SNR	15 dB
Reporting Time Trep	1 ms
Sensing Time Tsen	10 ms
Sensing Power Psen	0.1 W
Transmission Gain Gtran	45 dB
Probability of presence and absence of PU signal	0.5

Table 3.3.2. Hyper Parameter Values

Hyper-Parameter	Values
Packet Size of PU	12 KB
Packet Size of SU	10 KB
Cluster Size	20
Bandwidth of PU	2 MHz
Bandwidth of SU	2 MHz
Data rate of PU	1 MBPS
Datarate of SU	1 MBPS
Spectrum handoff delay	4 ms

4. Results and Discussion

4.1 Tools Used

- ✓ Operating System: Red Hat Linux 9
- ✓ Tools required: Network Simulator 2
- ✓ Packages: ns-all in one
- ✓ Languages used: TCL, C++

4.2 Simulation Results

Step 1: Initially create 100 nodes and select the cluster head to test the handoff process in a network.

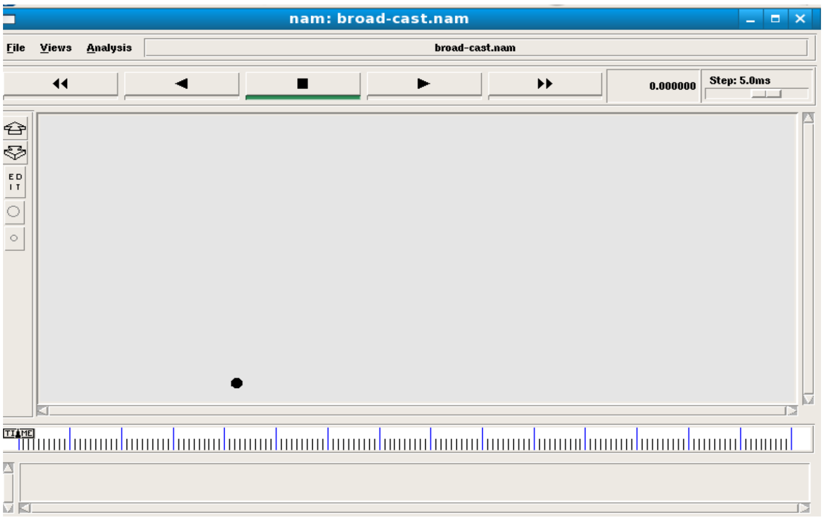

Figure 4.1. Node Creation

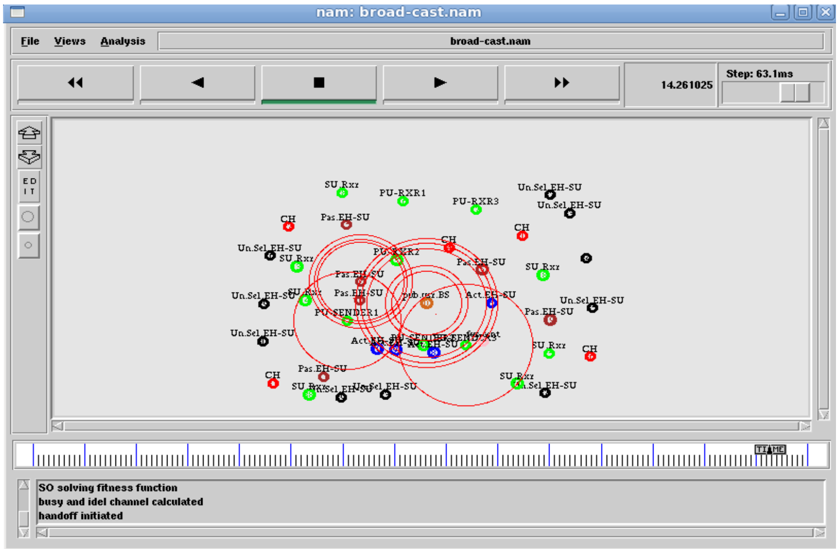

Figure 4.2. Cluster Head Selection

Step 2: Transfer the data between nodes. Network uses Snake Optimization algorithm and evaluates the fitness function for better handoff process.

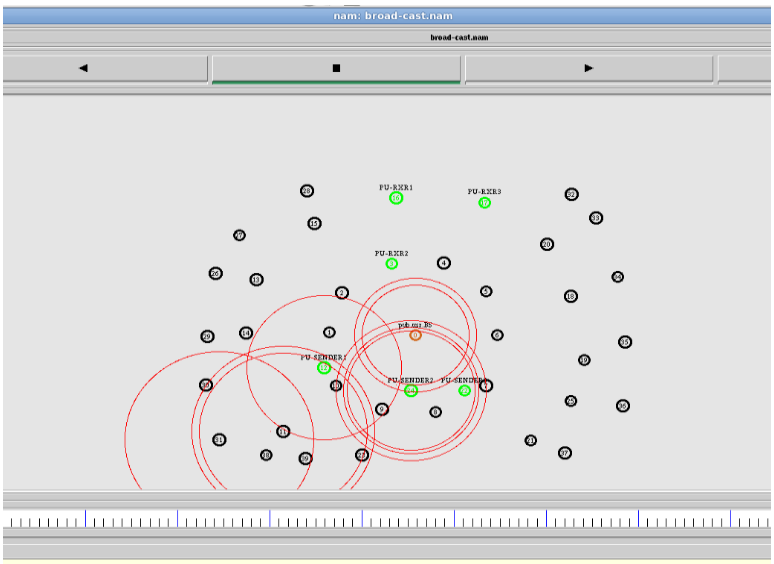

Figure 4.3. Data Transferring

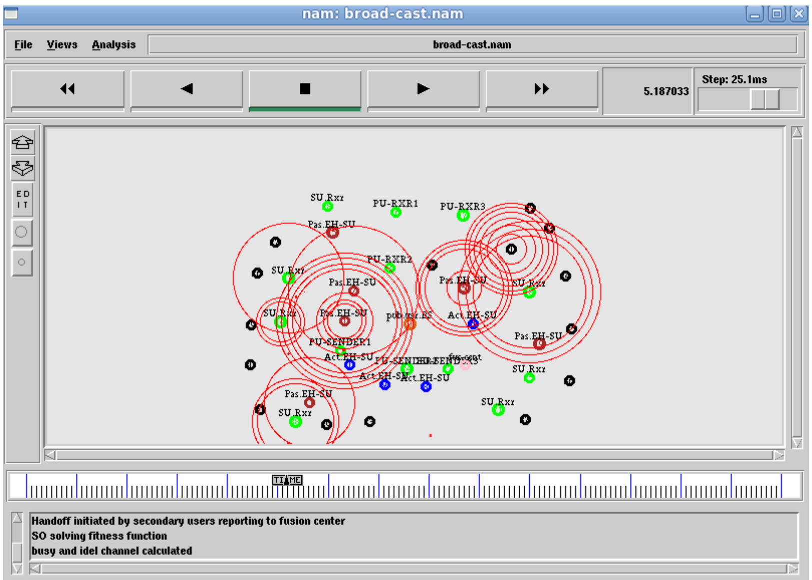

Figure 4.4. Fitness Evaluation

4.3 Comparison of Proposed and Existing Method

The simulation is done by creating 100 nodes and transferring the data through the network by selecting the cluster head. Delay in Carrier-to-Noise Ratio (CNR) refers to the time lag between the transmission of a signal and its reception, specifically in the context of the CNR measurement. Energy consumption in CNR refers to the amount of power consumed by a telecommunication system to maintain a specified CNR level. In telecommunication systems, CNR is a critical factor that determines the quality of the received signal, and maintaining a

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high CNR level is essential for reliable communication. The below tables show the comparison of existing and proposed method where the handover is 10 times faster than existing methodology. Consumption of energy & delay is less which shows that the Snake Optimization outperforms all the other conventional methodologies.

Table 4.3.1. Comparison of Completion % Analysis

Classify	Proposed	Existing
1	70	60
2	69	59
3	73	62
4	70	63

Table 4.3.2. Comparison of Handoff Delay Analysis

PU Arrival Rate	Proposed	Existing
1	40	50
2	40	55
3	45	60
4	50	60

Table 4.3.3. Comparison of Delay Analysis

No of Nodes	Proposed	Existing
20	0.68	0.98
40	1	1.6
60	1.5	2.5

Table 4.3.4. Comparison of EnergyConsumption Analysis

No of Nodes	Proposed	Existing
20	92	98
40	85	90
60	75	85

5. Conclusion

In this study, a queuing model and SBSO are used to choose the optimum channel for the secondary user. When compared to the channel allocation for SU from the queue during handovers, the suggested approach has shown better throughput. When the need for SU is great, cluster -based CSS with an OR rule overcomes the longer response time and the reporting issue. As a result, the interrupted SU efficiently uses the detected channel during the spectrum handoff.

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