Simulation of Firefly Algorithm-Based Routing Technique for Wireless Sensor Networks

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1 Introduction

In wireless sensor network, number of independent sensor nodes is deployed in a certain manner to gather information like temperature, humidity, pollution, etc. In order to overcome the limitations of traditional monitoring technologies (e.g., those relying on wired networks), more and more real-time status monitoring systems based on wireless sensor networks (WSNs) are employed in smart grids to provide a strong service guarantee for monitoring and communication of electrical grids. With the use of wireless communication channels and possible deployment in harsh environments or unattended areas, they are subject to many types of attacks. Also, there are some limitations on deployed security mechanisms in these environments. Therefore, such systems are vulnerable to cybersecurity risks. Recently, numerous system analysts are taking into account systems dependent on latest resemblance methods, like never before wireless communication. Wireless systems enable hosts to meander without the imperatives of wired associations. Wireless systems have a significant job in both military and regular citizen frameworks. A wireless sensor network is a collection of center points sifted through into a framework. Each middle

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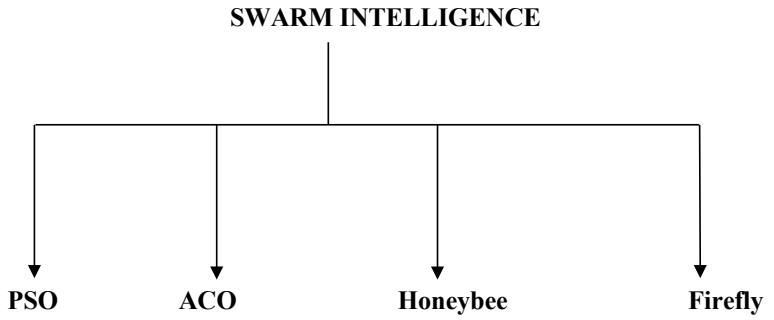

Fig. 1 Sub-domains of swarm intelligence

point incorporates dealing with limit, may contain different sorts of memory, have a RF handset, a power source, and suit different sensors and actuators. Many directing, control the board, and data spread shows have been expressly expected for WSNs where essentialness care is a key structure issue. Swarm Intelligence (SI) [1] is an artificial intelligence technique subject to the examination of total direct in decentralized, self-sifted through systems. Swarm information was exhibited by Beni and Wang in the year 1989, in the assistance of cell mechanical systems. Swarm understanding is given as "The rising total information on social affairs of essential administrators" [1]. It helps many-sided and sagacious direct through clear, independent relationship between a total amounts of self-ruling swarm people (Fig. 1).

Swarm intelligence is just another dimension of computational intelligence which offers response for complex streamlining issues which are not successfully taken care of by various systems. Swarm is portrayed as a great deal of versatile authorities that everything considered light up bothers. Every person of the swarm has simple guideline of activity and approach to a constrained measure of data through its prompt neighbor. Then again, even with restricted data and basic activities of individuals, the swarm, in general, is skilled to achieve exceptionally difficult issues of the calculation and streamlining. Swarm intelligence comprises Particle Swarm Optimization (PSO), Ant Colony Optimization (ACO), honeybee, and firefly ideal models. These models duplicate the conduct of genuine creepy crawlies for nourishment looking, sorted out living, and self-defensive styles for computational issues. The SI-based strategies are increasingly reasonable for the steering and energy assets advancement, because of the nature, design, topology, and usefulness of impromptu and remote sensor systems.

2 Related Work

J. Kennedy et al. proposed an idea of optimization with the implementation of swarm technology. There is the use of paradigms out of which one is implemented and

explained with the help of tests. Explanation of the genetic life and particle algorithms is given in this paper. This explains the implementation of paradigms [2]. R. Schoonderwoerd et al. paper was in inspiration of the ant colony that they had observed and took it as their base to find useful results in the field. The very known ant colony was used in this paper to be the inspiration behind it [3]. S Choudhary et al. in their paper discussed about how the WSN has been used in military and biological fields. The new field discussed in the paper is processing to reduce the replication of information shared by the sensor nodes and to increase the reliability of end-to-end data transmission. This paper helped people from across the fields to get research-driven solutions [4]. I. F. Akyildiz et al. designed a low-cost sensor which was used in military area, healthcare, and the paper included the solutions of protocol stack layer section. The paper is not just limited to more fields to be developed in the same, and hence a cross-field paper [5]. Kwang Mong Sim et al. did modifications and detailed study in the field of ant colony optimization and models of collective intelligence were then converted to better and more implementable techniques. They also provided comparison between the techniques [6]. Mishra et al. in their paper discussed about the LEACH with the pheromone energy-efficient routings in WSN. It also discussed the performance evaluation of the SWARM intelligence alongside with the routing in wireless sensor networking in ad hoc networks. This paper clearly explains the ACO, SWARM technology so that performance can be evaluated in better manner [7]. K. Akkaya et al. did a thorough research on the wireless sensor networks connectivity. The paper focuses and also provides us with different techniques that can be used for connecting WSN to external networks and hence provides useful results [8]. JN Al-Karaki et al. in their paper explained the design challenges that were being faced while routing the WSN and also did an extensive survey. They classified them based on the protocol operation. The design trade-off is mentioned and also how the process of energy trade happens. This survey-based paper provided data and trends which could provide predictions for the same [9]. A. Mishra et al. in their paper explained and discussed about the pheromone energy-efficient routing which was useful in wireless sensor networks. It considered LEACH with pheromone energy. Hence, the paper gave beneficial results for further analysis [10]. C. Ramachandran et al. in their paper discussed about the swarm intelligence and ant model-based detection network which was based on the wildfire detection. It focused on the detection of wildfire using swarm intelligence. This paper provided much insight on the practical implementations of the said technology [11]. E. Baburaj et al. used the swarm technique in a different way. An intelligent mesh-based technique, multicast routing algorithm was implemented using MANET's [12]. Y-F Yen in his paper used the ant-based network with the help of wireless network and also routing in this energy [13]. Zulfiqar Ali et al. in their paper gave details about analysis carried out in swarm intelligence. It included routing protocols as well as the communication between the sensors wirelessly [14]. Saleem M. et al. in their paper discussed about the reverse techniques used in the swarm technology. They also provided an overall evaluation on the ant colony optimization which was evaluated and expressed as a discussion [15]. Raghvendran V. et al. in their paper explained the routing techniques that concerned the ad hoc mobile networks that also included

swarm technology [16]. Sachan S. et al. in their paper "Comparative analysis of clustering algorithm for wireless sensor networks" did extensive analysis on the clustering algorithm that concerned the wireless sensor network, and they worked on the algorithm side of the technology to get useful results [17]. Jabeur et al. in the paper explained a new clustering approach that was based on the firefly approach that has micro- and macro-clustering approach for the WSN [18]. Dorigo M. et al. in the paper of ant colony optimization explained the metaheuristic techniques for their approach in the new ideas for optimization. Hence, it gave results that were helpful in further experimentation [19].

3 Swarm Intelligence-Based Routing Protocols and Algorithms

In the ongoing section, we surveyed the selected SI steering protocols for WSNs and feature their resources concerning the scientific bifurcations of directing conventions. The next few sections are a part of the larger picture where we talk about PSO- and FFA-based conventions.

3.1 Particle Swarm Optimization

Particle swarm optimization is another field of the SI that adventures the conduct of swarms for the arrangement of complex issues. PSO-natured calculation keeps up a swarm of particles. It misuses the common insight just as the data sharing limit of swarms. The PSO tries to put in the possibility of social cooperation for the arrangements of both hard and improvement issues. It was being created [2] in the year 1995 by the James Kennedy and the Russell Eberhart. In PSO, every molecule independently rose as a potential answer for the difficult issue to be comprehended. The working of PSO depends on the situation of molecule and speed of the molecule at some random time.

3.2 Centralized Particle Swarm Optimization (PSOC)

N. A. Latiff et al. presented [20] the energy mindful bunching for remote sensor systems utilizing Particle Swarm Optimization (PSO) calculation that is actualized at the base station. PSO expects to discover the molecule position that outcomes in the best assessment of a given wellness work. During every age, every molecule utilizes the useful data about its prior best individual position and worldwide finest position to refresh its up-and-comer arrangement.

3.3 Firefly Algorithm-Based Routing Protocol

Yang [21] built up the firefly calculation in 2008 dependent on this blazing conduct of fireflies. The target of firefly calculation is to discover the situation of the molecule that gives best outcomes in assessing a wellness work. The light force changes as indicated by the converse square law. The light power can be resolved as demonstrated as follows:

$$I(r) = I_0 \exp\left(-\gamma r^2\right), \tag{1}$$

where $I(r)$ refers to light intensity at a distance r, I_0 is the intensity at the source, and γ is the absorption coefficient of the medium.

The firefly's allure is straightforwardly relative to the light force observed by different fireflies; we presently characterize the engaging quality β with the separation r as

$$\beta = \beta_0 \exp\left(-\gamma r^m\right), \tag{2}$$

where β_0 is the appeal at $r = 0$. $r_{i,j}$ is the separation linked any two fireflies I and j, which are at positions xi and xj each one by one, individually. The Cartesian separation is given by the condition

$$r_{ij} = \sqrt{\sum_{k=1}^{d} (xi, k - xj, k)^2}, \tag{3}$$

where xi, k is the kth component of the spatial arrange xi of the firefly I and d is the quantity of measurements. The development of firefly I toward progressively another (more brilliant) firefly j is given by

$$x_i = x_i + \left[\beta_0 \exp\left(-\gamma r_{i,j}^2\right)\right]\left(x_j - x_i\right) + \alpha\varepsilon, \tag{4}$$

where the subsequent term is because of fascination and α is an arbitrary factor.

3.4 Group Arrangement Using Firefly Calculations

The base station runs the count as it is consolidated. The best K cluster heads that minimize the cost function are obtained.

$$\cos t = \beta \times d_1 + (1 - \beta) \times d_2, \tag{5}$$

$$d_1 = \max_{k=1,2,3...k} \sum_{\nabla ni \in Cp,k} \frac{d(ni, CHp, k)}{Cp, k}, \tag{6}$$

$$d_2 = \frac{\sum_{i=1}^{N} E(ni)}{\sum_{k=1}^{k} E(CHp, k)}, \tag{7}$$

where d_1 is the most extreme normal Euclidean separation of individual nodes to the related bunch heads, $|Cp, k|$ is the quantity of nodes that have a place with group C_k of molecule p, d_2 is the capacity which is the proportion of aggregate of beginning energy of all nodes ($n_i = 1, 2, 3 \ldots N$) to the total of the present energy of the group heads in the present cycle, and β is a client characterized consistent.

4 Customized Firefly Algorithm

There is a wide scope of divergence among the network of live people as far as wellness and quality. On the off chance that an individual have high wellness esteem, at that point it plays out its activity adequately than others and achieve superior. The part with low quality doesn't accomplish such superior. So as to improve the presentation of the network by making changes in the person's position another calculation dependent on firefly calculation is created. The new calculation permits making changes in the situation of the people and expanding the plausibility of getting the ideal arrangement in the firefly populace.

4.1 Proposed Methodology

This segment manages the modified firefly calculation (CFFA) with the suppositions made for building this novel convention. Suspicions are

- Every one of the nodes can speak with one another and with the base station (BS) directly.
- There is a solitary jump from customary node to cluster head (CH) and from CH to BS.
- Each one of the nodes is static, where the calculation runs at a specific time moment and updates for next round, and each one of the nodes is area mindful. They update their area data to the BS before going into the setup stage.
- 2-D space is considered for deployment of sensor node.

5 Simulation Environment

A lot of perceptible matrix can be utilized for assessing the presentation of routing protocols in WSN.

5.1 Performance Matrices

The following measurements are used for assessing the presentation of two directing conventions PSOC (centralized particle swarm optimization) and CFFA (customized firefly algorithm):

- Delay (second): The delay consolidates all reasonable and existing delay realized by buffering in between course disclosure dormancy, lining at the interface line, retransmission deferral, multiplication, and move time. The same is described as
  D = (Tr − Ts)
  Here Tr is receive time and Ts represents sent time.
- Energy Consumption: When transmission is done or getting information to/from neighbors, some energy of nodes get dispersed. So alongside the progression of time the rest of the energy or lingering energy of nodes diminishes.

5.2 Simulation Setup

As effectively laid out we have taken steering conventions, to be specific PSOC and tweaked FFA. For every one of the recreations, a similar development models were utilized and reproduction time is differed as 5, 15, 25, 35, 45, and 55 s. The presentation investigation is done on Ubuntu Operating System. Ns-3 was introduced on the stage. In this situation, a few parameters with a particular worth are considered. Those are as given in Table 1.

6 Results and Discussion

6.1 Delay

In Fig. 2, CFFA exhibits the minimum delay along with the increase in simulation time. It means packet delivery in between source and final destination requires less time as simulation time peaks in CFFA.

a. **Energy Consumption**

Figure 3 exhibits the connection between energy consumed at y-axis and simula-

Table 1 Scenario for implementation of PSOC and CFFA

Operating system platform	Ubuntu
Simulator used	NS-3
Protocols followed	PSOC, CFFA
Type of channel	Wireless channel
Traffic type	Constant bit rate (CBR)
Number of nodes	40
Area size of simulation	500 × 400
Mobility model	Random way point mobility
Antenna model	Antenna/omnidirectional
Packet size	712 Bytes
Max. packet in ifq	50

tion time at x-axis for PSOC and CFFA routing protocol. CFFA displays least value for the same. Therefore, CFFA is more energy efficient.

7 Conclusions

Energy efficiency is a basic factor in WSN so as to drag out framework lifetime. Because of the time-changing nature of the wireless channel, the throughput is extremely delicate to the packet size. The following paper presents an examination of the distinctive swarm-based steering methods for WSNs from the ongoing work. In this paper, grouping utilizing redid firefly calculation has been finished. Here cost capacity utilizes the separation between the nodes and the group head and the energy of the nodes. The re-enactment results show that the calculation gives low energy utilization and delayed system lifetime than the other convention. Future extension incorporates blend of other bio-enlivened calculations and presents crossover methods for effective clustering in WSNs. In future, much of the research work is required to reduce the security risk in wireless sensor network so that the data privacy may not get hampered.

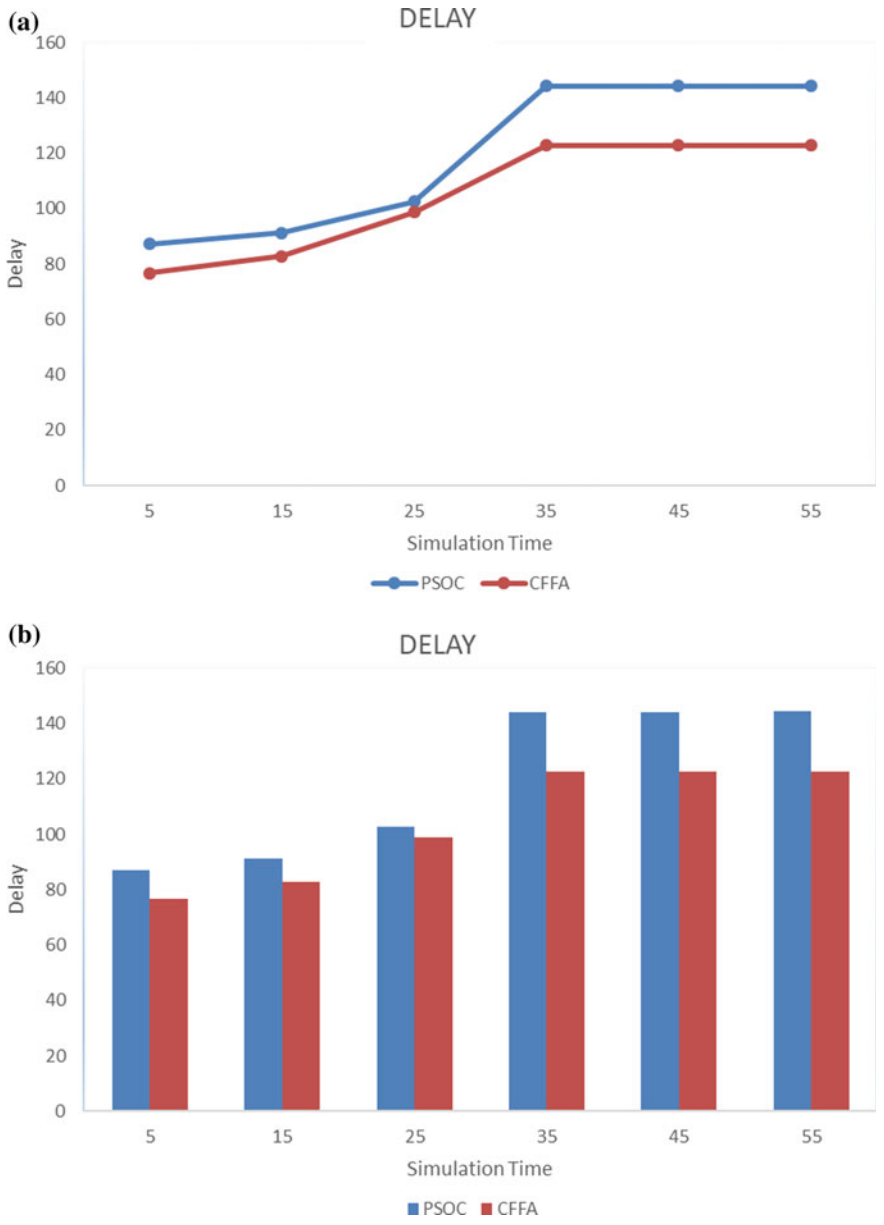

Fig. 2 Delay versus simulation time for PSOC and CFFA

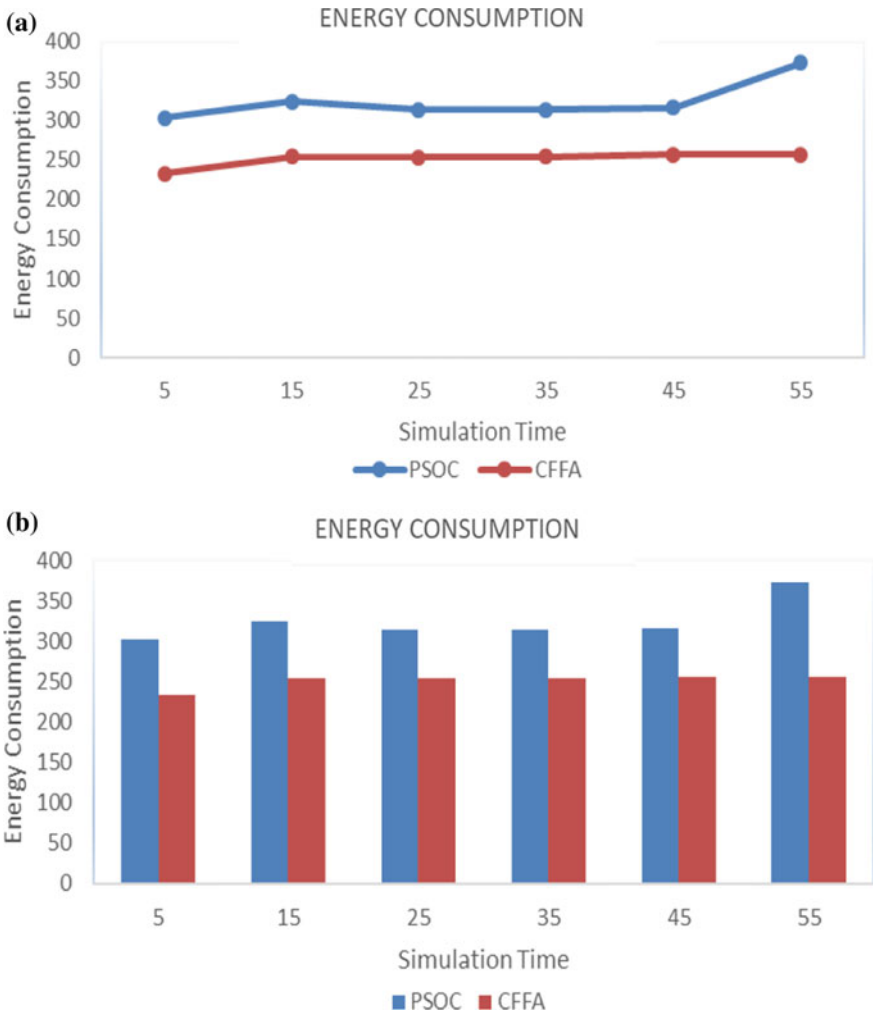

Fig. 3 Energy consumption versus simulation time for PSOC and CFFA

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