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Wsn Routing Optimization Utilizing The Fire-Fly Optimization Algorithm Based On Enhanced Leach Protocol Research

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Abstract - *LEACH routing protocol equalizes network energy usage by randomly picking cluster head nodes in a loop, resulting in the flaw of unstable network operation. To address this issue, it is vital to lower the energy consumption of data transmission in the routing protocol while also increasing the network life cycle. However, there is a problem with cluster heads counting with a broad range and the cluster head forwarding data wasted a lot of power in the LEACH, which has to be fixed. In this research, we propose a method for optimizing the routing protocol. To begin, the ideal number of cluster heads is computed based on total energy usage every round in order to limit the likelihood of excessive cluster heads. According to the MATLAB simulation results, the protocol may greatly extend the lifetime of WSNs when compared to the LEACH protocol and improve energy efficiency per unit node per round. The proposed solution consumes only a little amount of energy. The technique reduced the time to First Node Death (FND) by 127 percent, 22.2 percent, and 14.5 percent when compared to LEACH, SEACH, and MOFCA, respectively.*

Key Words: LEACH, SEACH, MOFCA, Optimized-LEACH, Fire Fly

1. INTRODUCTION

With the advancement of technology, WSNs are widely used in society and play an important role in areas such as environmental monitoring [1,2], weather forecasting [3, 4], precision agriculture [5,6], petroleum drilling [7, 8], natural disaster prevention [5,6], urban transportation [7,8], and indoor positioning [9]. Because of its low cost, low power, great integration, and high sensitivity, WSNs outperform in many practical applications [9]. Sensor nodes, on the other hand, continue to face issues such as too random layouts, huge quantities required, and restricted battery conditions in outdoor applications. As a result, boosting sensor node efficiency, lowering node energy consumption, and extending network duration are still hot topics in WSNs [10].

The communication transmission protocol's energy consumption in WSNs is inversely proportional to the transmission distance. As a result, more energy is used for data transmission in order to limit extra energy loss, resulting in a routing protocol [11]. There are two types of routing protocols: flat routing protocols and hierarchical routing protocols [12–16]. When compared to the flat routing protocol, the LEACH protocol balances the energy needs of the WSNs across each node, lowering energy consumption dramatically. To better address the energy control and WSNs throughput demands of a wide variety of nodes, the LEACH protocol employs data transmission local control technology and a low energy MAC layer protocol [17]. The LEACH procedure is built on the selection of a cluster head. First, define a threshold (T_n), and then assign different random values to each node in each round. If the sensor node's random value is less than T_n, the node operates as a CH in the current round. The T_n is denoted as

$$T_n = \begin{cases} \dfrac{p}{1-p*\left(r \bmod \dfrac{1}{p}\right)}, n\in G \\ 0, n\notin G \end{cases} \quad (1)$$

Where p represents the beginning proportion of CHs, r represents the round number, r mod(1/p) represents the node count that has been allocated as the CH in the period, and G represents the node-set that has not been assigned as the CH in the front 1/p wheel. As a result, the re-election of the CH is critical, because the number of cluster heads varies greatly. On the one hand, a large number of CHs will surely raise network stress since the CH must conduct data fusion on the received data before passing it to the base station. With fewer cluster heads, however, one cluster's coverage area gets too large, increasing data transmission energy demand. In this case, all nodes adopt the single-hop transmission strategy. If the transmission distance is too large, the CH will waste a lot of power for data transmission, causing the CH to expire prematurely from energy fatigue.

Cluster head selection is a tough optimization issue. Ant colony optimization [18], particle swarm optimization [19], and genetic algorithms [20] are examples of heuristic algorithms that are good at solving complex optimization problems. Many optimization solutions are employed to solve the aforementioned shortcomings. [21] offers a new variant of the bat algorithm in combination with the centroid method, resulting in a two-stage cluster-head node selection technique that saves more energy than the standard LEACH procedure. [22] created enhanced multi-hop LEACH (EM-LEACH), a novel LEACH-based clustering method that improved network efficiency, particularly in terms of energy allocation. [23] offered ESO-LEACH as an enhanced method. The improved suggested method is successful in suitably extending network lifespan, and it provides greater vitality proficiency and longer system lifespan than traditional LEACH.

This research proposes an improved algorithm based on the LEACH protocol to assure the stability of CH amount and increased energy usage of the entire network.

2. LITERATURE REVIEW

Many academics have studied clustering routing protocols based on the LEACH protocol. The study focus is divided into three areas: making clustering more uniform, optimizing cluster head selection, and controlling cluster headcount.

Homogeneous clustering may aid in the regulation of energy Consumption in the hierarchical routing protocol, preventing the untimely death of a cluster leader due to high energy consumption. Unequal Clustering Size (UCS) makes clusters of different sizes based on the distance between the CH and the BS [24]. This is done to balance the energy of the network. Hybrid Energy-Efficient Distributed Clustering (HEED) makes the distribution of CHs in a complete distribution more even by balancing the remaining power of the primary parameter node with the cost of communication inside the subordinate parameter cluster [25]. DK-LEACH changes how many cluster heads there are based on how many nodes are in a cluster. This makes sure that the energy is distributed out evenly [26]. The Energy Efficient Clustering Scheme (EECS) selects CHs with higher residual energy while achieving improved cluster dispersion [27]. The purpose of Efficient Clustering LEACH (ECLEACH) is to tackle the CH intensive problem. [28]. In the LEACH technique, the nodes with the least amount of energy are chosen as CH. LEACH-C [29] and Energy Efficient LEACH (EE-LEACH) [30] methods choose a CH based on the node with the largest residual energy. The LEACH Clustering Protocol Based on Three Layers (LEACH-T) divides WSNs into three tiers, with each tier voting a cluster leader [31]. Based on a weighted probability calculation, the Stable Election Protocol (SEP) decides if a sensor node chose a CH. [32].

CL-LEACH forwards data based on the node's current energy to better balance network energy [33]. By using deterministic cluster head selection, nodes with more residual energy are chosen as CHs with higher success rates in LEACH [34].

N. G. Palan proposed allocating a fixed amount of energy model benefit points to each network node [34]. Arifin presented an energy analysis of WSNs based on the LEACH approach during a black hole attack [35]. Nitin Mittal proposed utilizing energy-aware algorithms to balance load across nodes, resulting in a longer period of stability [36]. Julie E. G. presented a routing system that leverages the CCE Virtual Backbone cluster to determine how frequently messages are sent and how many connections may be established at the same time. [37].

The authors, however, give no advice for reducing the power consumption of negotiated communication inside a cluster. In the article, we commit to lowering network stress caused by having too many or too few CHs and to stabilizing the number of CHs. To reduce the energy consumption of long-distance data transmission, the firefly approach is used to optimize the multi-hop transmission routing protocol, and the Voronoi diagram is utilized to reduce the data transmission consumption of negotiated communication with the cluster.

LEACH (low-energy adaptive clustering hierarchy) was developed and tested. It merged the concepts of energy-efficient cluster-based routing and media access with application-specific data aggregation to create a system with a long life, low latency, and excellent quality as perceived by the application [38]. The study [39] investigated four distinct clustering techniques. The number of control packets, rounds, live nodes, data delivered to the base station, and energy left over after each round were used to make the comparison. The LEACH algorithm was used to create a hierarchical routing system that prevents cluster leaders from repeatedly establishing new clusters, which wastes a lot of energy. [40].

3. Network Model

Assume the WSN region is 100x100 m2 and there are 100 random sensor nodes distributed throughout it. The BS is located in the centre of the WSNs, which are all the same size. These 100 sensor nodes gather, aggregate, and transmit information. The following are the processes taken to configure the network model.

- **Cluster modelling**

All of the cluster heads are depicted using the Voronoi Diagram. The generator element is picked at random, followed by the selection of two cluster heads to construct their dual Delaunay triangle, which is then extended clockwise. Then calculate how long each triangle travels around. The final step in creating the Voronoi diagram is to link the circle to the outermost vertical line of the triangle. Figure 1 depicts the overall plan.

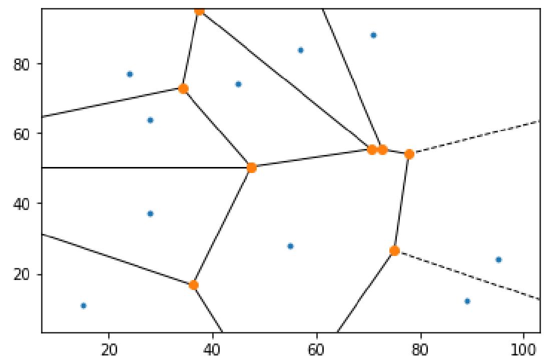

Fig -2: Voronoi Diagram for 10 randomly distributed nodes

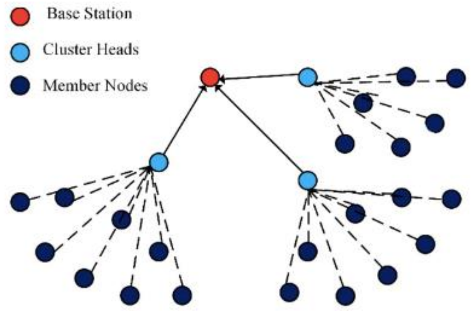

Fig -3: Clustering Model

The clustering stage is broken into two parts: electing cluster heads and negotiating clusters. The cluster head communicates directly with the member nodes. Cluster heads combine received data and send it to the BS. Figure 2 depicts a clustering example.

- **Firefly Optimization Algorithm**

Firefly algorithm is a metaheuristic algorithm inspired by the flashing behavior of fireflies and the concept of bioluminescent communication. Developed the Firefly Algorithm based on the following assumptions:

1. Because fireflies are unisexual, they will be attracted to each other regardless of gender.
2. Attractiveness is proportionate to brightness; therefore a less bright firefly will be drawn to a brighter firefly. However, as the distance between the two fireflies rose, so did their appeal.
3. If two fireflies have the same brightness, they will travel at random.

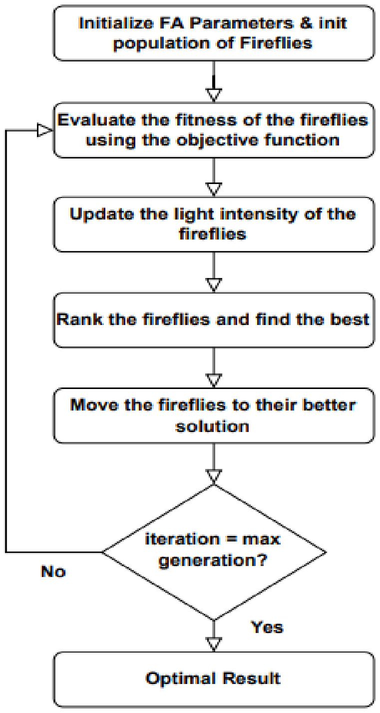

Fig -2: Fire-fly algorithm flowchart

Generations of novel solutions are generated by random walks and the attraction of fireflies. The flowchart of the fire-fly algorithm is stated in figure 1.

The brightness of the firefly should be linked to the objective function of the connected task. Their appeal allows them to break into smaller groups, and each subgroup swarms around the local models. Based on statistical performances assessed using typical stochastic test functions, FA is relatively efficient and can beat other traditional methods. The algorithm operates on the basis of global communication among fireflies. As a result, it can identify both global and local optimum solutions at the same time.

4. Experimental Results and Analysis

The simulation area was set to 100 m x 100 m and was randomly dispersed with 100, 200, and 400 sensor nodes. These nodes mimic in order to gather environmental characteristics like temperature and humidity. The base station is located in the middle of the region at (100, 100), with the BS station and sensor nodes shown as a red triangle and a solid dot, respectively. Figure 2 depicts the network lifetime graph with 100 randomly dispersed nodes. Figures 3 and 4 show the network lifetime graph with 200 and 400 nodes respectively with a Base station at 100x100. In all the graphs it can be clearly seen that the performance of the proposed algorithm with firefly optimization has outperformed the other related algorithms like LEACH, SEACH, and MOFCA. The simulation parameters are typically separated into two portions, one in the LEACH and the other in the ant colony method. The majority of the parameters are established by referring to other similar articles stated in Table 1.

Table -1: Simulation Parameters

Parameters	Value
Init energy of each node	2J
cluster heads %	8%
each node Packet length of per round	2000bits
each node Packet garneted per round	2
packet length Ctr	200bits
(E_{elec})	50nJ/bit
(E_{fs})	10 pJ/bit/m²
(E_{mp})	0.0013 pJ/bit/m²
(E_{DA})	5Nj
distribution type	Rand
Alive node energy level	0.009J
schth	0.5

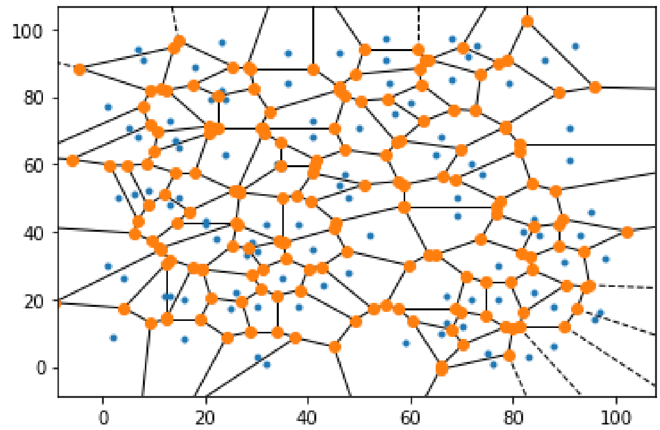

Fig -3: Voronoi Diagram of 100 randomly distributed nodes

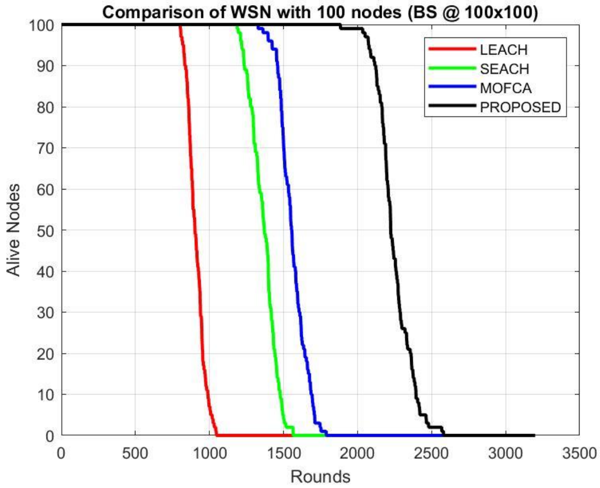

Fig -4: Comparison of lifetime with 100 nodes and BS @ 100x100

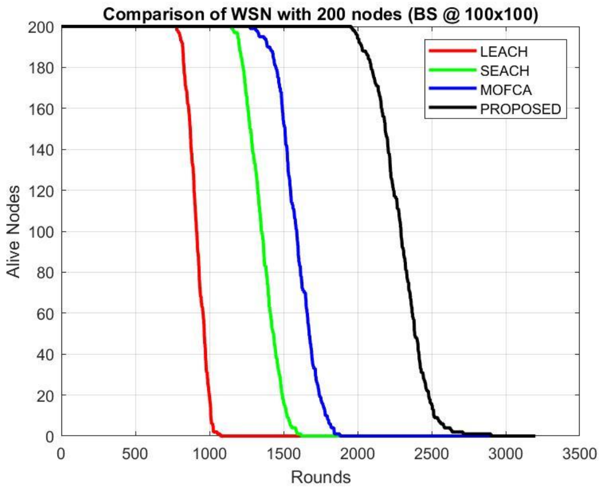

Fig -5: Comparison of lifetime with 200 nodes and BS @ 100x100

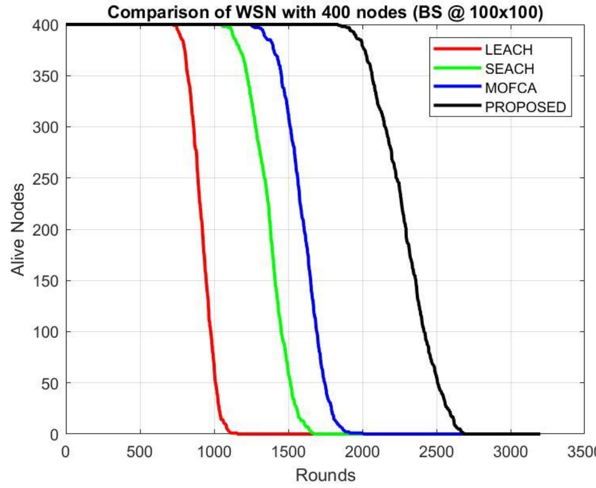

Fig -6: Comparison of a lifetime with 400 nodes and BS @ 100x100

Tables 2 and 3 illustrate the first and last node dead comparison in terms of the number of rounds. The proposed LEACH with firefly optimization using the Voronoi diagram concept has shown less consumption of the energy and the nodes are alive for a greater number of rounds as compared to other states of art algorithms.

Table -2: First Node Die (FND) Lifetime comparison

Number of nodes	Network Lifetime in rounds			
	LEACH	SEECH	MOFCA	PROPOSED
100	805	1193	1361	2020
200	781	1152	1312	1966
400	744	1082	1255	1855

Table -3: Last node Die (LND) Lifetime comparison

Number of nodes	Network Lifetime in rounds			
	LEACH	SEECH	EACUF/MOFCA	PROPOSED
100	1047	1565	1789	2581
200	1073	1621	1881	2900
400	1157	1673	2006	2688

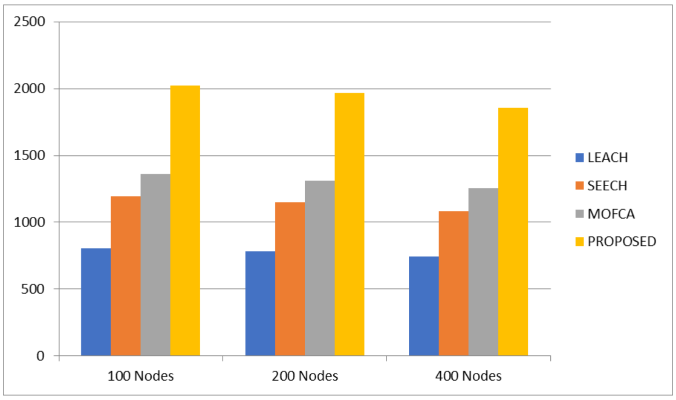

Fig -7: First Node Die (FND) comparison

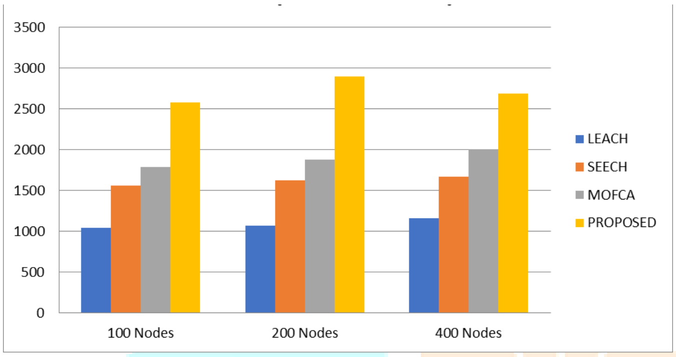

Fig -8: Last Node Die (LND) comparison

From Figures 7 and 8 it can be seen that the life of the proposed algorithm network is far much more as compared to the normal LEACH and SEACH algorithm in terms of the first node and last node dead situation respectively.

3. CONCLUSIONS

Wireless sensor networks are utilized in a wide variety of applications. The LEACH protocol has long been the focus of wireless sensor network research. To address the complexity of the standard LEACH protocol, the study suggests a clustering strategy based on a modified LEACH protocol and the Voronoi diagram concept. To begin, the proper number of cluster heads is estimated for each round based on total energy usage. The result is a Voronoi diagram. Finally, the firefly algorithm is included in the protocol to enhance the multi-hop routing protocol. Experiment findings demonstrate that the proposed approach can keep cluster headcount varying within a 3k10 range.

The goal of this research is to extend the life of WSNs and minimize data transmission energy usage. As a result, future research should optimize the LEACH protocol in conjunction with intelligent algorithms, compare it to other ways, and use it in practice.

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