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Research Article

Nonlinear Energy Optimization in the Wireless Sensor Network through NN-LEACH

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Researchers have developed a range of methods and strategies to decrease wireless sensor network energy consumption. Mote clustering is one of the competent topological control approaches to boost the networks' energy efficiency, scalability, and performance. Energy is dissipated during the cluster creation, cluster head selection, routing from the head and base stations of the cluster, and data aggregation—clustering and routing emphasis on the stability and the longevity of the network. This research work provides the optimization technique for the wireless sensor network to optimize the energy through NN-LEACH. The main goal is to extend network life and reduce power consumption by clustering and routing sensor nodes using the two-step NN-LEACH protocol, which is suggested. An additional goal might be to establish the appropriate course of action for the suggested approach for this network.

1. Introduction to Wireless Sensor Networks

Wireless sensor networks (WSNs) offer huge potential to improve people's lives and study the environment using sensor nodes. The key obstacle in using these motes is independent and low-powered devices with small batteries. According to the NSF, new technologies lower motes and sensor arrays' cost, size, and weight. Integration approaches reduce distance barriers by increasing performance and longevity while decreasing size [1]. WSNs are typically hidden and rely on small batteries for power. Changing batteries is not an option. Managing the power requirements of a wireless sensor network is difficult. Contrary to popular belief, energy consumption is not determining network efficiency [2, 3]. Figure 1 shows the example of the wireless sensor network [4].

Researchers focused on layer-based components, expecting that changes in one layer would immediately influence the whole system, but it did not work. Many energy-saving models consider sending and receiving data, ignoring other factors. Most contemporary energy reduction models ignore rest parameters [5].

2. Literature Review

The energy-efficient routing algorithm is categorized as communication architecture, network structure, reliable routing, and topology-based routing [6]. These protocols might be flat or hierarchical [7]. In the WSN, flat routing algorithms do comparable responsibilities. Smaller networks frequently use these networks. Algorithms such as SPIN and directed diffusion are examples of balanced routing algorithms. The cluster head rotates to balance the energy consumed. The hierarchical routing algorithm's architecture is efficient and scalable. Each network mote receives the data via the SPIN protocol. The data of each node are comparable

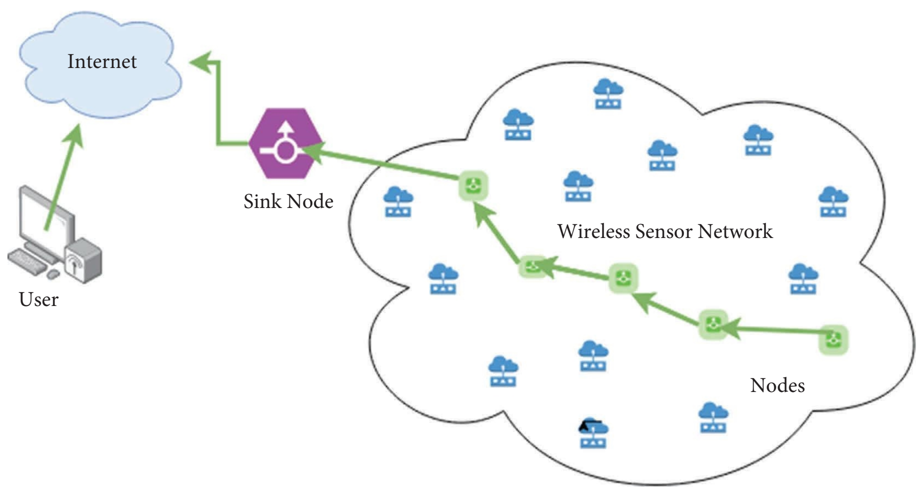


Figure 1: Example of wireless sensor network [4].

Table 1: Analysis of successors of LEACH [16].

Year	LEACH variants	Cluster types	Level of complexity	Delay in transmission	Energy efficiency	Overhead	Scalability
2000	LEACH	Distributed	Low	Less	Moderate	Higher	Lower
2002	LEACH-C single hop	Centralized	Low	Less	Highly efficient	Less	Lower
2002	LEACH DCHS	Distributed	Moderate	Less	Highly efficient	Higher	Lower
2003	LEACH B	Distributed	Moderate	Less	Highly efficient	Higher	Lower
2005	LEACH S	Distributed	High	Less	Very high	Higher	Moderate
2006	LEACH B- TL	Distributed	Lower	Less	Highly efficient	Less	Lower
2006	LEACH M	Distributed	High	Less	Highly efficient	Higher	Higher
2007	LEACH E	Distributed	Extreme	Less	Highly efficient	Higher	Lower
2008	LEACH-TB	Distributed	Extreme	Less	Moderate	Higher	Moderate
2008	LEACH-ME	Distributed	Extreme	Higher	Moderate	Higher	Higher
2010	LEACH-U	Distributed	Extreme	Less	Highly efficient	Less	Lower
2010	LEACH-C multihop	Distributed	Extreme	Higher	Highly efficient	Higher	Lower
2010	LEACH D	Distributed	High	Less	Very high	Higher	Very high
2011	LEACH-GA	Distributed	High	Less	Highly efficient	Higher	Lower
2011	LEACH-FZ	Distributed	Extreme	Higher	Highly efficient	Higher	Higher
2012	LEACH-FL	Distributed	Extreme	Less	Lower	Less	Higher
2012	LEACH-MR	Distributed	High	Higher	Highly efficient	Less	Lower
2012	LEACH-CELL	Distributed	Extreme	Less	Moderate	Very high	Very high
2013	LEACH-EP	Distributed	Extreme	Less	Very high	Higher	Lower
2013	LEACH-I	Distributed	High	Less	Highly efficient	Moderate	Lower
2014	LEACH-SAGA	Distributed	High	Less	Highly efficient	Moderate	Higher
2015	LEACH-V	Distributed	High	Less	Very high	Higher	Lower
2019	LEACH-MG	Distributed	Complex	Less	Moderate	Very high	Very high
2020	LEACH-MW	Adaptive	Low	Less	Lower	Very high	Very high
2021	LEACH-ESO	Distributed	Extreme	Less	Highly efficient	Moderate	Lower
2022	LEACH-IACO	Adaptive	Extreme	Less	Highly efficient	Very high	Very high

to those of its neighbor's. This protocol disseminates information to all motes when the user does not require data to be transferred between motes.

In 2000, Heinzelman et al. [8] introduced the first hierarchical method, LEACH ("low energy adaptive clustering hierarchy"). A strategy for geographically segmenting a system into smaller cells is suggested by Naghibi and Barati [9]. Each cell can contain both single-hop and multihop cells. A novel EGPRM is being used to collect data from sensor nodes using two portable sinks. EECS [10], HEED [11], PEGASIS [12], TEEN [13], LEACH-IACO [14], and T-LEACH [15] are all based on LEACH. LEACH and its derivatives aim to improve energy efficiency through coverage, data aggregation, data protection minimal latency, resilience, and scalability, and the main goal of these algorithms is to save energy. Table 1 compares various LEACH variants.

3. Network Model

The nodes are chosen at random. The starting energy of a node is E_0. The MS moves along the y-axis. We know that

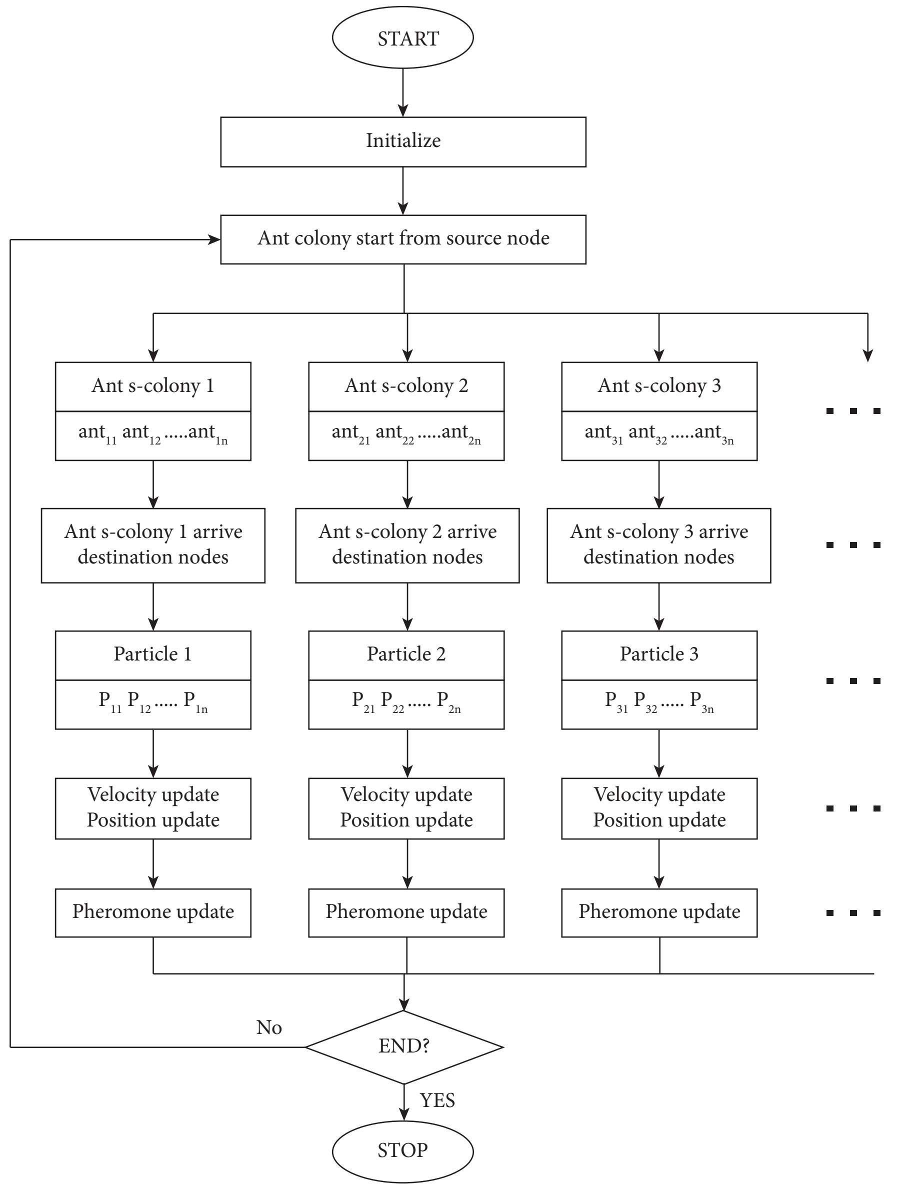


Figure 2: Flowchart of hybrid ACO/PSO.

the base station has unlimited power and that sensor nodes and sinks are everywhere. Now, we have setup and steady phases.

3.1. Step-Up Phase. The setup phase is divided into three stages: the Task Presentation (TP), the Selection of cluster head (CH), and rendezvous node (RN). Clustering, i.e., creating clusters and election of the cluster head are carried out during the next part of the setup phase [17, 18]. After the cluster formation, the last stage is known as scheduling (S). In the entire scheduling phase, the message is disseminated from the cluster head to every cluster member. Every node itself arranges their organization in the period of transmission.

3.2. Task Ordination. In this phase, firstly, RNs are selected. Initially, all nodes are assumed to be normal nodes. Every hub themselves choose whether they meet RN condition or not. To become a rendezvous hub, the hubs must fulfil a requirement. The situation representing RN is specified below the following equation:

$$\frac{y_w}{2}\,(1+\mathrm{Rx}) < \; = y_y < \; = \frac{y_w}{2}\,(1-\mathrm{Rx}). \tag{1}$$

Following points are needed to be considered to get the cluster head using the method of HNN:

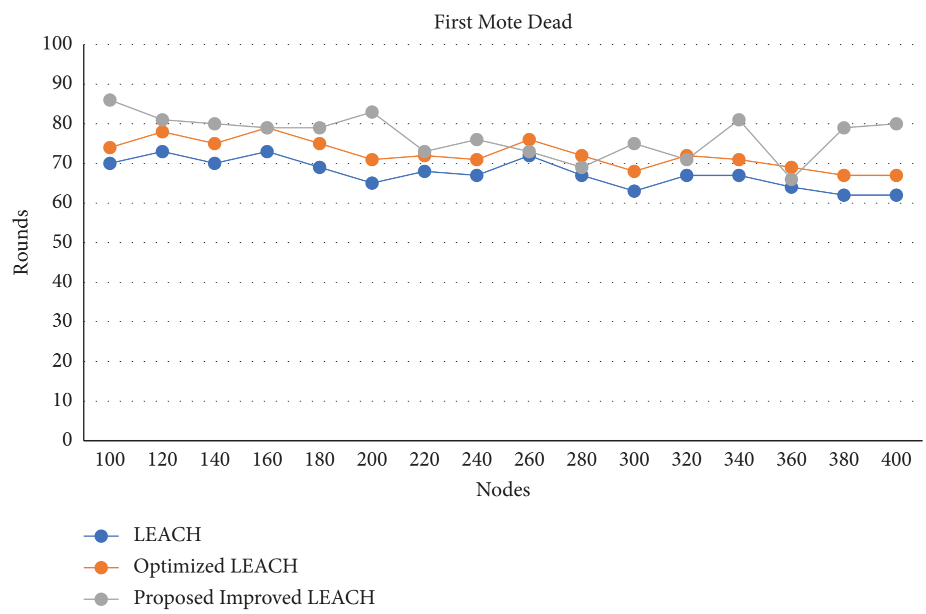
(a) Prepare weights $T_{xy} = \sum_{c=0}^{M-1} i_x^c i_y^c\ x \neq y$, where i_x^c is element of class c exemplar

(b) Put on input to the desired outputs $z = i$

Table 2: Final results for 1st, 10th, and all motes.

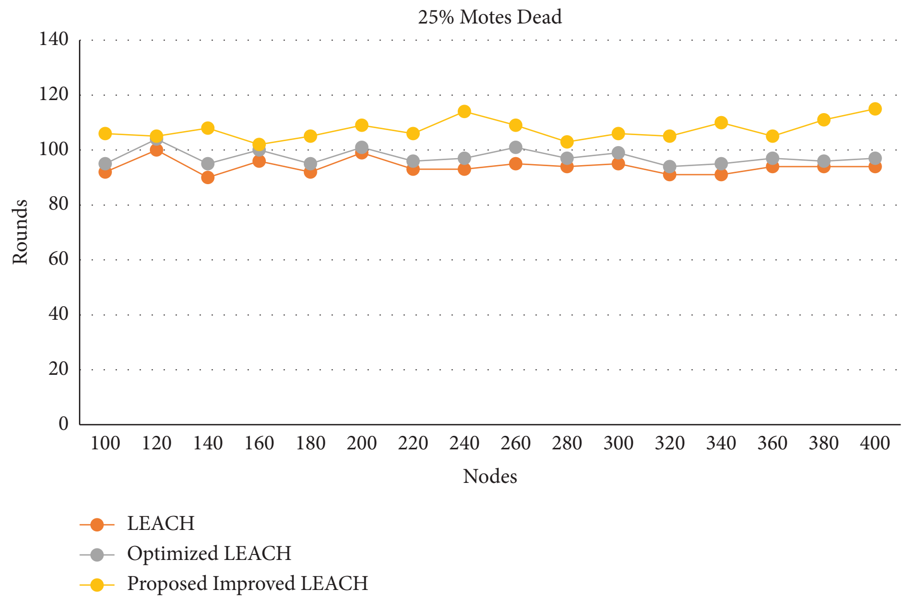
Motes	LEACH [8]			Optimized LEACH [17]			Proposed improved LEACH		
	1st mote dead	25% motes dead	All motes dead	1st mote dead	25% motes dead	All motes dead	1st mote dead	25% motes dead	All motes dead
100	70	92	222	74	95	232	86	106	241
120	73	100	222	78	104	233	81	105	243
140	70	90	220	75	95	233	80	108	244
160	73	96	224	79	100	234	79	102	243
180	69	92	224	75	95	234	79	105	242
200	65	99	223	71	101	233	83	109	244
220	68	93	224	72	96	233	73	106	244
240	67	93	222	71	97	232	76	114	242
260	72	95	223	76	101	235	73	109	243
280	67	94	224	72	97	235	69	103	244
300	63	95	222	68	99	234	75	106	243
320	67	91	223	72	94	233	71	105	243
340	67	91	224	71	95	235	81	110	244
360	64	94	225	69	97	234	66	105	245
380	62	94	225	67	96	234	79	111	244
400	62	94	224	67	97	235	80	115	245

Number of rounds (spanning header over all method columns)

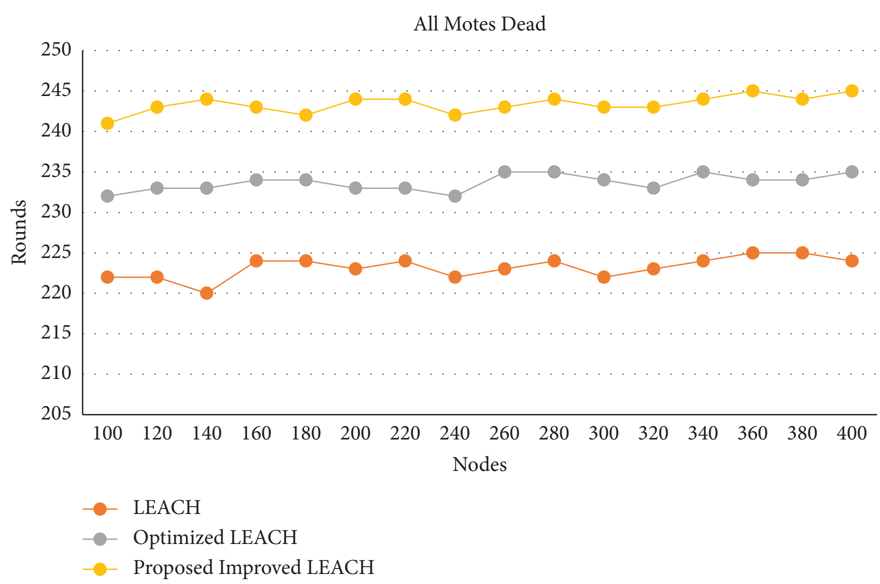


(a)

Figure 3: Continued.

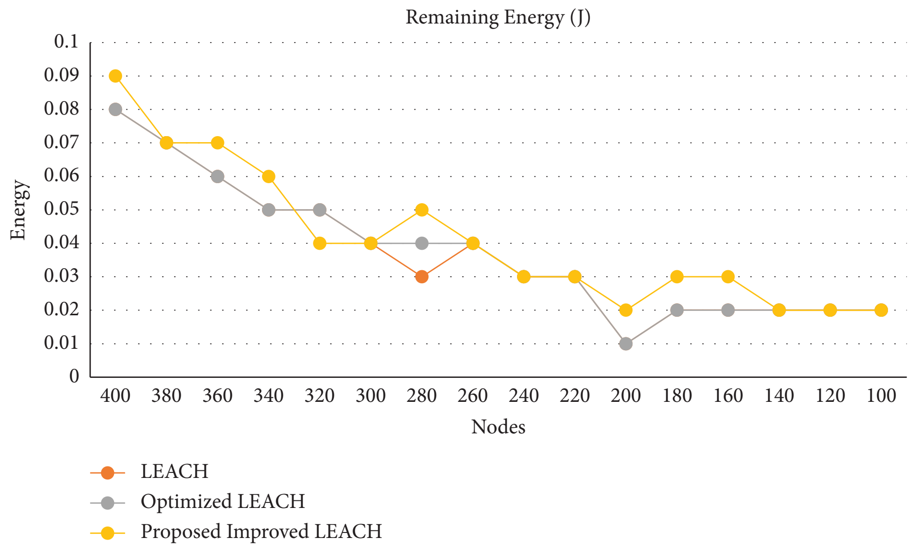


(b)

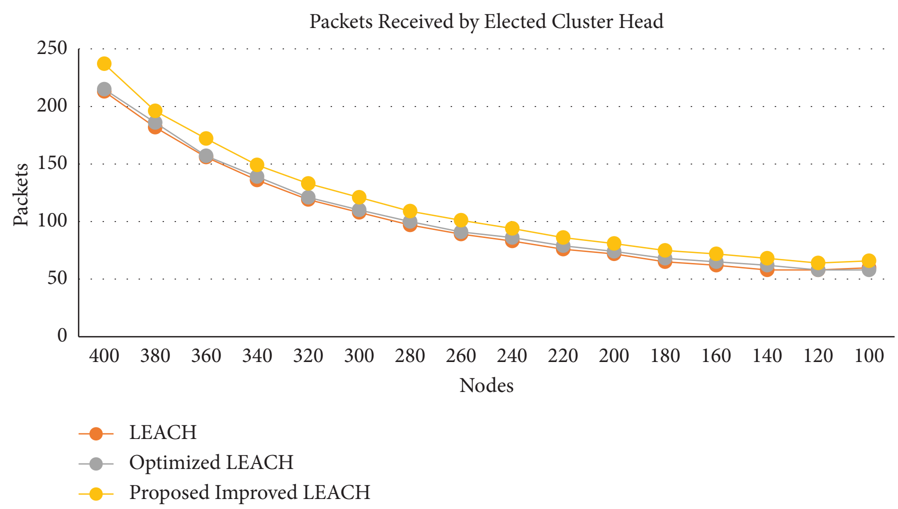


(c)

FIGURE 3: Continued.

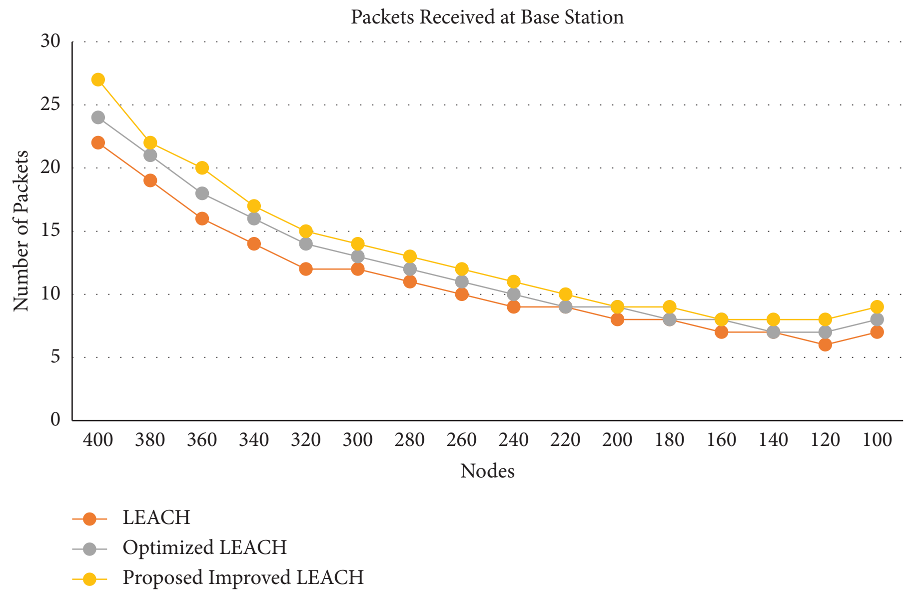


(d)



(e)

FIGURE 3: Continued.



(f)

Figure 3: Comparing LEACH, optimized and improved LEACH: (a) first node dead, (b) 25% nodes dead, (c) all nodes' dead, (d) residual energy, (e) packets received by the elected cluster head, and (f) packets received at the base station.

Table 3: Simulations results for energy remaining, data/communication packets received by the elected cluster head and finally packets received at the base station.

	LEACH [8]			Optimized LEACH [16]			Proposed improved LEACH		
Motes	Energy remained (J)	Packets received by elected CH	Packets received at the BS	Energy remained (J)	Packets received by elected CH	Packets received at the BS	Energy remained (J)	Packets received by elected CH	Packets received at the BS
100	0.08	213	22	0.08	215	24	0.09	237	27
120	0.07	182	19	0.07	186	21	0.07	196	22
140	0.06	156	16	0.06	157	18	0.07	172	20
160	0.05	136	14	0.05	139	16	0.06	149	17
180	0.05	119	12	0.05	121	14	0.04	133	15
200	0.04	108	12	0.04	110	13	0.04	121	14
220	0.03	97	11	0.04	100	12	0.05	109	13
240	0.04	89	10	0.04	91	11	0.04	101	12
260	0.03	83	9	0.03	86	10	0.03	94	11
280	0.03	76	9	0.03	79	9	0.03	86	10
300	0.01	72	8	0.01	74	9	0.02	81	9
320	0.02	65	8	0.02	68	8	0.03	75	9
340	0.02	62	7	0.02	65	8	0.03	72	8
360	0.02	58	7	0.02	62	7	0.02	68	8
380	0.02	58	6	0.02	58	7	0.02	64	8
400	0.02	60	7	0.02	58	8	0.02	66	9

(c) Recapitulate unless the system converges $z_y^+ = f_h(\sum_{x=0}^{N-1} T_{xy} z_x^-$, where f_h is hard restraint

3.3. Ant Colony Optimization (ACO). WSN performance is mainly measured via routing. Routing is a method of moving data from one place to another. While routing, two ideas are defined [17]. The first is optimum routing, where the quickest path is found using various methods, and the second is internetwork, where packets are transmitted.

3.4. Proposed PSO (Particle Swarm Optimization). Consider a situation where birds are randomly put in an area with only a piece of food to seek. The birds do not know where food is. They just know food distance. The easiest way to obtain food is to follow the bird to it. A particle is a bird. The particles have a fitness function and a velocity that can be computed. Every particle updates the "best" two values, pbest and gbest. Lesser particles update their locations and velocity using equations (2) and (3).

$$\text{velocity}[\,] = \text{veell}[\,] + c1 * \text{ran}() * (\text{perbest}[\,] - \text{present}[\,]) + c2 * \text{ran}() * (\text{glbest}[\,] - \text{present}[\,]), \tag{2}$$

$$\text{pre}[\,] = \text{per}[\,] + \text{vel}[\,]. \tag{3}$$

3.5. Nondominated Sorting Genetic Algorithm. In the last several years, EAs (evolutionary algorithms) *t* have evolved to solve mono-objective, multi-even-handed, and multi-target enhancement concerns in a precise order [18]. Despite explicit efforts to combine various mono-target developmental and nondevelopmental calculations, there are few studies that include all three types of enhancement concerns. The Pareto technique is used to segment the incoming population into subpopulations [19, 20]. Figure 2 shows the flowchart of hybrid ACO/PSO.

4. Simulations

Simulation is carried out using MATLAB for easy results computation. The limit limiting the framework's display has been disregarded. For reproduction, we dissect findings by several nodes and then by region.

Case 1: the proposed NN-LEACH is compared with existing RZ-LEACH and ACO-RZLEACH based on the node scalability by a varying number of motes and adjusting of the threshold values of various parameters such as alive nodes, dead nodes, the packet sent to BS, packet sent to CHs, and energy remained.

Case 2: in this case, the adaptability issue is considered for the organization's differing size for the consistent number of hubs ($n = 100$). The presentation of the present framework has been contrasted and existing one for the accompanying local sizes, for example, 50 m by 50 m, 100 m by 100 m, . . ., to 500 m by 500 m against the number of rounds.

5. Results Comparison of Leach and Optimized Leach

The proposed hybrid model is compared to the basic LEACH [8] and the optimized LEACH [17] with node scalability. Table 2 shows the simulation model's initial settings. Motes placed randomly in the area of interest. As demonstrated in Figure 3, assuming that all of the nodes have the same initial energy level (0.3 J), the energy optimization of the enhanced LEACH is compared to LEACH and optimized LEACH. Packets sent from the cluster head to the base station and residual energy are observed after round numbers 100, 120, 140, . . ., 400 (0 : 3 J), and we compare their leftover energy in Figure 3. Table 3 shows the simulations results for energy remaining, data/communication packets and finally packets.

6. Conclusion

As shown in the graphs of Figure 3, LEACH has better outcomes in terms of initial, tenth, and whole nodes dead for the specified population. Proposed LEACH also has higher residual energy and sends more packets to the base station and cluster head. All of these factors lower energy usage and so extend network lifetime. The number of packets transmitted from the cluster head to the base station determines performance. The WSN lifetime can be balanced extended by the NN-LEACH algorithm that has been presented. In three different network settings, experimental results demonstrate that NN-LEACH surpasses its competitors GAECH, GCA, EAERP, and LEACH. Most real-time applications can benefit from the performance gain when the base station is removed from the network. In the best-case scenario, where the base station is not linked to the network, NN-LEACH exhibits a significantly longer lifetime than its equivalent. Additionally, we discovered that LEACH optimization reduces energy use by distributing it evenly among clusters by 5%.

Data Availability

The data used to support the findings of this study are available upon request.

Conflicts of Interest

The authors declare that they have no conflicts of interest.

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