PSO BASED NETWORK LIFE TIME IMPROVEMENT OF WSNS CONSIDERING RESIDUAL ALIVE NODES

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Abstract: Wireless sensor networks (WSN) are rapidly picking up ubiquity because of the way that they are possibly minimal effort solutions for an assortment of formal objections of real world. Their minimal cost gives a way to send huge sensor arrays in an assortment of conditions fit for performing both military and regular citizen assignments. In any case, sensor organizes additionally acquaint serious asset imperatives due to their absence of information and power. The lifetime of CH would be a very short span of time if the fixed node performs all the above responsibilities and it becomes essential to shift the cluster head periodically in a well-structured manner. Many optimization algorithms have been used to improve the performance of the leach protocol in which PSO is dominated one, gives better results than others. The drawback of PSO is that it takes more iteration to optimize due to fixed weight parameter used in the PSO equation. An adaptive weight parameter at each iteration can enhance the performance of traditional PSO. This research work implemented the improved PSO in which CH selection mechanism for WSN architecture based on residual energy and communication distance between the sensor nodes/base station. This work proposes a two levels hierarchical approach. In the first level, the division of the network is done into super clusters like the way LEACH does. We added a new method for cluster selection i.e., PSO (Particle Swarm Optimization). The simulation results show that MODPSOLEACH performs better than LEACH. Using LEACH, the first node's death occurs after 150 rounds and at 1164 rounds, all the nodes are dead. While activating MODPSOLEACH, the first node dies after 250 rounds and all the nodes' energy expire after 1529 rounds.

Index Terms- WSN, Particle swarm optimization, Leach Protocol, Cluster head selection, energy minimization etc.

I. INTRODUCTION

sensors. They capture information from the environment (pressure, temperature, etc...), and transform them into electrical signal in order to be treated by the processor unit [6]. After getting the information, the sensors either send it to other sensors or store it. Actually, resources of sensors must be optimized efficiently because of multiple limitations such as memory, data processing, power of communication and most importantly energy. In fact, energy is responsible for the lifetime of the sensors. It's essential to take care of this issue [13]. WSN (Wireless sensor network) is composed of several sensors. Each sensor sends the captured data to the base station. Actually, many application fields use WSN like Airport Logistics, Security, health, natural disasters etc. It is characterized by the following constraints: high bandwidth demand, resource constraints and application-specification [13]. However, routing protocols in WSN consume a high portion of energy. As a result, it affects the lifetime of the network. In fact, there are two kinds of routing protocols: Planning protocols and clustering protocols. The first kind considers all the nodes at the same level. Actually, this category includes multiple routing protocols such as Multipath routing ring, GPSR, multipath routing protocol etc. The second one organizes nodes into groups called clusters. Many routing protocols are ranged in this category, such as Leach, MG-Leach, M-Leach [14] etc.

Leach has several drawbacks even if it makes energy consumption a priority compared to plane multipath routing protocols. First, the cluster-heads communicate directly to the sink which causes congestion and high energy consumption of transmission. Then, the cluster heads that are far from the sink will not be capable to reach the sink. For this reason, multiple improvements of leach were developed to overcome these drawbacks. In this work, Particle swarm optimizer has been used to evaluate the set of cluster heads.

1.1 LEACH Protocol

LEACH protocol is a low-power adaptive routing protocol based on clustering. Its working mechanism is that all nodes take the responsibility of cluster head in turn. The purpose of the cluster head is to collect information and send it to the next cluster head until Gate Node (GN). Generally, the energy consumption of cluster heads is much higher than that of ordinary nodes. therefore, the rotation mechanism of cluster heads avoids excessive consumption and death of cluster heads, equalizes energy consumption between nodes, and extends the life cycle of the network [7]. In each election of cluster heads, those who have served as cluster heads before no longer participate in the election. Suppose that, at the beginning, a node randomly chooses a number between 0 and 1. If the random number generated by a node is less than T (n), it will become the cluster head of the current round. the expression of T (n) is as follows:

$$T(n)\begin{cases}\dfrac{p}{1-p\mathrm{X}(r \bmod(1/p))'} & if\ n<G,\\ 0, & \end{cases} \qquad (1)$$

Otherwise.

In equation (1), r is the current rounds, P is the percentage of nodes which become cluster heads, and G is the set of nodes that have not been elected cluster heads in the 1/P round before the current round.

1.2 Energy Model.

The node communication model and energy consumption formula of WSN (wireless sensor network) were proposed in literature [10] and are shown in Figure 1 and formula (2), respectively. When the transmission distance is d, the transmission energy consumption of k-bit information is

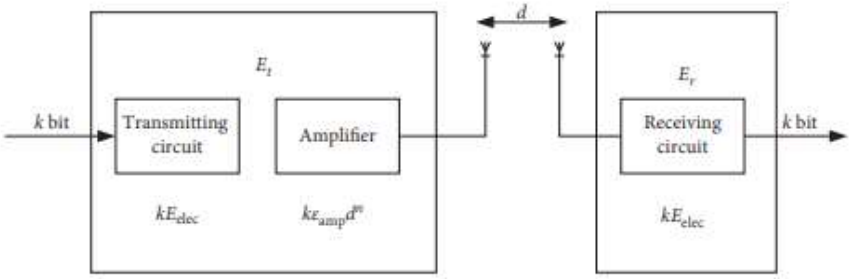

Figure 1: Node communication model diagram.

$$E_t = \begin{cases} kE_{elec} + ke_{fs}d^2, & d \le d_{0'} \\ kE_{elec} + ke_{amp}d^4, & d \le d_{0'} \end{cases} \quad (2)$$

$$d_a = \sqrt{\frac{E_{fs}}{\in_{amp}}}$$

In equation (2), $d \le d_0$ is a free space model and $d \ge d_0$ is a multipath attenuation model. In general, intra cluster calculations use d^2 and inter cluster transmission d^4. ε_{fs} is receiver sensitivity related amplification. E_{amp} is magnification energy related to the received noise image. E_{elec} is electricity related to factors such as digital coding. According to the above, the received energy consumption E_r can be defined as

$$E_r = kE_{elec} \quad (3)$$

WSN energy consumption mainly includes transmission energy consumption, reception energy consumption, idle energy consumption, and sleep energy consumption [11]. Research shows that receiving and transmitting energy are the main energy loss. In addition, during data transmission, many redundant nodes will appear. their idle energy consumption is far greater than the sleep energy consumption, so the sleep mechanism is used to the energy consumption of nodes in the cluster.

1.3 Particle swarm Optimization

J. Kennedy and R. Eberhart in 1995 [5] introduced the concept of Particle Swarm Optimization (PSO). At first, continuous nonlinear functions were solved by using PSO. The idea comes from bird-flocking. The basic idea is explained as under:

Consider a group of birds searching the n-dimensional space for its food and no ones knows where it is in the start but they know about the bird position which is close to the food. Hence all the rest followed the best bird nearer to the food. Hence PSO considers each bird as a particle in which its position can be given as

$$x_i = (x_{i1}, x_{i2}, x_{i3} \ldots x_{in}) \quad \ldots(3)$$

Initial solution are selected on random basis and then it tries to converges to the optimum solution after every new iteration. The objective function used to find the best optimum is called as fitness function which varies from one application to another. Also velocity of the particles needs to be evaluated in this which is represented as below

$$v_i = (v_{i1}, v_{i2}, v_{i3} \ldots v_{in}) \quad \ldots..(4)$$

It relates itself to the previous velocity best global and local known positions. It indicated the direction of the particle needed in the next iteration. The difference between them is that PSO use the history data other than crossover and mutation used in genetic algorithm.

The new updated velocity in PSO is given as under:

$$v_{d+1} = k * (w * v_d + \phi_1 . rand() * (p_{best} - x_d) + \phi_2 . rand() * (g_{best} - x_d)) \quad \ldots\ldots(5)$$

$$v_{d+1} = x_d + v_{d+1} \quad \ldots\ldots\ldots\ldots(6)$$

where w is the inertia weight factor, ϕ_1 and ϕ_2 are acceleration factors, rand () is a random value between 0 and 1. k is the constriction factor.

Acceleration factor decides the step size of the particle in the coming iteration.

The flow chart of the PSO algorithm is shown in figure 2.

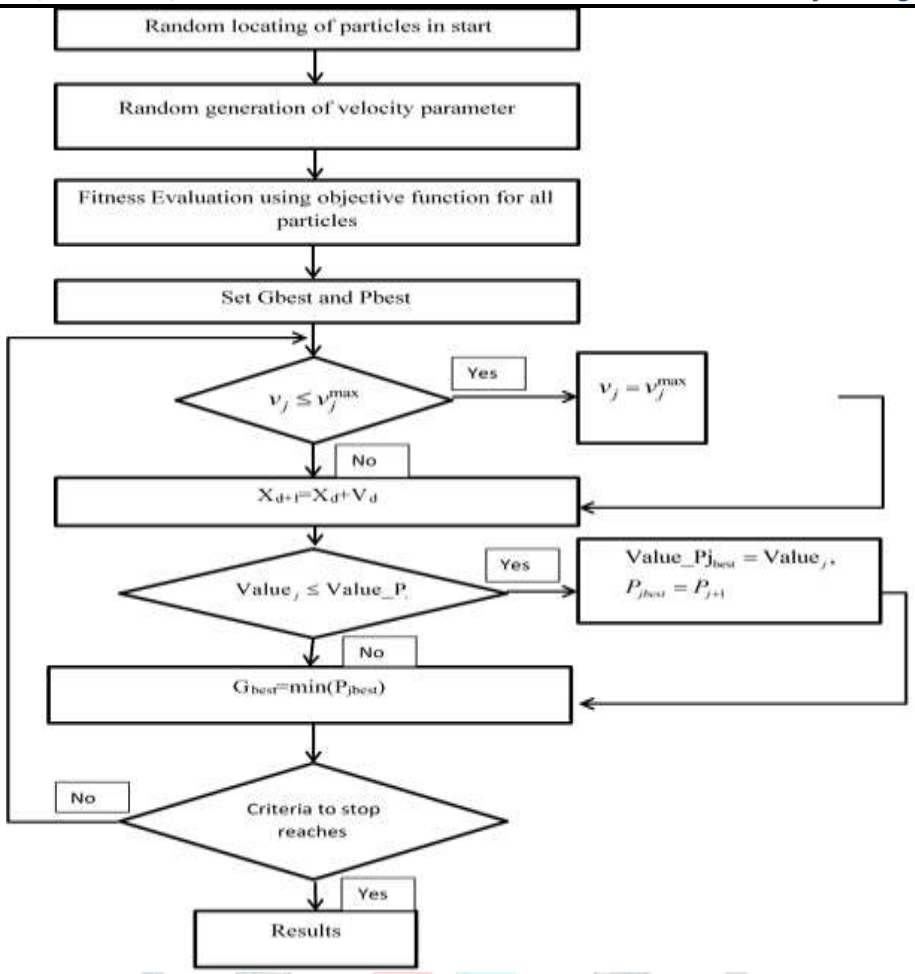

Figure 2: Flowchart of the PSO algorithm

II. EXISTED WORK

A. Yadav et al. [1] suggests an algorithm based on Particle Swarm Optimization (PSO) technique for improving network life time. It helps in forming the clusters as well as the Cluster Head (CH) selection. The proposed algorithm is extensively experimented and then the results of this algorithm are compared with the previously proposed algorithms such as LEACH, etc.

C. Vimalarani et al. [2] enhanced the network performance of the WSNs by various PSO-based clustering and cluster head selection scheme algorithms in terms of increasing the throughput, packet delivery ratio, residual energy, and number of active nodes. The enhanced PSO algorithm constructs clusters in a centralized manner within a base station and the cluster heads are selected by using PSO in distributed manner.

D. Rajendra Prasad et al. [3] proposed a MOPSODE for efficient clustering. Various network infrastructures as well as their routing protocols for reduction of power utilization as well as to prolong network lifetime are studied. After analysis, it is observed that network constructions that depend on clustering are the most effective methods in terms of power utilization.

Rejina Parvin et al. [4] proposed an Enhanced Optimized Energy Efficient Routing Protocol (E-OEERP). The individual nodes in WSN are eliminated by using Particle Swarm Optimization in the proposed work. This can be done by finding the fitness value of each and every node in the network. A new node called Cluster Assistant is introduced with Cluster Head in the proposed method. It acts as a coordinator node for the corresponding Cluster Head. Using Gravitational Search Algorithm, the parameters like distance and force between the sensors nodes are taken into consideration for finding the next best hop.

Azamuddin Abdul Rahman et al. [8] proposed a relay selection technique based on K-Optimal estimation to prolong the network lifetime of the 2-tier network. The relay selection approach selected the nearest relay nodes based on the distance threshold to effectively forward data to the BS while efficiently utilizing energy resources.

Riham S.Y. Elhabyan et al. [9] proposed a PSO inspired protocol. The protocol runs in two tiers: first one finds the best CHs and their associative clusters while the second tier solves the problem of the inter-cluster communication by finding the optimal routing tree. The protocol was developed and tested under realistic network and energy consumption model.

III. PROPOSED ALGORITHM

Leach protocol passes through different phases in the process. These are described as below

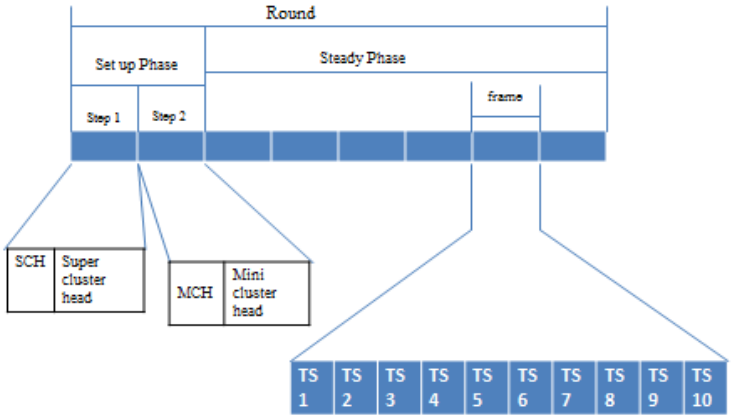

Figure 3: Time line operations of LEACH [12]

3.1 Initialization Phase

At first, the base station advertises its position by diffusing a packet that contains its position to the network using the maximum transmission of energy. When a sensor receives the packets, it saves the position of the sink and the signal strength of the received packet. Then, the node starts the election process. If it elects itself as a cluster-head, it retransmits the packet by adding its coordinates. Thus, the formation of clusters begins. The stored position of the sink will help the cluster-head to decide whether or not to send data directly or not.

1.2 Cluster head selection

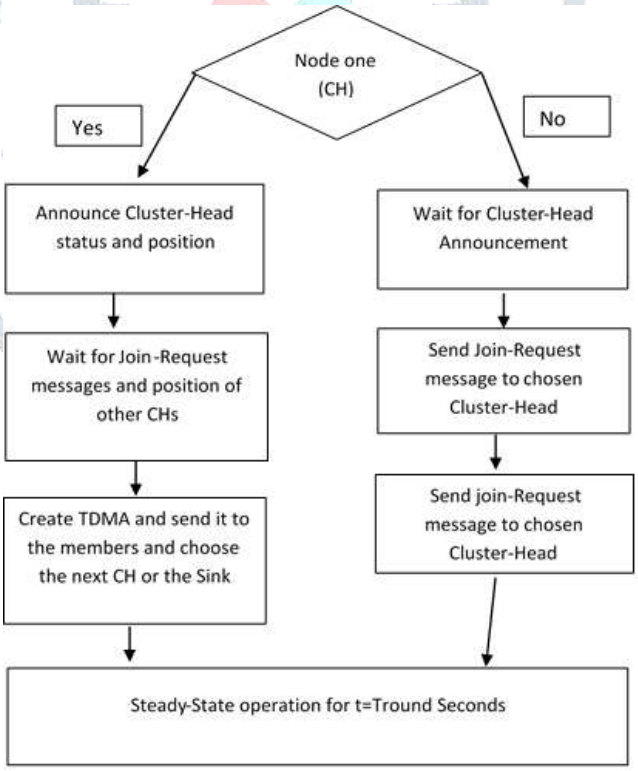

Figure 4: Criteria of CH selection

In this step Particle swarm optimization is used to find the set of clusters which are feasible as set then the remaining depending upon the minimum energy used when packets are sent through them to the base station.

Update Process The update process is initiated by the Sink. By sending the update packet to all accessible Cluster-heads, who receive the packet measure the throughput of the link. Then, they broadcast the same packet with the measured debit.

3.3 Transmission process

In this phase, the cluster-heads transmit their data to the base station if it is the closest node. However, it sends them to the intermediate cluster-head if the sink is not reachable. If a cluster-head receives a packet, it saves it until its turn comes.

IV. RESULTS AND SIMULATION

Table 1: Simulation parameters used in the experimentation

parameters	Value	Description
x_m, y_m	400m,400m	diameters of sensor network
E_0	0.5J	energy supplied to each node
E_{TX}	50×0.000000001 J	transmitter energy per node
E_{RX}	50×0.000000001 J	receiver energy per mode
E_{DA}	5×0.000000001 J	energy consumed for data aggregation
E_{amp}	0.0013Pj/bit/m^4	amplification energy when d is greater than d0
E_{fs}	10Pj/bit/m^2	amplification energy when d is less than d0
l	4000bit	data packet size

4.1 Simulation

Simulation is conducted using MATLAB (R2018b) confidence interval is taken to get precise plots. First of all, a field is taken having a network with 100 nodes distributed randomly in a square region (400m * 400m). The core idea of LEACH protocol is to divide the whole wireless sensor networks into several clusters. Initially, all nodes have same energy. The cluster head node is randomly selected, the opportunity of each node to be selected as cluster head is equal, and energy consumption of whole network is averaged.

4.2 Results

In experiment, our field dimension is 400m x 400m.

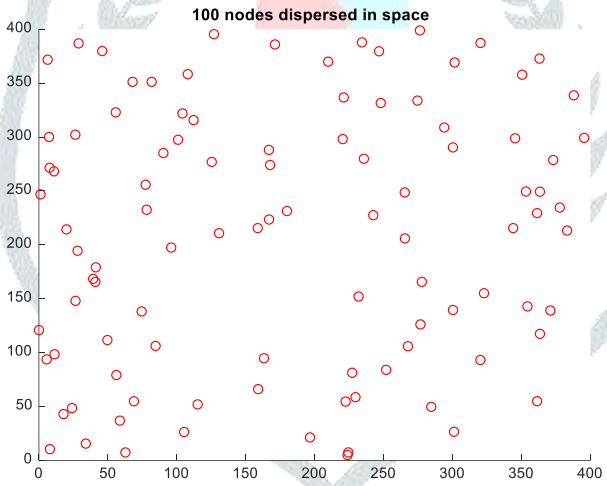

Figure 5: 100 nodes dispersed in space

Therefore, LEACH can prolong network life-cycle. LEACH algorithm is cyclical; it provides a conception of round. LEACH protocol runs with many rounds. Each round contains two states: cluster setup state and steady state.

Table 2: Difference between cluster setup state and steady state

Cluster setup state	Steady state
It forms cluster in self-adapt	It transfers data
The selection of cluster head depends on decision made 0 and 1 mode	The time of steady state is usually longer than the time of setup state for saving the protocol payload

Cluster heads are selected randomly at each round. There are certain requirements that a node needs to become cluster head. Nodes must have sufficient energy that is required to become a cluster head and also they must not far away from BS.

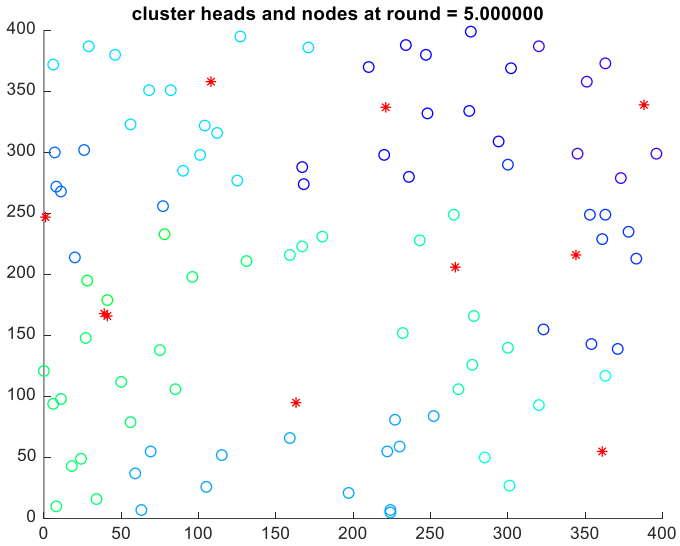

Figure 6: Cluster heads at round 5.

Considering network lifetime of LEACH and MODIFIED PSO LEACH, lowest performance is shown by simple LEACH as compared to MODIFIED PSO LEACH. As it has greater stable period due to efficient cluster head allocation scheme. All the schemes usually use same system of cluster head formation and calculation technique. However, I have divided the area into two parts for same base station to take better results so that energy can be conserved.

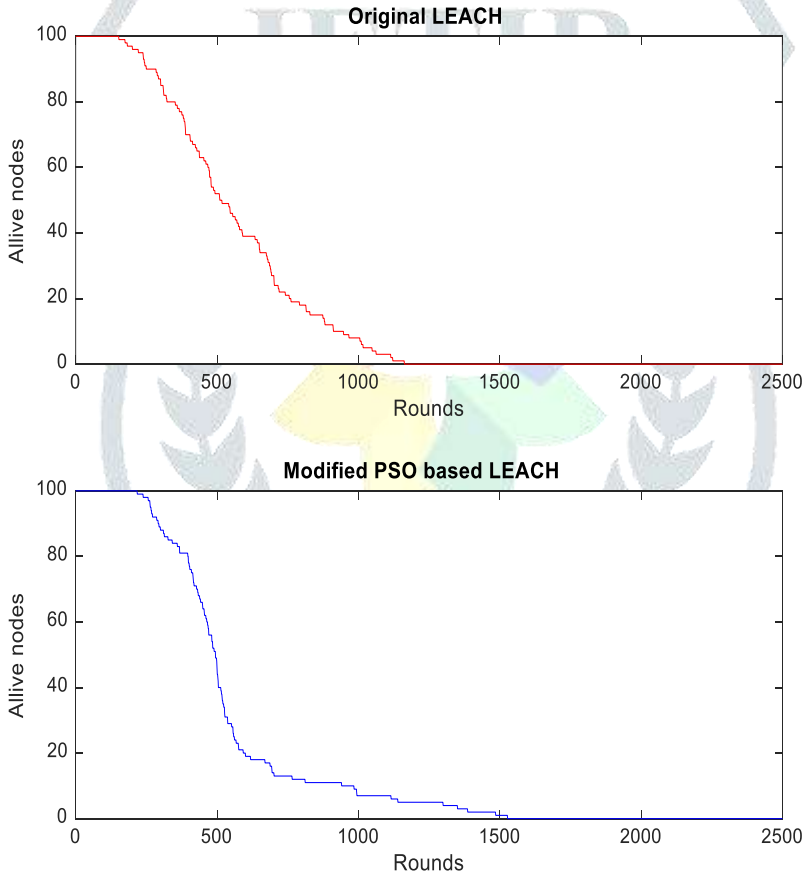

Figure 7: Comparison for alive nodes

In LEACH, the number of CH nodes is randomly picked wish makes the number of nodes in the formed clusters obviously unequal. Since the network delay depends on the nodes number in the cluster, the bigger is the cluster size (in terms of nodes number), the more important is the delay. This can lead to significant delays when using LEACH due to the fact that the formed clusters, having unbalanced sizes, can be very dense with many members and consequently many traffic flows which induce significant delays. However, when using MODPSOLEACH, the former super clusters and mini clusters are more balanced in terms of number of member nodes. In addition to its superiority in terms of delay over LEACH, we want to show how power conservative is MODPSOLEACH.

Table 2: Comparison of conventional and proposed LEACH

	Old LEACH	**MODIFIED PSO based LEACH**
All Dead nodes	1164 rounds	1529 rounds
Packet to base station	6965	14434
Packet to cluster head	49382	40318

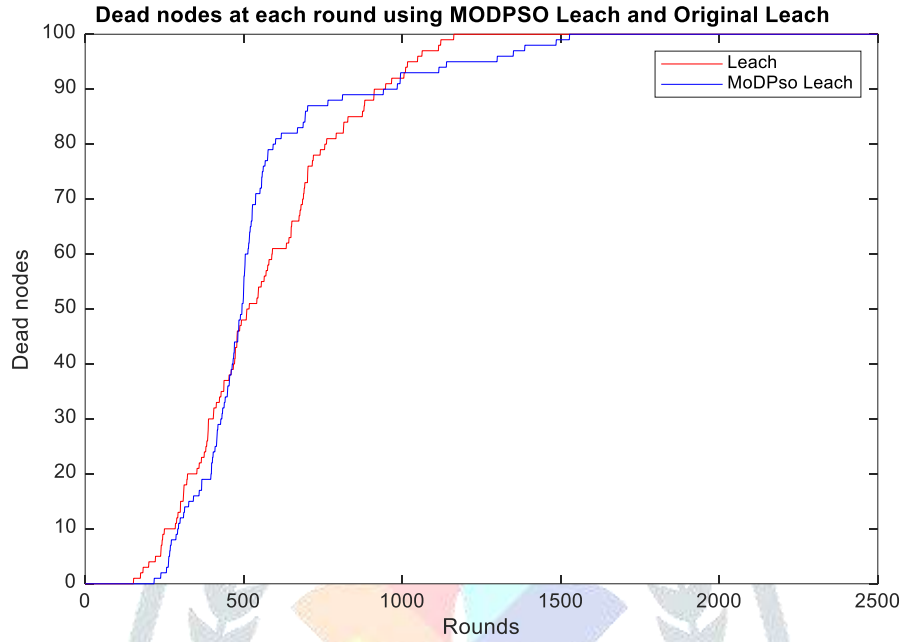

Figure 8: Dead nodes at each round using MODPSO Leach and Original Leach

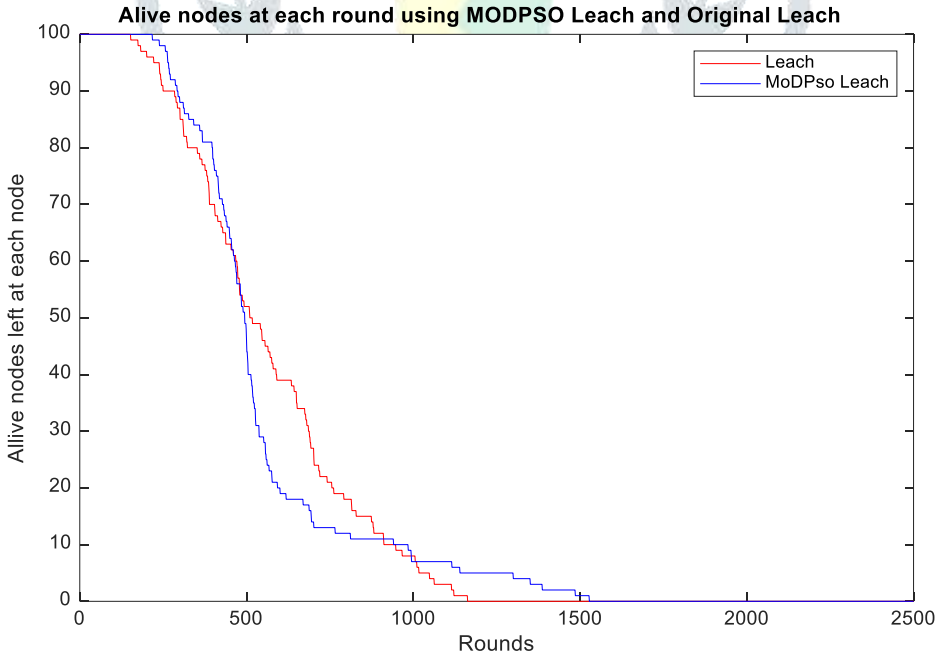

Figure 9: Alive nodes at each round using MODPSO Leach and Original Leach

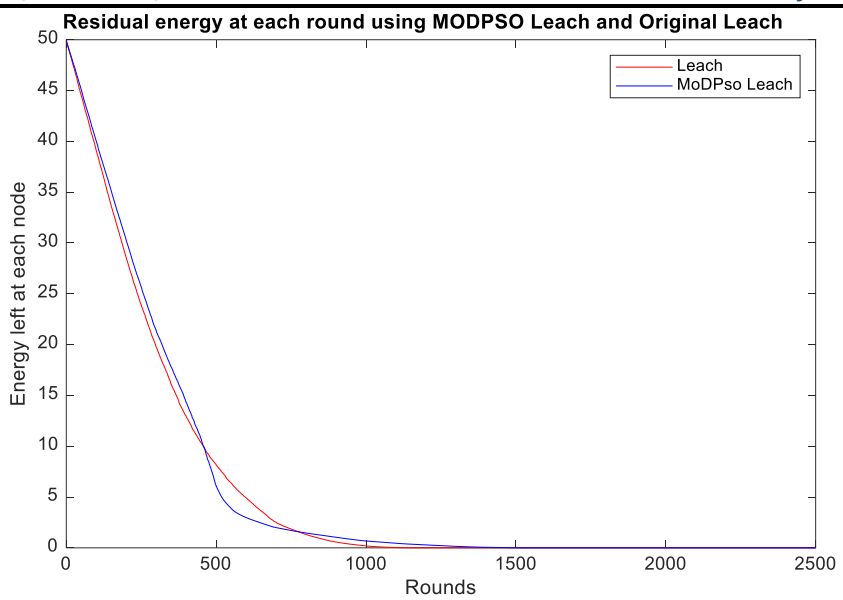

Figure 10: Residual energy at each round using MODPSO Leach and Original Leach

It has been concluded that MODPSOLEACH outperforms LEACH in terms of energy during all the studied rounds. Compared to LEACH, MODPSOLEACH stands out even when the number of rounds is important. LEACH fails to perform well when we increase the number of rounds which enlarge the difference between the studied mechanisms in terms of energy consumption. This energy consumption gain is mainly achieved by the two hierarchical routing structures in MODPSOLEACH instead of direct transmission strategy relative to LEACH. In addition the use of residual energy when electing the cluster head nodes increases the lifetime system.

The simulation results show that MODPSOLEACH performs better than LEACH. Using LEACH, the first node's death occurs after 150 rounds and at 1164 rounds, all the nodes are dead. While activating MODPSOLEACH, the first node dies after 250 rounds and all the nodes' energy expire after 1529 rounds.

5. Conclusion

The main problem in WSNs is controlling energy consumption across the whole network. The limitation of energy resources is major issue in every wireless device. This issue is particularly amplified in WSNs due to some reasons as A WSN comprises many nodes. Therefore, recharging or replacing batteries is almost impossible. WSNs may be deployed to inaccessible places. and are responsible for complex tasks such as sensing, processing, self-organizing, and communication. The failure of a few nodes leads to the manifestation of independent clusters. For these reasons, network lifetime constitutes a crucial factor in WSNs, requiring more investigation before improvement. Hence a moderate clustering algorithm should fairly distribute energy consumption in the entire network. As cluster head selection and selection of their number depending upon remaining nodes play a major role in energy consumption, a modified PSO based algorithm has been proposed in this work. PSO initializes random cluster head sets from which it tries to pick the most suitable combination after each iteration of running as objection function has been set the sum of total energy used when a particular set can deploy in field. The simulation results show that MODPSOLEACH performs better than LEACH. Using LEACH, the first node's death occurs after 150 rounds and at 1164 rounds, all the nodes are dead. While activating MODPSOLEACH, the first node dies after 250 rounds and all the nodes' energy expire after 1529 rounds.

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