Swarm energy efficient power efficient gathering in sensor information systems protocol in wireless sensor networks

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ABSTRACT

Wireless sensor network (WSN) is a network, which has more numbers of sensors that are small in nature and are self organised. The inbuilt battery system is provided in the sensor nodes through which the nodes can communicate and do good operations among the other nodes available in the network. Lifetime is the most essential parameter which needs to be maximised for the WSN. This measure is more important for conservation of energy, for adequate and efficient performance of sensor networks. This paper proposes a swarm energy efficient power efficient gathering in sensor information systems (PEGASIS) (SEE-PEG) based energy optimization algorithm for WSN in which clustering and clustering head selection are done by using modified particle swarm optimization (MPSO) algorithm with respect to minimizing the consumption of power in WSN. The parameters evaluated for the proposed method is compared with existing technique like energy efficient PEGASIS without optimization. The simulation results are obtained using matlab tool.

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1. INTRODUCTION

In twenty first eras wireless sensor network (WSN) gaining more and more importance and the research has been widely processed in this field by the researchers. The network fields for performing wireless communications are made with sensor nodes and the network consists of batteries with lower power [1], [2]. The sensor nodes deployed in the network have a lower supply of power and the nodes are designed to detect data, acquire information and the communication is performed wirelessly. The sensor nodes are the element which determines the life span of the network. One of major problems in the WSN is consumption of energy, to maximize the lifetime of the network many techniques are suggested by the researchers.

The sensor nodes which are available in the network are made with low battery power, microcontroller, external memory, transceiver and some sort of sensors. In these elements most of the power is used by the transceiver as the transceiver has four sets of operational modules. The four modules are idle, sleep, broadcast and receive. Among these modes the same amount of power is consumed by idle and receive mode. One of the energies saving modes is to turn off the transceiver module when the data is not been broadcasted or received [3]. The network remains active when there is sufficient power stored in the battery of sensor nodes. The more the energy dissipated the lifetime of network gets shorter. Thus, the major goal of all routing protocols devised thus far is energy consumption education and network lifespan enhancement. The WSN connects scattered nodes to detect field data [4], [5]. The information in the network is gathered by the sensor node is transmitted to the destination node and is said to be base station. The traffic nearby base station is boosted which leads to higher usage of energy. Clustering was used in WSN to lower the amount of energy consumed. Sensor nodes were coupled to generate various clusters based on some parameter in clustering-based protocols. The network also consists of clusters and the master cluster is known as cluster head (CH). Each cluster has a master known as a CH, and instead of communicating with the base station in a single hop, the CH were in charge of providing aggregated data to the target node [6]. The clustering in WSN is shown in Figure 1.

Clustering is an essential approach in WSNs for boosting lifespan of thenetworks and the scalability [7], [8]. Clustering is the process of grouping sensor nodes into different clusters and electing CHs for all accessible clusters in the network. To choose appropriate CHs, many routing techniques have been developed. Choosing adequate CH is a difficulty in WSN. Two major routing protocols used by researchers in the field of WSN are low energy adaptive clustering hierarchy (LEACH) and power efficient gathering in sensor information system (PEGASIS). The LEACH protocol is a progressive cluster-based routing system in which numerous groups of nodes are established called clusters, and each cluster has one master node called the CH. The information perceived by the other nodes in a cluster is sent to their corresponding master node (CHs). The base station receives the fused data from the CH, so that the traffic near the base station will be reduced which leads to saving of energy. The energy consumed by the sensor node during this process is low. The PEGASIS protocol gives the chaining notation structure. The sensor nodes present in the work are connected in the form of chains using the PEGASIS protocol. Figure 2 depicts the whole taxonomy of cluster-based routing techniques in wireless sensor networks.

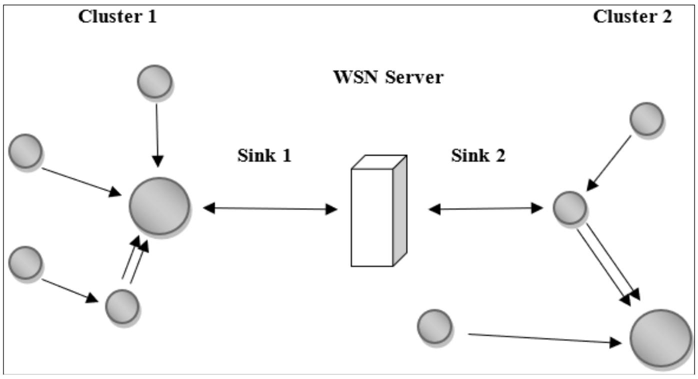

Figure 1. Wireless sensor networks

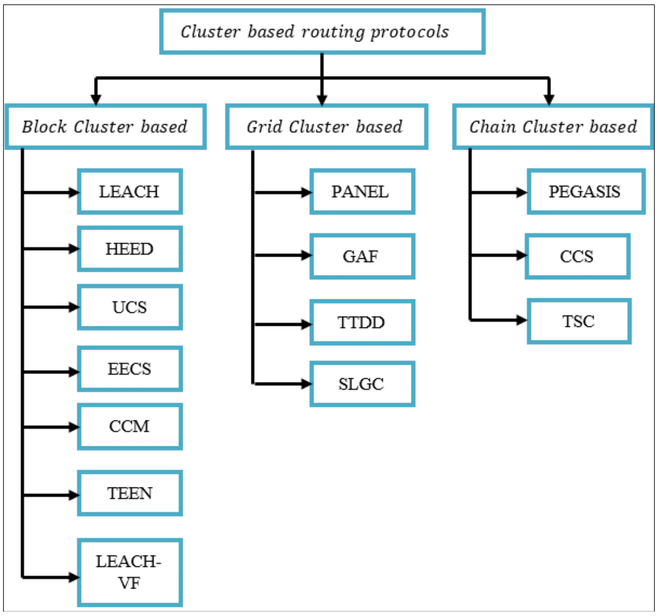

Figure 2. Classification of cluster-based routing protocol

2. RELATED WORK

A wireless sensor network (WSN) is made up of tiny low-energy sensing nodes that may detect phenomena and communicate the data to a sink. Micro electromechanical systems (MEMS) technological advancements have resulted in the creation of low-cost, multi-functional small sensor nodes that require less power. WSNs are essentially data collection networks in which the data is strongly correlated, and the end user requires a high-level description of the environment felt by the nodes.

WSNs are utilized to detect scope approach or the state of physical things such as bridges, allowing for proper response and avoiding potential harm. Because battery recharge may be difficult, the network has higher energy efficient nodes based on the protocol used in WSN.

The power units help the sensor nodes to operate, without the help of power unit the sensor nodes do not work. There are two critical parameters linked with each sensor node:

- Sensing range (S_R): The range which the sensor node can observe the phenomenon and the maximum distance limit sensing is termed as sensing range.
- Range of Transmission (T_R): The maximum range that a sensor node can transmit the information or data is termed as T_R.

In design of WSN the most difficult tasks are to provide a protocol that allows the randomly distributed number of sensing units to operate collaboratively, cooperatively, coordinated and organized. Every node transfers the information to its nearby node followed by sink. When compared to traditional communication networks, the protocol design for routing in the network becomes extremely important in the case of WSNs [9]. Hierarchical routing protocols or clustering, among the different suggested network routing protocols, significantly provides the scalability for the system contribute to system scalability, longevity, and efficiency of energy [10]. Kim *et al.* [11] the author proposed LEACH protocol to improve the efficiency of the network.

Clustering is a helpful approach in WSNs for dealing with scalability issues. Clustering, when paired with data aggregation, has the potential to improve the network's energy efficiency. Furthermore, by allocating a particular function to the CHs, clustering makes the network more resistant and prone to assaults [12]–[15]. In a WSN with direct communication, sensor nodes send their perceived data straight to the sink without any coordination between the two. However, with cluster based WSNs, the network is separated into clusters. The communication of information at node is done with the CH which sends the total data to the base station [16], [17]. Data aggregation at CHs reduces the quantity of data delivered to the BS significantly, conserving both energy and bandwidth resources [18]. WSN operates more efficiently when the clustering technique is effective. The key obstacles are to arrange CHs equally for the entire network and control the dissipation of energy caused by the exchange of information between the nodes and CH [19].

The CH selection technique is the most crucial phase of routing protocol which arecluster-based because it provides consistent energy allocation across sensors, hence prolonging the sensor network (SN) lifespan [20]. Once the CHs are discovered, they establish a backbone network to gather, consolidate, and send data to the BS on a regular basis utilising the least amount of energy (cost) routing. When compared to other existing ways, this strategy dramatically increases network longevity. In this instance, certain outliers may form that are not connected to any of the CHs despite being in the transmission range. This technique handles CH selection using the unique node idea [21]–[23]. A unique node is one that is not linked to any other CHs. For the selection of CH in WSN, the method suggested in this study employs two parameters: the number of surrounding nodes and the residual energy. The protocols initially construct the top level of clusters based on this global information by selecting specific nodes as CHs. The remaining nodes are then grouped as cluster members into the specified cluster. Many algorithms choose the CHs at random. In such a circumstance, the CH's energy may be lower than that of its member nodes. Such CH may die off soon, resulting in clusters of low quality. Our study is motivated by the need to provide efficient clustering without requiring global network information by reversing the clustering technique from top-down to bottom-up [24]. To do clustering, location data is often utilised to compute the distance between sensing nodes. This is referred to as quantitative agglomerative hierarchical clustering. However, location data may not always be accessible [25] owing to factors such as GPS failures, the expense involved, or the time required determining the exact location of the sensors. This is referred to as qualitative agglomerative hierarchical clustering. The current study examines several agglomerative techniques for qualitative and quantitative data.

Kaur and Bajwa [26] suggested employing BFO in chain for enhanced PEGASIS. When compared to alternative chain building strategies, such as PEGASIS, which builds chains using a greedy algorithm, the performance of the suggested method is shown to be superior. ReLeC protocol, a reinforcement learning-based, clustering-enhanced method for energy-efficient routing in WSNs and maybe other geographically dispersed IoT networks, is proposed by the author in [27]. The protocol uses clustering and RL to try to find a reliable data transmission path. For applications devoted to structural health monitoring in the construction sector, Yen *et al.* [28] explored the creation of the idea of "communicating concretes," which are concrete components integrating wireless sensor networks. Sleep mode and the data aggregation process are both considered in a chain-based data gathering technique that is provided. The threshold sensitive energy efficient sensor network (TEEN) protocol was proposed by Kumar *et al.* [29]. Reactive protocols like TEEN and directed query dissemination (DirQ) are used to cut down on transmissions by only allowing nodes to send when a detected property is within a certain range of interest.

3. PEGASIS PROTOCOL

Among the two major protocols in WSN, PEGASIS having more benefited when compared to LEACH. The faults in LEACH are being updated in PEGASIS. The main advantage of this protocol is its network longevity as it the follow the chaining principle for performing the operation. The chain is developed between the sensor nodes. The nearby nodes form a chain and extend to node situated at longer distance. In Figure 3, the illustrations of transmitting data using PEGASIS areobserved. The information is first detected by C0 and is transmitted to C1. The C1 receives the input data and mix the data with its own discovered data and send to next node C2. Here C2 is termed as leader node. The leader node is situated in center of nodes and near to base station. The leader node sends data to the base station. In same process the data is sent by C3 to C2 and C2 sends to base station. The energy consumed at every node will be less and overall energy consumption of network for transmitting the data from source to destination will be reduced. Hence when compared to LEACH the PEGASIS attains good performance in terms of energy efficiency. The CH aggregates data in LEACH, but no data fusion occurs in PEGASIS.

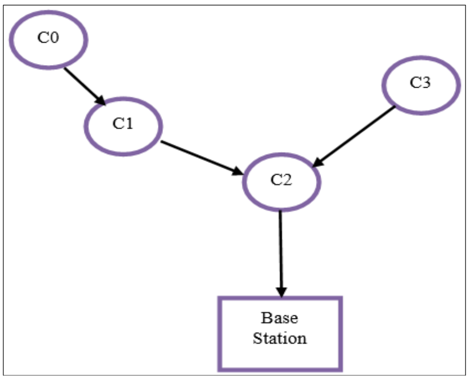

Figure 3. PEGASIS based transmission of data

4. PROPOSED METHOD

Distance is one of the important parameters in WSN for saving of energy. The distance between nodes and CHs or sinks need to be visualized and calculated for making the network efficient. The above problem is solved by using multiple sinks in a WSN.The current research work concentrates on two basic aspects related to multiple sinks WSN, namely:

A. Finding optimal number of sinks.

B. Finding the position of sinks

- Step1. Network clustering
- Step2. Selection of cluster head (CH)
- Step3. The optimum routing path needs to be identified
- Step4. Transmission of data from one node to another using single or multiple hops.

Each node in a chain transmits and accepts data from the node immediately adjacent to it. As a result, the information received is passed from node to node before being sent to the base station via a selected leader node. Following study, it was shown that this notion of chaining using greedy technique is highly effective.

4.1. Swarm energy efficient process

Initially the distance between the sink and nodes are calculated. To identify the CH, we propose optimization technique to find the global best node. The swarm optimization techniques are used to find the energy efficient CH selection for transmission of data. The major problem such as routing, and CH selection is solved using PSO technique. Here the modified PSO is designed for better improvement of proposed work. In this modified PSO we choose two swarms and calculate the distance and velocity based on two swarms.

Consider initial swarms as x, y, Let the starting position of I_{start}. The distance travelled by the swarms isdis_1, dis_2. The final position of the swarms with respect to their distances is given by:

$$S_{position} = \frac{I_x + I_y}{2} \quad (1)$$

now the position of the swarms will be updated based on local best to update the global best value. For velocity in PSO is having less potential in generating the best solution. The velocity is modified and updated to find the best optimal result. Now the velocity of the swarms which are considered in searching is given by,

$$Vel_x = |C.I_x(t) - I(t)| \quad (2)$$

$$Vel_y = |C.I_y(t) - I(t)| \quad (3)$$

the position is updated as,

$$Position_1 = I_x - B.Vel \quad (4)$$

$$Position_2 = I_y - B.Vel \quad (5)$$

where B and C are the vector coefficients which are calculated as,

$$B = 2b.r_1 - b \quad (6)$$

$$C = 2.r_2 \quad (7)$$

b is linearly decreased from 2 to 0 over thecourse of iterations and r_1, r_2 are random vectors.

It is advantageous to enhance the particle's location. However, there is still the possibility of slipping into a local optimum solution when using PSO to determine the new position. To improve its exploration capability, the algorithm must be able to create random solutions in the search space with a low probability. Based on the above considerations, the following new position may be generated.

$$Position_{best} = \frac{Position_1 + Position_2}{2} \quad (8)$$

Based on the above position the best CH is selected, which nodes are more energy efficient and the node which is nearest in the chain is identified and selected as CH. The Figure 4 shows the model of the work progressed. The modified optimization technique is used for selection of CH and for cluster formation process. Algorithm 1 shows the swarm energy efficient optimization algorithm for wireless sensor networks.

Algorithm 1. Swarm energy efficient optimization algorithm for wireless sensor networks

1. Initialization
2. Initialise swarm population of N particles X_i (i=1,2,3......, n)
3. for i=1,2,3,.....,n do
4. Generate swarms randomly based on the velocity and position
5. Calculate fitness value of each swarm
6. If a particle's present position is better than its previous best position, update it.
7. Identify the best swarm
8. Renew the current location of swarm
9. Update the particles velocity
10. end for
11. Update the position of swarm
12. Rank the swarm and find the current best
13. Cal new fitness value and estimate the fitness value of remaining swarms
14. Check for stopping condition i.e., whether the IterreachesItermax, if yes, print the best value of solution otherwise go to step 5
15. Update the position of current search agent
16. Update the search agent
17. Insert new swarm to the population
18. Output the best value found
19. Apply the best value to find cluster head (CH)
20. Cal corresponding parameters like packets to CH, packets to BS, alive nodes, dead nodes, throughput, and Residual Energy.

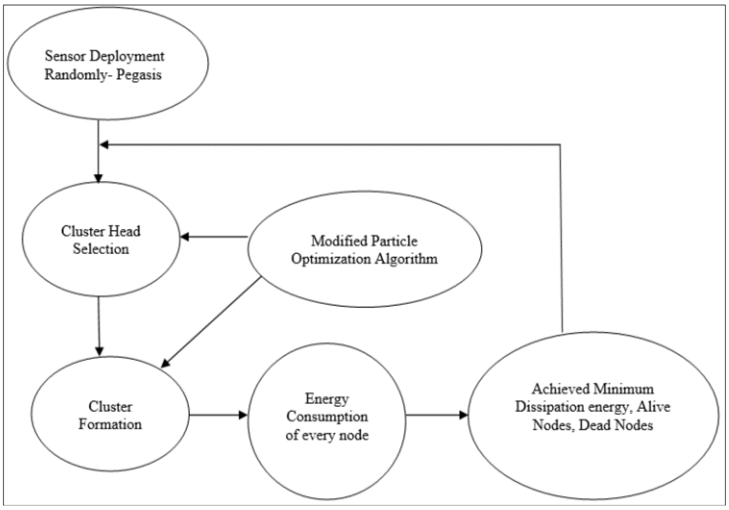

Figure 4. Proposed model of the system

The energy model is an important one in setting up the value of the energy loss during the process of transmitting and receiving of information. The network model has few assumptions on plot area, sensor nodes and other constraints. On the other hand, CH selection gives the information of how PSO is applied for our problem considered. The flowchart of the proposed system is shown in Figure 5.

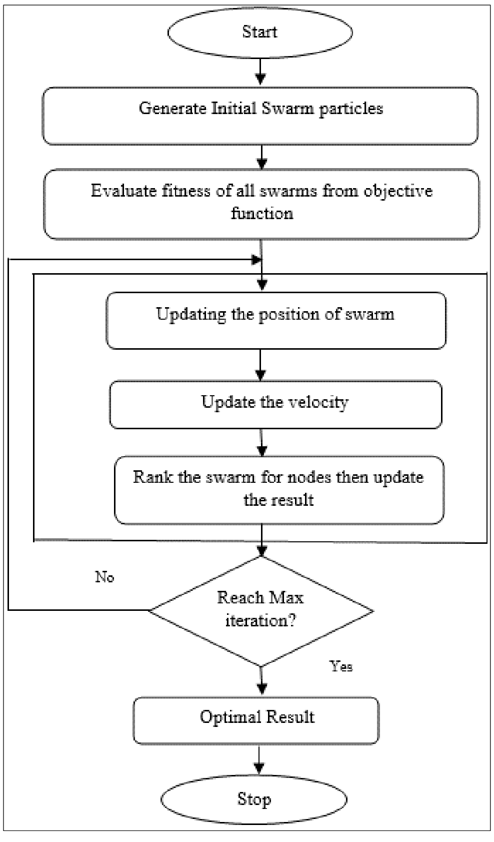

Figure 5. Flowchart of proposed system

5. RESULTS AND DISCUSSION

The simulation results are obtained using matlab tool. The environment consists of 100 nodes with a network size of 100×100 meters. The comparison is done between energy efficient PEGASIS and swarm energy efficient PEGASIS (SSE-PEG). By applying modified swarm optimization technique the network life time is increased and is shown in below simulation results. The parameters considered for performing simulation operation is shown in Table 1. For the parameters shown in Table 1, the obtained simulation results are shown in below Figures.

Table 1. Parameters set for simulation

Parameter	Value
Size of the network	100×100 meters
Nodes in network	100 numbers
Starting energy of node	0.5 J
Total energy for transmitting and receiving of data	50 J
Distance between the available nodes	50 m
Data considered for transferring	2,000 bits

5.1. Case 1

The performance output is considered for 100 number of nodes. Figure 6 shows the sensor node distribution of the network. From Figure 7 it is shown that proposed swarm optimization as good level of energy compared to EE-PEGASIS. If we consider 2,000 rounds for comparison the energy remained modified SEE-PEGASIS is around 10 J, whereas energy remained using EE-PEGASIS is 4 J. The energy becomes zero when 3,500 rounds are done for EE-PEGASIS, whereas the energy remained upto 5,000 rounds using modified SEE-PEGASIS. From Figure 8 it is shown that using swarm optimization alive nodes at 5,000 rounds is 4 nodes, whereas EE-PEGASIS approach the number of alive nodes is 0 nodes. This shows the nodes death rate is slow in proposed techniques compared to the existing technique. From Figure 9 it is shown that all the nodes are dead at around 4,600 nodes using EE-PEGASIS, modified SEE-PEGASIS the nodes are dead around 5,500 rounds, whereas using EE-PEG, the nodes complete zero after 8,000 rounds. The number of roundsare increased using proposed technique by which the data transmitting rate will be increased.

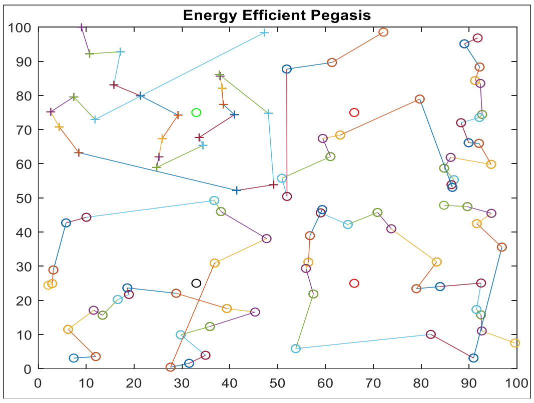

Figure 6. Sensor node distribution

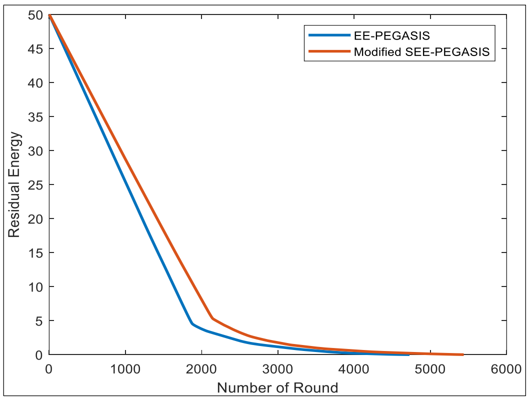

Figure 7. Residual energy (J) vs no of rounds

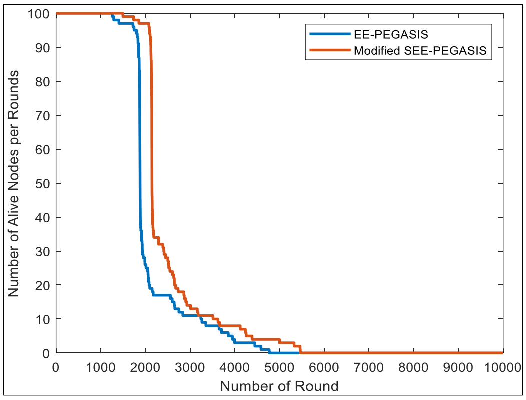

Figure 8. No of alive nodes vs no of rounds

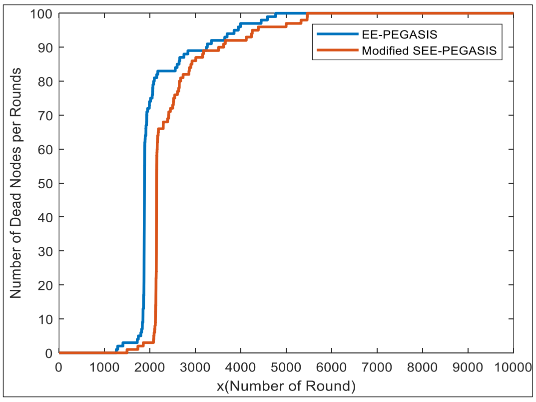

Figure 9. Number of dead nodes vs number of rounds

5.2. Case 2

The performance results obtained using 200 number of nodes are shown below. From Figure 10 it is shown that using Swarm optimization number of alivenodes are 20 nodes after reaching 5,000 rounds whereas in EE-PEGASIS approach the number of alive nodes is 10 nodes. This show the alive nodes are more active in proposed techniques compared to the existing technique. From Figure 11 it is shown that the nodes are completely dead after 6,200 round using modified swarm optimization and using EE-PEGASIS the nodes are completely dead after reaching 5,000 rounds. From Figure 12, if we consider 5,000 rounds for comparison the energy remained using modified SEE-PEGASIS is around 10 J, whereas energy remained using EE-PEGASIS is 3 J.

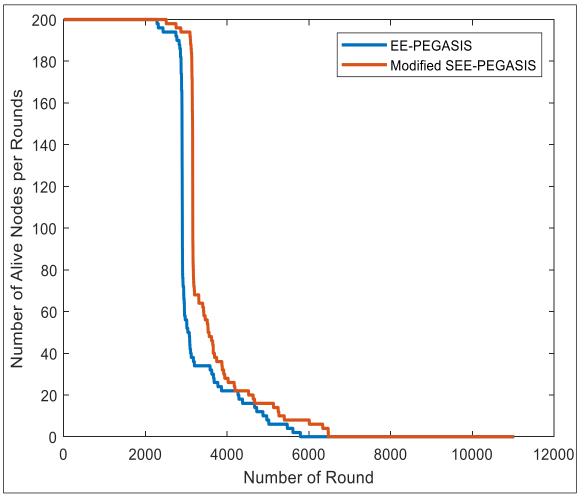

Figure 10. Number of alive nodes vs number of rounds

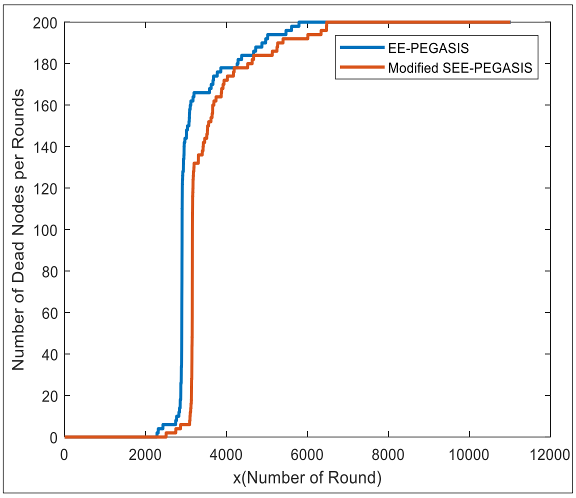

Figure 11. Number of dead nodes vs number of rounds

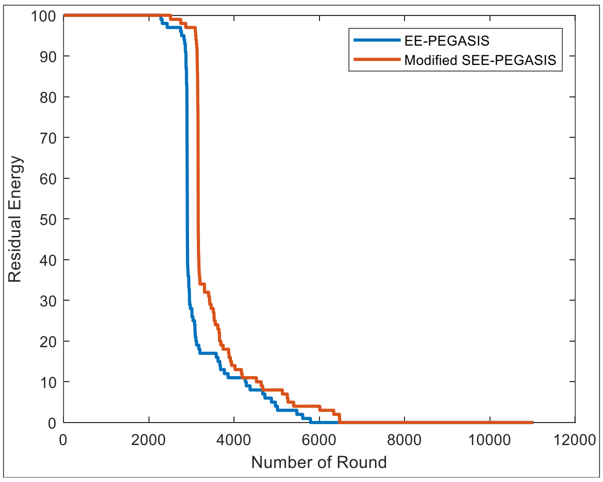

Figure 12. Residual energy vs number of rounds

5.3. Case 3

The performance results obtained by Considering 500 nodes, the results obtained are shown in Figures 13-15. Using modified SEE-PEGASIS, residual energy is around 25 joules where as energy remained using EE-PEGASIS is 10 joules. The delay in EE-PEGASIS is 16.93 sec whereas in SEE-PEGASIS is 15.07 sec. The number of dead nodes in EE-PEGASIS is 480 whereas in SEE-PEGASIS is 455. The number of alive nodes in EE-PEGASIS is 20 whereas in SEE-PEGASIS is 45.

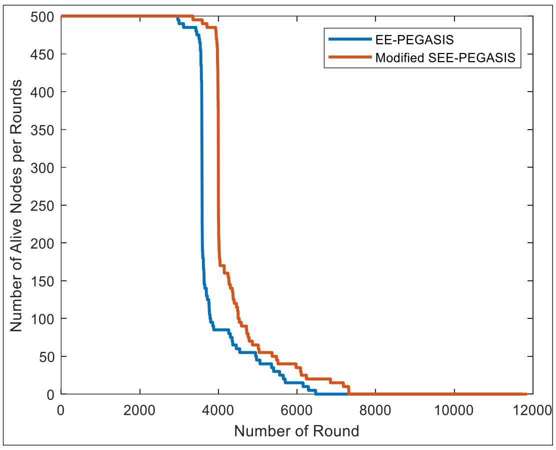

Figure 13. Number of alive nodes vs number of nodes

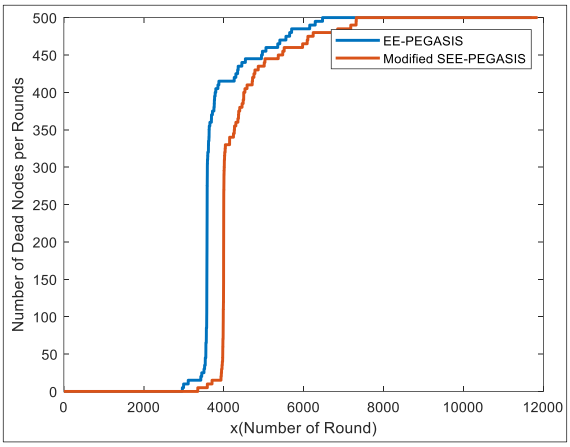

Figure 14. Number of dead nodes vs number of rounds

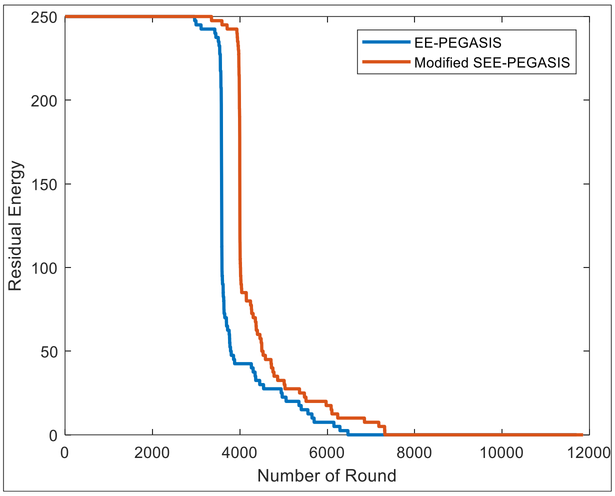

Figure 15. Residual energy vs number of nodes

In Table 2 the comparison of results is shown. The parameters shown are residual energy, number of dead nodes and number of alive nodes. The values are tabulated by considering 2,500 number of rounds for 100 nodes. From the Table 2 it is clear that proposed SEE-PEG retains its energy level for more number of rounds and also the number of alive nodes is higher compared to existing method. The Table 4 values are tabulated by considering 6,000 number of rounds for 500 nodes. The Table 3 values are tabulated by considering 5,000 number of rounds for 200 nodes. From Table 5, the proposed Improved ant lion optimization techniques provides high energy efficiency as the number of node present till 5,462 round performed by the wireless communication system while transmission of data.

Table 2. Results comparison for 100 nodes

Parameters	EE-PEGASIS	SEE-PEGASIS
Residual energy	3 J	9 J
Number of alive nodes	18	30
Number of dead nodes	82	70
Throughput (%)	82.96	86.3
Packet delivery ratio (%)	84.79	88.4
Delay (Sec)	18.87	17.11

Table 3. Results comparison for 200 nodes

Parameters	EE-PEGASIS	SEE-PEGASIS
Residual energy	4 J	10 J
Number of alive nodes	10	18
Number of dead nodes	190	182
Throughput (%)	82.87	86.49
Packet delivery ratio (%)	84.41	88.69
Delay (Sec)	17.39	16.44

Table 4. Results comparison for 500 nodes

Parameters	EE-PEGASIS	SEE-PEGASIS
Residual energy	10 J	25 J
Number of alive nodes	20	45
Number of dead nodes	480	455
Throughput (%)	82.89	86.65
Packet delivery ratio (%)	84.97	88.56
Delay (sec)	16.93	15.07

Table 5. The nodes status based on rounds

Parameters	EE-PEGASIS			SEE-PEGASIS		
	100	200	500	100	200	500
First dead nodes	1,490	2,283	2,966	1,735	2,509	3,352
Half dead nodes	2,079	2,903	3,586	2,345	3,158	4,401
Last dead nodes	4,767	5,791	6,474	5,462	6,475	7,318

6. CONCLUSION

Wireless sensor networks are one of the most modern technologies that are being utilised for a variety of applications such as landslide detection, military applications, health monitoring, and so on. To improve the longevity of the network many researchers are developing various techniques. In this work, first a hierarchical protocol called LEACH, while the second is a chaining protocol called PEGASIS is implemented. It has been determined that PEGASIS is more energy efficient than the LEACH technique. In this study, the PEGASIS protocol is explored and improved by altering it with a new approach, which will be useful to those working on building an efficient algorithm in WSN to obtain an increase in network lifespan by employing SEE-PEG. The results reveal that SEE-PEG-based clustering approaches provide longer network life than the energy-efficient PEGASIS strategy.

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