PSOGSA Based Improved LEACH Algorithm

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Abstract - In WSN, nodes are equipped with batteries which are always limited in power. So LEACH protocol is used which is hierarchical in nature and cluster head is chose to minimise the energy consumption. In our work we improved the LEACH by proposing the optimisation with LEACH. In our work, gravitational search algorithm (GSA) with Particle Swarm Optimisation (PSO) is used to make PSO hybrid. The cluster head is now optimally selected by PSO-GSA optimisation.

I. INTRODUCTION

Wireless sensor networks comprises sensor nodes, which are distributed in a specified region to sense the particular information/data and then transmitting the gathered information to the other nodes or to the base station depending upon the network architecture. Wireless Sensor Networks (WSNs) are used for a variety of purposes like habitat monitoring, military surveillance, forest-fire detection, temperature monitoring etc. The sensors have limited computation capability, small battery size and small memory storage. The prime concern of the WSN is the energy conservation as there is always scarcity of power, thus energy consumption to be reduced by allowing only a few nodes of the network, generally called cluster heads, to communicate with the base station [1]. Cluster based hierarchical routing protocol is an energy efficient routing protocol where sensor nodes are grouped into clusters. Each cluster has a node that acts as the CH (Cluster Head). The CH will collect the data sensed from all the nodes which belong to the same cluster [5]. The CH transmit the collected data to the BS (Base Station). Although clustering can reduce energy consumption, it has some problems. The main problem is that energy consumption is concentrated on the cluster heads. LEACH (Low Energy Adaptive clustering Hierarchy) is a clustering protocol designed to achieve prolonged network lifetime. In LEACH, the CHs are elected based on the probability model. The algorithm runs periodically and the probability of becoming a cluster head for each round is chosen to ensure that every node becomes a cluster head at least once within 1/P rounds, where P is the predetermined percentage of cluster heads. The LEACH protocol does not guarantee energy efficiency because each CH is selected on the basis of the probability model. There is a possibility that elected CHs maybe concentrated in a particular region or may be located at the boundaries of the network. The particle swarm optimization (PSO) is a simple, effective and computationally efficient optimization algorithm. PSO is one of the swarm based intelligence methods devised to find optimum solution by imitating the behavior of flocks of birds and fish schooling. It works through initializing population of random solutions and searching for the optima by updating generations [13].All particles have a fitness value that is evaluated with help of the fitness function, and have a velocity that direct the movement of the particles [16]. It has been applied on WSN to overcome a number of issues such as optimal deployment, clustering, node selection and data aggregation. The application of PSO algorithm to solve the problem of sensor network clustering has already been proposed [4]. Attempts have been made to equalize the number of candidate cluster heads to minimize the energy expended by the nodes and prolong the life of the network. In this paper a PSO based approach has been proposed in which effort has been done to choose the optimal nodes as cluster heads along with a reselect mechanism to extend the network lifetime.

But PSO is a local optimisation algorithm and has premature convergence tendency. So convergence point reached by PSO is not the absolute point, so we updated the PSO algorithm in our work. We mix it with another global optimisation algorithm which has good convergence accuracy. Gravitational Search Algorithm (GSA) is used along with PSO in this work to optimally select the cluster head position to have maximum residual energy.

II. PROPOSED WORK

In LEACH protocol hierarchical clustering is followed to minimise the energy consumption. In it two tier topology is followed in which clusters of nodes are formed with cluster head in the first tier. These cluster heads are responsible to pass the sensor information to the sink node. Clusters are formed on the basis of distance amongst nodes. Nodes with minimum distance are considered in a single cluster and these nodes are farther from nodes in other cluster. In second tier communication cluster head communicates with sink node, again in TDMA fashion. Every time in the cluster a cluster head is selected with maximum residual energy and another cluster head is chosen for next round with same criteria. Care has to be taken that no node is repeated as cluster head till all nodes are elected once. The energy model followed by LEACH protocol is dependent upon two channel model: one is free space (d^2) for the purpose of one hope and other is for multihop path with multipath fading (d^4). Thus the energy consumption for *l* bit packets over distance *d* is calculated as:

$$E_{TX}(l,d) = \begin{cases} lE_{elec} + l\varepsilon_{fs}d^2 & d < d_0 \\ lE_{elec} + l\varepsilon_{mp}d^4 & d > d_0 \end{cases} \quad (2.1)$$

where ε_{fs} = free space energy loss

ε_{mp}= multipath fading loss

d = distance between source and destination node

d_0 = crossover distance = $\sqrt{\frac{\varepsilon_{fs}}{\varepsilon_{mp}}}$

The energy spent in reception of this message is

$$E_{RX}(l) = lE_{elec} \quad (2.2)$$

This transmission and reception of power is designed in physical and MAC layer.

As is clear from equation 2.1, the energy consumption is dependent upon the square of distance for the single hop communication, so it's the inter cluster distance which is the affecting variable. If this distance is minimised then energy residual in each node can be increased. Previously researcher used Particle swarm optimisation (PSO) to optimally select the cluster head based on minimum distance which proved efficient than conventional LEACH protocol, but PSO is a local optimisation algorithm and has premature convergence tendency. So convergence point reached by PSO is not the absolute point, so we updated the PSO algorithm in our work. We mix it with another global optimisation algorithm which has good convergence accuracy. Gravitational Search Algorithm (GSA) is used along with PSO in this work to optimally select the cluster head position to have maximum residual energy. In our case the energy is the dependent variable which are dependent upon the node distance, so objective function must include the relation between these two variables. The fitness function used for our work is as:

$$ObjVal = \alpha_1 * \frac{\sum_{i=0}^{n} d(current\ node, member\ i)}{n} + \alpha_2 * \frac{\sum_{i=0}^{n} E(member\ i)}{E(current\ node)} + (1 - \alpha_1 + \alpha_2) * \frac{1}{no\ of\ members\ covered\ by\ current\ node} \quad (2.3)$$

here α_1 and $\alpha_2$are tradeoff factors and decide the weightage of distance and energy variable. In our work we chose both as 0.4.

In our proposed scheme PSOGSA optimized technique is used which is hybrid of PSO (Particle Swarm optimisation) and GSA (Gravitational Search Algorithm) optimisation algorithm which requires an objective function to minimize. The hybrid GSA+PSO algorithms work in the manner that PSO becomes alive to update the direction in the GSA algorithm. The update in position requires knowledge of step size and direction and in GSA the direction of movement of bacteria is random. Due to it, it takes time to converge of to reach at an optimal solution. This random direction is controlled by the PSO algorithm in our work. This make the convergence faster with each minima point checked. Initialization of direction is random but later on once for every particle, fitness function is evaluated, the direction is controlled by PSO.

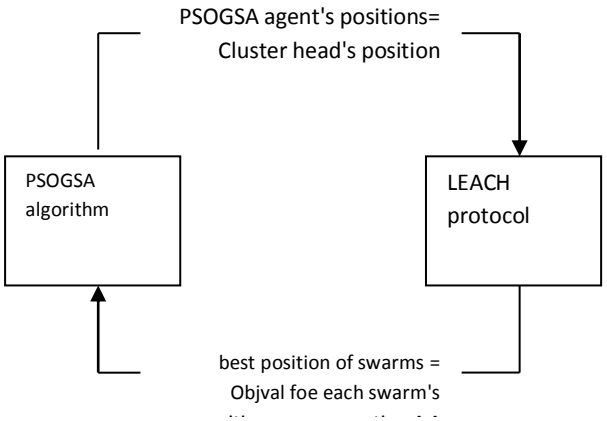

Fig.2.1: Representation of equilibrium of PSOGSA optimisation and LEACH protocol's cluster head selection

Output of fitness function becomes the local best for the PSO and based on that local best position is calculated, which is updated by the velocity update equation in PSO. This velocity is added into the old position of particle which was local best position obtained from GSA, to get the new position. This new position is updated as direction of agent. This way PSO tunes the direction of bacteria in gives them a direction to look for the food. The main task of our work is to allocate the cluster heads in each cluster which consumes very less energy in data transmission and reception. This work is done by hybrid PSOGSA algorithm which is a bio inspired algorithm and fired by the change in agents positions each time. Every change in position of agents is the change in cluster head's co-ordinates to achieve the minimum energy loss component. Table 2.1 shows the significance of bio terms in PSOGSA with our proposed technical terms. This table will correlate proposed optimisation with channel allocation task.

Table 2.1: Related terms of PSOGSA algorithm with channel allocation task

Bio terms of PSOGSA algorithm	Corresponding meaning in channel allocation
Position of agents/swarms	Position of cluster heads
Number of dimension of searching space	Total number of positions to be tuned for cluster head
Update in positions of patcicles/agents	Change in the cluster head's positions

III. RESULTS

We have worked to assign optimum cluster head in an hierarchical WSN network with two tier communication.

LEACH protocol here is used to reduce the energy consumption due to node to cluster head communication and cluster head to sink node transmission. This protocol's energy consumption is dependent upon the distance between nodes as in equation 2.1., so we optimised this distance using PSO-GSA hybrid optimisation algorithm.

We setup a WSN network and initialised each node with equal initial energy of 0.5 Joule. free space energy and multipath energy loss are also defined initially. These all network parameters are tabulated in 3.1.

Table 3.1: WSN and LEACH protocol's variable's values

Initial Energy	0.5 Joules
Number of Nodes	100,200,300
Rounds in LEACH	10,50,100,150,200
Energy for transferring of each bit (Etx)	50 nJ
Energy for receiving of each bit	50 nJ
Transmit Amplifier Free space energy (Efs)	10nJ
Transmit Amplifier MultiPath energy (Emp)	13nJ
Aggeragation Energy (Eda)	5nJ
Packet Length	6400

Using these network parameters a network with randomly placed nodes is created as shown in figure 3.1. The red dot at the centre of x axis and at the top is the location of sink node. These all nodes are clustered into 5 clusters as per 5% cluster criteria.

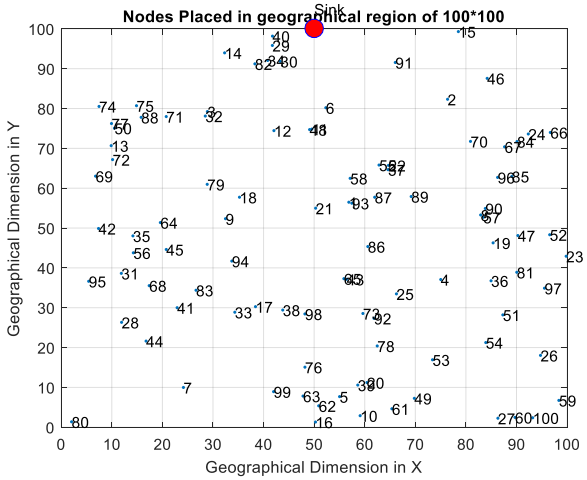

Fig.3.1: WSN network generated for 100 nodes placed randomly

In each optimisation algorithm the iteration curve which is plotted for best objective function value in each iteration. In our application, the objective value must increase in each iteration and converge as early as possible. In PSOGSA optimisation, the convergence value is higher than PSO and convergence time is less also for almost each round of data transmission. Figure 3.2 shows this iteration curve between PSO and PSOGSA for some rounds out of 10. The graph with square markers are for PSOGSA. Different colours are for different communication rounds. The RE for each round for all three algorithms is shown in table 3.2.

Table 3.2: RE energy comparison for all three algorithms

Rounds->	1	2	3	4	5	6	7	8	9	10
PSOGSA-LEACH	52.457	52.418	52.375	52.33	52.295	52.254	52.21	52.17	52.13	52.09
PSO-LEACH	52.451	52.401	52.354	52.309	52.262	52.217	52.164	52.119	52.070	52.028
LEACH	51.902	51.813	51.702	51.600	51.506	51.393	51.298	51.203	51.105	51.006

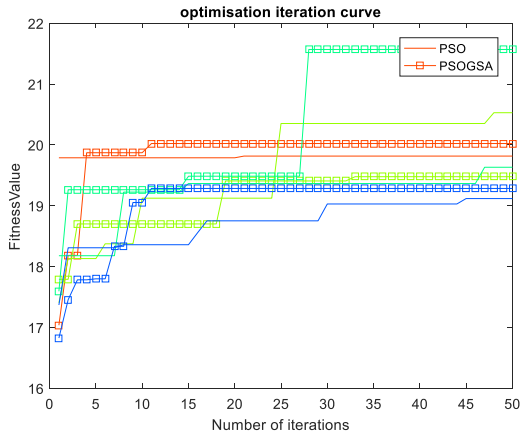

Fig.3.2: Iteration curve comparison for PSOGSA and PSO for different number of rounds

The comparison curve for RE is shown in figure 3.3. As the number of rounds increase, the RE energy decreases since the in each RE the previous rounds' RE is considered as initial energy, so if initially in the first round it was 0.5J for a node then in second round it is now 0.48J. So with increase in communication rounds, RE decreases.

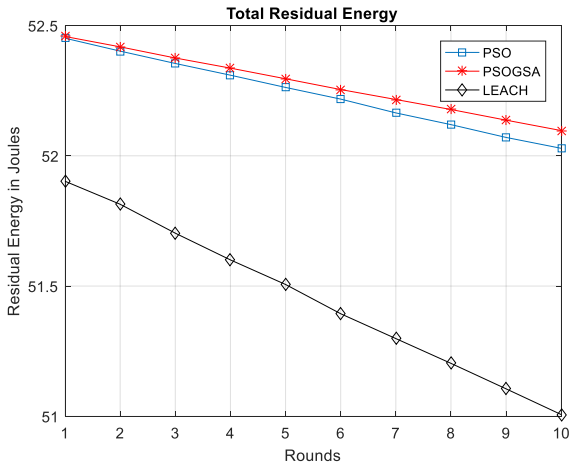

Fig.3.3: Residual energy comparison between PSOGSA-LEACH, PSO-LEACH and LEACH

The difference between RE with number of rounds is increasing in between different algorithms. The slope of decrement in of proposed scheme is least which proves PSOGSA optimised cluster head in LEACH protocol is better than PSO optimised cluster head.

IV. CONCLUSION

The LEACH protocol is improved by PSO-GSA optimisation algorithm. The distance between nodes in a cluster is minimised from cluster head and this cluster head is optimally chosen by hybrid PSOGSA optimisation which improves the result in terms of residual energy compared to PSO tuned LEACH and conventional LEACH. The improvement gap increases as the number of rounds in the LEACH increases.

V. REFERENCES

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