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An enhanced clustering with mobile sink for Wireless sensor netw orks based on swarm optimization

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ABSTRACT: *Preservation of energy and the streamlining of the power utilization are the indispensable aspect for designing any systematized wireless sensor network. Ceaseless and elongate accessibility of power play a important role in keeping the sensors stimulated. In wireless sensor networks, huge amount of sensors with limited energy is located in a network to collect important data or information from the surrounding. It is extremely hard to gather the field data proficiently in aspect of efficient energy and it can be accomplished from arrangement stage to routing. For utilizing the node energy efficiently clustering and routing are the two important phases. The fixed sink and clustering methods causes energy hole problem which leads to premature death of sensor nodes influences the information loss. Hence there is need to design a modified clustering algorithm to achieve energy efficient network which elongate the lifetime of the network. In this paper, a innovative clustering approach with particle swarm optimization based mobile data collector has been proposed for data collection. The proposed algorithm has been simulated and the out coming result show that the proposed approach enhance the lifetime of the network.*

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I. INTRODUCTION

Progression within the improvement of the micro electro mechanical system (MEMS), digital technologies and integrated circuits created a little device known as sensors. It has the subsequent units i.e. communication radio, sensing, processing and battery. The most recent progression in advanced innovations makes the size of the sensor as little or tiny. Wireless sensor networks have risen as profoundly as versatile and dynamic sides that are being conveyed in nearly each form of surroundings whether or not it is urban, rural or community in nature [1], as wireless sensor network comprise of an enormous number of sensor nodes that are gathered to form a network which may be want to monitor the varied real-time environments like traffic monitor, motion identification, military application, reconnaissance etc[3],[4]. When the sensors are deployed in an exceedingly particular atmosphere their batteries are neither reversible nor replaced [5]. Whether the majority of the nodes are required to transfer their information towards the sink. In this condition, nodes that are nearer to the sink devour a lot of energy because of the high rate of information forwarding and that result in loss of data. This issue in wireless sensor networks is known as an energy hole problem.

To avoid same problems within the wireless sensor networks, Researchers actualized a lot of methodologies in industrial advancement in several phases like localization, scheduling approach, optimization techniques, techniques of deployment, clustering and data routing techniques [6] & [8]. All these techniques are applied to improve the lifetime of the wireless sensor networks and also maintain the stability of the network to a certain extent. In Wireless sensor networks the monitoring region is divided into different regions which is known as clusters that leads to enhance the lifetime of the network. There are large numbers of sensor nodes exist in each cluster. Only a single sensor works as a cluster head among all sensor nodes and the remaining nodes are considered as cluster members [10]. Moreover, it is the responsibility of the cluster head nodes to obtain data from their sensors in that region. A node with the highest remaining energy as compared to other nodes in network was chosen as a cluster head [11]. Cluster head choice is a typical component of wireless sensor networks to enhance the lifetime of the network and various methods can be classified as follows:
(i) Cluster head rotation at specific intervals
(ii) Highest residual energy node
(iii) Algorithms for optimized cluster head selection
(iv) Cluster head selection depending on the communication distance between the sink and cluster head.

Researchers proposed the number of algorithm to solve the WSNs routing: like Wang J, Cao J et.al proposed the Ant colony optimization (ACO) based clustering algorithm particularly form home automation networks with portable sink assistance, P.K Jha et.al proposed the threshold-sensitive energy-efficient delay-aware routing protocol (TEDRP) based on differential evolution clustering algorithm for WSNs, this algorithm prolong the lifetime of the network and the author also describes the stability-aware model of TEDRP to enhance the stability period of the network. Ragavan and Ramasamy proposed a metaheuristic searchusing genetic algorithm to establish dynamic topology and forwarding reliable route packets (FRRPs) for optimal route selection. For getting ideal solution some of the algorithm are based on mathematical model, linear programming and heuristic algorithm. The heuristic algorithms are much better than other algorithms. However they don’t give any ensure to ideal solutions.

An intelligent technology algorithm called the Particle swarm optimization (PSO) algorithm was proposed by Eberhart and kennedy. PSO is a stochastic optimization method based on the population. PSO shares numerous similarities with evolution methods of computing like genetic algorithms. The scheme is instated through the updating of generations with a population of random alternatives. In contrast to genetic algorithm, PSO does not any advancement operators like crossover and mutation. The benefits of PSO compared to genetic algorithm are such that PSO is simple to execute and few parameters need to be adjusted. In many fields, PSO has been effectively implemented like fluid system control, function optimization, artificial neural network training and other fields where genetic algorithm can be implemented. PSO discovers the ideal solution based on the exchange of data between the particles of the individual that make up a swarm. The researchers have conducted and demonstrated a lot of research to discover the ideal effective solution based on PSO algorithm.

The paper’s primary contribution is summed up as following:

1 A modified algorithm for the selection of cluster head is proposed.
2 Routing algorithm based on Particle swarm optimization is implemented to complete the data collection process of portable sink.
3 The proposed PSO is contrasted with some techniques such as Random LEACH and Genetic algorithm.

The rest of the paper is ordered as follows: The preliminaries, network model and energy model are discussed in section II. In section II, the proposed technique with clustering and mobile sink routing based on PSO is briefly explained. The numerical assessment of the proposed simulation outcomes is explained in section IV, Section V finally conclude the paper.

II. SYSTEM MODEL

A. Preliminaries

To carry out the proposed work, the following definition and assumptions must be followed:

1. In network all nodes are taken as homogeneous.
2. In proposed network all sensor nodes must have same amount of energy.
3. All sensors in wireless sensor networks, including collection of data, communication and processing have the same operational capacities.
4. Communication technology is consider to be wireless and links are bidirectional.
5. A portable sink node can travel with unlimited energy, anywhere in the WSNs region.

B. Network model

The sensors are established randomly in the region and dividing the whole region into various clusters. The cluster heads are chosen based on the sensor energy level. Generally, the sensor with the highest energy is chosen as the cluster head. Then the other participants send the information to the cluster head. It is the responsibility of the cluster head to send information to the portable sink. In WSNs, a base station that can interact directly with the cluster head, In WSNs a base station is selected that can interact directly with the cluster heads, sensor nodes and portable sink.

Wireless sensor networks can be emulate as a graph G=<S,E>, Where, S represent the set of sensor nodes and E represent the set of sink (l,m). Node l and node m are neighboring nodes that can communicate with each other.

C. Energy Model

In this approach, first order radio model is used. There are a lot of studies currently being done in the field of low-energy radios. Various radio assumptions including energy dissipation in transmission and receiving modes will alter the benefits of distinct protocols. In proposed work, we assume a energy model where the radio dissipates E_{elec}= 60 nJ/bit (Here E_{elec} is the required energy to radio electronics) to run the transmitter and €amp=150 pJ/bit/m^2 for transmit amplifier to get an acceptable E_b/N_b. These parameters are slightly better in radio design than the present state of the art. We also suppose a loss of r^2 energy owing to the transmission of channels. Therefore to transmit a k-bit data, a distance ‘d’ by using our designed radio model, the radio expends as following:

$E_{trans}(k,d) = E_{trans\text{-}elec}(k) + E_{trans\text{-}amp}(k,d)$
$E_{trans}(k,d) = E_{elec} . k + €amp.k.d^2$ ……………..(1)
And to receive this message, the radio expand as following:
$E_{Rec}(k) = E_{Rec\text{-}elect}(k)$
$E_{Rec} (k) = E_{elec}.k$ ………………………….(2)

For these parameter values, receiving a message is not a low cost operation; the protocols should thus try to minimize not only the transmit distances but also the number of transmit and receive operations for each message. We make the assumption that the radio channel is symmetric such that the energy required to transmit a message from node A to node B is the same as the energy required to transmit a message from node B to node A for a given SNR.
Equations 1 & 2 are used to calculate the energy consumption.

III. PROPOSED APPROACH

For Data collection, the proposed clustering mechanism and the portable sink based on PSO elongate the lifetime of the wireless sensor networks. The flow sequence of proposed approach is shown in Figure 1. Further, the steps are discussed here:

Use the proposed methodology to deploy sensors randomly in the surveillance region and divide the region into the number of sub-regions. Further, by calculating the total remaining energy of the network and threshold values, select the cluster head from the nodes. Members of cluster send the data to the cluster head upon effective completion of the clustering system. The respective cluster heads process the data. Run the PSO algorithm to discover the ideal route through all the cluster head. Base station passes the routing information to the portable sink at the start of each process, which crosses the optimal route to obtain data from all cluster heads.

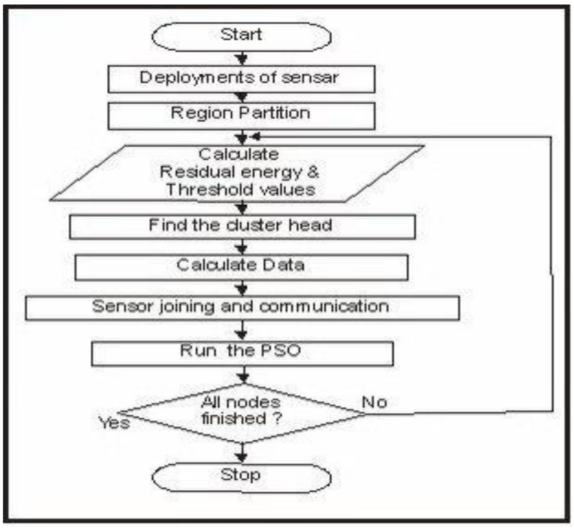

Figure 1. Work flow

A. Clustering

The whole network is split into several clusters in this stage. In each cluster, only one sensor node acts as a cluster head while the other sensors act as an ordinary node. A LEACH variation is adapter to fulfill the task of clustering.

The node with the highest residual energy is more likely to become a cluster head in this phase. The distance between the members of the cluster head and cluster should be lower than their reliable reception range. The member with the highest residual energy will be chosen as a cluster head among these members.

$$T(l) = \begin{cases} \frac{q}{1-q\left(s \bmod \frac{1}{q}\right)} \frac{E_l}{E_i}, & \text{if } l \in H \\ 0, & otherwise \end{cases} \quad ………………..(3)$$

Where E_p represent the residual energy nodes and E_i represent the initial energy of node, q is required percentage of cluster heads, s indicate the set of nodes which are not considered as a cluster head until recent rounds take place.

All time the sensor node produce a random number between the range 0 & 1 and compares it to a predefined threshold to select a cluster head T(l). The node will be selected as an active cluster head, when the node have the value less than T(l). It will also ensure that there are no other cluster heads with the highest residual energy value in its transmission spectrum. After the cluster head selection, the cluster head will deploy a broadcast data to all the other sensor nodes in the network. They obtain the signal linked to the cluster head according to the signal intensity of each node. The cluster head will transmit a Time Division Multiple Access (TDMA) data to exchange information successful cluster formation. TDMA is accountable for scheduling and transferring information without collision from member of nodes.

B. PSO based mobile sink.

Algorithm 1 PSO based mobile sink.

{r: region to monitor}
{s: set of sensors $s=\{s_1,s_2,s_3\ldots\ldots\ldots\ldots s_n\}$
{ c: set of cluster heads $c=\{c_1,c_2,c_3\ldots\ldots\ldots\ldots c_n\}$}
{MI: maximum number of iterations}
Initialize the size of swarm and the particles
Find out the position of the cluster heads
loop l=1 to n
Best personal solution=y
calculate the fitness of particle
Then calculate global best solution
then end loop.
loop i=1 to MI
By using equation 4 calculate the velocity
By using equation 5 update the position of the particle
then again calculate the fitness for particle
If (Fitness(y) < Fitness (personal best solution)
best personal solution = y
then store personal best solution and remove global best solution
end if
if (fitness(personal best solution < fitness(global best solution) then,
global best solution = personal best solution.
end if,
end loop
global best solution is best solution

The PSO is applied in the continuous domain to solve and optimize the difficult issues [14],[15]. It is based on watching the conduct of fish schools in a flock of birds. It's also simple and easy to enforce. PSO is linked to the genetic algorithm, but it differs from fundamental GA operation such as crossover and mutation.

As individuals, a swarm of particle is initialized and each swarm offers a possible solution. Initially, PSO begins to discover a solution with random position and velocity to each swarm. The particle moves around the search space with a specified velocity to enhance the search in each iteration. A particle's present position is regarded a prospective solution and the fitness function evaluates this solution.

PSO discovers best personal (BP) and best global (BG) solutions that are regulated by previous solutions. The particle also travel around the search space in each new iteration to discover a better best global (BG).

The swarm's location and velocity are updated with the following equations:

$$V_j^{i+1} = WV_j^i + b_iA\,(BP_j - S_j^i) + b_2B\,(BG - S_j^i)$$

Where i represent the number of iteration, W is the inertia's weight, b_1 & b_2 are the learning factors or positive weights, BP denotes best personal solution, BG denotes best Global solution, A & B are the random number in the range between 0& 1.

Velocity and position of j-th particle in the i-th iteration are given by:

$$S_j^{i+1} = S_j^i + V_j^{i+1}$$

This method will continue until reaching the maximum iteration limit. Algorithm 1 show the proposed PSO-based strategy.

Initially, it finds the coordinates of the cluster head and calculates the shortest distance between all the cluster head. The base station executes the shortest path based on PSO algorithm and the information acquired on the path is transferred to the portable sink to visit all the cluster heads for effective data collection.

IV. RESULT

Compared to the existing approaches such as random LEACH and PEGASIS algorithms, the performance of the proposed algorithm is evaluated by extensive numerical simulations to demonstrate the features and efficiency of the sensor network. Table 1 details all parameters of the experimental setup. For example, the tests were carried out in the different set of sensor nodes from 70 to 270, each test has been performed more than 10 times and the results obtained are shown in this section.

Table 1

Parameters	Value
Network size	250*250
Number of sensors	70-270
Number of rounds	4500-5500
Sensor energy	2.5 J
Data collection	Mobile
Cluster Head Probability	0.5

Three algorithms are implemented in this paper and the result from the experiments performed as per the setup are shown in the Table 2.

When the random LEACH algorithm is implemented Cluster Heads are selected andomly based on a function of probability. For this 15% of probability have been taken. By selecting cluster heads as maximum energy nodes, it is further improved by using a fair distribution of energy. This approach selects a fixed number of cluster heads as per the number of nodes lives. Another modification is done by using proposed algorithm where nodes are clustered based on inter distance. We calculate the efficiency of algorithm by calculating the total number of rounds up to which network survives. By considering the total energy greater than zero, a network is assumed to be live if more than 40% of nodes are alive.

Table2

WSN Routing Algorithm	Network Life (in rounds)	Rounds in which first node dead	Rounds in which 55% node dead	No. of packets sent in total rounds	Remaining energy after 65% node is dead (Joules)
RANDOM LEACH	482	93	258	10952	6.21
PEGASIS ALGORITHM	1237	80	794	6213	8.23
PROPOSED APPROACH	1135	1112	10241	11231	1.10

It is clearly shown in the table that proposed algorithm performs much better than another approaches if the no. of rounds covered by the algorithm is considered. We consider a Network is dead if 55% of nodes are dead then proposed algorithm perform better than PEGASIS algorithm and the Random LEACH algorithm performs the worst is every conditional situation.

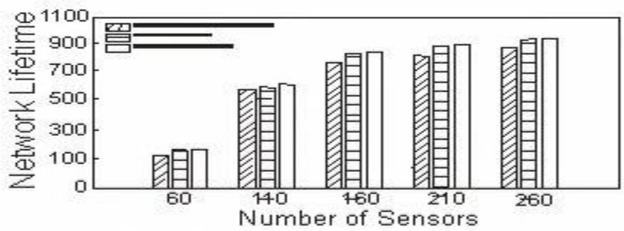

Fig. 2 Initial sensor node dies

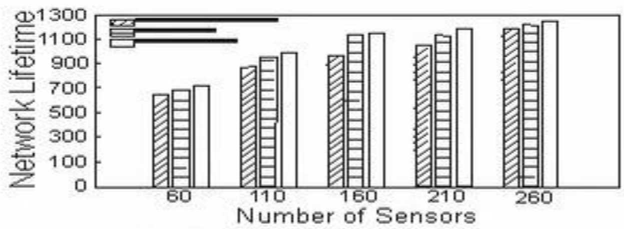

Fig. 3 Last sensor node dies

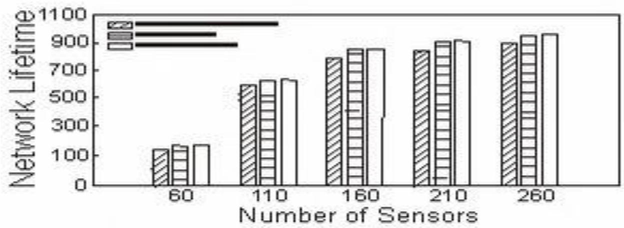

Fig. 4 Initial sensor node dies prop

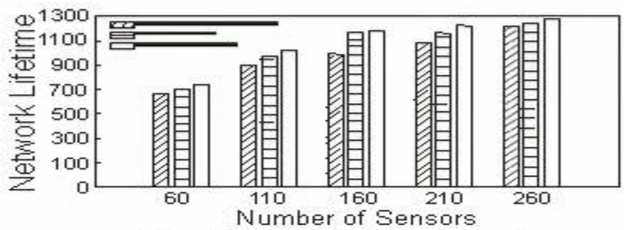

Fig. 5 Last sensor node dies

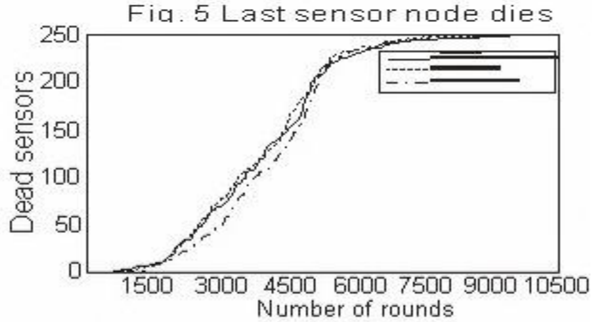

Fig. 6 No of rounds vs dead sensors

The lifetime of the network comparison of the existing algorithm with the conventional routing approach is shown by figure 2 & 3. When the no. of sensors varied between 60 & 260. Figure 4 & 5 shows the lifetime of the network which represent the comparison of the proposed approach. From the obtained result, it shows that the lifetime of the network increases by increasing the number of sensors. As compared to the proposed approach, this raises the lifetime of the network substantially. The proposed approach enhance the network lifetime with less consumption of energy as compared to Random LEACH and PEGASIS algorithm.

Lifetime of the network is an essential measure for assessing WSN. The comparison of the performance of WSN is illuminate in figure 2 to figure 5 from the simulation.

The analysis of the above result clearly shows that the proposed approach performs well and enhances the lifetime of the network. The proposed approach provide better stability of the network as compared to the existing algorithm and significantly improves the number of ounds by implementing the mobile sink for collection of data.

V. CONCLUSION

In this paper a modified clustering algorithm is proposed to collect the data for PSO based mobile sink and cluster head selection for traversal. These tasks are essential to optimize the lifetime of the network in wireless sensor network. It is concluded that the lifetime of the network is improves by the application of clustering and routing after deployment of the sensor node. Simulation results shows that when the proposed approach are successfully adopted the lifetime of the network is marginally extended. Further, it is observe that the mobilesink performs the routing function so that in the cluster head the data forwarding energy is saved which result in an enhancement of the total lifetime of the network. The proposed approach may be evaluated for efficacy in the future by contrasting it with other algorithms for optimization.

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