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A Distributed Energy Efficient Cluster Based Routing Scheme for Wireless Sensor Network using Particle Swarm Optimization

AshimaVijan, ShivenduDubey, Ashok Verma

M tech Scholar, CSE, Gyan Ganga Institute of Technology & Science, , Jabalpur& Sc
Asstt. Professor, Department of CSE, , GyanGanga Institute of Tech & Science, , Jabalpur& Sc
Assoc. Professor / Head,Department of CSE, Gyan Ganga Institute ofTech. & Science, , Jabalpur& Sc
. Email:ashima.vijan@gmail.com, dubeyshivendu@gmail.com,ashokverma@ggits.org

Abstract-In multi-hop wireless sensor networks that are categorised by many-to-one (centralized) traffic arrangements, complications associated to energy disproportion among sensors devices seemsfrequentl. When the range of transmission for a node is fixed all the way through the wireless network, the aggregate of data that sensors are obligatory to forward increases intensely as the distance to the base station becomes smaller. Consequently, sensors closest to the base station (sink)incline to die at the initial stage of transmission and instigating network partitions. Instead, if all sensors transmit straight to the sink, the extreme nodes from the data sink will die much more quickly than those close to the base station. Network lifetime can be improved to a limited extent by the use of a more intelligent transmission power control policy that balances the energy used in each node by requiring nodes further from the data sink to transmit over longer distances. However, transmission power control alone is not enough to solve the node dead problems. Here we develop an efficient clustering solution based on energy distribution by using different kind of energies and particle swarm optimization. Experimental results shows that with this network designing the network lifetime and stability period increases extensively.

Keywords—Wireless sensor network, Energy efficient clustering, Particle Swarm Optimization, routing, Energy Distribution, Network Lifetime, Intelligent clustering.

I. INTRODUCTION

Large scale wireless sensor networks are emerging technologies that have recently gained attention for their potential use in applications such as environmental sensing and mobile target tracking. Since sensors typically operate on batteries and are thus limited in their active lifetime, the problem of designing protocols to achieve energy efficiency to extend network lifetime has become a major concern for network designers. Much attention has been given to the reduction of unnecessary energy consumption of sensor nodes in areas such as hardware design, collaborative signal processing, transmission power control polices, and all levels of the network stack. However, reducing an individual sensor's power consumption alone may not always allow networks to realize their maximal potential lifetime. In addition, it is important to maintain a balance of power consumption in the network so that certain nodes do not die much earlier than others, leading to unmonitored areas in the network.

Previous research has shown that because of the characteristics of wireless channels, multihop forwarding between a data source and a data sink is often more energy efficient than direct transmission. Based on the power model of a specific sensor node platform, there exists an optimal transmission range that minimizes overall power consumption in the network. When using such a fixed transmission range in general ad hoc networks, energy consumption is fairly balanced, especially in mobile networks, since the data sources and sinks are typically assumed to be distributed throughout the area where the network is deployed. However, in sensor networks, where many applications require a many-to-one (convergecast) traffic pattern in the network, energy imbalance becomes a very important issue, as a hot spot is created around the data sink, or base station. The nodes in this hot spot are required to forward a disproportionately high amount of traffic and typically die at a very early stage. If we define the network lifetime as the time when the first subregion of the environment (or a significant portion of the environment) is left unmonitored, then the residual energy of the other sensors at this time can be seen as wasted.

Intuition leads us to believe that the hot spot problem can be solved by varying the transmission range among nodes at different distances to the base station so that energy consumption can be more evenly distributed and the lifetime of the network can be extended. However, this is only true to some extent, as energy balancing can only be achieved at the expense of using the energy resources of some nodes inefficiently [1]. We conclude from our study that transmission power control can alleviate the hot spot problem only to a limited degree, and alternative solutions are necessary for the network to operate in a more energy efficient manner.

One of the key challenges of Wireless Sensor Networks (WSN) is the efficient use of limited energy resources in battery operated sensor nodes. Hierarchical clustering [2], [3], [4], [5], [6] has been shown to be a promising solution to conserve sensor energy levels [7], [8], besides being an effective solution to organizational tasks. With Cluster Heads (CH) that act as local controllers of network operations, a clustered WSN has an easily manageable structure. When the network is partitioned into clusters, data transmission can be classified into intra- and inter cluster communication i.e. cluster member nodes first send their data to the cluster head, and cluster heads send the data to the base station. Although direct transmission is usually adopted for intra-cluster communication, multi-hop communication is more energy efficient and applicable than single-hop communication for inter cluster communication [18]. Thus it is better to let cluster heads cooperate with each other to forward their data to the base station. However, the many-to-one traffic pattern results in the hot spot problem [19] when the multi-hop forwarding model is adopted in inter-cluster communication. Because the cluster heads closer to the BS have much heavier traffic, the area near the BS becomes a *hot spot*. Nodes in the hot spot drain their energy and die much faster than other nodes in the network, reducing sensing coverage and causing network partitioning.

II. WIRELESS SENSOR NETWORK CHARACTERISTICS

A wireless sensor network (WSN) is a network that is made of hundreds or thousands of sensor nodes which are densely deployed in an unattended environment with the capabilities of sensing, wireless communications and computations (i.e. collecting and disseminating environmental data). These spatially distributed autonomous devices cooperatively monitor physical and environmental conditions, such as temperature, sound, vibration, pressure, motion or pollutants, at different locations. The basic architecture of Wireless sensor Network is shown in Figure 1. Each sensor node in a sensor network is typically equipped with a radio transceiver or other wireless communications device, a processing unit which can be a small micro-controller, sensing unit, and an energy source, usually an alkaline battery. Sometimes, a mobilizer is needed to move sensor node from current position and carry out the assigned tasks. Since the sensor may be mobile, the base station may require accurate location of the node which is done by location finding system. The size of a single sensor node can vary from shoebox-sized nodes down to devices the size of grain of dust. [6]

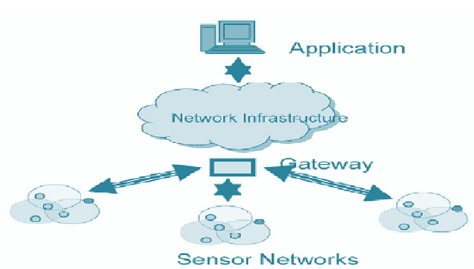

Figure 1. Basic Architecture of Wireless Sensor Network. (Ref [6])

Sensor nodes can be imagined as small computers, extremely basic in terms of their interfaces and their components. They usually consist of a processing unit with limited computational power and limited memory, sensors or MEMS (including specific conditioning circuitry), a communication device (usually radio transceivers or alternatively optical), and a power source usually in the form of a battery. Other possible inclusions are energy harvesting modules, secondary ASICs, and possibly secondary communication devices (e.g. RS-232 or USB). The base stations are one or more components of the WSN with much more computational, energy and communication resources. They act as a gateway between sensor nodes and the end user as they typically forward data from the WSN on to a server. Other special components in routing based networks are routers, designed to compute, calculate and distribute the routing tables.

A. Classification of Sensor Network

Sensor Networks can be classified on the basis of their mode of functioning and the type of target application into two major types. They are

a. Proactive Networks

The nodes in this network switch on their sensors and transmitters periodically, sense the data and transmit the sensed data. They provide a snapshot of the environment and its sensed data at regular intervals. They are suitable for applications that require periodic data monitoring like moisture content of a land in agriculture.

b. Reactive Networks

The nodes in this network react immediately to sudden and drastic changes in the value of the sensed attribute. They are therefore suited for time critical applications like military surveillance or temperature sensing.

B. Structure of this Assessment

The edifice steps of this paper are as follows. The Introductory Section ends with a brief introduction of wireless sensor network and basic principles. In Section II, we introduce the architecture of wireless sensor network, its characteristics, classifications, design factors and routing attiquettes in wsn.Section III gives a detailed analysis of background of routing and related work related to energy efficient routing schemes in wireless sensor network.In Section IV, we describe our proposed methodology, it is further devide into two parts, first one is distributed energy based optimal routing and second is optimization phase of particle swarm optimization.Section V describe the results section in which proposed method is compared with the traditional LEACH protocol and GA based LEACH protocol, and Section VIshows a general conclusion of the paper is in Section X before references.

C. Requirements and Design factors in Wireless Sensor Network–

Following are some of the basic requirements and design factors of wireless sensor network which serve as guidelines for development of protocols and algorithms for WSN communication architecture.

- *Fault Tolerance, Adaptability and Reliability*
- *Power Consumption and Power management*
- *Network Efficiency and Data Aggregation*
- *Intelligent Routing*
- *Management challenge*

D. Routing and Etiquettes in Wireless Sensor network

Since, data transmission from the target area towards the sink node is the main task of wireless sensor networks, the utilized method to forward data packets between each pair of source-sink nodes is an important issue that should be addressed in developing these networks. Due to the intrinsic features of low-power wireless sensor networks, routing in these networks is much more challenging compared to the traditional wireless networks such as ad hoc networks [4, 5]. First of all, according to the high density of sensor nodes, routing protocols should be able to support data transmission over long distances, regardless of the network size. In addition, some of the active nodes may fail during network operation due to energy depletion of the sensor nodes, hardware breakdowns or environmental factors. Moreover, as sensor nodes are tightly limited in terms of power supply, processing capability, memory capacity and available bandwidth, routing and data dissemination should be performed with efficient network resource utilization. Furthermore, since the performance demands of the wireless sensor networks are application specific, routing protocols should be able to satisfy the QoS demands of the application for which the network is being deployed.

III. BACKGROUND& RELATED WORK

A. *Data Transmission assortment Optimization*

Early work in transmission range optimization assumed that forwarding data packets towards a data sink over many short hops is more energy efficient than forwarding over a few long hops, due to the nature of wireless communication. The problem of setting transmission power to a minimal level that will allow a network to remain connected has been considered in several studies [20], [21]. Later, others noted that because of the electronics overhead involved in transmitting packets, there exists an optimal non-zero transmission range, at which power efficiency is maximized [22], [23]. The goal of these studies was to find a fixed network-wide transmission range. However, using such schemes may result in extremely unbalanced energy consumption among the nodes in sensor networks characterized by many-to-one traffic patterns. If we define sensor network lifetime as the model presented in [24], which is the network duration until the first node runs out of energy, this unbalanced energy consumption will greatly reduce the network lifetime. An energy efficient routing scheme was proposed in [25]. The objective function of this scheme is to extend network lifetime by routing outgoing traffic intelligently. Iterative algorithms that are based on the formulation of the problem as a concurrent maximum flow problem are presented as well. Our transmission range distribution problem is similar to this energy efficient routing problem in many aspects. However, we propose a heuristic scheme that can easily be implemented rather than only providing an upper bound on network lifetime for specific topologies. Also, we extend the solution to alternative strategies rather than attempting to solve the problem using transmission range distribution alone.

B. *Sensor arrangement strategies*

Several sensor deployment strategies exist that can help extend network lifetime. These strategies include the movement of data sinks [27], [28], [29], [30], [31], the deployment multiple base stations [32], and the formation of data aggregation clusters [33], [34], [35]. However, some of the research related to these strategies has primarily considered the case where the strategies are specifically chosen around the application requirements, while the others have focused only on the feasibility of the proposed solution while ignoring the fact that a more complex sensor deployment scheme may incur a larger financial cost. In this paper, not only do we investigate and compare the performance of each strategy using general terms such as normalized network lifetime, but we also propose some practical sensor deployment strategies from a cost efficient perspective.

C. *Traffic Hot-spot Problem in Sensor Network*

The severeness of the hotspot problem differs substantially whether the sensor nodes and/or the sink node are mobile or not. In the case where the sink node is mobile, as in [36, 37, 38, 39], the sink node moves around the sensing area and collects data from the sensor nodes, thus effectively balancing the energy consumption in the WSN. The sensor nodes can transmit the data periodically (e.g., as in applications that are not delay tolerant), or store the data and delay the transmission till the displacement between the senor nodes and the mobile sink node is minimal to decrease the power consumed while relaying data to the sink. In the case where sensor nodes are mobile, as in [40, 41], the nodes can adjust their position to help balance energy consumption in areas that have high transmission load and/or mitigate network partition. Deploying a mobile sinks and nodes will increase the WSN's deployment costs. Additionally, in some applications mobility is impractical.

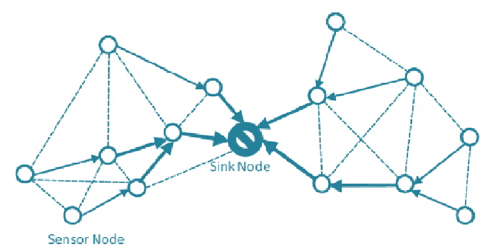

Figure 2: Flat multi-hop routing.

Periodic reassignment of the CH role to different nodes helps prevent the problem of a single point of failure in the event of node energy depletion. However, traffic hot-spots [42] , [43] in a WSN also pose error-prone situations. This is particularly important since clustered WSNs [44], [45], [46], [47] are mainly focused on data gathering applications (e.g. habitat monitoring and military surveillance), which involve periodic delivery of sensory data over multihop routes, creating highly congested areas, especially at locations close to a data sink (e.g. a control centre).Furthermore, there may also be other critically-located sensors not necessarily close to data sinks, which carry the burden of relaying large amounts of data traffic, especially when multiple high-rate routes pass through these sensors. Such nodes are usually frequently chosen to be data relays by routing algorithms and may serve a large portion of the network traffic, due to their convenient locations. Thus, avoiding the failure of such nodes caused by early energy depletion is critical to ensure a sufficiently long network lifetime.

IV. THE PROPOSED ALGORITHM

In this section we describe our model of a wireless sensor network with nodes heterogeneous in their initial amount of energy. We particularly present the setting, the energy model, and how the optimal number of clusters can be computed. Let us assume the case where a percentage of the population of sensor nodes is equipped with more energy resources than the rest of the nodes. Let m be the fraction of the total number of nodes n, which is equipped with α times more energy than the others. We refer to these powerful nodes as advanced nodes, and the rest $(1-m) \times n$ as normal nodes. We assume that all nodes are distributed uniformly over the sensor field.

1. Clustering Hierarchy

We consider a sensor network that is hierarchically clustered. Our proposed algorithm maintains such clustering hierarchy. In our protocol, the clusters are re-established in each "round." New cluster heads are elected in each round and as a result the load is well distributed and balanced among the nodes of the network. Moreover each node transmits to the closest cluster head so as to split the communication cost to the sink (which is tens of times greater than the processing and operation cost.) Only the cluster head has to report to the sink and may expend a large amount of energy, but this happens periodically for each node. In our protocol there is an optimal percentage p_{opt}(determined a priori) of nodes that has to become cluster heads in each round assuming uniform distribution of nodes in space.If the nodes are homogeneous, which means that all the nodes in the field have the same initial energy, the proposed algorithm guarantees that every one of them will become a cluster head exactly once every $1/p_{opt}$rounds. Throughout this paper we refer to this number of rounds, $1/p_{opt}$, as epoch of the clustered sensor network.

Initially each node can become a cluster head with a probability p_{opt}. On average, $n \times p_{opt}$ nodes must become cluster heads per round per epoch. Nodes that are elected to be cluster heads in the current round can no longer become cluster heads in the same epoch. The non-elected nodes belong to the set G and in order to maintain a steady number of cluster heads per round, the probability of nodes ЄG to become a cluster head increases after each round in the same epoch. The decision is made at the beginning of each round by each node s Є G independently choosing a random number in [0, 1].

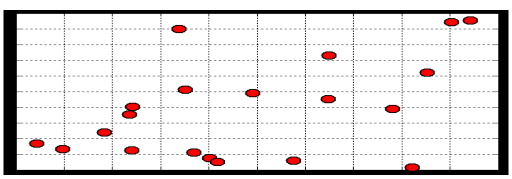

Figure 3. Node placement in network environment (for 20 sensors placed randomly in the filed of 10000 meter square area)

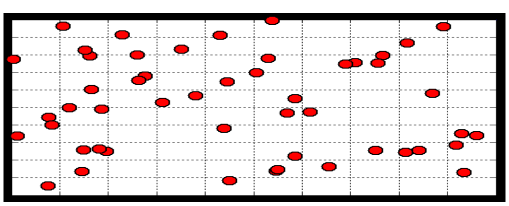

Figure 4. Node placement in network environment (for 50 sensors placed randomly in the filed of 10000 meter square area)

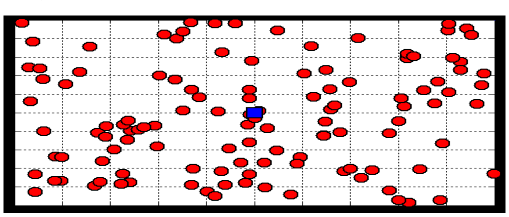

Figure 5. Node placement in network environment and base station blaced at the center of field (for 100 sensors placed randomly in the filed of 10000 meter square area)

If the random number is less than a threshold T(s) then the node becomes a cluster head in the current round. The threshold is set as: Where, r is the current round number (starting from round 0.) The election probability of nodes Є G to become cluster heads increases in each round in the same epoch and becomes equal to 1 in the last round of the epoch. Note that by round we define a time interval where all cluster members have to transmit to their cluster head once. We show in this paper how the election process of cluster heads should be adapted appropriately to deal with *heterogeneous* nodes, which means that *not* all the nodes in the field have the same initial energy.

2. Optimal Clustering

Previous work have studied either by simulation or analytically the optimal probability of a node being elected as a cluster head as a function of spatial density when nodes are uniformly distributed over the sensor field. This clustering is optimal in the sense that energy consumption is well distributed over all sensors and the total energy consumption is minimum. Such optimal clustering highly depends on the energy model we use. For the purpose of this study we use similar energy model and analysis as proposed in. According to the radio energy dissipation model illustrated in Figure, 3.1 in order to achieve an acceptable Signal-to-Noise Ratio (SNR) in transmitting an L-bit message over a distance *d*, the energy expended by the radio is given by:

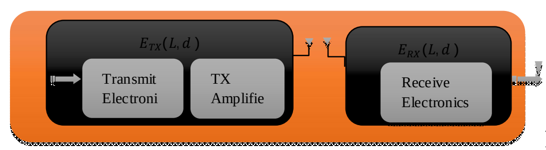

Figure 6. Radio Energy Dissipation Model

$$E_{T2}(l,d) = \begin{Bmatrix} L.E_{elec} + L.\epsilon_{fs}.d^2 \ \ if\ d \le d_0 \\ L.E_{elec} + L.\epsilon_{mp}.d^4 \ \ if\ d > d_0 \end{Bmatrix}$$

Here E_{elec} is the energy dissipated per bit to run the transmitter or the receiver circuit, ϵ_{fs} and ϵ_{mp} depend on the transmitter amplifier model we use, and *d* is the distance between the sender and receiver. By equating the two expressions at *d = d0*, we have$d_0 = \sqrt{\epsilon_{fs}/\epsilon_{mp}}$. To receive an L-bit message the radio expends$E_{Rx} = L.E_{elec}$.This radio model Help will Help us to calculate the amount of dissipated energy after every round based on distance vector based calculation.

3. Procedural Steps

First section is network initialization, in this phase we have to decide the network parameters, like filed area, number of devices, device parameters. The routing is based on distance vector, means we have to make communication between our network devices through calculation of distance vector in hop by hop manner (Node to Node communication is based on distance vector and node to cluster head communication is also based on distance vector) For this, first of all we have to calculate distance vector between network devices based on their position, and path and cost is calculate according to these distance vectors values. After the initialization and setup phase completed, the transmission phase is starts, in this phase, initially we calculate and update the energy values of every device and it will update at every transmission round. First thing to start a transmission round is the selection of cluster head, we defined a criteria based on certain energy values to select a node as cluster head, and the node will be selected as a cluster head only if it has a proper energy values to continue the round as cluster head. In the selection of cluster head a probability distribution is used based on probabilistic clustering, here classification of such devices is based on energy parameters like residual energy, initial energy, average energy, and the total energy. The considered network parameters are shown in table below.

Table 1. Parameter Settings Of The First-Order Radio Model

Parameters	Values
Initial energy (*E0*)	0.5 J/node
Transmitter Electronics (*Eelec*)	50 n J/bit
Receiver Electronics (*Eelec*)	50 n J/bit
Data Packet Size (*l*)	2000 bits
Transmitter Amplifier (εfs) if $d \le d0$	10or100pJ/bit/m^2
Transmitter Amplifier (εmp) if $d \ge d0$	0.0013 p J/bit/m^4

After the selection of cluster head, a cluster region created around the particular cluster head, and nodes belong to that region is labelled as cluster members. In transmission phase, The Cluster members transmits their data to cluster head and cluster head transmit the collected data to the destination directly, with every data packets transmission, a signature is added with the data packets sent, this complex signature will try degrading the network efficiency but it's the network design and routing which decreases the effect of authentication algorithm on routing performance.The Clustering and routing procedure continues till the network devices alive, the devices with a proper energy levels are selected as cluster head one after another every round. After every transmission round, device's residual energy is calculated with the radio energy model for wireless communication network, this helps us in deciding a cluster head node to continue transmission in the next transmission round. In case of research work in wireless network, system efficiency can be calculated from the relation of input and output data packets. Hence the throughput, end to end delay, packet delivery fraction ratio, and network lifetime are the best suited parameters to show research efficiency.

Algorithm in flow

Network Initialization

// A random Field created and nodes are randomly placed, every node contains a specified amount of energy

Setup Phase

// Bisection between nodes through Voronoi diagram, and path-cost calculated through distance vector estimation

Transmission phase

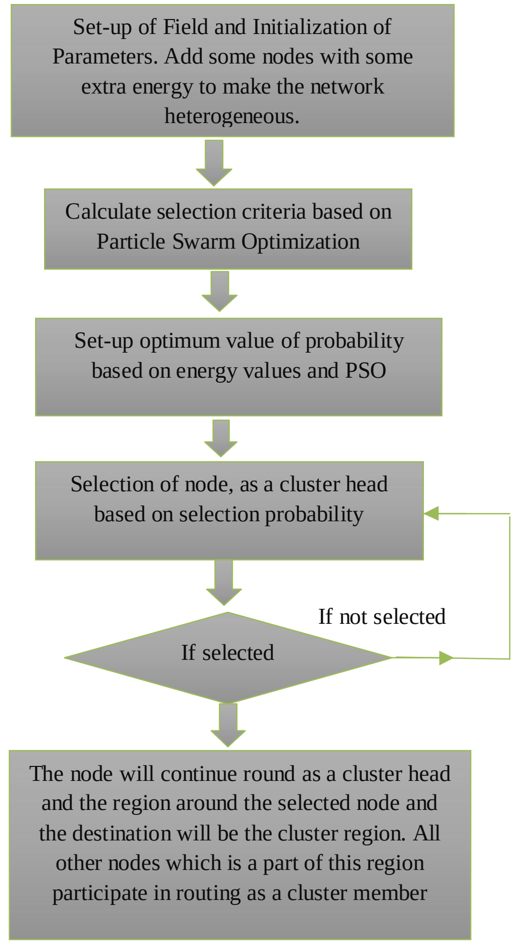

Figure 7. Flow chart for the procedural steps evolved

For 1: 1: Maximum transmission rounds

Update Average Energy with respect to rounds,

$$Et \times \left(\frac{1-\frac{r}{Rmax}}{n}\right)$$

Check for Dead Criteria at every Start Up

For i = 1: n

Check Nodes & Update Flags

Update Dead & Alive Statistics

End

For i = 1: n

If Ea>0 (means checking if there's maximum round reaches)

Calculate probability of selection of Cluster Head

$$P(i) = \frac{P \times n \times E(i)}{Ea}$$

Here, P is calculate through the Particle Swarm Optimization, based upon the optimum solution of our algorithm

If $(S(i).E > 0)$

Temp= a temporary random number allotted to every node

If temp<= $T(s_i)$

Where, $T(s_i) = \begin{cases} \frac{P_i}{1-P_i\left(r \bmod \frac{1}{P_i}\right)} & \text{if } \in G \\ 0 & \text{otherwise} \end{cases}$

Update Packet Counter as per selection as the set up phase completed

Update Clusters Counter as per Sub-Destination Selection

(We denote the methodology as cluster based because we first select a cluster head based on energy level and then assuming the region around it as a cluster and the selected sub-destination will be the head of that cluster)Update the selected node number value as an id number for cluster region formed

Update Cluster Area

(The Cluster Area is the area between the selected cluster head and the base station based on distance Vector calculated between them, and the devices between these Regions are called as cluster member) Data Transmission from Selected Cluster head based on Distance Vector Calculated

$$S(i).E = \begin{cases} lE_{dec} + l\varepsilon_{fx}d^2, d < d_0 \\ lE_{dec} + l\varepsilon_{fx}d^4, d \geq d_0 \end{cases}$$

Update Residual Energy for the selected cluster head from the formula above

(All the Nodes & Future Cluster heads are not active during this time or we can say that they are in sleep mode)

End

End

End

Residual energy can be calculated by radio energy model, the probability formula is based on energy values and genetic algorithm, that's why the selection of head nodes is optimum and we get an optimum results from the proposed approach, also the network design is such that, the delay produce in transmitting the data packets also decreases.

4. *Particle Swarm Optimization*

Particle swarm optimization has become a common heuristic technique in the optimization community, with many researchers exploring the concepts, issues, and applications of the algorithm. In spite of this attention, there has as yet been no standard definition representing exactly what is involved in modern implementations of the technique. The original PSO algorithm was inspired by the social behaviour of biological organisms, specifically the ability of groups of some species of animals to work as a whole in locating desirable positions in a given area, e.g. birds flocking to a food source. This seeking behaviour was associated with that of an optimization search for solutions to non-linear equations in a real valued search space. In the most common implementations of PSO, particles move through the search space using a combination of an attraction to the best solution that they individually have found, and an attraction to the best solution that any particle in their *neighbourhood* has found. In our proposed wireless sensor network, the routing strategy is fitness function for PSO and birds in which all birds have to find the best solution for calculating the selection probability of cluster head. In PSO, a neighbourhood is defined for each individual particle as the subset of particles which it is able to communicate with. The first PSO model used a Euclidian neighbourhood for particle communication, measuring the actual distance between particles to determine which were close enough to be in communication. This was done in imitation of the behaviour of bird flocks, similar to biological models where individual birds are only able to communicate with other individuals in the immediate vicinity. The Euclidian neighbourhood model was abandoned in favor of less computationally intensive models when research focus was shifted from biological modelling to mathematical optimization. Topological neighbourhoods unrelated to the locality of the particle came into use, including what has come to be known as a global neighbourhood, or $gbest$model, where each particle is connected to and able to obtain information from every other particle in the swarm.

Figure 8. Figure shows Birds or fish exhibit such a coordinated collective behaviour

Algorithm 1

Particle Swarm Algorithm

01. *Begin*

02. *Parameter settings and swarm initialization*

03. *Evaluation*

04. $g = 1$

05. *While (the stopping criterion is not met) do*

06. *for each particle*

07. *Update velocity (With Respect to fitness)*

08. *Update position and local best position (With Respect to fitness)*

09. *Evaluation*

10. *End For*

11. *Update leader (global best particle)*

12. g + +

13. *End While*

14. *End*

The PSO algorithm has several phases consist of Initialization, Evaluation, and Update Velocity and Update Position.

4.1 Initialization

The initialization phase is used to determine the position of the *m* particles in the first iteration. The random initialization is one of the most popular methods for this job. There is no guarantee that a randomly generated particle be a good answer

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and this will make the initialization more attractive. A good initialization algorithm makes the optimization algorithm more efficient and reliable. For initialization, some known prior knowledge of the problem can help the algorithm to converge in less iterations. As an example, in 0-1 knapsack problem, there is a greedy algorithm which can generate good candidate answers but not optimal one. This greedy algorithm can be used for initializing the population and the optimization algorithm will continue the optimization from this good point.

4.2 Update velocity and position

In each iteration, each particle updates its velocity and position according to its heretofore best position, its current velocity and some information of its neighbor's. Equation below is used for updating the velocity:

$$\overline{v_i(t)} = \underbrace{w\overline{v_i(t-1)}}_{inertia} + \underbrace{c_1 r_1\left(x_i^*(t-1) - \overline{x_i(t-1)}\right)}_{Personal influence} + \underbrace{c_2 r_2\left(\overline{x^*(t-1)} - \overline{x_i(t-1)}\right)}_{Social influence}$$

Where$\overline{x_\iota(t)}$ is the position-vector in iteration t (i is the index of particle), $\overline{v_\iota(t)}$ is the velocity-vector in iteration t. $x_i^*(t)$ is the best position so far of particle I in iteration t and its $j-th$ dimensional value is $x_{ij}^*(t)$. The best position-vector among the swarm heretofore is then stored in a vector $v^*(t)$ and its $j-th$ dimension value is $x_j^*(t)$. R1 and r2 are the random numbers in the interval [0, 1]. C1 is a positive constant, called as coefficient of the social component. The variable $\boldsymbol{w}$ is called as the inertia factor, which value is typically setup to vary nearly from 1 to near 0 during the iterated processing. In fact a large inertia weight facilitates global exploration (searching new areas), while a small one tends to facilitates local exploration. Consequently a reduction on the number of iterations required to locate the optimum solution as mentioned in figure below. The algorithm required to update the position based on equation below:

$$\overline{x_\iota(t)} = \overline{x_\iota(t-1)} + \overline{v_\iota(t)}$$

V. RESULTS

This work is apply Method in a Sensor Field of Area 100×100 m. However one can change the field area as per the result variations. Also, the base Station is Placed at the Centre of Sensor Field initially, however we can change the Position of base Station.Initially the dissipated energy is Zero & residual energy is the Amount of initial energy in a Node, Hence Total energy E_t also the Amount of residual energy because it is the sum of dissipated & residual energy. Simulations are carried out in **MATLAB R2013b** (Version 8.2.0.703)

The performance of the protocols are tested using two setups:

Setup 1: A 100x100 m of randomly dispersed homogeneous nodes, each with 0.5 J of energy and the BS located at the centre of the network system.

Setup 2: A 100x100 m of randomly dispersed heterogeneous nodes with the initial energies varying between 0.5J to 2.25 J and BS located at the centre of the network system. To be fair, the total energy of the system for each protocol are ensured to be the same; we use a total energy of 102.5 J.

After starting a round, firstly it checks if there is a dead node in the Sensor Field, and repeats these criteria after every round. Election of Cluster Heads for member nodes and a cluster head node are done in different loops which depend on the Election Probability used. After a Cluster Head sent its Data to Sink, Energy dissipated is calculated, through energy models considered in the propose work, in order to calculate how much energy dissipated after a steady state and whether a Cluster head is eligible to transmit data in the next round too. This Energy thoroughly depends upon the distance between BS and CH for CH, and Member node to CH for Member node.The 100 Nodes are placed in the randomly manner in the whole field, the number of clusters directly depends upon the number of cluster head. A single cluster head is assigned to clusters which act as a sub-destination and route data from other cluster member nodes to the destination (Sink or Base Station).

Node distance between the cells

The distance vector calculation is a very important process while developing a communication protocol for sensor network, as energy is directly dependent to distance, so it is necessary for a system to calculate the distance between all sensor devices with each other. Let assume that the node position in the cell is (x_n, y_n). It can be defined the distance between node i and the other node (x_c, y_c) as: $D_{[i]} = \sqrt{(x_c - x_n)^2 + (y_c - y_n)^2}$

We know a simple relation:

For all $D >= 0$, $D^2 >= D_1^2 + D_2^2$ Where, $D = D1 + D2$

Since, energy consumed in transmitting a signal to distance is D is proportional to the square of distance transmitted. We can easily concede that for the same set of parameters and targets, network equipped with Direct Communication protocol will run out of energy faster than rest of the types of networks. Because for a long range transmission sensor located far from base station will die very soon in order to send signals to the base station. So this kind of network is not efficient in a remote wide area. Now let us compare the no. of sensors alive at time iterations for rest of the routing algorithms for two different types of placements.

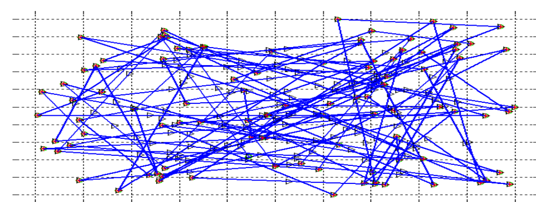

Figure 9. Shows the distance vector calculation between different sensor devices. This distance information is very useful for data communication based on distance in case of energy saving schemes.The distance-vector formula originates basically from the formula used in Ad-hoc on-demand distance-vector protocol as:

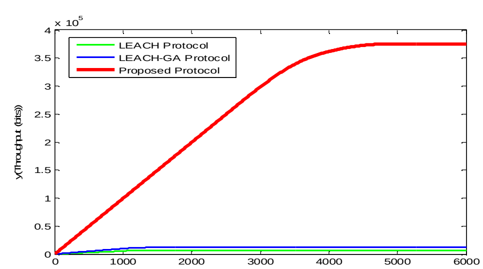

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Figure 10. The graph above shows a comparative view of obtained network throughput from both the proposed scheme and the LEACH and GA based LEACH. The throughput obtained with respect to number of rounds or communication period. It is measured in terms of bits/second. Although, the base station received the data in terms of packets. A single packet consist of 8 bit of data. Above experiment are done for 100 sensor nodes in the field area. It is clear from the figure that, in proposed approach a throughput of approximately 379000 bits is calculated which much higher than the approach proposed by LEACH and GA based LEACH.

Throughput of receiving bits: It is the ratio of the total number of successful packets in bits received at the sink or base station in a specified amount of time.

$$\text{TH} = \sum \text{Amount of Routing Packets recieved at the base station}$$

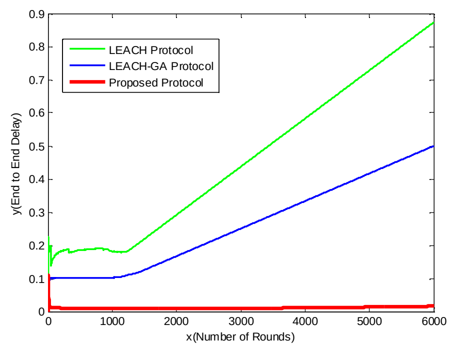


Figure 11. The graph obtained shows a comparative view of end to end delay measured at the base station or delay introduced by the routing scheme in delivering data packets to the base station from both the proposed scheme and the LEACH and GA based LEACH. The End-to-end delay obtained with respect to number of rounds or communication period. It is measured in terms of milliseconds. Above experiment are done for 100 sensor nodes in the field area. It is clear from the figure that, in proposed approach the end-to-end delay is much lower and about 0.022 which is lower than the approach proposed by LEACH and GA based LEACH.

End-to-End Delay: It is the delay that could be caused by buffering during route discovery, queuing delays at interface queues, retransmission delays at the media, and propagation and transfer times.

$$\text{EED} = \frac{\text{Current Transmission period}}{\text{Total Number of Data Packets Recieved}}$$

In Proposed model, a Node will becomes Cluster Head, if a Temporary number (between 0 to 1) assigned to it is less than the Probability Structure Below,

$$T(s_i) = \begin{cases} \dfrac{P_i}{1 - P_i\left(rmod\dfrac{1}{P_i}\right)} & if \ \in G \\ 0 & otherwise \end{cases}$$

Here, *Pi* is come out from New Expression for Optimum Probability P (i), *Pi* is the optimum probability for the selection of heads, developed in proposed methodology. Hence, only the nodes with higher weight amongst the other nodes can fulfil the criteria above and hence a node can transmit data as a cluster head for a longer period which results in increment of network lifetime and throughput. After a higher weight node becomes Cluster Head, Energy Models are applied to calculate the Amount of Energy Spent by it on that Particular Round and complete the round of steady state phase.

$$E_{TX}(l,d) = \begin{cases} lE_{dec} + l\varepsilon_{fx}d^2, d < d_0 \\ lE_{dec} + l\varepsilon_{fx}d^4, d \geq d_0 \end{cases}$$

When this dissipated energy is subtracted from the initial energy, then the amount of energy remain is called residual energy. When a node residual energy is zero then the node is called dead and is terminated from the network environment. The statistics of dead nodes with respect to transmission rounds is shown in figure below:

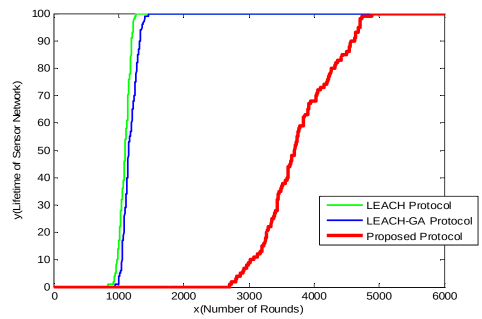


Figure 12. Figure above shows a comparative view of death of sensor nodes with each round for both the proposed scheme and the LEACH and GA based LEACH. Node dead statistics are obtained with respect to number of rounds or communication period. Above experiment are done for 100 sensor nodes in the field area.Result is taken when the base station is placed at the centre of sensor field and the selection probability is defined through the energy values considered. It is clear from the figure that both the network lifetime and stability of lifetime of network is achieved through proposed protocol. Also, it was observed that the technique network proposed in LEACH and GA based LEACH completely stopped functioning at an earlier simulation rounds compared to our proposed technique. We saw that the functional capacity for LEACH and GA based LEACH created network lasted till an estimated value of ~1300 rounds of simulation, while the functional capacity of the proposed approach lasted till an estimated value of ~4900 rounds of simulation.The average energy Ea of a Node after the particular round with the Knowledge of Total Energy and a particular number of round numbers.

$$Ea = E_t \times \left(\frac{1 - (r/Rmax)}{n}\right)$$

As per the formula of average energy, the average energy in network is zero when the current transmission round is equal to maximum number of rounds.

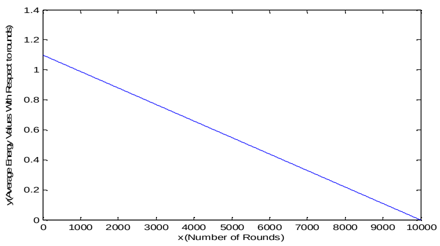
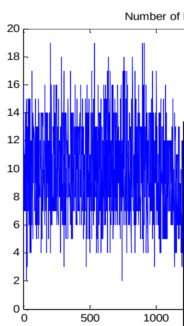


Figure 13. Graph above shows the average energy of all the sensor nodes in the network from start of communication till the end. As per the formula of average energy, the average energy in network is zero when the current transmission round is equal to maximum number of rounds, this is validated from the figure above.

TABLE 2: Mean and variance of residual energy in both the proposed method and the EACH-GA method



	Range (J)	Mean residual energy (J)	Variance residual energy (J)
Proposed	98.5569	43.9161	38.5569
LEACH-GA	29.7538	13.1419	11.7406

Figure 14. This figure shows the number of cluster head selected during the communication period in each round when communication is done for 3000 rounds. It is clear from the figure that maximum 19 cluster head is selected in a singleround not more than that, when taking a sensor network of 100 sensors.

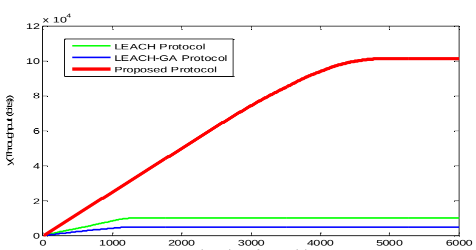


Figure 15. The graph above shows a comparative view of obtained network throughput from both the proposed scheme and the LEACH and GA based LEACH schemes. The throughput obtained with respect to number of rounds or communication period. It is measured in terms of bits/second. Although, the base station received the data in terms of packets.

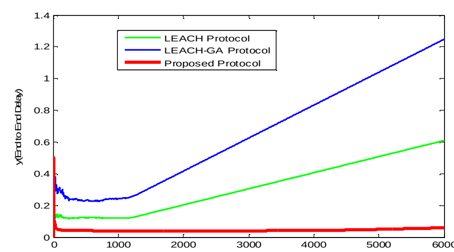


Figure 16. The graph obtained shows a comparative view of end to end delay measured at the base station or delay introduced by the routing scheme in delivering data packets to the base station from both the proposed scheme and LEACH and GA based LEACH schemes. The End-to-end delay obtained with respect to number of rounds or communication period. Above experiment are done for 25 sensor nodes in the field area.

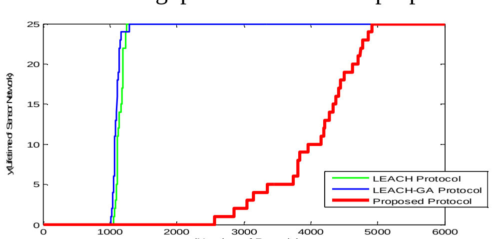


Figure 17. Figure above shows a comparative view of death of sensor nodes with each round for both the proposed scheme and LEACH and GA based LEACH schemes. Node dead statistics are obtained with respect to number of rounds or communication period. Above experiment are done for 25 sensor nodes in the field area.

Table 3. Comparisons Of Network Lifetimes (Number Of Rounds)

Number of nodes	Protocol	Prob	Nodes Dead(in Rounds)			
			1%	20%	50%	100%
25	LEACH-GA	0.1000	968	1006	1157	1326
	Proposed	0.1267	2612	3382	4186	4934
100	LEACH-GA	0.0957	947	1095	1319	1509
	Proposed	0.0793	2741	3448	3862	4893

Table 4. Comparisons Of Network Throughput (Bits)

Nodes	**Protocol**	**Prob**	**Network Throughput (in bits)**
25	LEACH-GA	0.1000	10200 bits
	Proposed	0.1267	101000 bits
100	LEACH-GA	0.0957	20000 bits
	Proposed	0.0793	379000 bits

This section conclude that and also here results shows that, this protocol successfully extends the stable region to more than 2000 rounds by being aware of heterogeneity through assigning probabilities of cluster-head election weighted by the relative initial energy of nodes, also the lifetime of network extended to more than 4500 rounds in this protocol.

VI. CONCLUSION

We have studied multiple strategies that can compensate for the hot spot problem seen in sensor networks using many-to-one traffic patterns. First, we found the optimal transmission range distribution that allows the lifetime of sensor networks to be maximized. Based on this model, we revealed the upper bound of the lifetime of a typical scenario and demonstrated the inability to make good use of the energy of nodes furthest from the base station, even when utilizing the optimal distribution and our quasi-optimal heuristic routing scheme. Thus, varying the transmission power of individual nodes cannot alone solve the hot spot problem. In addition to transmission power control, we have investigated several alternative strategies for solving the hot spot problem and analyzed the gains that can be obtained from their use. Specifically, we have considered the deployment of multiple base stations, where each node aggregates all of the network's data at one time, the deployment of a mobile robot, and the use of a clustering hierarchy, where heterogeneous sensors are deployed, some of which can act as data aggregators/compressors. When analyzing the use of each strategy, we also considered the necessary extra costs incurred and show how the network configuration can be optimized for cost efficiency in each case.This work proposed "A Distributed

Energy Efficient Cluster Based Routing Scheme for Wireless Sensor Network using Particle Swarm Optimization", which is further compared by genetically optimized improved LEACH. This protocol is used to determine the optimal probability for cluster formation in WSNs. As simulation results show that in terms of network lifetime of sensor node, since the use of the optimal probability yields optimal energy-efficient clustering. Results shows that, this protocol successfully extends the stable region to more than 2000 rounds by being aware of heterogeneity through assigning probabilities of cluster-head election weighted by the relative initial energy of nodes, also the lifetime of network extended to more than 4500 rounds in this protocol. Proposed algorithm is implemented using MATLAB.

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