

Augmenting the Network Lifetime in Wireless Sensor Network (Enhanced LEACH)

Roopali Garg¹, Deepika Gupta²

¹Coordinator (I.T)

¹Astt. Professor, U.I.E.T, Panjab University, Chandigarh, INDIA

²Research Scholar, U.I.E.T, Panjab University, Chandigarh, INDIA

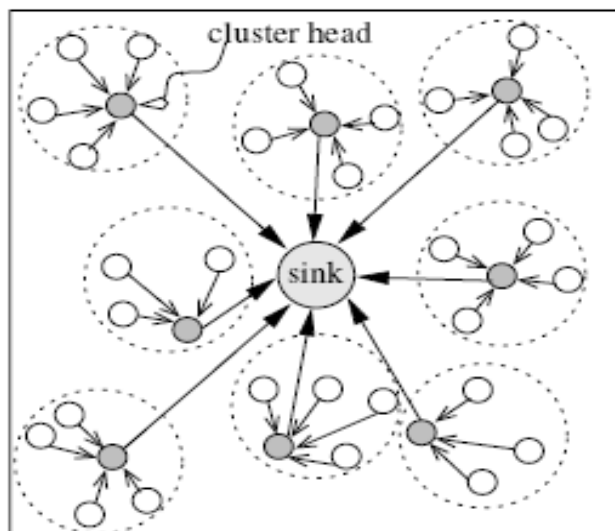
Abstract: A wireless sensor network is a network of power restricted nodes with the ability of sensing and communication covering a large region. Unlike its significant advancements in many areas; maximizing the lifetime of the whole network remains a major hindrance. Various protocols and approaches have been into existence to overcome this pitfall. One of the approaches is optimizing the angle by which sensors are placed in the grid formation. Here, in this paper we are going to implement this new approach through enhanced leach to have better cluster formation and enhance our results.

Keywords: WSN, LEACH, energy efficiency, CH, network lifetime

I. Introduction

A sensor node generally consists of sensors, actuators, memory, a processor and they have communication ability through a wireless medium. WSNs are deployed to carry out various applications, such as environmental monitoring [1], wildlife habitat monitoring [2], acoustic monitoring [3], and battlefield surveillance [4]. But these applications raises a few challenges like enhancing the network lifetime by making the sensor nodes operational for a longer period of time. Figure1 represents a typical wireless sensor network.

Figure 1: A typical wireless sensor network [5]



LEACH (Low Energy Adaptive Clustering Hierarchy) protocol is the basic and the most important protocol in wireless sensor network which uses cluster based broadcasting technique [6]. It is the first hierarchical cluster-based routing protocol for wireless sensor network. Still, LEACH needs improvement against the neglect of residual energy, location and the non-uniformity distribution in the selection of the cluster head [7]. Further, it also needs improvement against single-hop transmission [8]. Energy-LEACH protocol improves the cluster head selection procedure. It makes residual energy of node as the main criterion which decides whether the nodes turn into CH or not after the first round [9]. LEACH-C protocol is the further improvement over LEACH protocol. LEACH-C protocol uses a centralized clustering algorithm to determine good clusters. In addition to this, the sink also calculates the average node energy to have energy load uniformly distributed among all the nodes by determining which nodes have energy below this average [7]. In EE-LEACH-MIMO, both the location

and the residual energy are into criterion matrix for choosing the cluster head for clustering and cooperative nodes for the MIMO system[10]. In this paper we propose an enhanced LEACH in which the angle is optimized for partitioning the sensor nodes to have uniform clusters formation. The square network is plotted; location and residual energy of the nodes are considered for choosing the cluster head effectively and increase network lifetime.

The rest of the paper is organized as follows: Section II describes the proposed enhanced leach protocol. In section III, energy consumption model is discussed. Section IV shows the simulations done. Section V presents the results and comparison. Section VI concludes the paper.

II. Enhanced LEACH protocol

Clustering is an energy efficient method for wireless sensor networks. In clustering, the network is divided into many clusters; each cluster consists of cluster head and many other member nodes. LEACH protocol is one of the clustering protocols. The operation of LEACH is divided into rounds and each round consists of two phases: cluster setup and steady data transmission. In the cluster setup phase, clusters are formed and the cluster head is generated randomly. In steady data transmission phase, other member nodes send data to the cluster head; cluster head fuses the data and sends it to the sink.

To overcome the inefficiency of the LEACH in the neglect of residual energy of the nodes and the non distribution of the cluster heads, in Enhanced LEACH, both the residual energy and the location is considered for choosing the cluster head. The routing technique followed is multihop routing. The network is uniformly plotted to clusters. Each cluster consists of cluster head and many member nodes. N nodes are randomly distributed in S×S region space. The sink is located far from the monitoring area.

In this scheme, operations are performed in respective stages: area partition, cluster head generation and data transmission.

A. Area partition

In our scheme, firstly, the network is partitioned by the sink by applying the optimum clustering angle: *k-angle* that forms different clusters. Then, further *k-angle* is splitted into *h-opt* by the following strategy:

$$0 \leq h\text{-opt} \leq k\text{-angle} - 1$$

here *h-opt* varies from

0: .1: *k-angle* -1

This partitioning makes the sensor nodes centralized in the cluster and uniformly randomly deployed, which avoids the non-uniformity distribution of the cluster heads. Network partition helps in reducing energy consumption and prolongs the network lifetime.

B. Cluster head generation

In the network based on clustering, cluster head is responsible for coordinating the operations among other sensor nodes in the cluster, collecting and fusing the data and then sending it to the sink. Thus, the load on cluster head is more and it consumes more energy. So during the generation of cluster head, both the position and the residual energy of the node are considered to balance the energy.

In the first round, node whose position is close to the sink is chosen as the cluster head. In the following rounds, the member node can be the cluster head if it follows two conditions: 1) The location of the node must be close to the sink. 2) The residual energy of the nodes must be greater than the threshold. Then the strategy followed is:

$$\min_{\text{node } j \in \text{cluster}} d_j$$

$$E_{res}(j) > E_{th_d}$$

where d_j is the distance from the member node j to the sink, $E_{res}(j)$ is its residual energy and E_{th_d} is the threshold energy. The threshold energy is set to be the average residual energy of all the alive nodes in the cluster.

C. Data Transmission

After the above phases, data transmission takes place: nodes send their data during their allocated TDMA (time division multiple access) slot to the (CH) cluster head [11]-[12]. Then CH creates and broadcasts its own TDMA schedule which includes time slots for data transmission from member nodes to the cluster head and then from the cluster head to the sink. During the rest time, nodes fall asleep to save energy. CH fuses the data packet received from member nodes and then transfer it to the sink.

III. Energy Consumption Model

The energy consumed in the network depends upon various factors: 1. Data transmission from the member nodes to the cluster head and then from the cluster head to the sink. 2. Data received. 3. Energy consumed in fusing the data by the cluster head. 4. Additional overheads. The energy consumption model is introduced in [10]. The energy consumption for transmitting and receiving the l bit message covering a distance of d meters in the m -th power path-loss channel respectively are:

$$E_{tx_con}(l,d) = lE_{tx} + lE_{amp}d^m$$

$$E_{rx_con}(l) = lE_{rx}$$

where E_{tx} and E_{rx} presents the transmitter and the receiver circuit energy consumption per bit respectively. E_{amp} denotes the effect of antenna, amplifier and carrier frequency with the prescribed bit error rate (BER).

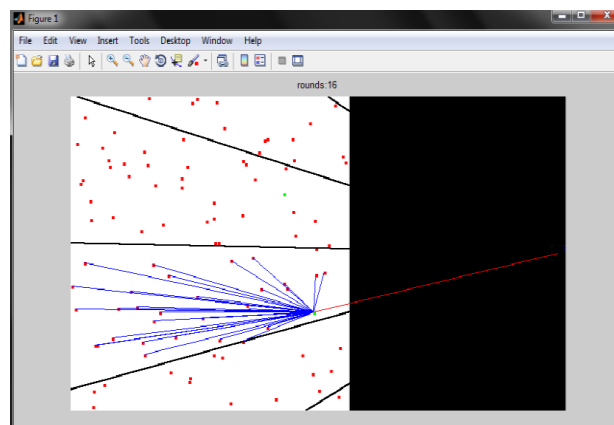
IV. Simulation

This section covers the simulation done for Enhanced LEACH in matlab. EE-LEACH-MIMO is taken as a reference. We use the number of rounds before the first node dies (FND), half node dies (HND) and last node dies (LND) for examining the lifetime of the network. The parameters taken for the simulation work are presented in Table1.

Table1. System Parameters

Parameters	Values
Sensor nodes(N)	100
Simulation Area(S×S)	100*100
k-angle	10-15 degrees
Sink position	(50,175)
Data packet	2000 bits
Initial energy	0.5 J
E_{amp}	100pJ/bit/m ²
E_{tx}	50nJ/bit
E_{rx}	50nJ/bit
Energy for data fusing	5nJ/bit

Figure 2: Simulation window showing deployment of 100 nodes in 100*100 area



In our simulation work, clusters are partitioned from the sink situated outside the network area. By taking a square area (100*100), sensor nodes are more centrally placed. Further the area is divided into square grids to deploy all the nodes optimally. The sensor nodes send the data to their respective cluster heads, which further sends the data to the sink. Multihop routing is followed.

The additional overheads in the simulation are also measured. This includes circuit setup which also consumes energy with that of transferring and receiving the data.

V. Results and Comparison

Figure3: Network profile for Enhanced LEACH

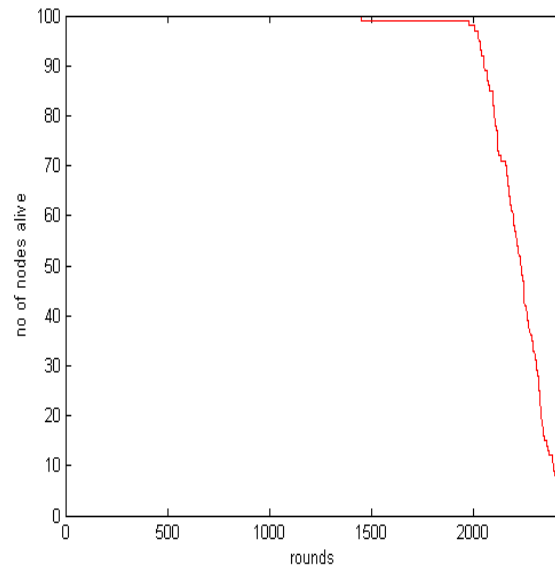


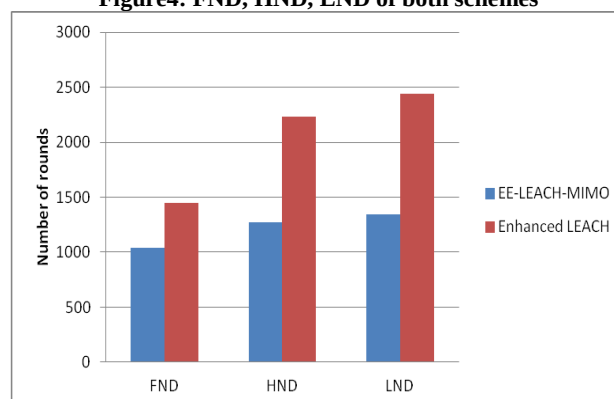
Figure3. illustrates that lifetime of Enhanced LEACH is greater than EE-LEACH-MIMO. The nodes are alive for a longer period of time. This states that energy consumed is well balanced and the network is efficient. The cluster heads are uniformly distributed considering both location and the residual energy of the nodes. Simulation results are shown in the Table2 and Figure4. FND, HND and LND of different schemes are presented in Table2.

Table2. FND, HND, LND of different schemes

Scheme	FND	HND	LND
EE-LEACH-MIMO [10]	1040	1274	1342
Enhanced LEACH (proposed method)	1447	2231	2438

Data above, shown in the tabular form depicts that Enhanced LEACH, has more network lifetime as compared to EE-LEACH-MIMO.

Figure4: FND, HND, LND of both schemes



By comparison with EE-LEACH-MIMO; FND, HND, LND of Enhanced LEACH prolong by 39%, 75%, 81%. Overall the lifetime of the network increases and the network is more efficient.

VI. Conclusion

In the proposed method, we implemented Enhanced LEACH that uses both the location and the residual energy of the node. Network is partitioned by the sink by applying the optimum angle to have uniform cluster head distribution. The network is a square area having square grids formation to centrally place all the nodes. Our scheme does not employ MIMO technique. No cooperative nodes are chosen. This avoids the computational complexity. Moreover, this Enhanced LEACH has overall improvement of 67% than EE-LEACH-MIMO. Thus; it is an energy efficient scheme.

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