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Ee-Leach(Low Energy Adaptive Clustering Hierarchy) Modified Protocol

Nishita Payar, Prof. Chandresh R. Parekh
Department of Wireless and Mobile Computing GTU PG-School, BISAG Gandhinagar, India
Department of Electronics and Communication Government Engineering College-Sector 28 Gandhinagar, India

Abstract
A wireless sensor network is made by many homogeneous and/or nodes which can sense data and communicate to each other. As energy is a scarce resource in WSN, the main issue is energy efficient routing. Many flat and hierarchical protocols have been projected to enhance the network lifetime. Low Energy Adaptive Clustering Hierarchy (LEACH) protocol is a basic energy efficient hierarchical routing protocol in WSN. In LEACH, cluster heads are selected and cluster is formed by joining non cluster head nodes. Member nodes transmit the data to respective cluster head and the cluster head is conscientious to transmit the gathered and aggregated data directly to the base station. This paper examines the performance of the conventional LEACH protocol and gives an enhancement to it for energy efficiency. The proposed protocol considers many parameters like residual energy and distance from base station etc. for cluster head selection and energy efficient routing.
Keywords— Prof. Chandresh R. Parekh

I. INTRODUCTION

Wireless Sensor Networks (WSNs) are almost same as mobile ad-hoc networks (MANET) with some extra features and restraint like limited energy capacity, non-rechargeable battery life and low memory capacity. Thus wireless sensor network originated as a battlefield surveillance application. Previously, the routing protocols did not require point to point communication. Nowadays, the field has been rising with new prospective in health, industrial and other monitoring applications and so it is required to make routing protocols more efficient. As memory is limited and more power is consumed, programmers need to consider these two challenges while designing wireless sensor networks. WSNs are application specific and nodes are responsible to sense, collect and aggregate data and send it further towards the destination. So in WSN routing protocol should be design in a way to fulfill these tasks. The main concentration for designing a good routing protocol is: awareness of energy, scalability in energy constrained and bandwidth constrained environment, adaptability in limited memory environment. Due to limited energy resource, clustering routing protocols are more important. They are scalable and more energy efficient and easy to manage than direct communication and flat routing protocols.

II. LOW ENERGY ADAPTIVE CLUSTERING HIERARCHY (LEACH)

Low Energy Adaptive Clustering Hierarchy (LEACH) is a clustering-based protocol that utilizes randomized rotation of the cluster-heads to evenly distribute the energy load among the sensor nodes in the network [2]. The protocol is presented by Heinzelman et al. [1]. In this protocol a dense network of homogeneous, energy constrained nodes. These nodes are responsible to send their data to a sink node. In this protocol, TDMA based MAC protocol is integrated clustering approach. In LEACH nodes are divided into clusters. Each cluster consists of a cluster-head which is responsible for creating and maintaining a TDMA schedule, and all other nodes are treated as member nodes. TDMA schedules are assigned to all member nodes. This schedule can be used to exchange data between member and the cluster-head. Member nodes within cluster send data to their CH and cluster-head sends this aggregated data to the sink.

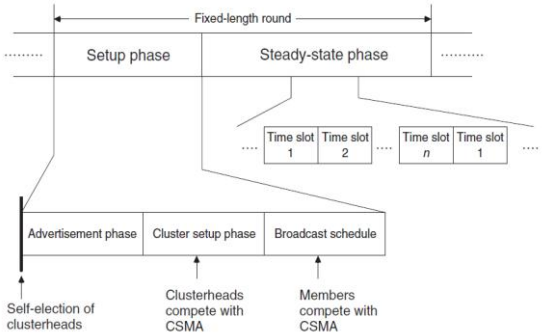

Figure 1: Organization of LEACH rounds [1]

LEACH protocol is organized into rounds. Each round is sub-divided into two phases, set-up phase and steady-state phase. A set-up phase is followed by steady state phase. The **setup phase** starts with the self-election of nodes to cluster-heads. The procedure of self election of nodes as cluster head is followed as a sensor node chooses a random

number, r, between 0 and 1. If this random number is less than a threshold value, T(n), the node becomes a cluster-head for the current round. The threshold value is calculated based on an equation that incorporates the desired percentage to become a cluster-head, the current round, and the set of nodes that have not been selected as a cluster-head in the last (1/P) rounds, denoted by G.
It is given by:

$$T(n) = \frac{1}{1-p(r \bmod (1/p))} \text{ if } n \in G \text{ [4]}$$

where G is the set of nodes that are involved in the CH election. In the following **advertisement phase**, the cluster-heads inform their neighborhood with an advertisement packet. The cluster-heads contend for the medium using a CSMA protocol with no further provision against the hidden-terminal problem. The non-cluster-head nodes pick the advertisement packet with the strongest received signal strength. In the following cluster-setup phase, the members inform their cluster-head ("join"), again using a CSMA protocol. After the cluster setup-phase, the cluster-head knows the number of members and their identifiers. It constructs a TDMA schedule, picks a CDMA code randomly, and broadcasts this information in the broadcast schedule sub-phase. After this, the TDMA steady-state phase begins. Because of collisions of advertisement or join packets, the protocol cannot guarantee that each non-cluster-head node belongs to a cluster. However, it can guarantee that nodes belong to at most one cluster.

The cluster-head is switched on during the whole round and the member nodes have to be switched on during the setup phase and occasionally in the steady-state phase, according to their position in the cluster's TDMA schedule.

With the protocol described so far, LEACH would not be able to cover large geographical areas of some square miles or more, because a cluster-head two miles away from the sink likely does not have enough energy to reach the sink at all, not to mention achieving a low BER. If it can be arranged that a cluster-head can use other cluster-heads for forwarding, this limitation can be mitigated.

LEACH protocol is energy efficient than the previous protocols but still, the protocol suffers from some deficiencies mentioned below:

- It assumes that every node is able to communicate with each other and is able to reach sink, which is not possible for large network.
- In the LEACH protocol election of CH is based on random number, and it doesn't consider the residual energy of nodes. So it may possible that some nodes may drain out their energy very quickly.
- Each CH directly communicates with sink without taking in to account if it is too far from sink.
- The size and density of cluster is different, so there are chances that CH in highly dense area may consume more transmission energy.

As energy is a scarce resource in WSN, the main feature to focus while designing routing protocol is always how to minimize the energy consumption and thereby improving network lifetime.

III. RELATED WORK

The LEACH is the most representative routing protocols among hierarchical protocols, whose purpose is to balance the energy consumption of all nodes and thereby to increase the lifetime of network. LEACH randomizes the selection of cluster-heads so energy load is balanced among the network and the lifetime is increased.

LEACH is more energy efficient than previous flat routing protocols. To make LEACH more energy efficient many solutions have been proposed, among which two base paper has been chosen for further research. The base papers are briefly described as follows:

Enhanced Cluster head Selection Algorithm Using LEACH

Rudranath Mitra and Anurupa Biswas [3] proposed the solution for the problem of uneven CH distribution where WSNs are deployed randomly in density. They gave the example that if the CH lies at a distant position from the majority of nodes. So to communicate between CH & sensor nodes, since the distance between them is high, energy consumption for the communication is also high. That means, the higher the distance between CH & sensor nodes the greater the energy consumption. For this, the authors have proposed following scheme to choose CH [3].

Select the CH in the dense node zone. As if nodes are near to the CH, energy consumption is less. They concentrated that the CH should be at optimum distance from the surrounded clusters' CH, that is means the distance between them should be balanced or on average. So, energy consumption will be in control.

Rudranath Mitra and Anurupa Biswas Proposed Mathematical formula [3]:

$$\frac{1}{1-p(r \bmod (1/p))} \frac{E_{n\_current}}{E_{n\_max}} \frac{D_{avg}}{\sum D_{inter\_node}} \frac{D_{ch\_avg}}{D_{centre\_avg}}$$

Where:
En_current is the current amount of energy
En_max is the initial amount of energy

Davg is the average distance from all other nodes in the cluster Einter_node is the distance between any two nodes in the cluster Dch_avg is the average distance from the node to the neighboring CHs Dcentre_avg is the average distance of the neighboring CHs from the centre of the cluster The advantages of the proposed scheme are as follows:

- Optimizes the distance between head nodes and other nodes, and thereby reduces energy consumption and chances of loss of signal strength.
- Optimizes the distance between the inter CH nodes, thus optimizing the communication between head nodes and central server.
- The new approach selects the optimized node as head node which has the minimal cost in terms of energy while communicating with other nodes, thus increasing the lifetime of the network.

A Location Based Clustering Algorithm:

Lin SHEN and Xiangquan SHIA [4] have analyzed the LEACH protocol. They assumed the precondition in this paper, that is, CHs are very closely located and the distance between them becomes negligible. Then they identified one loop-hole that when multiple CHs are randomly selected within a small area, a big extra energy loss occurs. The amount of lost energy is approximately proportional to the number of CHs in the area. In order to solve that, they gave the idea of CH selection on temporal distribution. The formula to elect CH in the paper was as follows [4]:

$$T(n)=\begin{cases}\dfrac{p}{1-p(r \bmod (1/p))-pk} & n \in G \\ 0 & others\end{cases}$$

They concluded that the lifespan of the new progressive clustering protocol is longer than that of the original LEACH protocol. The data transferred with the new protocol is 1/3 more than that with the old protocol, and the lifespan of the network with the new protocol is almost doubled compared with that of the old protocol.

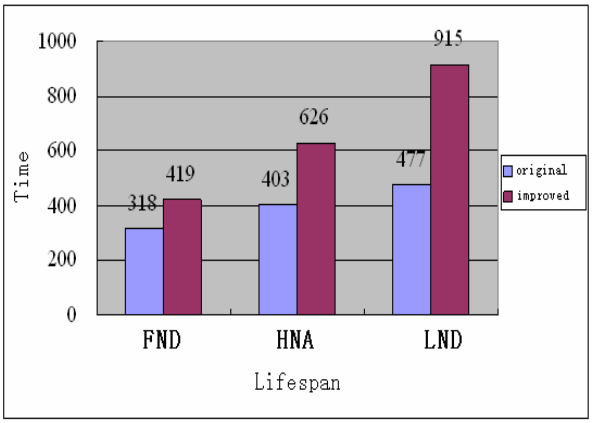

Figure 2: Comparison of the lifetime of two protocols [4]

Energy Efficient Routing Protocol:

H.Srikanth.Kamath [5] discussed the functionality of LEACH protocol. He pointed that random CH selection is less energy efficient and then he introduced the new scheme of CH selection, in which residual energy of the node is considered. H.Srikanth.Kamath gave the new equation of T (n) for CH selection is as follows [5]:

$$T_R(n) = \begin{cases}\dfrac{P}{1-P*(r \bmod \frac{1}{P})}\left[\delta P+(1-\delta P)\dfrac{E_{residual}}{E_0}\right] & if\ n \in G \\ 0 & if\ n \notin G\end{cases}$$

Where $E_{residual}$ is the residual energy of node, E_o is the initial energy of node, δ is the number of consecutive rounds during which a node has not been cluster-head by far. When elected as cluster-head, the value of δ for that node is reset to 0. This threshold ensures nodes of higher residual energy have a greater chance of becoming a cluster-head, which balances the energy consumption of the network. H.Srikanth.Kamath also suggested the concept of relay node, and introduced new protocol named LEACH-R has been introduced in the paper. This due to the energy saved in transmission by the improvement of cluster-head selection and the R (relay) node.

IV. PROBLEM STATEMENT AND PROPOSED SOLUTION

There are so many published literatures which have focused to improve energy efficiency using different techniques. And survey paper [6] is referred to analyze problem statement and area of research in the LEACH protocol. By referring the paper [6], it is concluded that still the level of energy in LEACH protocol is unbalanced because it suffers

from some deficiencies. The very first deficiency is that the CH sends data directly to the sink. So if the CH is far away from the sink, it will consume more transmission power to send data directly to sink.

Objective and analyses

While literature reviews, it has been analyzed that a conventional LEACH protocol is energy unbalanced due to the issue of random CH selection and uneven CH distribution. From this analysis and as energy is a very crucial resource in WSNs the future work will be concentrated on how to make conventional LEACH protocol more energy efficient and balance energy consumption within the network. The concentrated parameter of this proposed work is the residual energy of the nodes and the distance between CHs. The proposed work will focus on conventional LEACH protocol. The conventional LEACH protocol will be analyzed and area of improvement will be focused to make it energy efficient. For analyses, improvement and simulation Castalia simulator will be used.

Proposed scheme

To overcome the drawbacks and limitations mentioned above, a new scheme for LEACH protocol,, introduced as EE-LEACH modified, is projected in which following assumptions have been made:

1. All nodes are homogeneous.
2. All nodes are having same initial energy level when the network is deployed.
3. All nodes in the network are static.
4. The sink node is wired and far away from the network, so there isn't any issue regarding the energy level of sink.
5. All nodes are lying on the same surface. So the third dimension is ignored.

The main objective of the proposed scheme is as follows:

1. The election of CH should be based on residual energy rather than just random number so that Ch failure due to less residual energy can be avoided.
2. To maintain the distance between the CH so that the protocol can be optimized for energy consumption.
3. To improve the network lifetime

For Simulation and analyses purpose, the equations of transmission and receiving energy of basic radio model [7] have been taken into account. The equations are listed below:

$$E_{TX} = E_{elec}*k + E_{amp}*d^2$$

$$E_{RX} = E_{elec}*k$$

Where

E_{TX}= Transmission energy

E_{RX}=Receiving energy

E_{elec}=50 nJ/bit

E_{amp}=100 pJ/bit/m^2

k= number of bits to transmit or receive

d= distance between source and destination

Now, by taking the above assumptions into account, the following scheme has been proposed.

Each rounds of the improved algorithm of LEACH are of *Tr* time and has the following phases.

Set up Phase

In the first round of the set up phase, the CH selection will be same as the conventional LEACH protocol. It means a sensor node chooses a random number, r, between 0 and 1. If this random number is less than a threshold value, T(n), the node becomes a cluster-head for the current round. The threshold value is calculated based on an equation that incorporates the desired percentage to become a cluster-head, the current round, and the set of nodes that have not been selected as a cluster-head in the last (1/P) rounds, denoted by G.

It is given by:

$$T(n) = \frac{1}{1-p(r \bmod (1/p))} \text{ if } n \in G \text{ [4]}$$

where G is the set of nodes that are involved in the CH election.

From the second round of set up phase of the proposed LEACH protocol, the residual energy and the distance between the nodes will be considered and CH will be selected such that they have more energy as compared to other nodes and they are evenly distributed.

Algorithm 1 Algorithm for advertisement phase of modified LEACH for node *i*

```
1. Select one randomNumber between (0,1)
2. Calculate T(n) = 1/(1−p(r mod (1/p))) *energyRatio
3. If ( randomNumber < T(n)) OR (isSink) then
4.       node i is Clusterhead
```

As the algorithm1 will be executed, the Algorithm 2 described below will check if the elected cluster heads are located near by. And one of the cluster head will be again marked as normal node according to the algorithm if required.

Algorithm 2 Algorithm for advertisement phase of modified LEACH for cluster head *j*

```
1   if( isCHj) then
2      if((ch_Dist)^2 <= energyThreshold) then
3         if(remainingEnergy_j== remainingEnergy_i)
4            if(i<j) then
5               isCH_i=false
6            Else
7               isCH_j=false
8         else
9            if(remainingEnergy_j<
```

```
        remainingEnergy_i) then
10              isCH_i= false
11          Else
12              isCH_i=false
```

Steady State Phase

The steady state phase of the proposed LEACH protocol will be same as of the conventional LEACH protocol.

V. ANALYSES AND SIMULATION

The above proposed algorithm gives many improvements on the base papers. The improvement of the proposed protocol is shown in the following table.

Parameters	**Conventional LEACH**	**Enhanced CH selection LEACH**	**Location based clustering**	**EE LEACH modified**
CH election based on energy	No	Yes	No	Yes
Participation of Sink as CH	No	No	No	Yes
Distance between two CH considered	No	No	Yes	Yes

Figure 3. Comparison of proposed LEACH with base papers

For the further procedure and analyses the Castalia simulator along with omnet++ is used. The proposed scheme has been implemented in Castalia simulator. For the simulation following network scenario has been considered.

Number of nodes: 100
Grid: 1000 x 1000
Simulation time 2000s

For above network scenario the conventional, enhanced CH Selection CH, Location based clustering and EE modified LEACH protocols has been simulated and following result has been generated. The results in Figure 4 shows that after making sink node as cluster head and electing cluster heads by considering residual energy, the nodes with high residual energy are being selected as cluster heads. There by the proposed scheme is making the protocol energy reliable.

In the second scenario for analyses and simulation the following simulation parameters have been considered and network lifetime for each protocol has been analyzed.

Number of nodes: 400
Grid: 200 x 200
Simulation time 2000s

While analyses and simulation, it has been observed that by considering residual energy of the node in cluster head selection process, the nodes which are having more residual energy are selected as cluster head. So the proposed protocol gives reliability in term of energy. The second simulation scenario approves that the proposed protocol is more energy efficient than the previous protocol and network lifetime is improved.

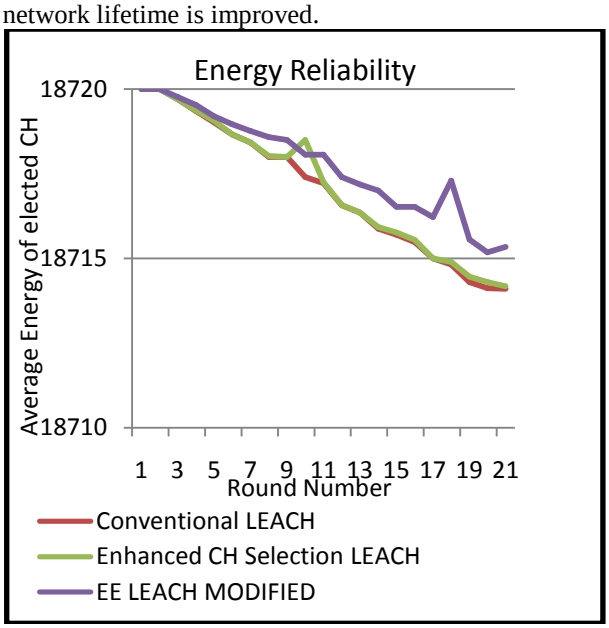

Figure 4. Comparison of the results for energy reliability

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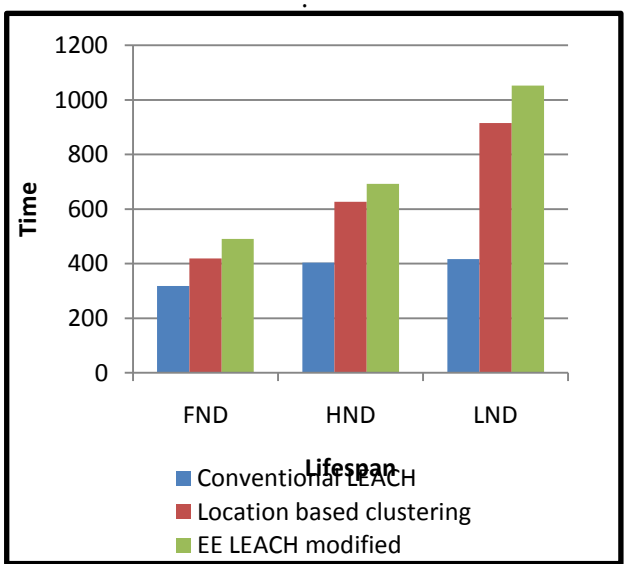

Figure5. Comparison of protocols based on lifetime

VI. CONCLUSION AND FUTURE WORK

Routing in WSN is quiet different than the wired network. Its challenges has got a lot of attention and opened wide doors for research. When it is about WSNs, energy should be considered the most while considering the routing. In the research so far it has given that LEACH is energy efficient than the previous routing protocols. And still it could be more energy efficient. As shown in analyses and simulation the conclusion came into picture that the proposed protocol is more energy efficient than that of previous protocols. The proposed protocol is for the scenario where nodes are deployed on the same surface, that is only two dimensions for node position is considered. The focus of the future work will be to consider the third dimension and simulate results

VII. ACKNOWLEDGMENT

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