

Routing protocol of wireless sensor network (ED-LEACH)

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Abstract: This paper presents a new version of leach protocol called “ED-LEACH” which aims to conserve energy considering BS distance and central distance of cluster by the passage of time. Compared to leach protocol, ED-LEACH has more longevity. The researcher evaluates both LEACH and ED-LEACH in Matlab. Results proves that energy consumption decreases about 20% Moreover in protocol of wireless sensor the first node lasts 6 times longer than leach protocol.

Keywords: Clustering, Energy, Distance, LEACH Protocol, ED-LEACH Protocol

1. Introduction

Wireless Sensor Network (WSN) consists of hundreds and even thousands of tiny devices called sensor nodes distributed autonomously to monitor physical or environmental conditions such as temperature, sound, vibration, pressure and motion at different locations. Energy plays an important role in wireless sensor networks because nodes are battery operated. Consequently many protocols have been proposed in order to minimize the energy consumption of these nodes. [1][2]

Each node in a sensor network is typically equipped with one or more sensors, a radio transceiver or other wireless communications device, a small microcontroller, and an energy source, since in most WSN applications battery supplies the required energy [6] plays an important role in wireless sensor network. Preserving the consumed energy of each node is an important goal that must be considered while developing a routing protocol for wireless sensor networks.

Many routing protocols have been proposed in the literature such as LEACH, PAMAS.[4][6][12].

Leach is considered as the most popular routing protocol that use cluster based routing in order to minimize the energy consumption. IN this paper, we propose an improved version of on the Leach Protocol that further enhance the Power consumption, simulation results show that our protocol outperforms Leach protocol in term of energy consumption and overall throughput.(potential)

In section 2-3the researcher will discuss the Leach protocol in details. Section 4 will present the related literature, in section 5; investigator will introduce our

proposed protocol ED-LEACH. In section 6 evaluation of protocol and presentation of the simulation results will be done. In section 7the conclusion will be given

2. Energy Routing Analysis of Routing Protocols

2.1. Directs Communication Protocol:

Each sensor sends its data directly to base station. If base station is far away, large amount of transmission power from each node will quickly drain to nodes+ reduction system longevity.

2.2. Minimum-Energy Routing Protocol:

Each node acts as a router for other nodes data in addition to sensing data.

- Some variations of this protocol only consider energy of transmitter + neglect energy dissipation of receivers.
- The intermediates are chosen in this waybecause transmit amplifier energy is minimized –as shown in formula.
- Every node sends a message to the closest node on its way to base station.
- When transmission energy is on the same order as receive energy (transmission destination is short), direct method of transmission is more energy efficient.

2.2.1. Cluster-Based Routing

The basic objective of any routing protocol is to make the network useful and efficient. A cluster is based on the sensor nodes of protocol groups where each group of nodes has a CH or a gateway. Sensing data is sent to the CH instead of being sent to the BS; CH performs some aggregation function on data it receives, then sends it to the BS where these data are needed.[2][3][4].

Two of the most well-known hierarchical protocols are LEACH, PAMAS and PEGASIS. All these show significant reduction in the overall network energy over other non-clustering protocols.

Hierarchical routing protocols are designed to reduce energy consumption by localizing communication within the cluster and data are aggregated to reduce transmissions to the BS.

3. Leach Protocol

Low Energy Adaptive Clustering Hierarchy (LEACH) is the first hierarchical cluster-based routing protocol for (WSN) which partitions the nodes into clusters, in each cluster a dedicated node with extra privileges called Cluster Head (CH) is responsible for creating and manipulating a TDMA (Time Division Multiple Access) schedule and sending aggregated data from nodes to the BS where these data are needed using CDMA (Code Division Multiple Access). Remaining nodes are cluster members.

The operation of LEACH is divided into rounds. Each of these rounds consists of a set-up and a steady-state phase.

During the set-up phase, cluster-heads are determined and the clusters are organized. During the steady-state phase data transfers to the base station occur. This paper presents an improvement of LEACH's cluster-head selection algorithm; the formation of clusters is not the topic of this paper.

We use the same radio model as stated in [10] with $E_{elec}=50\text{nJ/bit}$ as the energy being dissipated to run the transmitter or receiver circuitry and $\epsilon_{amp}=100\text{pJ/bit/m}^2$ as the energy dissipation of the transmission amplifier. Transmission (E_{Tx}) and receiving costs (E_{Rx}) are calculated as follows:

$$E_{Rx}(k) = E_{elec}k \quad E_{Tx}(k, d) = E_{elec}k + \epsilon_{amp}kd^2$$

Set-up Phase

- (1) Advertisement Phase
- (2) Cluster Set-up Phase

Steady Phase

- (1) Schedule Creation
- (2) Data Transmission

3.1. Setup Phase

Each node decides independent of other nodes if it will convert into a CH or not. This decision is taken into account when the node served as a CH for the last time (the node that hasn't been a CH for a long time is more likely to elect itself than nodes that have been a CH recently).

In the following advertisement phase, the CHs inform their neighborhood with an advertisement packet that they become CHs. Non-CH nodes pick the advertisement packet with the strongest received signal strength.

In the next cluster setup phase, the member nodes inform the CH that they become a member to that cluster with "join packet" containing their IDs using CSMA.

$$T(n) = \frac{P}{1 - P \times \left(r \bmod \frac{1}{P} \right)} \quad \forall n \in G$$

$$T(n) = 0 \quad \forall n \notin G$$

After the cluster-setup sub phase, the CH knows the number of member nodes and their IDs. Based on all messages received within the cluster, the CH creates a TDMA schedule, pick a CSMA code randomly, and broadcast the TDMA table to cluster members. After that steady-state phase begins.

3.2. Steady-State Phase

Data transmission begins; Nodes send their data during their allocated TDMA slot to the CH. This transmission uses a minimal amount of energy (chosen based on the received strength of the CH advertisement). The radio of each non-CH node can be turned off until the nodes are allocated to TDMA slot, thus minimizing energy dissipation in these nodes.

When all the data have been received, the CH aggregates these data and sends them to the BS.

LEACH is able to perform local aggregation of data in each cluster to reduce the amount of data that is transmitted to the base station.

Although LEACH protocol acts in a good manner, it suffers from many drawbacks namely;

- CH selection is random, that does not take into account energy consumption.
- It can't cover a large area.
- CHs are not evenly distributed; where CHs can be located at the edges of the cluster.

Since LEACH has many drawbacks, many researches have been conducted to make this protocol performs better.

Longevity of a Micro Sensor Network

The definition of the longevity of a micro sensor network is determined by the kind of service it provides. Hence, three new approaches of defining longevity are proposed. In some cases it is necessary that all nodes survive as long as possible, since network quality decreases considerably as soon as one node dies. Scenarios for this case include intrusion or fire detection. In these scenarios it is important to know when the first node dies. The new metric First Node Dies (FND) denotes an estimated value for this event for a specific network configuration. Furthermore, sensors can be placed in proximity to each other. Thus, adjacent sensors could record related or identical data. Hence, the loss of a single or few nodes does not automatically diminish the quality of service of the network.

In this case the new metric Half of the Nodes Alive (HNA) denotes an estimated value for the half-life period of a network. Finally, the metric Last Node Dies (LND) gives an estimated value for the overall lifetime of a network

4. Related Work

4.1. AHP Protocol

Three parameters; energy, movement, and distance of the central cluster have an impacts on cluster head selection. This algorithm undertakes the central method.[7]

4.2. LEACH-C protocol

LEACH offers no guarantee about the placement and/or number of cluster heads. In [13], an enhancement over the LEACH protocol was proposed. The protocol, called LEACH-C, uses a centralized clustering algorithm and the same steady-state phase as LEACH. LEACH-C protocol can produce better performance by dispersing the cluster heads throughout the network. During the set-up phase of LEACH-C, each node sends information about its current location (possibly determined using GPS) and its energy level to the sink. In addition to determining good clusters, the sink needs to ensure that the energy load is evenly distributed among all the nodes. To do this, the sink computes the average node energy, and determines which nodes have energy below this average.

Once the cluster heads and associated clusters are found, the sink broadcasts a message that obtains the cluster head ID for each node. If a cluster head ID matches its own ID, the node is a cluster head; otherwise the node determines its TDMA slot for data transmission and goes to sleep until it is time to transmit data. The steady-state phase of LEACH-C is identical to that of the LEACH protocol.

4.3. E-LEACH Protocol

Energy-LEACH protocol improves the CH selection procedure. It makes residual energy of node as the main metric which decides whether the nodes turn into CH or not after the first round [9]. Same as LEACH protocol, E-LEACH is divided into rounds, in the first round, every node has the same probability to turn into CH, it means that nodes are randomly selected as CHs, in the next rounds, the residual energy of each node is different after one round communication and it is taken into account for the selection of the CHs. In other words, nodes with more energy will become a CHs rather than nodes with less energy.

4.4. TL-LEACH

In LEACH protocol, the CH collects and aggregates data from sensors in its own cluster and passes the information to the BS directly. CH might be located far away from the BS, so it uses most of its energy for transmitting because it is always on it will die faster than other nodes.

A new version of LEACH called Two-level Leach was proposed. In this protocol; CH collects data from other cluster members as original LEACH, but rather than

transfer data to the BS directly, it uses one of the CHs that lies between the CH and the BS as a relay station.[10]

4.5. M-LEACH Protocol

In LEACH, Each CH directly communicates with BS no the distance between CH and BS does not matter. It will consume lot of its energy if the distance is far. On the other hand, Multichip-LEACH protocol selects optimal path between the CH and the BS through other CHs and it uses these CHs as a relay station to transmit data over through them.

First, multi-hop communication is adopted among CHs. Then, according to the selected optimal path, these CHs transmit data to the corresponding CH which is nearest to BS. Finally, this CH sends data to BS.

M-LEACH protocol is almost the same as LEACH protocol, only makes communication mode from single hop to multi-hop between CHs and BS.[8]

4.6. HEED Protocol

That is a distributed protocol that is independent from how nodes are deployed and it depends on how much energy is remaining in every node.[11]

4.7. ICLA Protocol

A CLAB based is another protocol that counts of neighbors and energy are two parameters to select cluster head.

4.8. Distributed Clustering Algorithm

This algorithm, considers that nodes are fix and with especially weight. This algorithm combines some factors to select head cluster.

4.9. Minimal tree algorithm

In this algorithm, energy is not a factor for being head cluster.

4.10. Adaptive Clustering for Mobile Wireless

In this algorithm, the rank of connectivity and lower id of nodes are important factors to be cluster head.

4.11. Learning Automata-Based Clustering

By using learning automata, a way is introduced that remaining energy of nodes and count of neighbors are important factors to be cluster head.

5. Proposed Work

In this protocol, there are some assumptions that are included:

1. Time (round) has divided to equal parts.
2. All nodes work synchronously in related to sending data to CH.
3. All nodes are deployed in half cycle.
4. Radius of all cycles is equal.

5. Nodes are not mobile.
6. Energy of nodes is not the same and they can be different.
7. Nodes were deployed in half cycle monotonously.

Hypothesis of protocol: With considering the distance of nodes to the centre of cycle and distance to BS and energy of nodes and putting them in especially formula, energy consumption can be reduced compared to leach protocol.

5.1. ED-LEACH Protocol

According to last part, in LEACH protocol selecting cluster head is random, so in this way nodes which have a low energy can be selected at first and longevity of network will be shorter, but in ED-LEACH, to be a cluster head it has considered to distance between node and its neighbors, duty cycle of every section and energy of nodes will be explained in the next section.

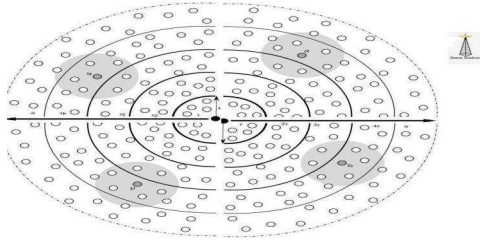


Figure 1

5.2. Algorithm Of Selecting Cluster Head

In this proposed protocol three parameters are very important to select cluster head energy, distance of BS or Sink, and distance of cycle centre are three fundamental parameters in selecting cluster head for the proposed protocol.

$f(t)$ is a very important factor to select cluster head it is calculated according to:

$$f(t) = C_{ave} * (1/\sqrt{D_{ave}}) * (2E_{ave}/t)$$

1-Init D_{ave} is an average distance between $node_x$ that is the nearest one to base station and $node_y$ that is the furthest one to base station that it can be calculated at a central cycle.

$$D_{ave} = \sqrt{(X_{BS} - X_i)^2 + (Y_{BS} - Y_i)^2}$$

2- C_{ave} : shows average distance between the nearest and the furthest nodes to the centre of cycle.

$$C_{ave} = \sqrt{(X_f - X_n)^2 + (Y_f - Y_n)^2}$$

There are some expressions in relation to formula:

2- D_{ave} : is average value of the nearest distance and the furthest distance node to base station

3- E_{ave} : is an average energy of all nodes that will be decreased by node energy, it will be reduced.

$f(i)$ is a parameter that every node after calculating of its distance to base station and its distance to centre of

cycle and its energy is calculated according to the expression below:

$$f(i) = C_i * (1/\sqrt{D_i}) * (E_i)$$

Starts to be compared to $f(t)$, and if it's $f(i)$ becomes more than $f(t)$, it can be selected as a head cluster, and in every t , some nodes can be selected as a head cluster. In this expression:

D_i : is a parameter that shows distance $node_i$ to BS.

C_i : is a parameter that shows distance $node_i$ to centre of cycle.

E_i : is a parameter that shows energy of $node_i$.

For the next round, $f(t)$ will be calculated again. Additionally, every node starts to calculate $f(i)$ and tries to compare with each other, if $f(i)$ is less than $f(t)$, it loses its chance to be a cluster head.

5.3. Comparison of Routing Algorithms

Finally, in order to understand this proposed work with previous works, table 1 shows some properties of algorithms and compares them with each other, that priority of CH selection and how data are sent to BS and type of protocol have been shown in table 1.

Table 1. comparisons of proposed work with previous works

| | CH Selection | Data Transmission | Mobility |
|---------------|---|-----------------------------|------------|
| LEACH | Random | All CH sends directly to BS | Stationary |
| C-LEACH | Energy | CH sends directly to BS | Stationary |
| AHP | energy, movement, distance of central of cluster, | CH sends directly to BS | Mobility |
| TL-LEACH | Energy, distance | In Two level | station |
| E-LEACH | Two round(randomly, Energy) | CH sends directly to BS | Stationary |
| Proposed work | Energy, distance of BS, distance of central cluster | CH sends directly to BS | Stationary |

6. Experimental Study

6.1. Simulation and Result:

MATLAB is used as a simulation platform.

6.2. Simulation parameters:

Table 2. Summary of the parameters used in the simulation experiments.

| parameters | Values |
|-----------------------|-------------------------------|
| Rounds | 1000 times |
| Topology size | 60*60 m ² |
| Number of nodes | 300 |
| Node distribution | Randomly |
| Base station position | 65*70 (x,y) |
| E(Amp) | 0.0013*0.000000000001 |
| E(tx) | 50*0.000000001 |
| Initial node power | Randomly 0.01<power<0.9 joule |
| k | 400b |

6.3. First Evaluation

For evaluation of our proposed work, we compare our algorithm with leach protocol. Input data in first experimentation is our expression and our output variable is count of live nodes that shows lifetime of sensor network.

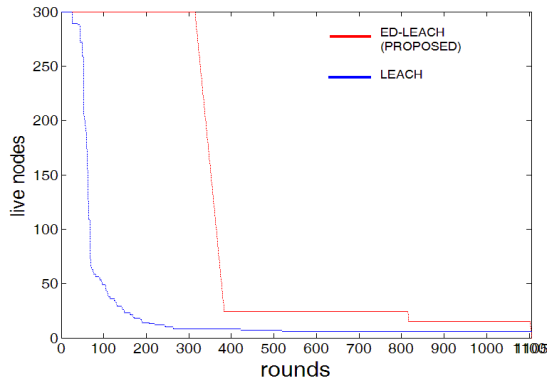


Figure 2

As can be seen in this picture, our proposed work has three times more lifetime than leach protocol.

6.4. Second Evaluation

In under figure below, consumed energy until 500 rounds, is shown.

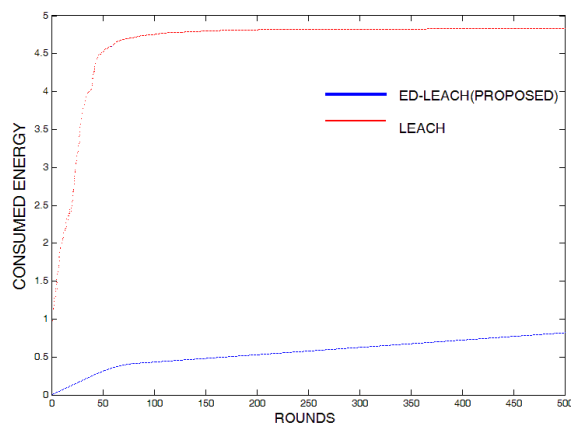


Figure 3

The figure shows that, consumed energy in leach is more than ED-leach (proposed work). Almost consumed energy in ED-LEACH is 1/5 times less than LEACH protocol.

7. Conclusion

In this paper, to make longevity duration for (WSN) a very important factor of quality service, ED-LEACH is reduced as a way of clustering that considers about distance to BS, and distance to Centre of cycle and energy of nodes. Results of experimental energy consumption has been decreased about 20% and in this proposed protocol the first node death times 6 times longer in comparison with leach protocol.

8. Future Work

A lot of good solution is introduced but in the future being a cluster head can be with using fuzzy logical ways.

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