

IMPROVED LEACH COMMUNICATION PROTOCOL FOR WSN

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Abstract—A wireless sensor network with a large number of sensor nodes can be used as an effective tool for gathering data in various situations. One of the major issues in wireless sensor networks is developing an energy-efficient routing protocol which has a significant impact on the overall lifetime of the sensor network. This paper focuses on reducing the power consumption of wireless sensor networks. Therefore, a communication protocol named LEACH (Low-Energy Adaptive Clustering Hierarchy) is modified. We propose a clustering routing protocol that partitions the network into clusters; the cluster contains, CH, sub-CH (the node that will become a CH of the cluster in case of CH dies), cluster nodes; thus extends network lifetime. We have conducted simulation-based evaluations to compare the performance of the proposed protocol against Low-Energy Adaptive Clustering Hierarchy (LEACH). Our experiment results show that this protocol outperforms LEACH in terms of network lifetime and power consumption minimization.

Keywords—Clustering methods, energy efficiency, routing protocol, LEACH, wireless sensor networks.

1. INTRODUCTION

Sensor networks can contain hundreds or thousands of sensing nodes. It is desirable to make these nodes as cheap and energy-efficient as possible and rely on their large numbers to obtain high quality results. Network protocols must be designed to achieve fault tolerance in the presence of individual node failure while minimizing energy consumption. In addition, since the limited wireless channel bandwidth must be shared among all the sensors in the network, routing protocols for these networks should be able to perform local collaboration to reduce bandwidth requirements. Eventually, the data being sensed by the nodes in the network must be transmitted to a control center or base station, where the end-user can access the data. There are many possible models for these sensor networks. Thus, communication between the sensor nodes and the base station is expensive, and there are no “high energy” nodes through which communication can proceed.

By analyzing the advantages and disadvantages of conventional routing protocols, LEACH (Low- Energy Adaptive Clustering Hierarchy) Protocol was developed [2, 5], a clustering based protocol that minimizes energy dissipation in sensor networks. However, LEACH outperforms classical clustering algorithms by using adaptive clusters and rotating cluster-heads, allowing the energy requirements of the system to be distributed among all the sensors. Instead, when the cluster-head die, the cluster will become useless because the data gathered by cluster nodes will

never reach the base station. So, there is a requirement to improve LEACH protocol to enhance the performance.

2. Energy Dissipation Radio Model

We assume a simple model for the radio hardware energy dissipation where the transmitter dissipates energy to run the radio electronics and the power amplifier, and the receiver dissipates energy to run the radio electronics [7, 8], as shown in Figure 1. Depending on the distance between the transmitter and receiver, both the free space (d^2 power loss) and the multi path fading (d^4 power loss) channel models are used. If the distance is less than a threshold, the free space model is used; otherwise, the multi path model is used.

Thus, to transmit a k -bit message a distance d , the radio expends:

$$E_{Tx}(k, d) = E_{Tx_elec}(k) + E_{Tx_amp}(k, d) \quad (1)$$

$$E_{Tx}(k, d) = \begin{cases} kE_{elec} + k\epsilon_{friss_amp}d^2 & : d < d_o \\ kE_{elec} + k\epsilon_{two_ray_amp}d^4 & : d \geq d_o \end{cases} \quad (2)$$

Where

$$d_o = \sqrt{\frac{\epsilon_{friss_amp}}{\epsilon_{two_ray_amp}}} \quad (3)$$

The electronics energy E_{elec} depends on factors such as the digital coding, modulation, filtering, and spreading of the signal, whereas the amplifier energy depends on the distance to the

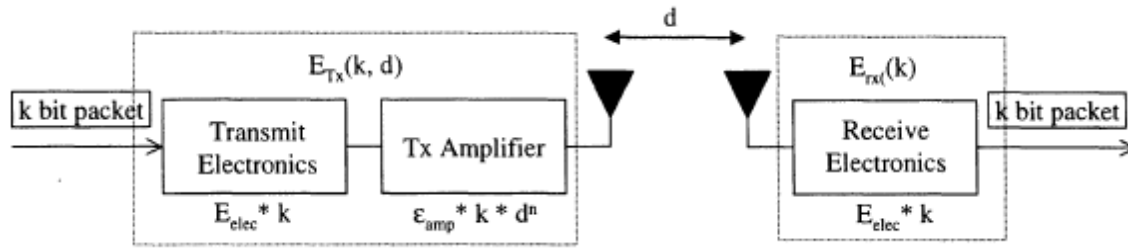


Figure 1: Radio energy dissipation model.

receiver and the acceptable bit-error rate. For the experiments described in this paper, the communication energy parameters are set as:

$$E_{elec} = 50nJ / bit, \epsilon_{friss_amp} = 10pJ / bit / m^2 \text{ and}$$

$$\epsilon_{two_ray_amp} = 0.0013 pJ / bit / m^4.$$

And to receive this k-bit message, the radio expends:

$$E_{Rx}(k) = E_{Rx_elec}(k) \quad (4)$$

$$E_{Rx}(k) = kE_{elec} \quad (5)$$

3. LEACH PROTOCOL

Low Energy Adaptive Clustering Hierarchy (LEACH) is the first hierarchical cluster-based routing protocol for wireless sensor network 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 is needed using CDMA (Code division multiple access). Remaining nodes are cluster members.

This protocol is divided into rounds; each round consists of two phases:

3.1 Set-up Phase

Each node decides independent of other nodes if it will become a CH or not. This decision takes into account when the node served as a CH for the last time (the node that hasn't been a CH for 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" contains their IDs using CSMA. 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 allocated TDMA slot, thus minimizing energy dissipation in these nodes.

When all the data has been received, the CH aggregate these data and send it to the BS.

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

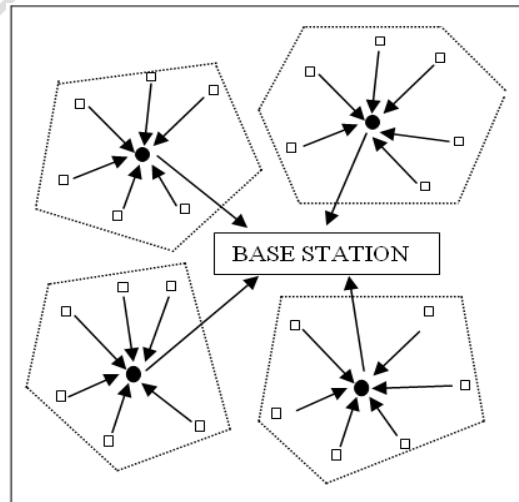


Figure 2: LEACH Protocol Architecture.

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

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

Since LEACH has many drawbacks, there is a requirement to make this protocol performs better.

4. PROPOSED PROTOCOL

In our new version of LEACH protocol, the cluster contains; CH (responsible only for sending data that is received from the cluster members to the BS), sub-CH (the node that will become a CH of the cluster in case of CH dies), cluster nodes (gathering data from environment and send it to the CH), as shown in figure 3.

In the original leach, the CH is always on receiving data from cluster members, aggregate these data and then send it to the BS that might be located far away from it. The CH will die earlier than the other nodes in the cluster because of its operation of receiving, sending and overhearing. When the CH die, the cluster will become useless because the data gathered by cluster nodes will never reach the base station.

In our protocol, besides having a CH in the cluster, there is a sub-CH that takes the role of the CH when the CH dies because the reasons we mentioned above.

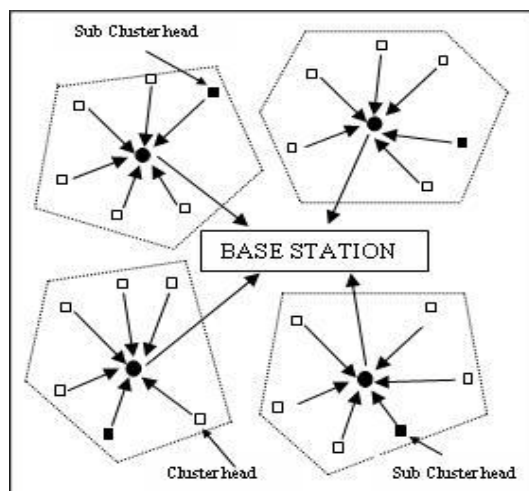


Figure 3: LEACH-sub-CH Protocol Architecture.

5. SIMULATION RESULTS

To validate the performance of proposed LEACH-sub-CH protocol, we simulate the protocol and utilize a network with 100 nodes randomly deployed between $(x=0, y=0)$ and $(x=100, y=100)$ and base station at $(50,175)$. The bandwidth of channel is set to 1 Mb/s; each data message is 500 bytes long. The initial power of all nodes is considered to be 2J and duration of each round is 20s. It has revealed analytically that the number of clusters for above assumptions is optimized for $1 < k < 6$. So for the rest of the experiment, we set $k=5$. These parameters are summarized in Table1.

Table.1: Summary of the parameters used in the simulation experiments.

Number of Nodes	100
Network size	100m * 100m
Base station location	(50,175)
Radio propagation speed	$3*10^8$ m/s
Processing delay	50 μ s
Radio speed	1 Mbps
Data size	500 bytes
Initial node power	2 Joules
Simulation time	900 sec

Figure 4 shows the comparison of average energy dissipation (in J) for LEACH and proposed protocol as a function of the distance of Base station from the sensed area.

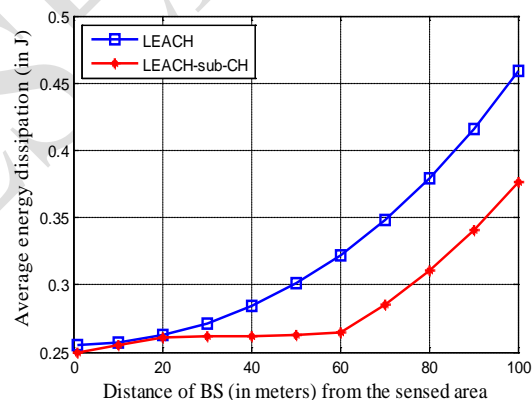


Figure 4: Average energy dissipation (in J) vs. the distance of BS from the sensed area.

6. CONCLUSION AND FUTURE WORK

In this paper we considered a well known protocol for wireless sensor networks called LEAH protocol which is the first and the most important protocol in wireless sensor network which uses cluster based broadcasting technique. Followed by a new version of LEACH protocol called LEACH-sub-CH protocol. From the simulation results, we can draw a number of conclusions.

- Number of messages created by the LEACH-sub-CH is less than the messages created by the original LEACH.
- The network energy remaining using LEACH-sub-CH is more than the remaining network energy using the original LEACH.

Therefore, the new version of LEACH outperforms the original version of LEACH protocol.

As another improvement, the cluster heads could form a multi-hop backbone whereby data are transmitted among cluster heads until they reach the BS. Alternatively, LEACH can evolve into a hierarchical protocol by forming “super-clusters” out of the cluster head nodes and having a “super-cluster head” that processes the data from all the cluster head nodes in the super cluster. These changes will make LEACH suitable for a wider range of wireless sensor networks.

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