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Using an Energy Efficient Extended Leach Work with Multilevel Clustering Approach

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ABSTRACT

Wireless Sensor Networks (WSNs) is a network of an inexpensive low coverage, sensing, and computation nodes. The difference between the wireless networks and WSN is that sensors are sensitive to energy consumption. In design of routing protocols for WSN the energy saving is the crucial issue. Till today many protocols have been proposed for energy efficiency in continuous driven clustered sensor network. LEACH is the simplest routing protocol in WSN whose main aim is to distribute the energy load equally among all sensor nodes in the network and prolong network life time. In this paper we propose an improved version of LEACH protocol which is more energy efficient by taking less radio communication distance than original LEACH. In this paper, we study a modification in Low Energy Adaptive Clustering Hierarchy (LEACH) protocol and also its implementation based on algorithms.

Keywords: WSN, Protocols, Cluster, Radio Communication, LEACH

INTRODUCTION

A Wireless Sensor Network (WSN) consists of a large number of tiny nodes with sensing, computation, and wireless communications capabilities. The sensors attached to the nodes measure ambient conditions related to the environment in which they are deployed, process the data and transmit them to the base station. Besides, sensor nodes are equipped with a radio transceiver or other wireless communications device, a small microcontroller and an energy source. Since in most WSN applications the energy source is a battery and energy plays an important role in such applications because sensor nodes are generally constrained with limited energy. Therefore, preserving the consumed energy of each node is an important goal that must be considered when developing a routing protocol for WSN. In general, routing in WSNs can be divided into flat, hierarchical, and location based routing depending on the network structure. Hierarchical routing is also known as cluster based routing because in this type of routing sensor nodes are grouped together and form clusters. In each cluster, a higher energy node is assigned as a head- node and known as cluster-head (CH). The CH acts as the leader of their own cluster having the responsibilities like collection and aggregation the data from their respective clusters and transmitting the aggregated data to the Base station (BS).

2. Preliminary Investigation

The main Aim of Cluster Based Routing protocol is to extend the network life time of WSN. In hierarchical routing protocols whole network is delivered into multiple clusters. One node in every cluster plays leading role i.e.cluster head (CH).Cluster head is that the solely node which will communicate to base station in clustering routing protocols. This considerably reduces the routing overhead.

2.1 Clustering Techniques

Dividing the sensor networks into little manageable units is known as Clustering. Although the most reason behind the implementation of the Clustering theme is to improve the measurability of the network, it's a vital factor in achieving energy efficient routing of data among the network. With the exception of achieving measurability of the network it's additional benefits like conserving communication information measure among the clusters, avoiding redundant message transfer between the sensor nodes, localizing energy efficient route setup among the clusters. A number of the energy efficient routing protocols based on clustering are LEACH, HEED, DECA.

2.2 LEACH Protocol

LEACH stands for Low Energy Efficient Adaptive Leach and it absolutely was the one in every of the primary cluster based hierarchical protocols used for wireless sensor network to extend the life time of network. LEACH performs self-organizing and re-clustering performs for each round. In this protocol, the sensor nodes are grouped together and form a cluster. In each cluster one in every of the sensor node act as cluster head and re-maintaining sensor nodes as member nodes of that cluster. Only cluster head will directly communicate to sink and member nodes use cluster head as intermediate router just in case of communication to sink. The major role of cluster head is to gather knowledge from their several cluster and mixture those collected knowledge and eventually sent to sink/base station. A randomize rotation technique of cluster head(CH) is employed by this protocol whose aim is to distribute the energy load equally among all sensor nodes within the network that ultimately provides results of an extended life to the node's battery. LEACH operations are split into two phases as:

2.2.1 Set-up phase

• Advertisement phase
• Cluster set-up phase
• Schedule creation phase

2.2.2 Steady phase

• Data Transmission Phase
In the set-up phase cluster heads are randomly chosen and cluster are organized as shown within the figure1. In the steady phase nodes transmit their knowledge/data to their respective CHs and at that time the CHs transmit the entire cluster compressed knowledge/data to the base station. Let us see the steps concerned in every round in the LEACH protocol.

3. Classification and Comparison of LEACH

Each routing protocol addresses specific problem and tries to enhance the conventional clustering routing protocol LEACH. Each routing protocol has some advantages and features. These routing protocol face some challenges like Cost of Clustering, Selection of Cluster-heads and Clusters, Synchronization, Data Aggregation, Repair Mechanisms, scalability, mobility, and initial energy level all nodes. We compare above mention routing with respect to some very important performance parameters for wireless sensor network. These parameters are following.

3.1 Classification: The Classification routing protocol indicate that it is flat, location-based or hierarchal.

3.2 Mobility: It specifies that routing protocol is designed for fixed are mobile nodes.

3.3 Scalability: It how much routing protocol is scalable and can be efficient if the network density is increased.

3.4 Self-organization: It is very important for routing protocol to adopt the changes in network. Nodes configuration and re-configuration should be performed by routing protocol by self- organization at the time when
nodes enter or leave the network.

3.5 Randomized Rotation of Cluster-head: Randomized Rotation of cluster-head is very necessary in order to drain the battery of all nodes equally.

3.6 Distributed clustering algorithm: Cluster- heads are self-elected in distributed clustering algorithm also nodes
select their cluster-head in distributed manner.

3.7 Centralized clustering algorithm: Cluster-heads are selected by Base station by central control algorithm.

3.8 Single-hop or Multi-hop: It is also important feature of routing protocol. Single-hop is energy efficient if it is smaller area of network and multi-hop is better for denser network.

3.9 Energy Efficiency: It is the main concern of energy efficient routing protocol to maximize the life time of the network.

3.10 Resources awareness: Sensor network has limited resources like battery and sensing capability routing protocol should be well aware from the resources.

3.11 Data Aggregation: In order to reduce the data amount to be transmit to Base station, Cluster-head perform data- aggregation in this way cluster-head transmission energy cost is reduce.

3.12 Homogeneous: Homogeneity of all nodes is considered in the routing protocol which describe that initial energy level of all the nodes is similar.

Table 1: Radio Characteristics

Operation	Energy Dissipation
Transmitter Electronics (EelectTx)	50 nj/bit
Receiver Electronics (EelecRx)	50 nj/bit
Transmit amplifier (Eamp)	100 pj/bit/m2

Table.1 shows the comparison LAECH, sLEACH, M- LEACH and Multi-Hop LEACH. Performance comparison shows that these routing protocol are similar in many ways. All routing protocol are hierarchal,homogeneous, having fixed BS despite M-LEACH, perform Data aggregation, self-organization and randomized rotation of CHs. LEACH, LEACH-SC, ELEACH, and Multi-Hop LEACH are use distributed algorithm for Cluster head selection. LEACH-C uses central control Algorithm for cluster-head selection and sLEACH is designed for both centralized and distributed algorithm. LEACH, sLEACH and M-LEACH are routing protocol in which Base Station is at single-hop and in Multi-Hop LEACH Base station can be at multi-hop distance from the cluster-head. LEACH and M-LEACH allow limited scalability. sLEACH allows good scalability while Multi-Hop LEACH is providing maximum scalability feature due to multi-hop communication option for cluster-heads.

4. Implementation

The routing protocols DTx, LEACH and EEE LEACH have been simulated accurately in MATLAB. These have been made assuming a network having dimensions 200 x 300 meters. The number of nodes in each protocol is assumed to be 200. The cost of transmission and receiving was calculated by the formulas mentioned above in the section I. The nodes are generated and placed randomly. The parameters that are used to calculate the transmission time and throughput are given below:

- Distance between the normal nodes and Bs.
- Distance between the normal node and CHs.
- Distance between the CHs and BS.
- Distance between the CHs and MCHs.
- Distance between the MCHs and BS.
- Speed of em waves.
- Size of the data packet

Table 2: Simulation Parameters

Sl. No.	Simulation Parameters and their Values	
	Parameters	***Value***
1.	Routing Protocols	DTx, LEACH, EEE LEACH
2	Environment Size	200 x 300
3	Number of nodes	200
4	Packet Size	2000 bits
5	Speed of em wave	3×10^8 m / s
7	Election Probability value of CHs (p)	10% to 30%
8	Election Probability value of MCHs (pm)	2% to 15%
9	Number of rounds	5 to 10,000 rounds
10	Initial energy per node (E_0)	1 J
11	E_{elec}	50 nJ / bit
12	E_{fs}	10 pJ / bit / m^2
13	E_{mp}	0.0015 pJ / bit / m^4
14	E_{DA}	5 nJ / bit

We have suggested two separate algorithms for both Cluster head selection in Setup phase and for data transmission in Steady state phase.

Algorithm 1: Cluster head Selection Algorithm:
Input: No of Sensor nodes, Initial node energy, probability (p), No of rounds.
Output: Cluster heads, Clusters.

Start:

1. Base station broadcasts Beacon packets.
2. All Sensor node replies with residual energy and location.
3. If network life time is not over then,
   i. For first round, Cluster heads are randomly selected.
   ii. For rest of the rounds, Base station chooses p% of the nodes as Cluster heads having more residual energy.

4. If a node is Cluster head then,
   i. It broadcasts its Cluster head advertisement packet.
   ii. All non-Cluster head nodes, sends joining request packet to those cluster head, who's received signal strength is more.

5. Cluster head accepts the joining request and forms respective clusters.

End.

The Cluster head selection is the crucial decision. In our proposed algorithm, first base station broadcasts because packets. As soon as sensor nodes receives beacon packet, they send their residual energy and location as a reply to base station. For the first round of communication we used randomized approach in selection of Cluster head, as in the first round the entire sensor nodes are assumed to have equal energy level and have same probability to become the Cluster head. In successive rounds base station chooses the Cluster head based on the residual energy of a node.Once the Cluster-heads are selected, they start forming clusters. Cluster heads broadcast advertisement packets to announce themselves as a Cluster heads. Sensor nodes replies to respective Cluster heads their cluster joining request packet based on received signal strength of Cluster heads advertisement packets. Now Cluster heads grant the joining request packets arrived from non-Cluster head nodes and form the clusters .After Cluster head selection and cluster formation, Steady state phase starts. In Steady state phase actual data transmission occurs. Steady state phase lasts longer then Setup phase.

Algorithm 2: Data Transmission Algorithm:

Input: Cluster heads, Clusters.
Output: Actual data transmission, Residual energy of network, No of dead nodes.

Start:

1. Cluster head creates TDMA schedule for all sensor nodes in their cluster.
2. All Cluster heads chooses different CDMA codes to avoid radio interference among inter-cluster communication.
3. All non-cluster head nodes send their sensed data to Cluster head as per the assigned TDMA schedule.
4. All Cluster heads aggregate their cluster's data.
5. Cluster heads send their data to other Cluster heads which lies in between base station and itself, which in turn aggregates data with their own data to reduce packet size and send it to base station.

End:

Once the clusters are formed, our protocol now enters into steady state phase in which actual data transmission occurs. Cluster head creates TDMA schedule as per the no. of nodes present in their cluster. Sensor nodes are assumed to have sensed data all the time ready to transmit, so as soon as sensor nodes turn come, it starts sending their data to Cluster head. After one cycle of data transmission, Cluster head aggregates the data. Now aggregated data is sends to base station in Multi-hop transmission Multi-level data aggregation way. Fig.6 explains the concept of Multi-Hop transmission with Multi Level aggregation of aggregated data. Here in data transmission phase, first Cluster heads aggregate their data locally and send it to those Cluster heads which lies in between base station and itself. This also recursively aggregate and send data to those Cluster heads which again lies in between base station and itself, this process continues until there are no Cluster heads left in-between. This way we have reduced the transmission distance between Cluster heads and base station with reduction in packet size by suggesting multi-level data aggregation. Both the factors have significant impact on energy saving. As the communication distance is
reduced due to Multi-Hop communication, we gain the energy efficiency and as the packet size is reduced due to Multi Level data aggregation, we gain energy is efficiency.

5. Conclusion

In this paper we considered a well-known protocol for wireless sensor networks called LEACH protocol which is the first and the most important protocol in the wireless sensor network which uses cluster based broadcasting technique followed by an overview of LEACH protocol implementation. The main concern of this paper is to examine the energy efficiency and throughput enhancement of these routing protocols. We compare the lifetime and data delivery characteristics with the help of analytical comparison and also from our simulation results. Significant research work has been done in these different clustering routing protocols in order to increase the life time and data delivery features. Certainly further energy improvement is possible in future work especially in optimal guaranteed cluster-heads selection.

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