

An Effective Approach for Minimizing Energy Consumption in WSN

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Abstract

Wireless Sensor Networks finds it difficult to transfer equal amount of data through all nodes, and in minimizing the level of energy consumption during transmission of data. This paper is an improvement to LEACH protocol; suggested to increase the overall lifespan of the network. Formation of clusters is based upon distance of nodes from base station, number of neighbor nodes and distance among neighbor nodes. The cluster heads are selected on the basis of nodes holding maximum energy. We have proposed the concept of selecting the master cluster head from the elected cluster heads based on the strength of energy that CH nodes have and the distance from the Base station. Further, using this concept, the fused data from master CH are forwarded to the sink node. Proposed work reduces the frequency and length of data exchanged between the CHs and the Base station. Simulation results revealed that the proposed method reduces the consumption of energy by 46.85 percent and increases the lifespan of the network efficiently. The parameters for comparison are First Node Dead and Half Node Alive.

Keywords: Clustering, LEACH, Master Cluster Head, Network Lifetime, Sensor Nodes

1. Introduction

Wireless technologies are used for many applications. Speed and other factors such as reduction in number of wires required for connections, accessibility in remote areas, make requirement for wireless technologies more prominent as compared to wired ones. But some applications of Wireless systems are designed to monitor the environment with special sensors and conveying that information to Base station where the potential information can be used for constructive work. In order to increase the network lifetime, it is necessary to design effective and energy aware protocols. Many researchers have proposed different protocols in the past in order to increase the network lifetime but they suffer from robustness and scalability¹.

1.1 LEACH Protocol

Low-Energy Adaptive Clustering Hierarchy (LEACH) is

the initial and most favored energy-conservation protocol for WSNs. Its principle works on aggregation technique, which aggregates the collected data. It reduces the message size and requirements by transmitting only meaningful information to individual sensors. LEACH divides the whole network into multiple bunches of sensors as shown in Figure 1. Clusters are formed through localized coordination and are designed not only to reduce the size of data to be transmitted to the destination, but also to make routing and data dissemination more scalable and robust.

LEACH uses an unarranged spinning of CH position rather than working in static manner, to give an opportunity to all sensors to work as CHs and avoid the battery exhaustion of an independent sensor and perish rapidly.

As compared to ordinary node, a CH node completes the tasks of data fusion and forwarding. In LEACH, consumption of energy is much higher as compared to available energy in nodes. So, in order to maintain the balance in consumption of energy among nodes and to

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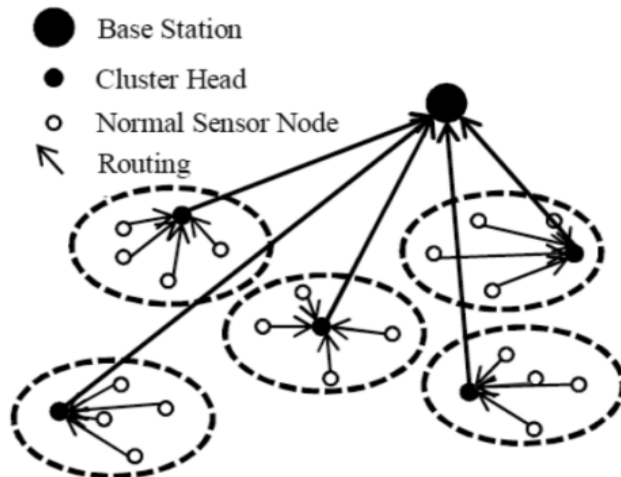


Figure 1. Clustering model: LEACH.

avoid earlier cluster head's death, periodical Cluster Head selection method is used and each period in this process is defined as the round. When clusters are made, each node takes the decision whether it can become a CH for the present round or not. It is found by the suggested percentage of the CHs for the network. This decision is taken by the node n by selecting a number between 0 and 1. If the number lies below a threshold value $T(n)$, then that node becomes a CH for the present round. The threshold value is calculated as:

$$T(n) = \begin{cases} \frac{p}{1 - p \times \left(r \bmod \frac{1}{p} \right)} & \text{if } n \in G \\ 0 & \text{otherwise} \end{cases} \quad (1)$$

Where n is the quantity of sensor nodes, r is the current round, p is the desired % of cluster heads, G is the set of nodes that are not selected as CH in last $1/p$ round. LEACH protocol ensures that each node within $1/p$ rounds will be a CH at some point of time.

1.2 HEED Protocol

Though, LEACH protocol is more significant when compared with its predecessors still some drawbacks of this protocol are found during its use. It is the random selection of CH. The thought of unarranged choosing, brings additional overhead like announcement of change in cluster etc. Due to these overheads, more energy is consumed while processing and forwarding. To avoid the unarranged spinning of CHs, an improvement in the form of HEED (Hybrid Energy-Efficient Distributed clustering protocol)

is suggested which chooses the CHs based on remaining energy scenario of node and communication cost. HEED supports heterogeneous sensor nodes, so highest energy may vary for dissimilar nodes according to its functionality and potential.

1.3 AODV Protocol

Ad-hoc on-demand routing protocol is an On-Demand routing protocol. This protocol is a collaboration of both Dynamic Source Routing (DSR) and Destination Sequenced Distance Vector (DSDV) protocols. It borrows route finding and route upkeep algorithms from DSR and hop-by-hop routing algorithm from DSDV protocols. The routes are only built when required. It minimizes the routing table information leading to more throughput and less redundancy. For finding path to the destination, AODV broadcast route request messages into the network.

2. Conventional Clustering Strategies

The authors figured out the means of energy depletion in the node and proposed a novel diffusive CH choosing algorithm². LEACH-DT for sensor networks is based on the node distance to the BS. Those nodes that are in the vicinity of the base station are only allowed to be the CH; in order to equalize the energy usage amid the nodes. Later in 2012, author proposed an energy-saving clustering algorithm for WSNs based on the LEACH algorithm³. The proposed algorithm solves the frequent transmissions problem that can occurs in LEACH algorithm³. It is done to preserve energy at nodes.

A new energy efficient clustering protocol DE-LEACH for homogeneous Wireless Sensor Network is designed which is claimed as an extension of LEACH. It improves the network lifetime, stability and throughput of sensor network. For increasing the network energy efficiency, it uses a residual energy and distance based cluster head election scheme⁴. DE-LEACH ensures that nodes which are far away from base station will become cluster head only when they have sufficient energy for performing this duty and nearby nodes particularly in the mid of the sensing region have the highest probability to become a cluster head in a round.

Hybridization is done to combine the advantages of two techniques so as to give birth to a new technique equipped with multiple good properties. This combined

effect has been suggested⁵ by authors producing a hybrid technique named HEECA. The perspective is achieved as 41.7 percent energy is saved in nodes during the operation as compared to the EECA-F and H-PEGASIS protocol.

Practically homogeneous networks do not exist. A network usually has nodes with different capabilities and resources. This property of heterogeneous is exploited; where the nodes are classified into two categories: Advance nodes and normal nodes⁶. Advanced nodes are more powerful and hence the authors suggested using advance nodes as CH. The results proved the significance of the scheme.

To save energy, authors proposed an algorithm in which cluster selection is carried out only once in the network, which is usually during the initialization phase. Thus, circumventing energy wastage linked with re-clustering process⁷. The cluster head spinning process is based on energy consumed by the nodes on performing various activities. The timing and frequency of CH spinning is decided on the basis of remaining energy of nodes. This results in equalized energy discharge of the nodes in network, improving the lifetime of the network.

Finding of optimized routes led the authors think upon the way to choose the next hop nodes towards Base station⁸. It is very essential to choose the optimized path for data transfer. It not only leads to effective delay less communication rather it conserves energy of intermediate nodes. Residual energy is also considered as the parameter for the selection of Cluster Head from surrounding nodes⁹. Time Division Multiple Access (TDMA) technique is used for the information exchange between independent nodes and CH. Cluster Head (CH) selects time slots to be acquired in its cluster. Code Division Multiple Access (CDMA) technique is preferred for communication between clusters. The suggested technique emphasizes on energy conservation by limiting the packet size and by using multi-level data aggregation scheme among cluster head.

Clustering is not merely a formation of nodes into a group. Other factors like deciding upon total number of clusters also play a vital role. It may also add reliability and restricts the network to unnecessary consume energy for creation of abundant cluster heads¹⁰.

3. Proposed Methodology

This section elaborates the improved form of LEACH Protocol incorporated with Master Cluster Head mech-

anism. Master Cluster Head scheme is an extension of existing LEACH Protocol. The entire system consists of two phases:

- Setup phase.
- Cluster Head Selection.

3.1 Setup Phase

Clustering is a prominent method for enhancing the network lifetime in WSN. It involves clubbing of sensor nodes having similar properties into clusters and electing Cluster Heads (CHs) for all the clusters. CHs receive the data from their cluster nodes and propagate the collected data towards base station. Performance of this technique is measured through simulation where initial parameters of considered network are mentioned in Table 1.

3.2 Cluster Formation

In this phase, clusters are formed depending upon information such as distance from base station, number of neighbor nodes and distance among neighbor nodes. The members of cluster will elect cluster head on the basis of respective energies of nodes. Approximately $1/10^{\text{th}}$ of the nodes will be elected as Cluster Head in every round. The selected 10 (in case of 100 nodes in totality) Cluster Heads will be responsible for electing one Master Cluster Head among them (refer Figure 2). The common nodes will transfer data to cluster heads and cluster head will pass on data to Master cluster head. The Master cluster head will aggregate the data and send it to Base station. The location of the base station is at the centre of the target area. There are no energy constraints for Base Station as it is directly connected with the mains.

3.3 Cluster Head Selection

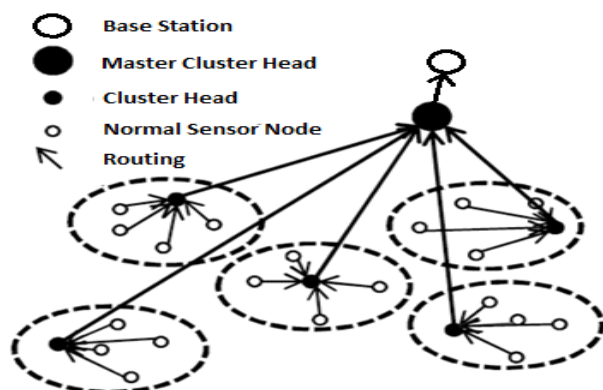
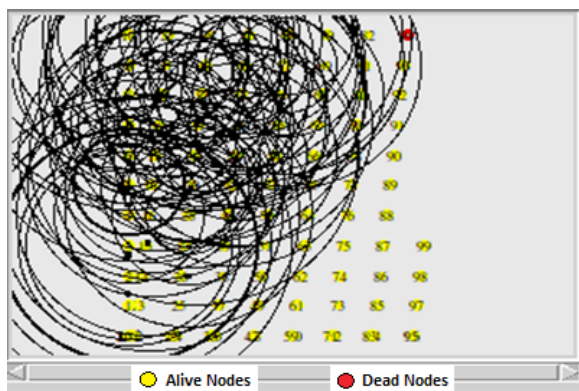
The CH are chosen on the basis of nodes with maximum energy. The algorithm for Cluster Head selection runs periodically. A threshold value is defined below which a node is not allowed to become Cluster Head. LEACH organizes its working into rounds, which is constituted of setup phase followed by data transfer phase.

4. Results

In the proposed research work, entire scheme has been simulated on Network simulator. The parameters

Table 1. Network specifications

Network size (m2)	1200 × 1200
Location of BS	(600, 600)
Number of nodes	100
Data packet size	500 bytes
Packet length for path set-up	20 bytes
Network topology	Random
Initial energy of each sensor	1.0 Joule

**Figure 2.** Master cluster head selection.**Figure 3.** First node died after 950 rounds.

considered for comparison are Network life time and Number of Nodes alive after certain rounds. Rounds are the number of times that the algorithm runs periodically and selects cluster heads. During the simulation, it is found that in proposed scheme nodes live for the longer duration as compared to LEACH and Conventional technique¹⁰. It is well observed from Table 2 and Figure 3 that the first node died on round 950 which are 60 round

ahead from existing technique and approximately more than 400 rounds as compared to traditional LEACH.

Similarly half nodes were died during the operation in just 780 rounds for LEACH and 1230 rounds for Conventional technique.

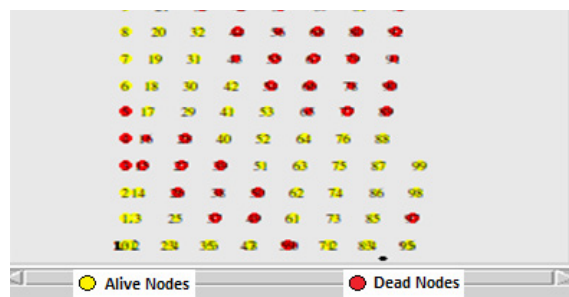
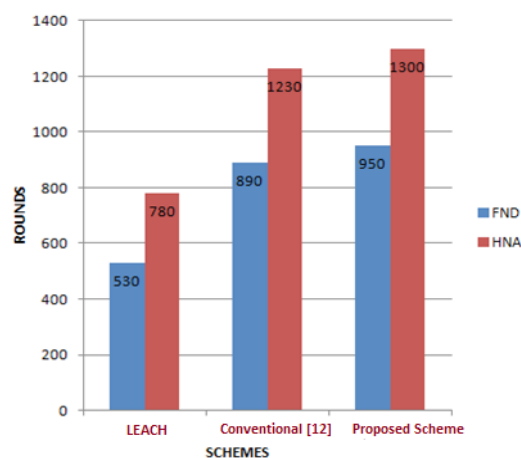
Table 2: Comparison of different approaches

Parameters	LEACH	Conventional [10]	Proposed Work
FND	530	890	950
HNA	780	1230	1300

FND: First Node Dies;

HNA: Half of the Nodes Alive

The effectiveness of the proposed technique can be well noticed as half of the nodes were still alive even after the 1300 rounds (refer Figure 4.) which are far more than existing ones.

**Figure 4.** Half node dies after 1300 rounds.**Figure 5.** Comparison in terms of FND and HNA.

From Figure 5, it is evident that the proposed technique enhances the lifetime of the network through the introduction of the master cluster head.

5. Conclusions

WSN witnessed in significant growth due to battery constraints. To address these issues, the proposed scheme introduced a new threshold parameter which is used in selection of cluster heads in the network. Suggested scheme helped to mitigate the problem and obtained good results in minimizing the energy consumption of the sensor nodes with the introduction of Master Cluster Head. As a result, the proposed scheme significantly reduced energy consumption at nodes by a large scale and has capability to enhance the network lifetime as compared to the conventional techniques discussed in the literature¹⁰.

6. References

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