

# A Survey of Energy Efficient Cluster Head Selection Techniques in Leach Protocol for Wireless Sensor Network

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**Abstract**— A wireless sensor network (WSN) consists of a large number of small sensors with low weight and low battery power. A sensor network is comprised of sensing, processing, communication ability which helps to observe, instrument, React to events and phenomena in a specified environment. Sensor cannot have an infinite lifetime without battery recharge or replacement. Sensors are divided and collected as group called clusters to collect the data from where it is deployed. Clusters are maintained by Cluster Head and it maintains the transmission process which needs high energy. Cluster formation and selection of Cluster Head (CH) are important problems in sensor network application and drastically affect the network lifetime. LEACH (Low Energy Adaptive Clustering Hierarchy) is good hierarchical protocol. In this paper, first outline the basics of wireless sensor network, then overview of LEACH protocol, describe review of several cluster head selection method in LEACH protocol based on energy consumption, lifetime of the nodes are defined.

**Key words:** Cluster Head (CH) Selection, Hierarchical Routing, Energy efficiency, LEACH, Wireless Sensor Network (WSN)

## I. INTRODUCTION

A wireless sensor network is type of wireless network. Wireless sensor networks (WSN) consist of a huge number of small self-contained devices with computational, sensing and wireless communication capabilities [3]. WSN aims to apperceive in collaborative mode, gather, deal with and send information to observer in network areas [2]. Nodes in WSN are compact size, lightweight devices. Due to these characteristics, routing in WSN is challenging from other wireless network. Sensor nodes are densely deployed in unattended environment, communicate with each other and make ad-hoc network. Sensor, sensing object and observer form the three factors in WSN. Nodes "sense" the environmental phenomenon and send the signals to the data collection center known as "base station". Sensor nodes have limited battery and it is not easy to replace or recharge the battery.

A cluster network is divided into various clusters. In each cluster, one node is elected as a cluster Head (CH) among all sensor nodes and others are cluster members. In each cluster, cluster members send the sensed data to CH. CH performs aggregation of that data, compress the data and send it to Base Station (BS) either directly or via multihop transmission. Cluster head utilizes more energy than cluster members do. Therefore, Cluster head is rotated among the cluster members. Energy saving of sensor nodes is a major design issue. Since nodes are usually battery-operated devices. Sensor network's lifetime can be prolonged by minimizing the energy consumption. Hierarchical routing is

an efficient routing technique to reduce energy consumption [1]. LEACH (Low Energy Adaptive Clustering Hierarchy) is the first hierarchical protocol [1].

## II. LEACH PROTOCOL

Heinzelmon introduced a hierarchical clustering algorithm for sensor networks [1]. LEACH (low Energy Adaptive Clustering Hierarchy) is a self-arranging, clustering convention and based on round-based technique. It is a cluster based routing protocol for sensor networks, which achieves energy efficient and scalable routing for sensor nodes.

LEACH expect that the BS is settled and arranged far from the sensors, all sensors are homogenous and have confined energy source, sensors can sense the earth at a changed rate and can grant among each other, and sensors can particularly compare with BS[4]. LEACH divides the network into several clusters. In every cluster, one node is selected as a Cluster Head (CH). Other non-Cluster Head node send their data to CH and all the CH aggregate that data and send compressed data to Base Station (BS). All CH use the direct communication to forward the data to BS.

In LEACH, the role of a CH is rotated periodically among all the nodes of clusters to balance the load. CH rotation takes place rather than selecting one in static manner and give opportunity to all the member of clusters to become CH to reduce the energy consumptions.

The important operation of LEACH can be divided into number of rounds. Each round, it has two phases, one is setup phase and other one is steady state phase. Each round begins with a set-up phase when the clusters are formed, followed by a steady state phase where several frames of data are transferred from the nodes to the cluster head and on to the base station.

1) Set-up phase is where the nodes are grouped into clusters and election of CH is carried out. The threshold function calculates the node probability to elect as CH.

$$T(n) = \begin{cases} P & n \in G \\ 1 - p \times (r \times \text{mod } 1/p) & n \in G \\ 0 & n \notin G \end{cases}$$

Where the  $P$  denotes probability of cluster head, number of current round us denotes using  $r$ ,  $G$  denotes the set of nodes which are not been elected as CH in previous  $1/p$  rounds and  $n$  denotes random number between 0 and 1. The nodes, which chose a lesser value than the threshold function is announced as CH for this round [7]. After its selection of each CH will broadcast an advertisement to all other nodes by using CSMA MAC protocol. Now each node selects a CH

based on the received signal strength of the Advertisement. Each node sends its join packet to its selected CH. Then cluster are formed, each CH creates a TDMA schedule according to the number of nodes in their cluster [5].

2) Steady Phase deals with aggregation of data. Once the clusters are formed, a TDMA schedule is created by CH in each cluster to organize the communication among cluster members. When the non-CH nodes receive the TDMA scheme, the network comes into the steady-state operation, i.e. data transmission. Nodes send their data to the CH once per frame during their allocated transmission TDMA slots. After a certain amount of frames, i.e. a TDMA round, the network re-elect CHs and re-form clusters [6].

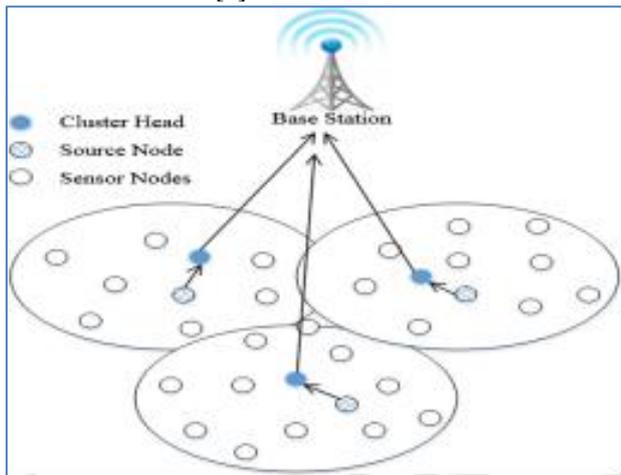


Fig. 1: schematic structure of LEACH protocol [8]

#### A. Advantages of LEACH

Various advantages of LEACH are as following [9]:

- 1) The Cluster Heads aggregates the whole data, which lead to reduce the traffic in the entire network.
- 2) As there is a single hop routing from nodes to cluster head it results in saving energy.
- 3) It increases the lifetime of the sensor network.
- 4) In this, location information of the nodes to create the cluster is not required.
- 5) LEACH is completely distributed, as it does not need any control information from the base station, as well as no global knowledge of the network is required.

#### B. Disadvantages of LEACH

Besides the advantages of LEACH, it also has some demerits, which are as follows [9]:

- 1) LEACH does not give any idea about the number of cluster heads in the network.
- 2) One of the biggest disadvantage of LEACH is that when due to any reason Cluster head dies, the cluster will become useless because the data gathered by the cluster nodes would never reach its destination i.e. Base Station.
- 3) Clusters are divided randomly, which results in uneven distribution of Clusters.

### III. RELATED RESEARCH WORK

#### A. An Application-Specific Protocol Architecture

Develop and analyze low-energy adaptive clustering hierarchy (LEACH), a protocol architecture for micro sensor

networks that combines the ideas of energy-efficient cluster-based routing. Distributed Cluster Formation Algorithm is proposed that reduce energy consumption and increase network lifetime [10].

#### B. CCWM approach

A cluster head weight selection method called Cluster Chain Weight Metrics approach (CCWM) has been discussed that takes service parameters for enhancing performance of the overall network. Cluster heads are selected first in a network by limiting the Node degree based on weight metric and then cluster formation takes place. This approach not only aims to conserve energy of sensors but also balances load. A local clustering mechanism is adopted within the cluster to reduce computation and communication cost. In addition, a new technique for data transmission is explored [11].

#### C. MODLEACH

MODLEACH (Modified LEACH) uses three transmission power levels which reduces energy consumption in network; also it uses different cluster head election algorithm in which node have remaining energy greater than threshold it remain as cluster head for next round. Equation used in MODLEACH for electing cluster head was same as used in LEACH. Election of CH based on remaining energy of the node. Energy hole removing mechanism is proposed such that if node has Energy less than threshold, it puts a node into sleep mode. If number of sleep nodes greater than 10 then putting sleep nodes one by one into active mode. Approach increases network lifetime in terms of first dead node, stability period and packets to base station or sink [12].

#### D. Node-ranked LEACH (NR - LEACH)

Proposed protocol improves the total network lifetime based on node rank algorithm. Node rank algorithm depends on both path cost and number of links between nodes to select the cluster head of each cluster. This enhancement reflects the real weight of specific node to success and can be represented as a cluster head. The proposed algorithm overcomes the random process selection, which leads to unexpected fail for some cluster heads. Proposed protocol increases sensor lifetime, throughput, and the delivery packet ratio and decreases both the packet delay and the sensors power consumption [13].

#### E. Time Based LEACH (TB - LEACH)

Time based cluster head selection algorithm (called TB-LEACH) is proposed & algorithm is based on random timer. In TB-LEACH, competition for cluster-heads (CHs) no longer depends on a random number as in LEACH, and a random time interval instead. Nodes, which have the shortest time interval, will win the competition and become cluster heads. In order to obtain a constant number of cluster-heads, counter is used. When the number of the counter has reached specified value, nodes no longer continue competition for cluster-heads [6].

#### F. Energy Efficient CH Selection

CH election based on Distance between node and neighbor node and Number of Neighbor Node include with the threshold function of LEACH protocol. In this, the node, which is chosen as CH, should adhere to the two parameters.

They are, i) Distance between CH and neighbor nodes and ii) Number of neighbor nodes. The mentioned parameters are specified using two score functions (ScFn). Second, the nodes that have more number of Neighbors parameter is used to choose a CH, which is having a most number of neighbors [14].

#### G. Residual Energy (REsEn) Algorithm

ResEn algorithm, which improve the lifetime of the network. ResEn algorithm is based on deterministic cluster-head selection which inclusion of the remaining energy level available in each node [15].

#### H. A Change in Node Death Scenario of LEACH for Surveillance Wireless Sensor Networks

Proposed scheme divides the network area into two parts: Border area nodes and Inner area nodes. High energy consuming cluster head role is restricted to only inner area nodes. In proposed scheme, though inner area nodes attempt a number of times for cluster head, but still network is load balanced Because inner area nodes has to communicate for short distance as cluster head is also from inner area. In addition, border area nodes have always-long communication distance as compared to other nodes but never attempt for cluster head role [16].

#### I. Enhanced LEACH

Fixed LEACH is an efficient centralized clustering technique where cluster is formed only once and then becomes fixed. BS broadcasts the schedule of future cluster heads and cluster heads rotates based on that schedule. Fixed-LEACH solves the repeated cluster setup problem, Power Consumption and Extra Overhead [17].

#### J. Ridge Method Cluster Head Selection (RMCHS)

This method is quiet useful as the weights are calculated dynamically. This technique also enhance the network lifetime as energy of all the nodes is used in a fair manner i.e. highest node with highest weight is elected as cluster node. In addition, Sleep Awake Method is incorporated; the working of SWM is that whenever a node remains "ideal" for a long time, the node is consuming the energy. So this technique sends the status of these nodes to sleep which saves energy and whenever any request is admitted to node, the node immediately turn its status to awake [18].

#### K. Associate CH Approach

This paper proposes a concept of associate cluster head selection that reduces the overhead of clustering process, reduce the load over cluster head, avoiding re-clustering and thus reduce the energy consumption within cluster in large-scale and dense sensor networks. The selection of the associate cluster head is based on the distance between the cluster and the base station and on the residual energy of the sensor node in wireless sensor network. In proposed algorithm, introduce a technique that save the energy the sensor nodes consume that during the re-clustering process, so it saves the energy and enhances the lifetime of the sensor network [19].

#### L. Variable round LEACH (VR – LEACH)

Extension of LEACH stochastic cluster-head selection algorithm via changing the round time according to the situation of sensor network. In this paper, an improved version of LEACH was proposed, named Variable-round LEACH (VR-LEACH). In VR-LEACH, When there is less (no) cluster head or cluster head has less energy, The length of round time is changed according to the situation of sensor network (such as number of CH, energy of network). The number of the CH decides the next change time and the average energy of the CH [20].

### IV. PROBLEM STATEMENT

The main purpose is to find out the method, which is more energy efficient. For better operation and to increase the lifetime of the network, energy consumption must be the major factor of concern. There are various algorithms for CH selection. But there are problems like some of the techniques are not sufficient for smaller area network and also for some of application specific network if the network is divided in inner area and outer area. They are energy efficient but it still needs some improvement in terms of CH selection by considering distance parameters and remaining energy of the nodes.

### V. CONCLUSION

LEACH is First hierarchical cluster based routing protocol, which is energy efficient and increase lifetime of the sensor networks. In this paper, we describe LEACH protocol along with its advantages and drawbacks. Various algorithms and techniques for CH selection with clustering are described. In this survey paper, to increase the lifetime of the network and energy efficiency various CH selection methods based on distance parameters, residual energy, node degree are defined.

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