

# A Survey Paper on Leach Routing Protocol and Its Variants in Wireless Sensor Network

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**Abstract:** Wireless sensor network is a non-infrastructure network which contains a number of homogeneous or heterogeneous sensor nodes. These sensor nodes have limited battery power. One of the major factor that we have to consider while designing the WSN routing protocol is efficiently use of energy resources. So minimizing the energy consumption and increasing the lifetime of the network is the major issue in the wireless sensor network. Study shows LEACH is one of energy efficient routing protocol. LEACH is a hierarchical clustering based routing protocol which improve the lifetime of the network by distributing of energy load throughout the whole network. This paper will present a brief detail of LEACH protocol and its variants.

**Keywords:** wireless sensor network (WSN), Low Energy Adaptive Clustering Hierarchy Protocol (LEACH), Q-LEACH, Network lifetime.

## I. INTRODUCTION

Wireless sensor network is the collection of many sensor nodes. These sensor nodes have finite resources constraints, like these have limited battery power, small memory etc. replacing the batteries of these sensor nodes is not possible always because these are deployed in the remote or hostile areas. As the sensor nodes have limited battery power, so developing an energy efficient protocol is the major issue in the WSNs. There are the various applications of WSN, it is used in area monitoring, forest fire detection, environment monitoring, natural disaster prevention etc.

The main objective in the wireless sensor network is to increase the lifetime of the network and proper utilization of the resources. Different approaches based on the clustering have been developed.

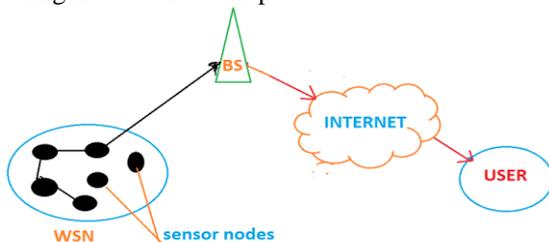


Fig-1 WSN Architecture

### A. WSN Routing Protocol

Due to the limited resources constraints and the dynamic nature of the wireless sensor network routing is main challenge in the WSN. There are number of routing protocols in the wireless sensor network.

- Location based routing protocol
- Flat based routing protocol.
- Hierarchical routing protocol

In the location based routing protocol communication between the sensor nodes is done by knowing the location

of each other node. The location can be found out by GPS (global positioning system). Minimum energy

communication network (MECN), geographic and energy aware routing (GEAR) and small minimum energy communication network (SMECN) are the location based routing protocols.

In the flat based routing protocol all the nodes have the same functionality or performing the same sensing task and all are treated equally.

Sensor Protocol for Information Negotiation (SPIN), Directed Diffusion and Rumor Routing are the flat based routing protocols. SPIN protocol avoid the redundant data transmission as it sends the Meta data to the neighbor nodes instead of sending the desired data.

In the clustered hierarchical routing protocol, the whole network is divided into the number of clusters and one node from each cluster is selected as the cluster head node. LEACH protocol, an energy efficient protocol which is based upon the hierarchical clustering method of routing.

PEGASIS (Power-Efficient Gathering in Sensor Information System) is a hierarchical routing protocol. It is based upon the greedy chain algorithm [16] and have basic ideas i.e. Chaining, and Data Fusion. PEGASIS uses the same technique as LEACH.

In PEGASIS, each node can be leader of the chain during its turn, where the chain can be constructed using greedy algorithms that are disposed by the sensor nodes. PEGASIS assumes that sensor nodes have a global knowledge of the network, nodes are stationary, and nodes have location information about all other nodes.

PEGASIS eliminate the overhead of dynamic cluster formation, minimize the sum of distances as non-leader

nodes must transmit, limiting the overall number of transmissions and receives among all nodes, and using only one transmission to the Base Station per round

## II. LEACH (LOW ENERGY ADAPTIVE CLUSTERING HIERARCHICAL) ROUTING PROTOCOL

LEACH is a self-organized and adaptive clustering based routing protocol. It uses hierarchical method to send the data. The data is aggregated and sanded to the base station. All the nodes are divided into the clusters of uniform size and a cluster head is selected from every cluster [1]All the nodes collects the physical data and send to their respective cluster head using TDMA schedule[2] CHs will further transmit the data to the base station.

Energy will be drained out, if the same node will remain the cluster head and that CH node will die sooner which will decrease the overall lifetime of the network.To avoid this type of situation a different node is selected as a CH after every round of operation and energy will be balanced. LEACH protocol uses randomized rotation of the cluster heads which distribute the energy load equally among the sensor nodes in the network.

LEACH protocol is based upon the two basic assumptions:-

- Base station is fixed and located far away from the sensor nodes.
- All the nodes in the network are homogeneous and energy constraints

LEACH protocol have two basic operations: -

- 1) Setup or cluster building phase
- 2) Data communication phase
- 3) Setup phase: in the setup phase neighbor nodes make a cluster dynamically and a cluster head is selected randomly from that cluster nodes for every cluster. In this phase a number in the range 0 to 1 is chosen randomly, while forming clusters, and the same is compared with a threshold,  $t(s)$ . The node is made as a CH for the current round, if chosen value  $< t(s)$ ; otherwise, the node remains as a member node. The threshold  $t(s)$  is computed by using equation [3], [4], [5].

$$T(S) = p / (1 - p(\text{rmod}(1/p))) \text{ if } n \in G$$

Otherwise 0

Where-

- P - Desired probability of a node to become Cluster Head at any round,
- r - Current round number,
- G - Set of nodes that have not been Cluster Heads in the last  $1/P$  rounds.
- n – Node

Once a cluster head is selected it will notify all the other nodes of that cluster by broadcasting a advertisement

message. If more than one CHs exists, a node can choose one of the CH based on the received signal strength.

- 1) Steady State Phase:- After cluster formation, a CH allocates its TDMA schedule to the nodes supported by it [6]. Based on this schedule a node in one cluster send data to the CH and after collecting all the data from the member nodes CH will aggregate other nodes data and its own data and send the aggregate value to base station. A new cluster head is selected after each round.

LEACH has shown many good features for the sensor networks, but it also suffers from the following drawbacks:

- When it is applied to the time-constrained applications, results in a long latency
- The number of clusters may not be fixed every round.
- It cannot be applied to large sensor networks.
- Number of nodes are not equally distributed in each cluster so there is no proper load distribution.



Fig-2- Leach Protocol

## III. VARIANTS OF LEACH PROTOCOL

### A. LEACH-C (Centralized LEACH)

In this protocol a centralized cluster head selection approach is used all the nodes send their physical location and their energy level to the base station.

Base station will track the location of nodes and check the energy level of the nodes.

The base station than select the CHs from the nodes on the basis of the energy level of the nodes, the node which has enough energy level will be selected as cluster head.

Advantage:

- There is predetermined selection of the cluster head nodes which will result in the batter distribution of the nodes in the network.
- Disadvantage:
- Require physical location information of all the node, which is robust[7], [8].

### B. TL-LEACH (two level LEACH)

In the LEACH protocol cluster heads send data directly to the base station in a single hop due to this cluster head die sooner than the other nodes specially when CH node is far from the base station, but a TL-LEACH protocol uses two-levels of CHs.

Cluster head selection process is same as that of LEACH. During setup phase, we select 1-level CH and then 2-level CH.

The 2-level CHs are selected among the 1-level CHs [13],[15]. This protocol reduces data transmission energy.

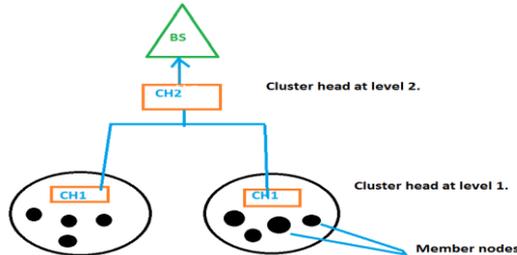


Fig 3-TL-Leach Protocol

C. MH-LEACH (multi-hopping LEACH)

CH nodes will send data to the base station irrespective of their distance so in this way the CH nodes which are located far away from the base station will consume more energy and will die sooner which will cause a network failure. It will cause high energy dissipation of those CH nodes.

The distance between the cluster head nodes and the base station will increase as the network diameter increases, a multi-hopping protocol is introduced to increase the lifetime of the network.

In this protocol cluster member nodes will send data to their respective CH node and then cluster head nodes will further send to the nearest CH node instead of sending directly to the base station.[8][10].

- Advantage of MH-LEACH protocol is that energy efficiency is very good and overall improve the lifetime of the network as CH node will send their data to nearest CH rather than sending directly to the base station
- Disadvantage of MH-LEACH is that the CHs which sends its own data and also sends the data of other CH node also will consume more energy which impact on the overall lifetime of the network.

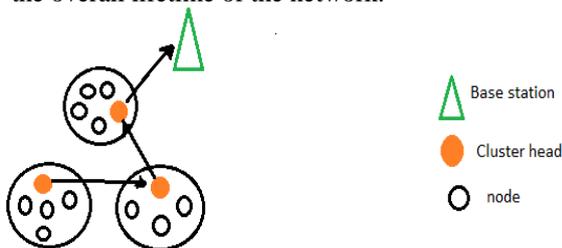


Fig- 4-MH-Leach Protocol

D. M-LEACH (Mobile-LEACH)

M-LEACH protocol was proposed to recover the mobility issue of the LEACH protocol. M-LEACH protocol will allow the mobility of the both non cluster head nodes and CH nodes. M-LEACH protocol will take a basic

assumption that all the nodes are homogeneous and know their physical location through GPS and assume that base station was also fixed as like in conventional LEACH protocol.

It has two basic steps one is setup phase and 2<sup>nd</sup> is data communication phase. In the setup phase CH is selected, the node which has less mobility and lowest attenuation power, will be selected as CH node. The selected CH node then broadcast its advertisement message to all the nodes in its transmission range, then the member node will select the CH according to the maximum residual energy.

In the data communication phase there will be actual transmission of data is, if any CH is moved away from its member nodes or vice-versa then other CH will be available for the member nodes. A handover mechanism is used to deal with this problem [15].

- Advantage of the M-LEACH is that Energy efficiency is very good and provide the mobility of non-cluster head nodes and the cluster head nodes.

E. IMPROVED V-LEACH (Vice cluster Head LEACH)

In the V-LEACH protocol every cluster contains cluster head, vice cluster head and member nodes. The cluster head will be responsible for receiving and sending the data from the member nodes to base station, and vice cluster head is act as an alternate cluster head when a cluster head node is dead, and member nodes will collect all the information and send to the CH node [9]. The process of vice cluster head selection is based upon the following factors minimum residual energy and minimum distance and minimum energy. This approach will increase the lifetime of the network and as the CH nodes will never die, when a cluster head die it will be immediately replaced by the vice cluster head node.

Advantage:-

- There is no need to select a new cluster head every time when a cluster head died
- Overall increase the lifetime of network and there is no data loss occur when a CH node die.

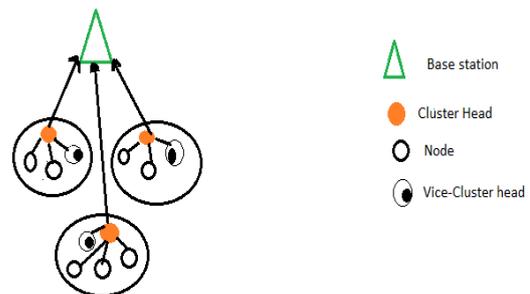


Fig-5-V-Leach Protocol

F. CELL-LEACH PROTOCOL

In the cell LEACH protocol the whole network is divided into the no. of clusters, these clusters are further divided into the 7 sections which are known as cells.

A cell-head node is selected for each cell node and a cluster head node is selected for each cluster. A cell head node will collect and aggregate the data from the cell member nodes and send it to the CH node, the CH nodes will further send the same to the base station.

The selection of the cell head nodes and the cluster head nodes is random after first round. [13][14]

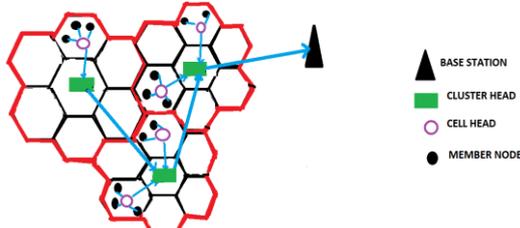


Fig-6- Cell-Leach [13]

**G. Q-LEACH PROTOCOL (Quadrature LEACH)**

In the Q-LEACH protocol the whole network is divided into the four equal quadrants which will result in the better distribution of the nodes in the network [10]. All the nodes send their physical location information to the base station, based upon their location information base station divide the whole network into four quadrants, in which exact distribution of the nodes are defined. CHs will broadcast message to the nodes and nodes receive CH advertisement select CH according to their signal strength.

Fig 1 describe the exact distribution of the nodes in the network. The whole network is divided into 4 equal parts that is  $(a_1, a_2, a_3, a_4)$

Advantage:-

- Better energy utilization of the sensor nodes than the conventional leach protocol.
- Proper distribution of the nodes into the network will result in better coverage of all the nodes in the network.
- Disadvantage:
- The cluster head which are far away from the base station will consume more energy and will die sooner

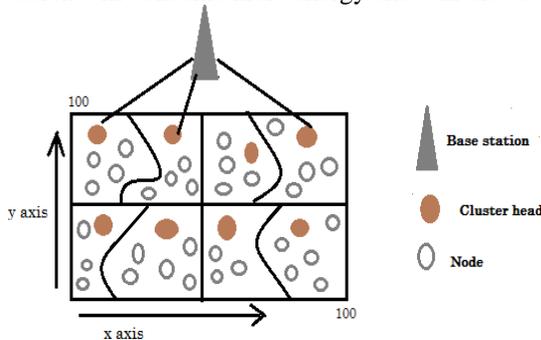


Fig-7-Q-Leach Protocol [10]

**IV. CONCLUSION**

Study shows that LEACH protocol is very energy efficient routing protocol. In this paper we have discussed the conventional LEACH protocol and its different variants,

various advantages and disadvantages of these protocols are discussed, so from this paper we have concluded that there is lots of research scope in this area. The lifetime of the network can be further improved by making some improvements in the LEACH protocol or its descendants, like choosing the efficient cluster head selection method, making equal load distribution in each cluster or using multi-hopping for far away CH nodes etc.

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