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Review of LEACH Protocol and Its Types

Amandeep Kaur[1], Er. Swaranjeet Singh[2], Navjot Kaur[3]

PG Student, Dept. of ECE, Baba Farid College of Engineering and Technology, Bathinda[1]
Assistant Professor, Dept. of ECE, Baba Farid College of Engineering and Technology, Bathinda[2]
PG Student, Dept. of ECE, Global Institute of Management & Emerging Technologies, Amritsar[3]

ABSTRACT

LEACH protocol is the clustering routing protocols in wireless sensor networks. The advantage of LEACH is that each node has same probability to be a cluster head, which makes the energy dissipation of each node be relatively balanced. Assisted LEACH (A-LEACH) achieves lessened and uniform distribution of dissipated energy by separating the tasks of Routing and Data Aggregation. It tells the concept of Helper Nodes which contain Cluster Heads for Multi-hop Routing. The designs of the E-LEACH algorithm, which increase the network lifetime, improve node energy utilization. LEACH-C is a cluster algorithm in which cluster heads are randomly selected from the nodes with energy above the average, and the simulated algorithm is utilized to find the solution with better position to reduce the energy loss of cluster heads. Q-LEACH for homogenous networks which establish stability period, network life-time and throughput quiet significantly. In this paper we have given a brief review of these techniques and compared it.

Keywords: Wireless Sensor Network; LEAH; E-Leach; C-Leach; A-Leach; Q-Leach

INTRODUCTION

A wireless sensor network system includes sensor mode, sink node and management node. A large number of sensor nodes are established in the monitoring area, constituting a network through the way of self-organization. The data monitored by sensor nodes is transmitted along other nodes one by one, that will reach the sink node after a multi-hop routing and then reach the management node through the wired and wireless Internet [2]. Clustering in WSN is the process of dividing the nodes of WSN into groups, where each group agrees on a central node, called the Cluster Head (CH), which is responsible for storing the sensory data of all group members, and sending to Base Station (BS). Cluster based routing is a effective research area in wireless sensor networks. Classical LEACH protocol has many advantages in energy efficiency, data aggregation and so on.

Assisted-Leach Protocol abbreviated as A-LEACH. In most of the clustering protocols, the whole load of data aggregation and data routing is done by cluster heads. LEACH protocol directly transmits aggregated data from cluster heads to the base station. This reduces the lifetime of a network. We the concept of Helper Nodes where a node closer to the base station in every cluster is assigned the routing job whereas cluster heads take care of data aggregation. We give a new idea for route formulation for the helper nodes to reach base station. Every helper node chooses as the next hop, the node nearest to the base station from all its neighboring helper nodes. Good clustering algorithm cannot only reduce the energy consumption of the sensor nodes can also reduce communication interference, improve the efficiency of the MAC and routing protocols. Therefore, it is proposed that a highly efficient and stable rational algorithm has become an urgent need to solve the problem. In this paper, considering the residual energy for each node, a more efficient, more reasonably low overhead adaptive layered E-LEACH algorithm based on LEACH algorithm. In LEACH-C, the location information and the residual energy value of all the nodes will be sent to the base station at the starting of each round. After receipting this information, the base station calculates the average energy value of all nodes, the nodes with residual energy higher than average are considered as the candidate, then the base station will choose a group of cluster heads from the candidate using the simulated annealing to minimize the objective function. **A**ccording to this q leach sensor nodes are implied in the territory. In order to acquire better clustering we partition the network into four parts. Doing such

Address for correspondence

amandeepgill954@gmail.com

sort of partitioning better coverage of the whole network is achieved. Additionally, exact distribution of nodes Moreover, it also presents an idea of efficient clustering mechanism which yields significantly in better coverage of whole network.

LEACH PROTOCOL

LEACH is an adaptive clustering routing protocol proposed by Wendi B.Heinzelman, et al. The implementation process of LEACH includes many rounds. Each round has a setup phase and the steady data transmission phase. In the set-up phase, the cluster head nodes are randomly selected from all the sensor nodes and several clusters are constructed dynamically. In the steady data transmission phase, member nodes in every cluster send data to their own cluster head, the cluster head compresses the data that received from member nodes and sends the compressed data to the sink node. All the sensor nodes generate a random number between 0~1, and if it is less than a threshold $T(n)$, the sensor nodes will broadcast an announcement message to notify others that it is a cluster head. In each round, if a node has been elected as a cluster head, its $T(n)$ is set to zero, so that the node will not be elected as a cluster head again.$T(n)$ can be expressed as:

$$T(n)=\begin{cases}\frac{P}{1-P*\left[r\bmod\left(\frac{1}{P}\right)\right]}, n\in G\\ 0, \text{otherwise}\end{cases}$$

Where P is the percentage of the number of clusters in the network (usually P is **0.05** in [1] [5] [6]), r is the number of the election rounds, $r$mod(1/ P) is the number of nodes which have been elected as cluster heads in the round r, and G is the set of nodes that have not been elected as cluster heads in round r .After cluster head selection, the cluster head gives its identity message to non-cluster head nodes. The non-cluster head nodes send a join-REQ message to the nearest cluster head to join in the corresponding cluster. After the cluster head receives all the join-REQ information, it will produce a TDMA schedule, and notify all the member nodes in the cluster. After a member node receives the schedule, it sends data in its own time slots, and remains in the sleep state in other slots. After a frame time of data transmission, the cluster head runs the data compression algorithm to process the data and sends the results directly to the sink node [5].

ALGORITHM FOR DIFFERENT TYPES OF LEACH

There are different types of algorithm for different types of leach. The pattern of clustering hierarchy in A-LEACH, C-LEACH and Q-LEACH.

Assisted-Leach

Assisted Leach protocol has the following sub-stages:

- Cluster Head Selection
- Cluster Formation
- Helper Node Selection
- Routing Set-Up
- Sensing, Aggregating and Routing

Cluster Head Selection

The Cluster Head selection follows an extended procedure to Leach's [7] Cluster Head Selection. Each Node calculates its threshold based on the Formula

$$T(n)=\begin{cases}\frac{P}{1-P*\left[r\bmod\left(\frac{1}{P}\right)\right]} \text{ if } n\in G\\ 0.5*\frac{P}{1-P*\left[r\bmod\left(\frac{1}{P}\right)\right]} \text{ if } n\in H\\ 0 \text{ otherwise}\end{cases}$$

where

P: Desired Percentage of Cluster Heads

r: Current Round in protocol operation

G: Set of Nodes that have neither been Cluster Heads nor been Helper Nodes in the last $\lfloor 1/p \rfloor$Rounds.

H: Set of Nodes that haven't been Cluster Heads but played

role of Helper Nodes in the last $\lfloor 1/p \rfloor$Rounds.Each sensor elects itself to be a Cluster Head by picking up a random number between '0' and '1' and comparing it to be less than the threshold.

Cluster Formation

Cluster Heads broadcast a HEAD_BOAST message containing their IDs to facilitate cluster formation. It can happen that a non-cluster node receives such messages from different Cluster Heads. They decide upon the Cluster Head whose message possesses highest Received Signal Strength to be their head and send a JOIN_CLUSTER packet with their IDs to corresponding Cluster Heads showing consent to be part of their clusters.

Helper Node Selection

- Helper Node in a Cluster is the node which is nearer to the base station with sufficient remaining energy
- Base Station sends a packet containing its ID to every node assuming that the base station can reach every node at single hop over a common channel
- The nodes in each cluster store the Base Station ID from the received packet and then make a packet
- "RSS_PACKET" with the Received Signal Strength values (RSS Values) and (Self) Node ID as entries

A copy of this "RSS_PACKET" is sent to the corresponding Cluster Heads

Routing Set-Up

- This stage finding the helper node at next hop for each helper node to route aggregated data to base station
- In this stage, only the helper nodes are operational and all other nodes including cluster heads go into sleep mode
- Each Helper Node sends the "RSS_PACKET" made in Helper Nodes Selection Phase to nodes in transmission range
- Thereby, every helper node receives "RSS_PACKET" from all its neighbours

Sensing, Aggregation and Routing: Steady State Phase

All above five stages form set-up phase and now, actual data transfer begins. Cluster Heads follow a TDMA schedule to assign timeslots for the sensor nodes inside the cluster. The sensor nodes send the sensed data to the corresponding Cluster Heads. The Cluster Heads aggregate the data, remove redundancies and forward the data to their Helper Nodes among which the actual Routing takes place. All other nodes except helper nodes go into sleep mode while routing takes place.fig 1describes the overall procedure.

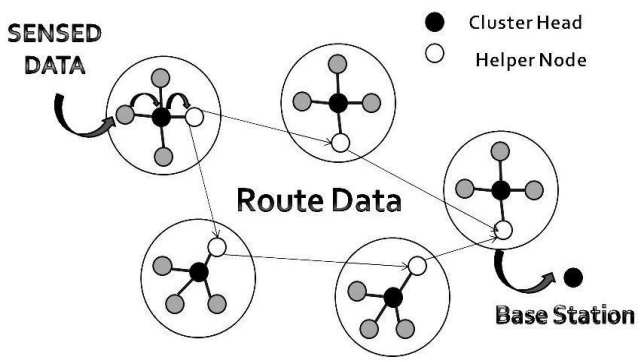

Fig1. *Design for protocol operation. [4]*

E-LEACH

A LEACH algorithm inadequacy, this article is designed E-LEACH algorithm to largely solve the above problems, E-LEACH algorithm build cluster after two choices. The first collection of nodes selected to meet the energy conditions and from the minimal condition, The second option is true cluster head selection phase, randomly selected to meet the requirements in the collection of the cluster head node. First, E-LEACH algorithm introduces the concept of the energy threshold. Energy threshold is to determine whether the node can be used as a prerequisite of the cluster head node. Energy threshold of the formula:

$$E(r)=KpE_r/m \quad (1)$$

Where E (r) of the r- round of the energy threshold, K is an energy threshold factor; p is the desired percentage of the share of all valid node cluster head node, Er is the sum of the energy of the randomly selected node r-cycle network, m is the total number of nodes of the cluster head round r. In before every a cluster head selection, compared to each meet the conditions of the cluster head node energy and energy threshold, Node energy is less than the energy threshold, the node removed from the cluster head node candidates. Secondly, E-LEACH algorithm introduces a distance factor:

$$w= (dm-d (i))/dm \quad (2)$$

Where in dm is the maximum distance of the node to the base station monitored area, d (i) for the node i to the distance of the base station. With the distance factor, in each round to select a cluster head node and the data sent to the base station, will take into account the distance cost. We use this method to select the path with the smallest data transmission distance. After a first choice, we can get a cluster head candidate set Q.

$$T\square(n) = \begin{Bmatrix} \frac{P}{1-P*\left[r\bmod\left(\frac{1}{P}\right)\right]}, n \in G \\ 0, \text{otherwise} \end{Bmatrix} \quad (3)$$

Q is 1/p round did not become a cluster head and energy is greater than the energy threshold node collection.

C-LEACH

LEACH-C (LEACH Centralized)[5] is a kind of improved LEACH. In LEACH-C, the location information and the residual energy value of all the nodes will be sent to the base station at the beginning of each round. After receipting this information, the base station calculates the average energy value of all nodes, the nodes with residual energy higher than average are considered as the candidate, then the base station will select a group of cluster heads from the candidate using the simulated annealing to minimize the objective function. Finally the cluster head group will be broadcasted to the network. If the node's own ID is included in the cluster head group it received, the node will put itself as a cluster head; if not, the node will establish the contact with the corresponding cluster head, and transfer data to the cluster head in the corresponding TDMA slot. LEACH-C will end the process of simulated annealing by controlling the maximum number of iterations until a better solution is got. Since the simulated annealing is a theoretical global optimum algorithm, the result depends on the number of iterations and the choice of the annealing method. The focal point of the simulated annealing is the introduction of parallel computing to the algorithm [6] or using the algorithm in conjunction with the genetic algorithms [7].

Q-LEACH

Q-LEACH network is partitioned into sub-sectors and hence, clusters formed within these sub-sectors are more deterministic in nature. Therefore, nodes are well distributed within a specific cluster and results in efficient energy drainage. Concept of randomized clustering as given in [1] for optimized energy drainage is applied in each sector. Assigning CH probability P = 0.05 we start clustering process. In every individual round nodes decides to become CH based upon P and threshold $T(n)$ given in [1] as:

Algorithm.1 defines CHs selection mechanism. Overall network is divided into four areas as: Area A, B, C and D. Initially each node decides whether or not to become a CH. Node chooses a random number between 0 and 1. If this number is less then certain threshold $T(n)$, and condition for desired number of CHs in a specific area is not met, then the node becomes a CH. Similarly the same process

continues for rest of the sectors and optimum number of clusters are formed. Selection of clusters will depend upon received Signal Strength Indicator (RSSI) .After decision of clusters, nodes must tell CHs about their association information from sensor nodes to *CHs* and then to *BS* . Packet length *K* of 2000 bits is used in our simulations. According to above mentioned flow chart, initially all nodes send their location information to BS. BS performs logical partitioning of network on the basis of gathered information. Network is divided into four quadrants and broadcasts information to nodes. On the basis of threshold some nodes are elected as CH in each division. Normal nodes choose their CHs within their own quadrant based on RSSI. For association nodes sends their requests to CHs. TDMA slots are assigned to every node for appropriate communication without congestion. Every node communicates in its allocated slot with its defined CH.

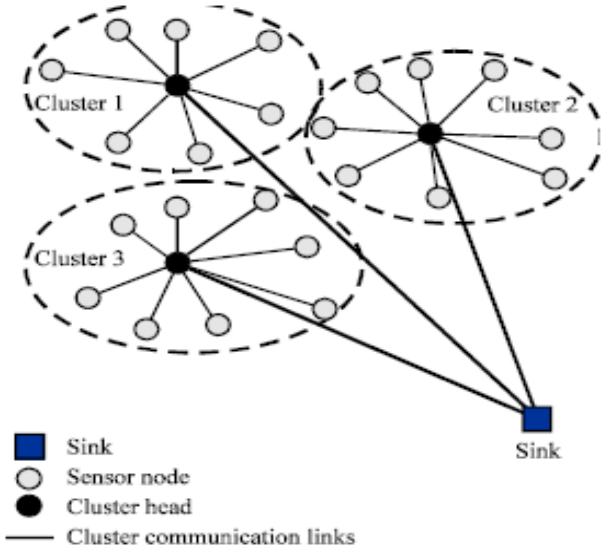

Fig2. *Networking Topology in Q-LEACH [5]*

On the basis of gathered information from attached nodes, guaranteed time slots are allocated to nodes using Time Division Multiple Access (TDMA) approach. Moreover this information is again broadcasted to sensor nodes in the cluster. It defines association of nodes with their appropriate CHs. Non-CHs nodes will locate themselves in specified area they belong to. Then they will search for all possible CHs, and on the basis of RSSI they will start association. This process will continue until association phase comes to an end. Once cluster setup phase is complete and nodes are assigned with TDMA slots every node communicates at its allocated time interval. Rest of the time radio of each non-cluster head node will remain off in order to optimize energy utilization. When all nodes data is received at the CHs then, the data is compressed and is sent to BS. The round completes and new selection of CHs will be initiated for next round. In proposed idea, we implement above mentioned concept of localized coordination in each sectored area. We used same radio model as discussed in [1] for transmission and reception.

CONCLUSION

In this paper we studied the leach and its different types .we also studied the algorithm for A-LEACH, C-LEACH and Q-LEACH. According to the performance quality Q-LEACH is better protocol. Q-LEACH significantly improved network parameters and seems to be an attractive choice for WSNs by extending and enhancing overall network quality parameters.

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AUTHORS' BIOGRAPHY

Amandeep kaur received her B.Tech degree in electronics and communication engineering from Bhai Maha Singh College Of Engineering and Technology (Shri Muktsar sahib) in 2013.She is currently working toward the M.Tech degree in Electronics and Communication from Department of Electronics Engineering, Baba Farid college of Engineering and Technology(Bathinda). Her current interest wireless communication

ER.Swaranjeet Singh did his B.Tech from Giani Zail Singh College of Engineering & Technology Bathinda in Electronics and Communication Engineering in 2010 and M.Tech from Ludhiana College of Engineering and Technology,Ludhiana.Presently he is working as Assistant Professor in the Department of Electronics and Communication Engineering at Baba Farid College of Engineering & Technology,Bathinda,Punjab.

Navjot kaur received her B.Tech degree in electronics and communication engineering from Bhai Maha Singh College Of Engineering and Technology (Shri Muktsar sahib) in 2013.She is currently working toward the M.Tech degree in Electronics and Communication from Department of Electronics Engineering,Global Institutes of Management And Emerging Technologies,Amritsar. Her current interest wireless communication