LEACH and its Improved Versions-A Survey

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Abstract: The biggest reason for reduction of energy in the wireless sensor network is the communication. Nearly 70% of sensor node energy is used in the transmission of data. Efficient usage of energy in sensor node is a desirable method to improve the life time of WSN. In order to improve the lifetime of the network energy efficient routing protocols should be designed. This paper will study the LEACH and enhancements in the LEACH. The improvements are made by changing the selection mechanism of cluster head node. The selection of the cluster head (CH) is based on the parameters such as 1) Energy 2) position of nodes 3) Distance of nodes from base station. Many improved version of LEACH are also studied in this paper.

Keywords: WSN, LEACH, Energy efficiency, network lifetime, CH.

1. Introduction

The key limitation of WSN are the power, storage and computing. These limitations will lead to develop the secure and energy efficient communication protocols. In WSN, all sensor nodes process the collected local information them and transfer this processed information to remote base station (called sink). Sensor nodes are energy constrained because they carry a limited energy. Because nodes are positioned randomly in a severe environment so swapping or recharging of battery is quite impractical. Consumption of energy in transmission is directly proportional to the square of the distance between sender and receiver. So, decreasing consumption of energy for expanding network lifetime is thus taken as the most critical challenge in WSN. Clustering is necessary where a large no. of Ad-Hoc sensors are placed for the sensing purpose. If each and every sensor starts to communicate and get engaged in data transmission in the network, great data congestion and collision will occur in the network,

In clustering, group of nodes is known as cluster. One node from each cluster is chosen as Cluster Head. All the left over nodes in the cluster transmit their data to their respective cluster head. Cluster Head aggregate the data and sends to the base station. Network's lifetime depends on lifetime of Cluster Head and Cluster Head consumes more energy than other nodes and may die early.

Following are advantages of a cluster based WSN.
- decreasing energy consumption considerably ·
- conserves communication bandwidth ·
- and improves the overall scalability of network

Among all the protocol data transmission protocols have much more importance in terms of energy, Clustering based routing protocols are useful solution of increasing the life span of the network.

2. LEACH Protocol

LEACH is most popular energy efficient hierarchical clustering algorithm for WSNs which was proposed to decrease power consumption and also to prolong lifetime of the network. Leach performs the re-clustering function and self organization after each round. Sensor nodes are combined to form cluster in LEACH routing protocol. In every cluster only one node will be selected as the head node and other nodes will remain the member nodes of the cluster. Only cluster head can communicate directly with sink but member nodes have to use CH as an intermediate to communicate with sink. The aim of LEACH is to provide data compression for the sensor network while providing the energy efficient communication that will not reduce energy of some nodes greater than others.
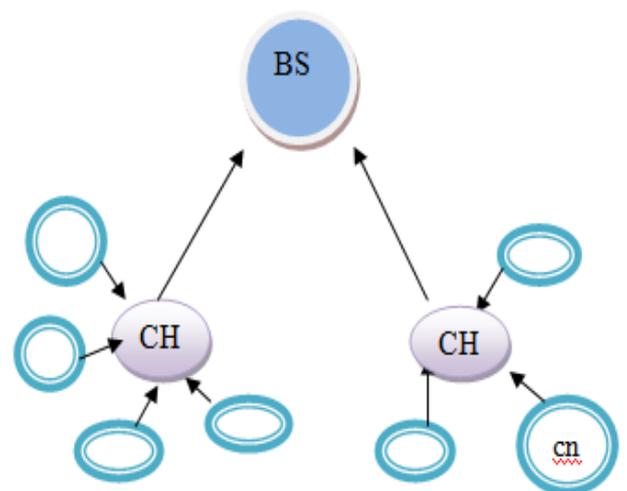

FIG1. LEACH PROTOCOL

In LEACH protocol, All nodes will transmit their information to the CH node, here CH node will do the

data aggregation and compression and after this it will transmit this aggregated information to the sink. **B**ecause the cluster head will perform the additional task of data aggregation it will dissipate more energy and if it will remain the Cluster head permanently then it will die quickly. LEACH will face this problem by randomly rotating cluster head to save the battery of individual node .Each node uses a particular algorithm at each round to decide whether to become a cluster head or not. In order to become a cluster head, that node should have higher energy level than others.

Thus the ultimate goal of LEACH protocol is to increase the lifetime of whole system by selecting cluster head among more powerful sensor network. The process of implementation of LEACH includes many rounds.

Each round contains two phase a) cluster set-up phase b) steady phase

a) CLUSTER SET-UP PHASE: in this phase organization of cluster take place. It will work in three steps.

- **Advertisement phase**: each node decides based on formula whether to become (CH) cluster head or not for current round. After this each elected CH node sends the broadcast message advertizing all nodes. After this member nodes will decide to which it relate depending upon strength of signal and distance for current round.

- **Joining phase**: Once cluster head is selected , all the nodes join their corresponding cluster by sending a message to CH informing that it is a member of that cluster .

- **Schedule creation:** CH will receive messages from all nodes that would like to be in its cluster. Once CH knows the number of nodes in that cluster it will initiate a TDMA schedule such that only single node will transmit in each time slot. After this, CH broadcast the schedule to member nodes of cluster. Here the set-up phase is completed and network will enter into a steady state phase

b) STEADY PHASE: the steady phase is divided into slots, all nodes sends their information to cluster head atmost once per frame during their allotted TDMA time schedule. When all data is received then cluster head will do the data aggregation and compression and transmit it to base station. When the base station receives all data aggregated from the CH, CH sends the message to all member nodes to start a new round.

2.1 ADVANTAGES OF LEACH

- Network scalability can be done with the help of clustering.
- Cluster heads aggregates or compresses the information which was collected by sensor nodes

and improves the bandwidth usage.
- Better energy efficient network topology can be achieved as compared to the flat-topology.
- Single-hop routing is possible between member node and cluster head, and by this means we can able to save the energy of the network.
- Distributiveness property of CH in network.
- It prolong network lifetime in three aspects. First, it distributes the role of CH to the other nodes in the cluster. Second, it aggregates information sense by the CHs. Finally, by the process of TDMA, set most of sensor nodes in the sleep mode.
- Information about location of the sensor nodes does not require in the network to create the clusters Therefore it is very powerful and simple routing protocol.
- It gives the dynamic clustering approach.

2.2 DISADVANTAGES OF LEACH

- It significantly based on cluster heads in preference to cluster members of that cluster for communicating to the sink. Because of this it leads to the death of cluster heads.
- It incurs additional overheads due to process of cluster head changes in iteration of the communication of information.
- It also incur overhead due to calculations which leads to the energy inefficiency for dynamic clustering in large scale networks.
- Inter-cluster communication is not there in the network because CHs directly communicate with sink. This process needs high range of transmission power in the network.
- LEACH is not best suited for large- scale networks which interns require single hop communication with the sink.
- In LEACH CHs are no uniformly distributed within the cluster that means CHs may be positioned at the boundary of the cluster.
- It does not work well with the applications that require large area coverage along with multi-hop inter-cluster communication.

3. Improvement in LEACH

3.1 A-LEACH (Advance Low energy Efficiency Cluster Hierarchy)
In A-LEACH, a mobile agent technique based on leach protocol is used for data processing. A-LEACH developed a heterogeneous energy protocol for decreasing the node's failure probability and improves the stability period. A-LEACH uses a synchronized clock with the help of which each sensor node know the starting of each round for transmission of information. Nodes with maximum energy are selected as CH and called as CAG nodes. CAG nodes continue to send the data to the sink even after the death of others normal nodes.
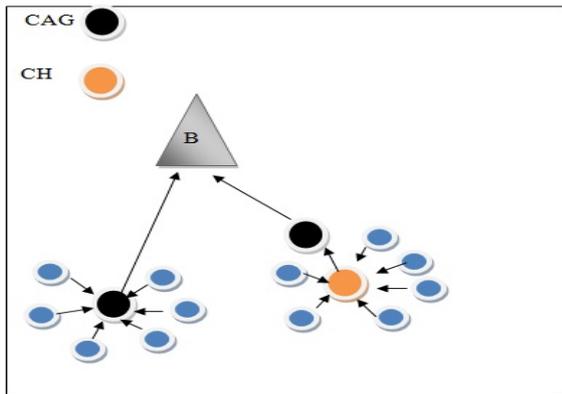
FIG2. ADVANCED LEACH PROTOCOL

3.2 *ENHANCED LEACH* (Enhanced Low Energy Adaptive Clustering Hierarchy)

It solved the overload energy utilization problem of Original LEACH. Algorithm used for CH selection have global information about others sensor nodes. Total number of CHs used in network effects the performance of routing protocols. We need to select the CH which has large residual energy to reduce energy utilization. Residual energy of every node will decide whether they will become CH in next round or
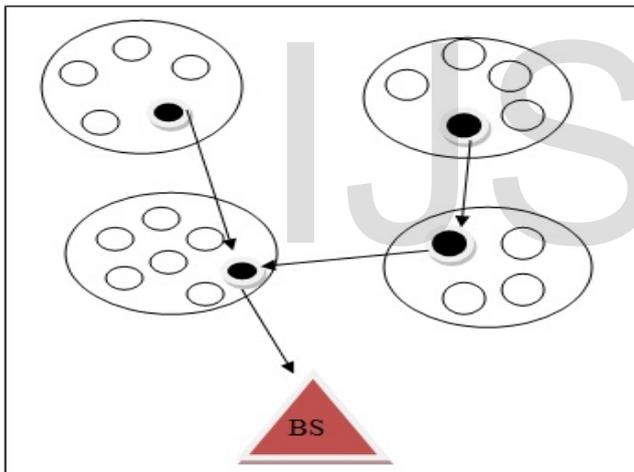

FIG3.ENHANCED LEACH PROTOCOL

3.3 *LEACH C (*Centralized Low Energy Adaptive Cluster Hierarchy*)

In LEACH-C, selection of CH is performed by centralized cluster algorithm. The setup phase of LEACH-C is same as in original leach but steady state phase is different. Base station collects the location and energy information from each sensor node. Leach c uses GPS and other location tracking system. After collecting information base station calculate the average nodes energy. nodes which have energy greater than the average node energy is selected as CH. Base station broadcast CHs ID to the nodes in network, nodes which have same ID that is similar to the CHs ID are nominated as CH and it collects data from others nodes in the cluster according to TDMA schedule. The central control algorithm is used to form cluster in leach -c which

formed improved cluster by distributing the CH through the network.

3.4 LEACH-F (Fixed No. Of Cluster Low Energy Adaptive Cluster Hierarchy)

In LEACH-F the clusters which are formed at the beginning of the network set-up is fixed and can't be changed. At the beginning of round there is no set-up overhead. Like LEACH-C it also uses centralized cluster formation algorithm. Main drawback of LEACH-F is that new nodes are not allowed to enter in the network and it does not change their behavior when any node dies in the network. LEACH-F can't handle the node mobility. Only the CH can be rotated among the nodes in the network.

3.5 B-LEACH (Balanced Low Energy Adaptive Cluster Hierarchy)

It is an improvement in original leach. For cluster formation B-LEACH uses a decentralized algorithm. All sensor nodes contain information about their location and receiver location but they don't have any information about other nodes. Multiple access techniques are used for data transmission.

Each cluster node elected their CH on the analysis of energy lost in the path way between them and final recipient. Efficiency of B-LEACH is better than original LEACH.

3.6 *LEACH-L (*Energy Balanced Low Energy Adaptive Cluster Hierarchy*)

LEACH-L is an advanced energy balanced multi-hop cluster based routing protocol. LEACH-L relies on the distance only and optimal hop counts are assumed in it. When CHs are placed near BS then they directly interact with the BS. When CH is positioned away from Base Station then CH communicates via multi-hop mode and the shortest communication distance is limited. Sensor nodes communicate with BS at different frequency in LEACH-L. Clusters are reconstructed in each round. New CH is selected in each and every round and load is circulated and balanced between the nodes in sensor network. LEACH-L covers large area than the M-LEACH and allocates equal power to all sensor nodes

3.7 *I-LEACH (*Improved Low Energy Adaptive Cluster Hierarchy)

I-LEACH performs two main functions, a) Twin nodes detection and b) sub cluster head (SCH) assignment. Two nodes which are close to each other are called twin nodes. Same information is sense by twin nodes so one of them should be keep in sleep mode until first node dies. Uniform distribution of CH is done in I-LEACH so that it does not go out of energy and die.

3.8 *A-LEACH (*Angle Low Energy Adaptive Cluster Hierarchy)

A-LEACH reduces the amount of traffic generated at the base station. Cluster formation is same as in leach. It also considers that there are some nodes that are not belonged to

any of cluster formed and they send data directly to the sink. It affects the load balancing and energy efficiency. A-LEACH calculate the angle among the nodes such that nodes which are transmitting their data to CH should lie at the angle less than or equal 45. By this method the overall traffic of the network is reduced and utilization of energy is done. Calculation of angle between nodes and CH is done by dot product of position of nodes, Ch, sink.

3.9 V-Leach (Vice Cluster Head Low Energy Adaptive Cluster Hierarchy)

V-LEACH provide a solution to main drawback of LEACH that is each cluster has a CH which transmit information to base station and it dies when it does not have enough energy to send data to base station and data will be lost when the CH dies. In V-LEACH a vice cluster node will become CH in case of existing CH dies. V-LEACH does not provided any solution when vice CH dies. CH and vice CH are elected on the basis of residual energy and distance. V-LEACH improves network's life time.
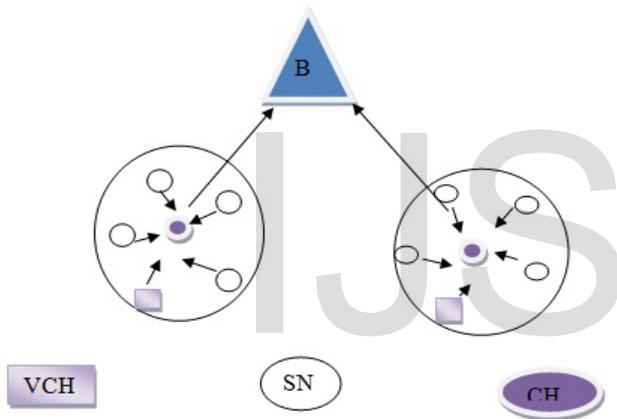

FIG 4. V-LEACH

3.10 M-LEACH (Multi Hop Low Energy Adaptive Clustering Hierarchy)

When the area of network is increased over and above a level, distance between sink node and CH also increases. Energy consumption will be more when the distance is more. To overcome this problem M-LEACH allows the sensor nodes to do multi hop communication into the cluster and outside the cluster. Data fusion or compression is done by the CH to allow a reduction in the total transmitted and forwarded data. M-LEACH is complete distributed cluster based routing protocol.
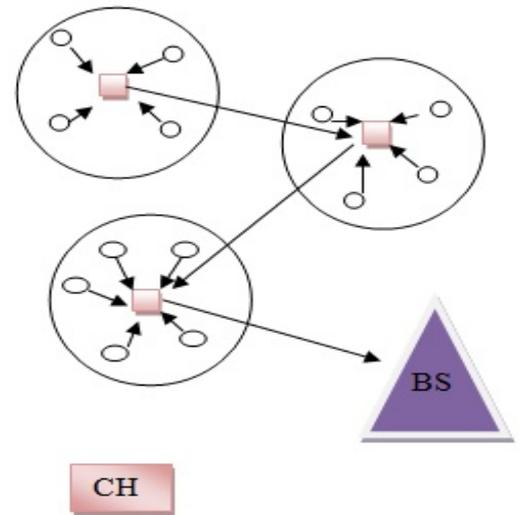

FIG 5. MULTI HOP LEACH

3.11 LEACH-M (Mobile Low Energy Adaptive Clustering Hierarchy)

Mobility support is a necessary concern in the hierarchical clustering routing protocol, to overcome this mobile LEACH is proposed. In LEACH-M cluster nodes and CH nodes can move during setup and steady state phase but base station is fixed. Initially all the nodes are supposed to be homogeneous and information about their position gets through GPS. The distributed setup phase of original leach has been modified to select the suitable cluster head in LEACH-M. Selection of CH is done on the basis of minimum mobility and lowest attenuation energy, CH will transmit their position to all nodes in cluster which are in its communication range. If CH moves from its cluster nodes or cluster nodes moves away from its CH, another CH is elected in the steady state phase which result into effective cluster formation. M-LEACH offers a handover mechanism to switch to new CH to deal with this problem.

3.12 TL-LEACH (Two Level Low Energy Adaptive Clustering Hierarchy)

In original LEACH, CH collects data from the sensor nodes of its cluster and compresses the information then transfer to the base station. Reason because CH is active all the time and it uses all its energy in the data transmission so the CH will die faster. Like original LEACH CH collects data from the member nodes and aggregate that but instead of transferring the information directly to the BS it will first transmit to the CH that lie between that CH and base station as a relay station. Thus CH will have to transfer data to a small distance and its energy will be saved
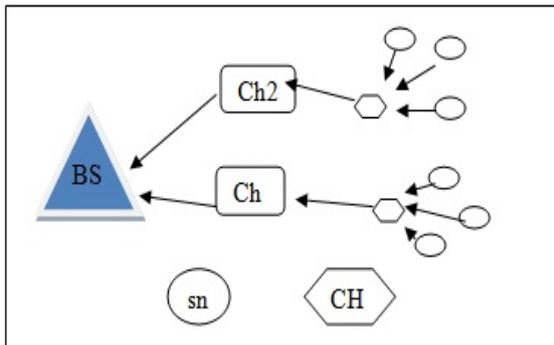
FIG 6. TWO LEVEL LEACH PROTOCOL

4. Conclusion

In this paper, the most important issue is energy efficiency in designing cluster based routing protocols for WSN, because sensor nodes have limited energy. Sensor nodes mostly consume energy during data transmission and reception. So, routing protocols used in Wireless Sensor Network should be energy efficient to increase the lifetime of nodes as well as the lifetime of the whole of the wireless sensor networks. A well-known protocol of energy efficiency in wireless sensor networks called LEACH is described in this paper. LEACH is first low energy protocol introduced in WSN which save energy and increase lifetime of the sensor networks. With the number of merits of LEACH protocol it also comes with some disadvantages. To overcome those disadvantages and make LEACH more efficient many descendants of LEACH protocol are introduced like E-LEACH, A-LEACH,I-LEACH, TL-LEACH, MULTI-HOP LEACH, LEACH-C, M-LEACH, LEACH-F,I-LEACH, and VLEACH and this is also described that how these protocol overcome the disadvantage of the LEACH protocol and make the sensor networks more efficient. Each of the routing protocol has its own advantages compared to the fundamental leach routing protocol.

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