International Journal of Scientific Engineering and Research (IJSER)
www.ijser.in
ISSN (Online): 2347-3878, Impact Factor (2014): 3.05

A Survey on Cluster Head Selection Techniques

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Abstract: ***Low energy adaptive Hierarchical clustering Protocol (LEACH) is used to transfer the data to sink node by utilizing minimum amount of energy. It forms clusters of nodes that can adapt according to the various parameters like energy etc. TO enhance the network lifetime various modifications are proposed to the LEACH. These modifications include different procedures to form clusters and to select cluster head. This paper compares LEACH and its various enhancements. This paper also describes the active and the passive clustering.***

Keywords: Wireless Sensor Network, Clustering, LEACH, E-LEACH, C-LEACH, LEACH-A, LEACH-F

1. Introduction

Wireless sensor networks are usually consists of thousands of inexpensive, low-powered sensing devices having limited battery and communication resources [1,2]. These networks offer a good range of applications in the military as well as in civilian applications. The most signification feature of the WSN is the low deployment cost that results in several limitations like limited battery life etc. The network life can be prolonged by saving the battery. Therefore, in order to reduce the power consumption of wireless sensor networks, several mechanisms are proposed such as control packet elimination, topology control, and data aggregation [3]. Data aggregation targets to combine and summarize data packets of several sensor nodes so that amount of data transmission is reduced [1].

2. Clustering

All nodes can transmit their data to the sink node but it will increase the network traffic So to decrease the network traffic i.e. to reduce the energy consumption the several Clustering technique are used. In these techniques a group of nodes is formed and they select a Cluster Head (CH) for transmission. All nodes within the cluster transmit their data to CH, where, it aggregates data and send to the Base Station (BS). Now the cluster head will transmit at large distance so, less energy is consumed. A clustered protocol shows better performance in terms of energy consumption when compared to other protocols. Clustering networks are classified in two types i.e. homogeneous and heterogeneous network [4]. All clustering techniques consist of two phases; setup phase and steady state phase. In setup phase, formation of clusters and election of CHs is performed and in steady state phase, nodes transmit data to CH and it aggregates the data for sending to BS.

Clustering techniques are of three type active, passive and hybrid. In active clustering scheme, all the sensor nodes are synchronized to maintain the clusters. While in the passive technique, no control packets are used. It exploits the data packets to transmit neighbor's information. Hybrid approaches use a combination of active and passive techniques [5].

2.1 Active Clustering

In this technique hello packets are used to collect information about the network. Active clustering algorithms use various criteria for the selection of a cluster-head Lowest-ID and use the identifiers of nodes and the number of neighbors. Basu et al.[6] adds the degree of mobility to the LEACH. It also assigns different roles to distinct nodes according to the Round-Robin policy management. Bagrodia et al.[7] said these algorithms require two phases: Neighbor discovery and cluster formation phase. However, nodes are assumed fixed over the steps and synchronization between them is necessary for the success of these algorithms. In addition, following each change of network topology these steps are repeated periodically, which degrades the stability of clusters.

2.2 Passive Clustering PC

Passive clustering [8] is the demand cluster formation protocol that does not use any protocol-specific control packets. In this data packets are used to transmit neighbor's information. Clusters are formed flooding the data message. It reduces the initial set-up period that results in reduction of the total energy consumed as the main function of the clusters is to optimize the exchange of flooded messages. Passive Clustering uses the MAC frame to encode the state of a network node. Passive Clustering uses two bits to encode four states (1) Initial, (2) Cluster head, (3) Gateway and (4) Ordinary [5].

3. Leach and Its Descendant

3.1 LEACH

Low Energy Adaptive Clustering Hierarchical Protocol (LEACH) uses the following techniques to achieve the design goals: randomized, self-configuring and adaptive cluster formation, Local control for data transfers and low-energy media access control and application specific data processing [11]. LEACH protocol has many rounds and each round has two phases, a setup phase and steady state phase, in set up phase it provides cluster formation in adaptive manner and in the steady state phase transfer of data takes place. LEACH

uses a TDMA or a CDMA MAC to reduce inter-cluster and intra cluster collisions. Cluster formation based on many properties such as the number and type of sensors, communication range and geographical location. The energy consumption of the information gathered by the sensors node to reach the sink will depend on the number of cluster heads and radio range of different algorithms, because the energy consumption can be reduced by organizing the sensor nodes in the clusters [12].

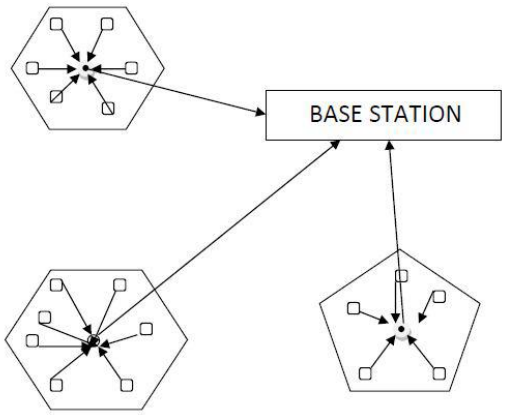

Figure 1: Leach protocol architecture [13]

Although LEACH protocol prolongs the network lifetime in contrast to plane multi-hop routing and static routing, it still has problems. The cluster heads are elected randomly, so the optimal number and distribution of cluster heads cannot be ensured. The nodes with low remnant energy have the same priority to be a cluster head as the node with high remnant energy. Therefore, those nodes with less remaining energy may be chosen as the cluster heads which will result that these nodes may die first. The cluster heads communicate with the base station in single-hop mode which makes LEACH cannot be used in large-scale wireless sensor networks for the limit effective communication range of the sensor nodes [13].

3.2 Enhanced-leach (E-LEACH)

E-LEACH basically removes overload energy consumption problem of the LEACH. The E-LEACH adopts the same round concept with the original LEACH. E-LEACH selects optimal number of cluster-heads to enhance the performance. If the number of cluster-heads is less then each cluster-head covers larger region, this will lead the problem that some cluster-members get far from their cluster-heads and consume much more energy. When the numbers of cluster heads are less then more energy is consumed in the communication between cluster heads and the base station. Therefore, it is necessary to select optimal cluster head number to make the energy consumption minimum. In the E-LEACH minimum spanning tree between cluster heads is used. The node with largest residual energy is selected as the root node [13].

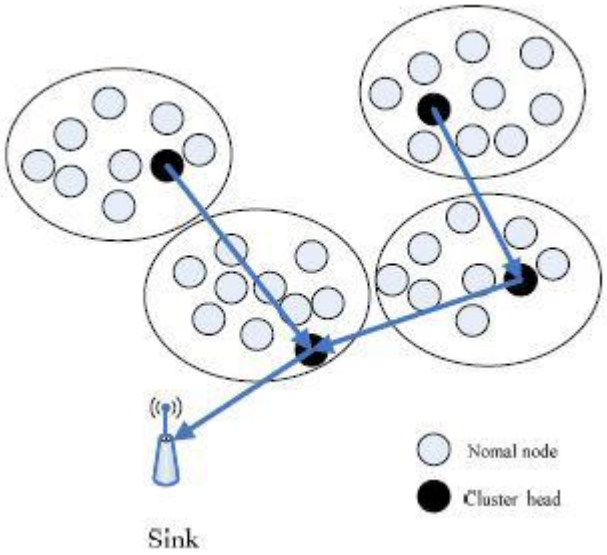

Figure 2: Architecture of E-LEACH [13]

3.3 LEACH-C (Centralized Low Energy Adaptive Clustering Hierarchy)

It involves a centralized clustering algorithm. The steady state of LEACH-C will remains same as LEACH whereas the setup phase is different. In the setup phase of LEACH-C each node within the network transfers the information about the current location and energy level to the base station. The base station uses this information to produce better clusters that requires the less energy for data transmission [14].Each sensor node is equipped with GPS to track the location. The base station elects the cluster head on the basis of energy level of node. Leach-C has a deterministic threshold algorithm to form the cluster and to elect the cluster head [14].

3.4 LEACH-F

LEACH-F, here F stands for the fixed. In this technique the number of clusters remains fixed throughout the network lifetime and the cluster heads rotated within its clusters. As the Steady state phase forms the clusters so the steady state phase of LEACH-F is similar to that of LEACH. LEACH-F can provide the energy savings but doesn't support flexibility. In other words LEACH-F doesn't provide mechanism to add or remove sensor nodes from the sensor networks [11].

3.5 LEACH-A (Advanced Low Energy Adaptive Clustering Hierarchy)

LEACH-A decreases the head node energy consumption to increase the network lifetime. In this algorithm the data is processed using mobile agent technique based on Leach. Advanced Leach uses a synchronized clock to decrease the node's failure probability hence increasing the time interval before the death of the first node [10].

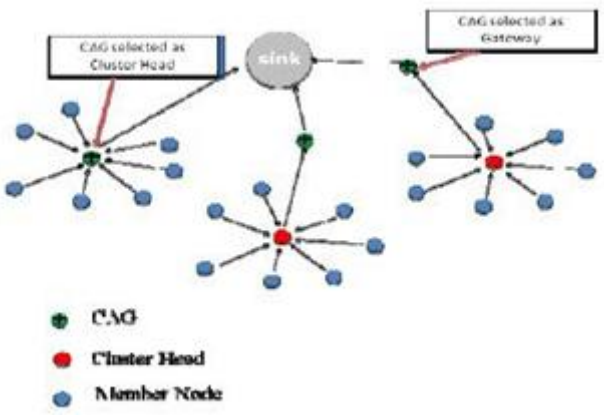

Figure 2: LEACH – A Network style

If n is the total number of nodes in network and m being the fraction of n that are equipped with clock. Then these nodes are called CAG nodes, the nodes selected as cluster heads and the others (1-m) x n as the normal nodes.

4. Conclusion

In this paper, a well-known protocol in WSN called LEACH is described. We have surveyed different clustering algorithms in wireless sensor networks along with LEACH. We have presented the comparison of different LEACH descendant. Each of the routing protocol has its own advantages compared to the fundamental leach routing protocol. The drawbacks and issues addressed by the LEACH protocol are also discussed. We have found that the some energy efficient algorithms increase the network lifetime. In future we propose to modify the LEACH by using soft computing techniques to enhance the network lifetime. As soft computing techniques are highly dynamic so by applying these techniques LEACH can adapt easily according to parameters changes results in energy saving.

Table 1: Comparison of LEACH and its DESCANDS

Clustering Routing Protocol	Classification	Mobility	Scalability	Self-organization	Randomized Rotation	Distributed	Centralized	Hop count	Energy efficiency	Homogenous	Data aggregation
LEACH	Hierarchical	Fixed BS	Limited	Yes	Yes	Yes	No	Single Hop	High	Yes	Yes
E-LEACH	Hierarchical	Fixed BS	Very Good	Yes	Yes	Yes	No	Single Hop	Very High	No	Yes
LEACH-C	Hierarchical	Fixed BS	Good	Yes	Yes	No	Yes	Single hop	Very High	Yes	Yes
LEACH-F	Hierarchical	Fixed BS	Limited	No	Yes	No	Yes	Single hop	Very High	Yes	Yes
LEACH A	Hierarchical	Fixed BS	Good	Yes	Yes	Yes	No	Single hop	Very high	No	Yes

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Author Profile

Monika received the B.Tech and M.Tech degrees in Computer Sciece and Engineering from R. N. College of Engineering & Management in 2013 and 2015, respectively.