Clustering Methodologies and Their Implications in Sensor Networks

Mohan Aradhya, K.A. Sumithradevi, Andhe Dharani, and Vijay Singh

Department of MCA,
R.V. College of Engineering
Mysore Road, Bangalore
{mhanaradhya72o,sumithraka}@gmail.com,
dharani_ap@yahoo.com, vijaysingh@rediffmail.com

Abstract. Currently many algorithms like LEACH, HEED, EECH are applied to sensors networks to achieve better lifetime of a network. But each of these algorithms has some drawback in achieving a effective lifetime of a sensor network. This paper deals with existing algorithm and comparing the simulated results to know the effective solution to increase lifetime of the sensor network.

Keywords: LID, LEACH, HEED, EECH, TEEN.

1 Introduction

Wireless Ad Hoc Networks comprise a fast developing research area with a vast spectrum of applications. The Energy efficiency continues to be a key factor in limiting the deploy ability [1] of ad-hoc networks. Deploying an energy efficient system exploiting the maximum lifetime of the network has remained a great challenge. The lifetime of the wireless sensor network [2] is largely dependent on efficient utilization of energy. While looking at energy efficient protocols, they have significant impact on the lifetime of these wireless sensor networks.

2 Different Methods of Clustering Algorithms

2.1 Based on Selection of Cluster Head

2.1.1 ANDA

ANDA (Adhoc Network Design Algorithm) [1]assigns the ordinary nodes to the cluster heads such that energy is not drained out from them easily and the lifetime of the whole system increases drastically. A matrix is computed, which lists the probable lifetime of the cluster heads for a particular node is assigned to all the cluster head. ANDA algorithm basically comprises two algorithms. One, the covering algorithm which is applied to the static and dynamic case and second, the reconfigure algorithm which applies only to the dynamic scenario.

Drawback: But this algorithm takes into account a fixed set of cluster-heads which continuously dissipate energy throughout the network functioning time.

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Overcome: We came up with the idea of having dynamic set of cluster-heads, thereby distributing the energy dissipation among the set of nodes for a better lifetime

2.1.2 LID

The LID (Lowest Id) Algorithm [1] defines which nodes will behave as cluster heads and determines the nodes that constitute the cluster. ANDA is then implemented to cover the nodes. It assigns a unique ID to each node in the network. The LID algorithm chooses arbitrarily the node with the lowest ID as the cluster-head and declares all the nodes within the range of this cluster-head as its members.

Drawback*:* It is difficult to choose the cluster head in the mobile network. Because other nodes within some range to cluster head have to accept that head as their cluster head, if the cluster head is keep on changing its position means some node may get out of that range and some new node may get in.

Overcome*:* So need of a dynamic selection of cluster head.

2.1.3 LEAD

LEAD deals with dynamic selection of cluster heads among the set of nodes in the network and then allocate the other ordinary nodes to the cluster heads dynamically. It adapts itself to the network, and node selection and allocation is done according to the current status of the network.

LEAD achieves three goals:

First, we select a set of cluster heads among the nodes randomly which is very practical in case of wireless ad hoc networks instead of having a fixed set of cluster heads.

Second, set of cluster heads are selected dynamically after a time in a round schedule balancing the load (energy dissipation) throughout the nodes of the network thus increasing the lifetime.

Third, dynamically allocates the nodes to the cluster heads using the enhanced feature of ANDA thereby reducing the load on each cluster head and to make the cluster head sustainable for more number of rounds.

2.2 Based on the Execution of Algorithm

In this method there are 2 types of execution:

Centralized: In this all nodes will depend on the central Base station

Distributed: In this method all nodes are independent.

2.2.1 HEED

In order to avoid the random selection of the cluster head problem occurred in first method, the HEED (Hybrid Energy-Efficient Distributed clustering) [2], that periodically selects cluster heads according to a hybrid of their residual energy and a secondary parameter, such as node proximity to its neighbors or node degree.

HEED has four primary goals:

1) Prolonging network lifetime by distributing energy consumption
2) Terminating the clustering process within a constant number of iterations/steps,
3) Minimizing control overhead (to be linear in the number of nodes)
4) Producing well-distributed cluster heads and compact clusters.

Requirements:

1. Clustering is completely distributed. Each node independently makes its decisions based on local information.
2. Clustering terminates within a fixed number of iterations.
3. At the end of each TCP, each node is either a cluster head, or a non-head node (which we refer to as regular node) that belongs to exactly one cluster
4. Clustering should be efficient in terms of processing complexity and message exchange.

Drawback: Can't guarantee that the node having highest energy will become cluster head. Only limited to small clusters, because single hop connection.

2.2.2 LEACH

LEACH (Lower-Energy Adaptive Clustering Hierarchy)[3] a clustering protocol, using randomly rotation of cluster head to balance energy . The principle of LEACH is to determine the cluster head and cluster. The cluster head accepts data from other sensors in its cluster and makes data aggregation then sends it to BS.

Advantage: It can reduce energy consumption and uses minimum transmission power and nodes walkup only during assigned TDMA slots. Longer network lifetime and larger data capacity

Drawback*:* Need to know number of neighbor (n) to calculate k and energy level of all nodes.

2.3 Data Collection

Data collection is a major application of wireless sensor networks. Currently, there are some energy efficient data collecting protocols. LEACH is also used for Data Collection which is discussed in above section.

2.3.1 TEEN Protocol

TEEN (Threshold Sensitive Energy Efficient Sensor Network) protocol utilizes multi-level clustering mechanism. When cell changing, cluster head will broadcast three parameters: attribute, Hard Threshold (HT) and Soft Threshold (ST). [4]

Sensor nodes sense information continually from environment. If the information value beyond HT or the varied range of characteristic value beyond ST, then the node will send sensing information to cluster head. Using this method, TEEN can reduce more network traffic.

Drawback: If the thresholds are not reached, the nodes will never communicate, not well suited for applications where the user needs to get data on a regular basis, practical implementation would have to ensure that there are no collisions in the cluster.

Overcome: TDMA scheduling of the nodes and CDMA can be used to avoid collision.

2.3.2 PEGASIS

PEGASIS (Power-Efficient Gathering in Sensor Information Systems) algorithm is based on chain [5], which uses greedy algorithm to form data chain. Each node aggregates data from downstream node and sends it to upstream node along the chain.
Advantages : compared to LEACH it eliminates the overhead in dynamic formation of cluster so that PEGASIS can save much energy.
Shortcoming: results in distance a long distance between a pair of sensors which leads to more consumption of energy.

2.4 Based on Formation of Hierarchy of Cluster Heads

2.4.1 Energy Efficient Hierarchical Clustering Algorithm for Wireless Sensor Networks

The communication or message passing process must be designed to conserve the limited energy resources of the sensors [6]. A distributed randomized clustering algorithm is used to organize the sensors in a wireless sensor network into clusters. We then extend this algorithm to generate a hierarchy of cluster heads and observe that the energy savings increase with the number of levels in the hierarchy.

Advantage: Simple to implement, Distributed Solution, Larger Cluster

Drawback: Ties need to be break, Parameter k and p need to calculate in advance, Sub optional clusters.

3 Results and Comparison

The major clustering process can be classified as shown below figure

3.1 Comparison Based on Cluster Head Selection

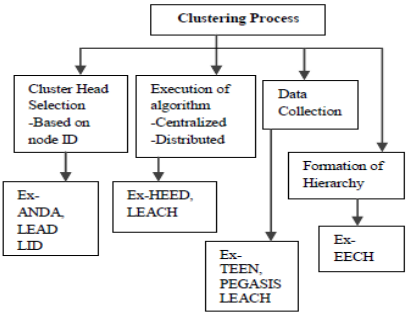

Fig. 1. Clustering Process

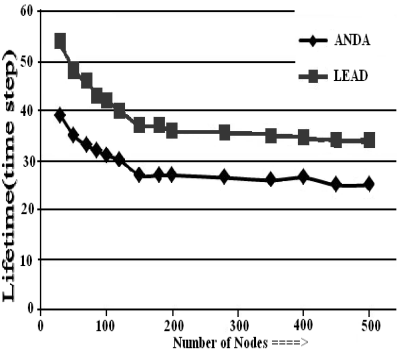

Fig. 2. LEAD vs. ANDA

Fig-2 Shows the network lifetime as a function of the number of nodes, for a percentage of cluster heads P=0.05.

The life-time decreases as the number of nodes grow; however for a number of nodes greater than 100, the life-time remains almost constant as the number of nodes increases. Lifetime decreases because Cluster heads have to cover more nodes as the number of nodes in the network size increases. But LEAD has a high lifetime compared to ANDA for higher number of nodes. Hence we can say that LEAD has better performance than ANDA. But in LEAD the node are assigned randomly to CH so to avoid this we go for leach in which nodes are assigned to CH by calculating the shortest distance from the node to and energy level of CH. LID has a major problem as defined above section, so we are not considered it for the comparison.

3.2 Comparison Based on Execution of Algorithm

Figures below shows the comparison of LEACH and HEED

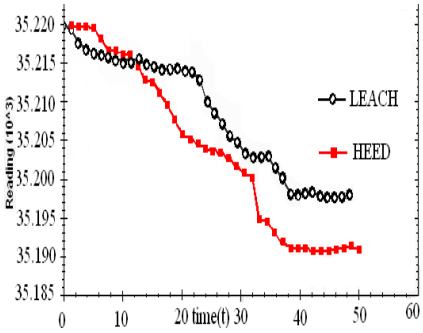

Fig. 3.1. Average residual energy for Simulation radius 100m

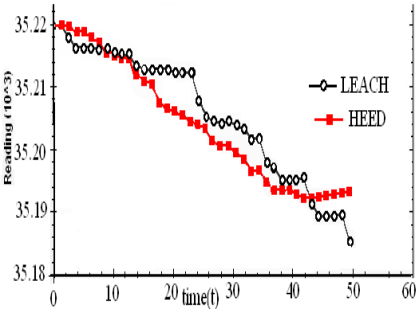

Fig. 3.2. Average residual energy for simulation radius 500m

The figure above is result obtain by simulating the LEACH and HEED in WSN simulator. In this we used the alkaline battery of capacity 2850mAh, number of nodes 100, simulated for a time t=50sec and communication radius are the parameters used. Where X-axis is time and Y-axis is power in mA. Fig-3.1 the energy saved by LEACH is more than the HEED. This show that LEACH consumes less energy than HEED and hence we can say that LEACH is more energy efficient than HEED. But in Fig-3.2 we can see that average energy left behind in LEACH is less than HEED, this is due the larger communication area. In this we simulated for a radius for 500 m. Hence LEACH can be used for smaller network area to achieve significant energy efficiency. EECH can give better performance over LEACH but the problem is in calculating its optimal parameters.

3.3 Comparison Based on Data Collection

PEGASIS create a chain for data transmission for that it uses greedy algorithm but some time it leads to formation of long chain. Another algorithm TEEN it is difficult to maintain that if the thresholds are not reached, the nodes will never communicate; the user will not get any data from the network at all and will not come to know even if all the nodes die. Thus, this scheme is not well suited for applications where the user needs to get data on a regular basis.

4 Conclusions

The simulation results of different algorithm were compared and based on that we can say the LEACH algorithm has better performance than others and it can increase the life time of a sensor network by consuming less energy. So it can be used efficiently to achieve a better lifetime of a sensor and it can be still improved in better way to achieve a good energy efficient for larger network area. LEACH is better clustering algorithm for sensor networks and among the different data collection algorithm in wireless sensor network when the lifetime of a sensor in the network is a major issue.

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