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A New Dynamic Clustering Control Method in Wireless Sensor Networks

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Abstract

Wireless sensor networks (WSNs) are composed of many low cost, low power devices with sensing, local processing and wireless communication capabilities. Clustering is a useful topology-management approach to improve lifetime and reduce the energy consumption in wireless sensor networks. In this paper we have proposed a new dynamic clustering method where clusters are created periodically and cluster head (CH) is selected based on threshold function. Unlike the LEACH protocol that clustering are static and cluster head number is fixed in the entire scenario, CHs in our method distributed in Land dimensions and the number of cluster can be dynamically adjusted based on the number of nodes. The simulation was performed in MATLAB software and it was compared with LEACH, LEACH-C, O-LEACH, LEACH-B, M-LEACH, V-LEACH AND W-LEACH algorithms. The simulation results show that proposed method have been reduced energy conservation and enhancement of network lifetime comparing with LEACH algorithm. Coverage of the number of clusters in proposed method is shown too. The results showed that in a test network life of leach protocol were 1100 rounds, whereas network life of proposed method was 3100 rounds.

Keywords: *LEACH Protocol; Clustering Algorithm; Lifetime; Wireless Sensor Network*

1. Introduction

Recent advances in micro-electro-mechanical systems (MEMS) technology, wireless communications, and digital electronics have enabled the development of low-cost, low-power, multifunctional sensor nodes that are small in size and communicate unmetered in short distances. These tiny sensor nodes, which consist of sensing, data processing, and communicating components, leverage the idea of sensor networks based on collaborative effort of a large number of nodes [1]. Sensor nodes are relatively inexpensive and low-power. They have less mobility and are more densely deployed than mobile ad-hoc networks. Since nodes are always left unattended in sometimes hostile environments, it is difficult or impossible to re-charge them [2-3].In a hierarchical topology, nodes perform different tasks and typically are organized into clusters. Each cluster consists of a cluster head (CH). The CHs can be organized into further hierarchical levels. In general, nodes with higher energy act as CH and perform the task of data processing and information transmission, while nodes with low energy perform the task of information sensing[4-6].Clustering routing protocols have many advantages such as more scalability, less load, less energy consumption and more robustness. WSN aims to apperceive in collaborative mode, gather, deal with and send information to observer in network areas. Sensor, sensing object and observer form the three factors in WSN. WSN protocol stack contains physical layer, data link layer, network layer, transport layer and application layer. According to network architecture, routing protocols are generally classified as plane routing, and level routing. Among the numerous routing protocols, Low-Energy Adaptive Clustering Hierarchy (LEACH) is one of the first major improvements on conventional clustering approaches in WSN. Many clustering algorithms are based on the LEACH's ideology and architecture. However, the LEACH clustering strategy is mainly depends on the randomly selected cluster-heads (CHs), resulting the fluctuation of the number of cluster heads and the ignorance of the node's residual energy .In order to prolong the life span of the entire network, this paper represent a modified LEACH protocol with a second selection of the cluster heads each round to keep the constant and near-optimal cluster heads number. As a result, the total energy dissipation of the sensors is balanced and minimized. In this paper we focus on main challenges of WSNs like minimizing energy conservation, maximizing network lifetime and minimum overhead of network. In this paper, according the weakness of control of clustering in sensor network, routing is improved in wireless sensor network with a controlled clustering based on dynamic clustering. Provided a new equation in phase of cluster head election that CHs election done based on merit of nodes and also the clustering done based on dynamic clustering. Clusters number is fixed based on our opinion. The rest of this paper is organized in the following manner: Section 2 presents the related work. The proposed method for dynamic clustering is presented in section3. Section 4 presents the simulation results. Finally, conclusions are given in section 5.

2. Related Work

Heinzelman et al.[4] propose a low-energy adaptive clustering hierarchy (LEACH) for micro sensor networks. LEACH uses probability to elect cluster heads. The remaining nodes join the cluster head that requires minimum communication energy, thus forming a 1-hop cluster. LEACH also calculates the optimal number of Cluster heads that minimizes the energy used in the 1-level network. Bandyopadhyay et al.[5] propose a hierarchical clustering algorithm to minimize the energy used in the network. They generate a hierarchical structure, which is up to 5-levels in intra cluster communication. They assume all nodes transmit at the same power levels and hence have the same radio ranges. Based on the size of the network, they calculate the optimal number of cluster heads in a network and the optimal number of hops from the nodes to the cluster heads. Multipath Routing Protocol [7] is proposed according to the converge cast traffic pattern of wireless sensor networks to improve data transmission reliability. In this protocol, each node identifies multiple paths towards the sink node through constructing a spanning tree rooted at the sink node. Through N-to-1 Multipath Routing Protocol, all the nodes utilize single-path forwarding strategy for transmitting every data segment, while they also use an adaptive per-hop packet salvaging technique to provide fast data recovery from node or link failures. Since all the paths identified in the tree routing topology are located physically proximal to each other, concurrent data transmission over these paths causes high inter-path interference which in turn degrades the network performance. Multi-Constrained QoS Multipath Routing Protocol (MCMP) [8] is mainly designed to provide soft-QoS guarantee in terms of reliability and latency. Interference-Minimized Multipath Routing Protocol (I2MR) [9] aims to improve network throughput through transmitting every source node's traffic over zone disjoint paths which are constructed using location information of nodes and employing special hardware equipments X. AOMDV-Inspired Multipath Routing Protocol [10] is designed based on the AOMDV [11] to provide low latency and energy-efficient data delivery in wireless sensor networks through exploiting some information from the MAC layer. Energy-Efficient and Collision-Aware Multipath Routing Protocol (EECA) [12] is proposed to construct two collision free paths in both sides of the straight line between every source-sink pair using location information of network nodes.

3. Proposed Model

In proposed model, we adjusted a threshold function in two ideas for dynamic clustering control which follows: At First, propose algorithm tries to cluster head election from diverse and different distances in land, and in second idea, the numbers of clusters is fixed in a specific range based on number of alive nodes. In LEACH protocol the CHs number is random which cause a different number of clusters (lower, higher) in every round, which has a negative impact on network's load and energy consumption. In LEACH protocol, sometimes we see that cluster heads are very close to each other and because of that CHs not cover the whole area properly and sometimes they are far apart, which makes Increasing energy consumption. Each node in every round generate a random number between (0,1) which is compared to threshold value and if that is less that threshold, then node will be cluster head in this round. For proposed method, threshold function for selection of cluster head be written in equation 1.

$$\left(\frac{E_i \times D(m)}{d(i,BS)}\right) \times \left(\left(\frac{n - DEAD}{\frac{n}{n \times p}} - CH_{number}\right) \times 0.2\right) \qquad (1)$$

Where E_i *is* the node's residual energy and $d(i, BS)$ is the Euclidean distance of node i from sink (Base Station). n is the number of network nodes, *DEAD* is the number of network dead nodes, CH_{number} is the number of clusters in that round and $D(m)$ is the index of m^{th} attribute in sorted array which cause the selection of nodes from different distances. This Parameter (m) would be updated by increases the number of clusters so that it can mention some higher indexes in sorted arrays in next round of CHs election which would increase the chance of node which is different in distance from last CHs to be selected as the new CHs. D array is calculated by equation 2:

$$D(m) = sort\sum_{i=1}^{n} d(i,BS) \qquad (2)$$

And m is also measured by equation 3:

$$m = m + \left(\frac{n}{n * p} \right) \times CH_{number} \tag{3}$$

In Eq.2 we can argue that the distance between all nodes to central station is sorted incrementally in an array and every time we select the m index from Eq. 3 it will increase the chance of selection for those nodes which are at a different distance from current head node. Every time a CH is selected the chance for other nodes selection for$\left(\frac{n}{n*p}\right)$index in D array increase and we are looking for this node to be selected as the next head node. In other words, and from another view point, we can say that the selection mechanism consists of sorted arrays for a node with $\left(\frac{n}{n*p}\right) \times CH_{number}$ Index which is higher than first next index and that node has the highest chance for selection. In this process in every round the CHs cover a larger area of land and in fact the head nodes have a wider distribution. In Eq. 1 we use $\left(\left(\frac{n-DEAD}{\frac{n}{n\times p}} - CH_{number}\right) \times 0.2\right)$To fix the number of CHs with respect to live nodes of network in a specific range and after many experiments we concluded that having a constant number of 5 clusters for every 100 nodes is the best possible situation. Since this side of equation can have an impact on first side we multiplied the equation in 0.2 to transform the biggest possible value for this equation (1) to 1 to neutralize the negative impact on first side of equation. Every time we subtract the number of nodes from $\frac{n-DEAD}{\frac{n}{n\times p}}$until the number of nodes reach 5 and then the result of this equation would be zero which is considered as zero in threshold function and no more head nodes would be selected which holds the number of nodes in 1. After CHs election, based on LEACH protocols the nodes with least distance to the cluster are considered as its members.

3.1 Energy Model

In this research we defined energy consumption method based on leach protocol which is introduced by heinzelman [4] and the calculated equations for a k byte message send/receive with a distance of d are presented in equations 4-5 , for message transmission we use equations 4 and 5:

$$E_{Tx}(k,d) = E_{Tx-elec}(k) + E_{Tx-amp}(k,d) \tag{4}$$

$$E(k,d) = E_{elec} * k + P_{amp} * k * d^{r} \tag{5}$$

And for message reception equations 6 and 7 are used:

$$E_{Rx}(k,d) = E_{Rx-elec}(k) \tag{6}$$

$$E_{Rx}(k,d) = E_{elec} * k \tag{7}$$

In these equations r is the distance between of nodes. K for this simulation is 2000 [20].

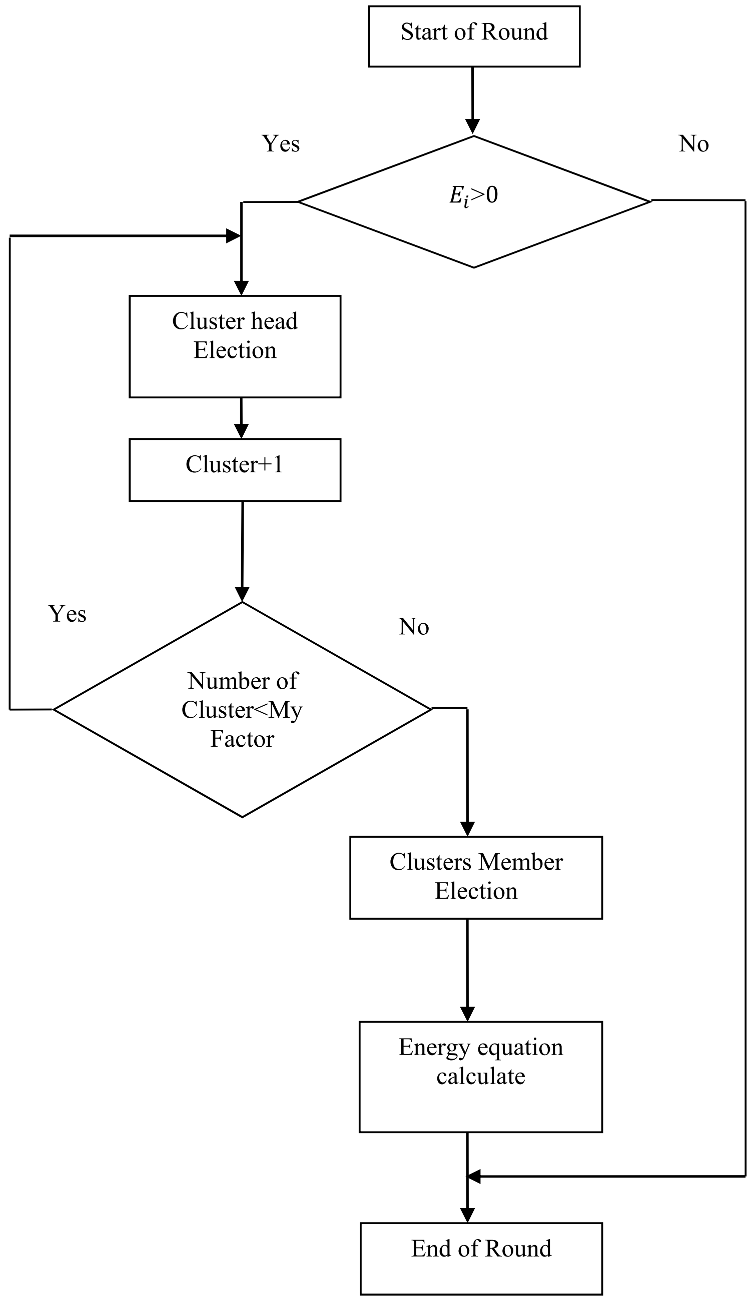

Figure 1: Flowchart of Proposed Method

```
1.star of round
2.for i=1 to n
3. threshold calculate
4.if rand(i)< threshold(i)
5.i=cluster head
6.cluster number=cluster+1
7.if cluster number<my factor
8.go to step 4
9.else
10.for i=1 to cluster number
11.calculate (distance(i) to normal nodes)
12.min (distance i to normal  nodes)=cluster(i).member
13.claculate of energy equation
14.end of round
```

Figure 2: pseudo code of Proposed Method

4. Simulation Results

For simulations we used MATLAB software and the parameters for LEACH protocol and proposed method are adjusted equally and based on table 1:

Table 1: Parameter Setting

Parameter	Value
Simulation area	100*100
Network size	100
E_{elec} (Radio electronics energy)	50 NJ/bit
E_{amp} (Radio amplifier energy)	100 PJ/bit/m2
E_{fs}(Radio free space)	0.013pJ/bit/m4
E_{init} (Initial energy of node)	2J
Energy model	Battery
Packet size	200
Base station at	50 , 150

In figure 3 a sample of wireless sensor network's node clustering based on proposed algorithm is presented. Based figure 3, clustering is done regularly with diverse distances with respect to cluster heads and full area coverage for all nodes. CHs are distributed regularly all over the ground which each one can cover a special part of network area.

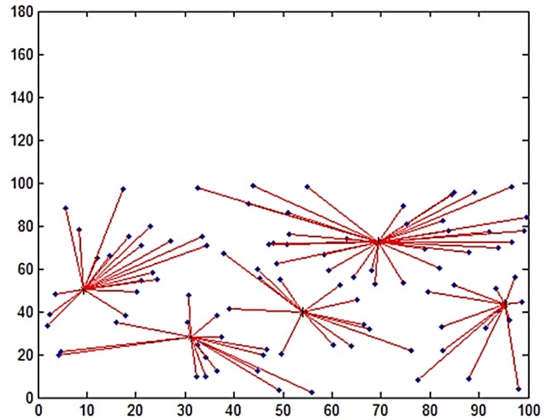

Figure 3: Clustering Model in Propose Model

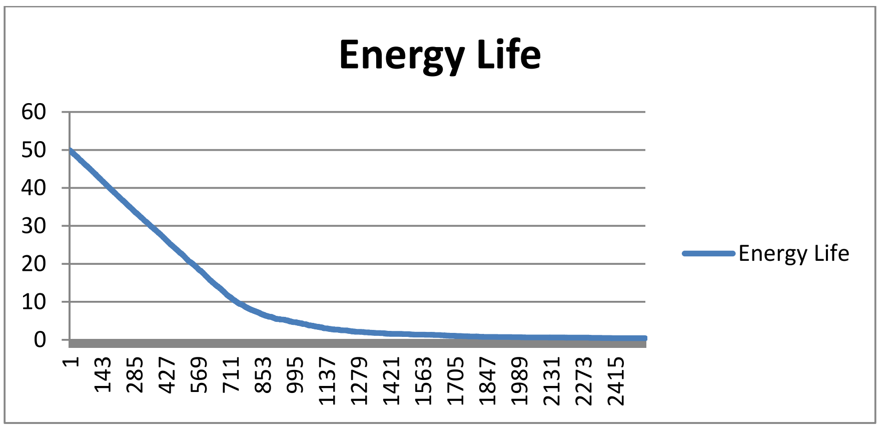

Figure 4: Energy Life in Proposed Method

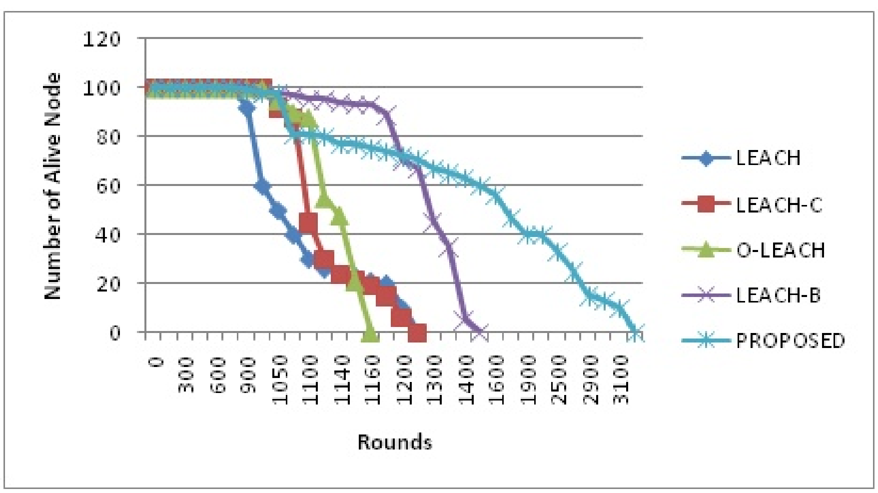

Figure 5: Number of Alive Nodes Proposed Methods and LEACH, LEACH-C[13], O-LEACH[14], LEACH-B[15].

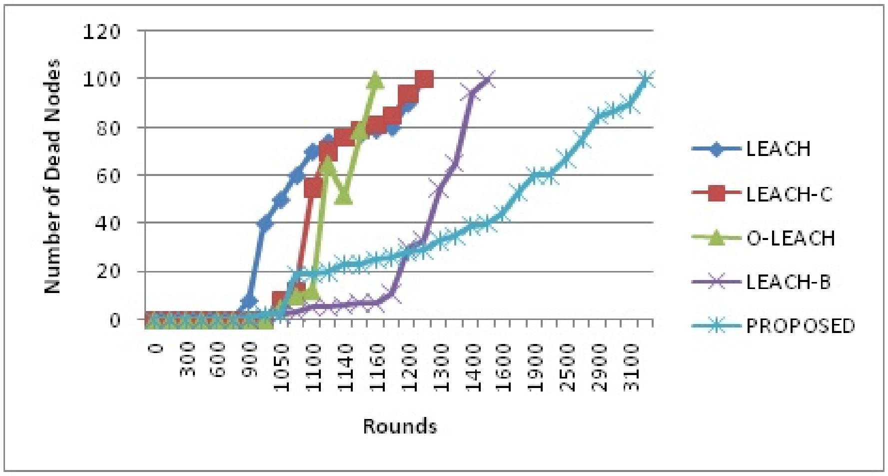

Figure 6: Number of Dead Nodes Proposed Methods and LEACH, LEACH-C, O-LEACH, LEACH-B

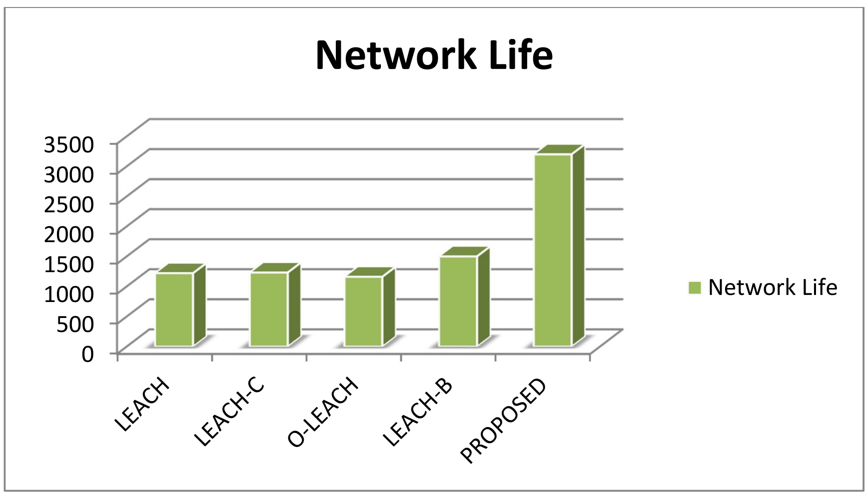

Figure 7: Network Life in Proposed Methods and LEACH, LEACH-C, O-LEACH, LEACH-B

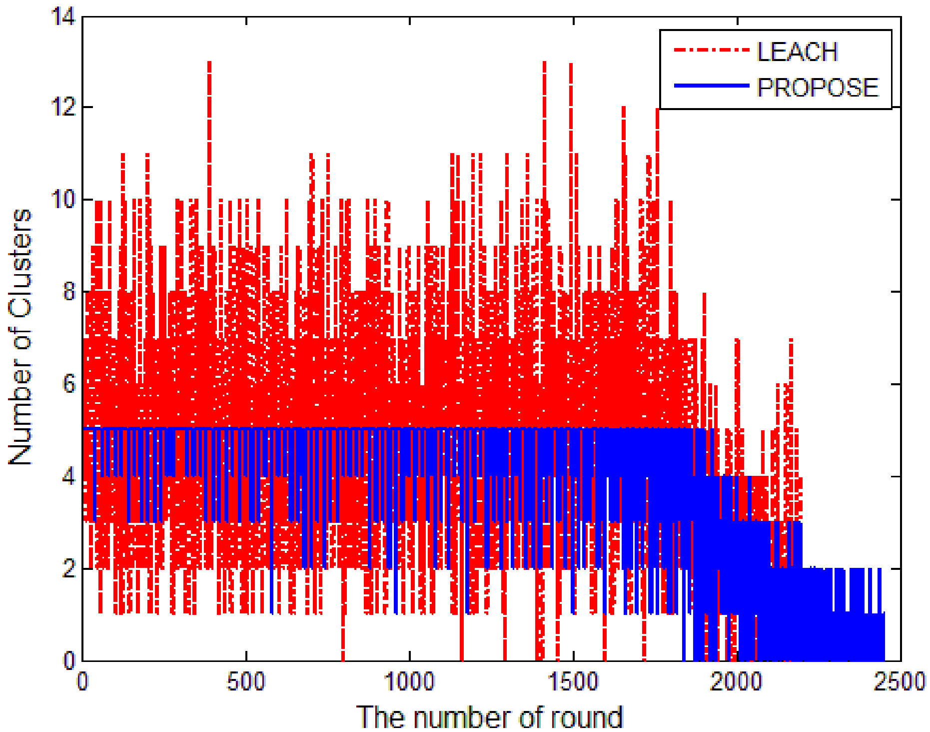

Figure 8: Number of Clusters in Proposed and LEACH Protocol

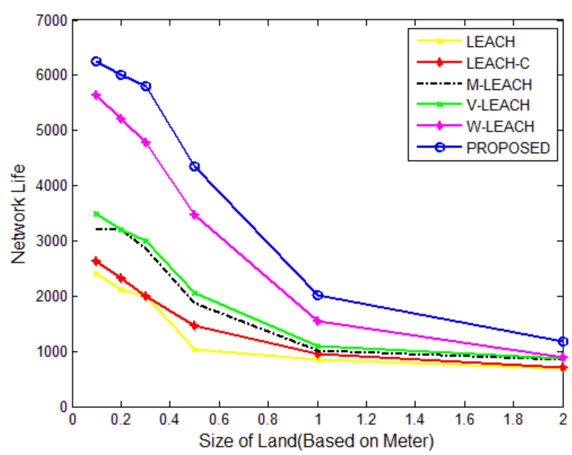

Figure 9: Network Life According Various Size of Land in Proposed Method and LEACH, LEACH-C[13], M-LEACH[16], V-LEACH[17], W-LEACH Protocol[18].

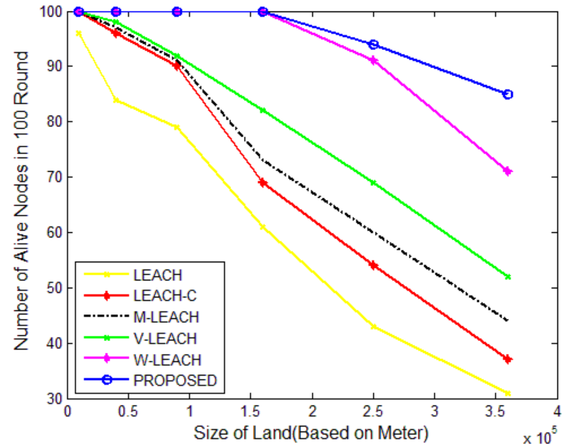

Figure 10: Number of Alive Nodes According Various Size of Land in Proposed Method and LEACH, LEACH-C, M-LEACH, V-LEACH, W-LEACH Protocol

5. Conclusion

In this paper we presented a new dynamic clustering model in WSNs to improve the efficiency of leach protocol which tries to cluster heads election from different distributed parts of ground and then we fixed the number of clusters in every round. To do so we adjusted a threshold function that makes the necessary controls to ensure two goals. The simulations show that the proposed model is an efficient model to improve the performance of leach protocol and also had better results than leach protocol. This model was superior to leach protocol with respect to all aspects of the time of death for first node, network's lifetime and also energy consumption of networks. For future works, we must find a technique for recruitment of clusters members.

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