A Head-Node Selection Scheme for Mobile Wireless Sensor Networks

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Abstract. Clustering is a technique that can effectively reduce the energy consumption of sensor nodes. In self-organizing clustering strategies, sensors elect themselves to be cluster-heads independently. This cannot guarantee the even distribution of cluster-heads over the entire sensor-network field or even the election of an optimal percentage of cluster-heads. We proposed Two-Tier Clustering in [1] to solve these problems. However, this process still generates head-nodes that are distributed too closely. In this paper, we suggest adjusted-TTC to achieve the even distribution of cluster-heads in a network field. Our scheme eliminates head-nodes if there are two or more adjacent at the first step and additionally generates an equivalent number of head-nodes at the second step. Our Two-Tier Clustering results in reduced data loss and increased energy efficiency by reducing the number of Advertisement Message non-receiving nodes.

Keywords: cluster-head, Two-Tier Clustering, energy efficiency, non-receiving nodes, mobile wireless sensor network.

1 Introduction

As mobile sensor devices and communication technology are developing, varieties of applications using mobile wireless sensor networks have been proposed. The energy efficiency of sensor nodes in MWSN [2] is a most important issue. Sensors are generally equipped with data processing and communication capabilities. The sensing circuit measures parameters from the environment surrounding the sensor and transforms them into an electric signal. The sensor sends such sensed data, usually via radio transmitter, to a base station, either directly or through a data concentration center [3]. The communication activities of sensors are the main consumers of energy in a sensor network. Since sensors are battery operated, keeping sensors active at all time will limit their endurance. Therefore, an efficient routing protocol is required to extend the life of MWSN.

Self-organization clustering proposed in LEACH (Low Energy Adaptive Clustering Hierarchy) is a clustering-based protocol that minimizes energy dissipation in sensor networks. The use of clusters for transmitting data to the base station magnifies the advantages of small transmission distances for most nodes, requiring
only a few nodes to transmit greater distances to the base station. LEACH outperforms classical clustering algorithms by using adaptive clusters and rotating cluster-heads, allowing the energy requirements of the system to be homogenously distributed among all the sensors [4]. However, the even distribution of cluster-heads over the entire sensor-network field or even the election of an optimal percentage of cluster-heads cannot be guaranteed in LEACH because sensors elect themselves to be cluster-heads independently. These problems have been ameliorated by our Two-Tier Clustering proposed in [1].

Existing self-organization clustering protocols achieve clustering in one-step, whereas Two-Tier Clustering consists of a two-step process. Initially, in order to create clusters in our proposed method, each node decides whether or not to become a cluster-head node according to a pre-determined rate. Each node that has elected itself a cluster-head broadcasts an Advertisement Message to the other nodes within a radius (R). Non-cluster head nodes will decide the cluster to which they will belong after they receive a few Advertisement Messages from various cluster-heads and compare their signal strengths. After each node has selected its cluster, it must inform the cluster-head node that it will be a member of that cluster. That is the first step in our Two-tier clustering method. After a predefined waiting time, the nodes that have not received any Advertisement Message decide once again whether or not to become a cluster-head node. The nodes that have become head-nodes configure their clusters as they did in the first step. Two-Tier Clustering (TTC) can reduce the number of nodes which do not belong to clusters compared with existing self-organization clustering protocols for any arbitrary (R). However, this process still generates head-nodes that are distributed too closely.

In this paper, we suggest adjusted-TTC to further improve the even distribution of cluster-heads in a network field. Adjusted-TTC removes multiple head-nodes that were selected in the same cluster field at the first step due to their closeness, and then additionally recreating the original number of head-nodes at the second step with more optimal spacing. All head-nodes that are selected at the first step send Advertisement Messages to all the other nodes in the same cluster. At this time, each head-node reports its remaining energy reserve. All head-nodes that received Advertisement Messages from other head-nodes compare their remaining energy with

2 Proposed Scheme

In self-organization clustering, if a non-cluster-head node does not receive any Advertisement Message, it cannot belong to any cluster and successfully transfer its sensing data through a cluster-head to the base station [1]. TTC could reduce the number of non-receiving nodes effectively through a two-tier head-node decision process. However, both LEACH-Mobile and TTC sometimes produce more than two head-nodes in the same cluster.

Adjusted-TTC reduces this problem by eliminating multiple head-nodes that were selected in the same cluster field at the first step due to their closeness, and then additionally recreating the original number of head-nodes at the second step with more optimal spacing. All head-nodes that are selected at the first step send Advertisement Messages to all the other nodes in the same cluster. At this time, each head-node reports its remaining energy reserve. All head-nodes that received Advertisement Messages from other head-nodes compare their remaining energy with
the sender’s remaining energy. If its own remaining energy is larger than the sender’s is, then it remains a head-node. If its own remaining energy is smaller than the sender’s is, then this head-node sends a relinquishment message to all the nodes to which it sent an Advertisement Message. In the second step of clustering, we generate a pre-determined number of head-nodes plus the number of head-nodes discarded at the first step. In the second step of clustering, all selected head-nodes form their own clusters. This clustering process is same as TTC’s.

It is important to get rid of adjacent head-nodes at the first step because the number of head-nodes generated by the first step is greater than the number from the second step.

3 Simulation

To evaluate the performance of our adjusted-TTC, we simulate LEACH-mobile and TTC together. We assume 1000 nodes are scattered randomly over a 1000m X 1000m sensor field. The total percentage of cluster-head-nodes is 5%.

In LEACH-Mobile, each node calculates a threshold $\theta$ and generates a random number for the threshold to decide for itself to become a cluster-head-node or not [5].

In TTC and adjusted-TTC, we suppose the percentage of cluster-head-nodes is 4% in the first step of cluster-head-node selection and 1% in the second step in order to generate the same percentage of cluster-head-nodes as in LEACH-Mobile. In adjusted-TTC, the number of head-nodes additionally generated in the second step is the same as the number of head-nodes eliminated in the first step [6].

![Chart](image_url)

**Fig. 1.** Comparison of the Number of Non-Receiving Nodes
Figure 1. shows the average number of non-receiving nodes that cannot receive an Advertisement Message that were generated through simulations using each clustering strategy.

From the results of this simulation, adjusted-TTC reduces the number of non-receiving nodes by more than 29% compared with LEACH-Mobile and achieves a 19% reduction when compared with TTC for a transmission radius of 80m. As the transmission radius increases, the number of non-receiving nodes is reduced. In adjusted-TTC, when the transmission radius is 140m, a more than 85% reduction in the number of non-receiving nodes is achieved compared with LEACH-mobile and a 39% reduction is achieved compared with TTC.

4 Conclusion

TTC can reduce the number of non-receiving nodes in mobile wireless sensor networks, thus resulting in reduced data loss and increased energy efficiency.

The adjusted-TTC proposed in this paper removes multiple head-nodes that are selected in the same cluster, resulting in the even distribution of head-nodes in the sensor field as well as reducing the number of non-receiving nodes. The simulation results shows the number of non-receiving nodes is reduced in adjusted-TTC compared with both LEACH-Mobile and TTC.

References