Hybridization of the LEACH Protocol with Penalized Fuzzy C-Means (PFCM) and Self-Organization Map (SOM) Algorithms for Decreasing Energy in Wireless Sensor Networks

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ABSTRACT

Wireless Sensor Networks (WSNs) consist of many sensor nodes, which are used for capturing the essential data from the environment and sending it to the Base Station (BS). Most of the research has been focused on energy challenges in WSN. There are many notable studies on minimization of energy consumption during the process of sensing the important data from the environment where nodes are deployed. Clustering-based routing protocols are an energy-efficient protocols that improve the lifetime of a wireless sensor network. The objective of the clustering is to decrease the total transmission power by aggregating into a single path for prolonging the network lifetime. However, the problem of unbalanced energy consumption exists in some cluster nodes in the WSNs. In this paper, a hybrid algorithm is proposed for clustering and cluster head (CH) election. The proposed routing protocol hybridized Penalized Fuzzy C-Means (PFCM) and Self Organization Map (SOM) algorithms with LEACH protocol for the optimum numbers of the CHs and the location of them. Simulation results reveal that the proposed algorithm outperforms other existing protocols in terms of network life, number of dead sensor nodes, energy consumption of the network and convergence rate of the algorithm in comparison to the LEACH algorithm.

Keywords: Cluster Head, Fuzzy C-Means, LEACH Protocol, PFCM Clustering, Wireless Sensor Networks

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1. INTRODUCTION

Wireless sensor networks are wireless networks consisting of independent sensor nodes, communicating with each other over wireless links. Each node of the sensor network has a central processing unit, memory, a radio frequency transceiver, and a power source (Akyildiz et al., 2002). The main task of the sensor node is to collect data in regular intervals and to convert it into an electronic and emission signal to the sink node by wireless communication media (Yick et al., 2008). While nodes’ energy is limited, sending and receiving data consume most of it. So energy efficient routing strategies are essential to prolong network lifetime (Anastasi et al., 2009). There are so many ways to reduce energy consumption in sensor networks, each emphasizing on certain points (Das and Misra, 2013).

Therefore, energy consumption for the sensor nodes is the most challenging issue for the long run operation of WSNs (Lattanzi et al., 2007). Various issues have been studied for this purpose that includes low-power radio communication hardware, energy-aware medium access control (MAC) layer protocols, etc. Among the most important protocols are clustering based ones. Clustering is the most effective technique for energy saving of the sensor nodes (Kuila and Jana, 2014). Essentially, there are several clustering-based protocols and algorithms. In a cluster based architecture, the sensor nodes are divided into several groups called clusters. Each cluster has a head known as cluster head (CH). All the sensor nodes sense local data and send them to their corresponding cluster head. LEACH is one of the most important and well-known algorithm that is based on other ones (Handy et al., 2002). A WSN using LEACH is built on several clusters, each of which has a cluster head (CH) and some non-cluster heads (Non-CHs). The CH controls all the sensor nodes within the cluster, fuses data sent by the sensor nodes, and forwards them to the Base Station (BS). However, the main disadvantage of this approach is that a node with low energy may be selected as a CH which may die quickly. Moreover, the CHs send directly the packet to BS via single-hop communication which is impractical for WSNs with large coverage area (Kuila and Jana, 2014).

Non-CHs methods, on the other hand, collect data and send them to the CH. This idea is base on other clustering based protocol such as LEACH-C (Hainzelman et al., 2002; Yassein et al., 2009). LEACH-C is a clustering based algorithm where the cluster formation is performed in a centralized and base station. In this algorithm, the central control center decides the node to be the CH. The control center gathers the information of all nodes and decides the CH according to this information and also the whole status of the network. So, the LEACH-C algorithm increases the lifetime of the network.

Clustering coefficients can be differentiated in two categories: quantitative and qualitative (Yigitel et al., 2011). For example, the location of sensor nodes is one kind of quantitative data. The distance between two nodes can
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