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Improved Cuckoo Search-based Clustering Protocol for Wireless Sensor Networks

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Abstract

In a large-scale Wireless Sensor Networks (*WSNs*), designing of an energy efficient data gathering protocol has become a challenging research issues. This is due to fact that each sensor node is generally equipped with limited energy resource. In the literature, clustering-based technique for data gathering has been proved very efficient in terms of energy saving. Although, it is pointed out in the literature that design of an energy-balanced clustering for maximizing the network lifetime of WSNs is a NP-hard problem. For solving this NP-hard problem, many meta-heuristic approach based clustering protocols are proposed in the recent years. However, these existing clustering protocols suffer from unbalanced energy consumption problem. In this problem, cluster heads are not uniformly distributed and overloaded cluster heads die out faster than under-load cluster heads. In order to solve this problem, an improved Cuckoo Search-based Clustering Algorithm (*ICSCA*) is proposed in this research paper. Performance evaluation of the *ICSCA* and its comparison with the state-of-art clustering scheme in terms total energy consumption and residual energy are presented.

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Keywords: Wireless sensor networks, Clustering, Cuckoo Search

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1. Introduction

Advancement in wireless communication and VLSI technologies motivates the manufacturers to design low cost and small size wireless sensor devices that can be used in the design of wireless sensor networks (*WSNs*) [1, 2]. A *WSN* is a distributed network which contains a set of autonomous and self organised sensor nodes and one or more Base Station (*BS*). This kind of network can be designed and deployed for monitoring and tracking applications such as smart environments like smart cities, smart grid, smart home; habitat monitoring, military target tracking and surveillance etc [1, 3].

In WSNs, a sensor node is equipped with limited energy resource. Generally, it is operated using 2AA batteries. Due to the limitation of energy resources, judicial uses of the energy resources of the sensor node is an important research issue which required urgent research effort for better solution in order to enhance the network lifetime. For saving of the energy resource of the sensor node and enhancing the network lifetime, various methods are proposed such as clustering, data compression and aggregation, mobile sink based data gathering, duty cycling etc. Clustering based data gathering scheme has been proved in many literature for providing energy efficient and scalable solutions [4-6].

In clustering process, nodes are organized into various groups known as clusters. Each cluster is provided with a Cluster Head (*CH*) whose main work is to receive the sensed data from its cluster members (*CMs*), aggregate it and then transport the aggregated data to the base station [4-6]. In each cluster, *CH* removes redundant data by doing data aggregation. Thus, proper selection of *CHs* and its spatial distribution are very important issues in the energy balanced clustering process.

The problem of energy balanced cluster head selection is NP-hard problem. For solving this problem, many heuristics and meta-heuristic based clustering algorithms are proposed in the literature [6-14]. However, these existing clustering protocols are suffering from unbalanced energy consumption problem. In this problem, *CHs* are not uniformly distributed and overloaded *CHs* die-out faster than under-load *CHs*. This is due to fact that average distance between *CH* and *BS* is used in the fitness function which causes selection of all *CHs* near to the *BS*. In order to solve this problem, an improved Cuckoo Search [15-17] based Clustering Algorithm (*ICSCA*) is proposed. In the proposed scheme, a novel fitness function is derived which includes three parameters such as energy, distance and cluster size. For improving the performance of Cuckoo Search, a novel encoding scheme is used for encoding the population. Performance evaluation of the proposed clustering scheme and its comparison with the state-of-art clustering scheme such as LEACH [3], E_OEERP [12], and PSO-ECHS [13] are discussed.

The remaining section of the paper is organized as follows: Section 2 discusses related work on the meta-heuristic optimization-based clustering scheme. Section 3 presents the proposed clustering scheme. In Section 4, performance evaluation of the proposed scheme and its comparison with the well known clustering scheme are included. Finally Section 5 concludes the proposed work.

2. Related Works

Clustering protocols are categorized into two groups: heuristic-based clustering and nature-inspired computing-based clustering [6]. Several heuristic protocols have been developed for increasing the lifetime of sensor network. Among these, LEACH [4] is one of the most famous clustering protocols. LEACH selects *CH* based on some probability. Due to this, role of *CH* is transferred to other node after every round. The main limitation of LEACH is that low energy sensor node can be selected as *CH*. This causes *CHs* to die quickly. To improve the performance of LEACH, number of clustering protocols has been developed, among these, HEED [5] and PEGASIS [6] are very popular. PEGASIS uses greedy approach to arrange sensor nodes into an ordered list such that each node can communicate with its adjacent nodes in the list. In HEED [5], residual energy of node is the main constrained which is used in the selection of *CH*. This protocol mainly focuses on the energy efficient *CH*s selection and reduction of the communication overhead. This causes to maximize the network lifetime.

In LEACH-C (Centralized LEACH) [7] firstly sink node computes average node energy for each round and nodes having energy higher than average node energy is selected as eligible candidate for becoming *CHs*. Cluster formation is done using simulated annealing-based meta-heuristic algorithm. It performs better than LEACH as it selects *CH* based on energy, thus increases network lifetime. This protocol does not consider, how to balance the