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FULL-LENGTH ARTICLE

Improved multi-objective weighted clustering algorithm in Wireless Sensor Network

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Abstract In Wireless Sensor Networks (WSNs), the network's performance is usually influenced by energy constraint. Through a well-designed clustering algorithm, WSN's energy consumption can be decreased evidently. In this paper, an Improved Multi-Objective Weighted Clustering Algorithm (IMOWCA) is proposed using additional constraints to select cluster heads in WSN. IMOWCA aims at handling a WSN in some critical circumstances where each sensor satisfies its own mission depending on its location. In addition to fulfill its mission, the sensor tries to improve the quality of communication with its neighboring nodes. Our proposed algorithm divides the network into different clusters and selects the best performing sensors based on residual energy to communicate with the Base Station (BS). IMOWCA uses four critical parameters: $\mathbf{EC}_i$: Energetic Characteristic of sensor i, $\mathbf{DD}_i$: Degree Difference of sensor i, $\mathbf{DC}_i$: Sum of distances between sensor i and its neighbors and $\mathbf{DM}_i$: Mission distance of sensor i. To balance the consumed energy in different formed clusters, a Base Station Genetic Algorithm (BGA) is developed. Simulation results demonstrate that the proposed algorithms are advantageous in terms of convergence to the appropriate locations and efficients in regard to energy conservation in WSNs.

1. Introduction

In recent years, wireless communication and sensor technologies have seen tremendous evolution. Wireless Sensor Networks (WSNs) have emerged as a promising research domain and have been used in a wide variety of applications [1]. They have been used in health field [2,3], Environmental field [4–6], and smart home-field [7]. By means of this recent technology, it becomes possible to interact with the surrounding environment through the use of multiple tiny sensors. WSNs use sensors to co-operatively monitor complex environmental or physical conditions. Such sensors are generally equipped with communication capabilities and data processing in order to collect data and to route information back to a Base Station (BS) [8]. WSNs are examples of resource-constrained networks in which the processing resources, the

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storage and the energy are limited [9]. As a result, this constraint of energy is a critical issue which needs to be tackled so that WSNs can be widely employed. In WSN, the power source consists of a battery with a limited energy budget which results in a finite lifetime of nodes. Moreover, it could be impossible or inconvenient to recharge the battery because nodes may be deployed in a hostile or unpractical environment [10]. In the last few years, several studies have established for the extension of nodes' battery life as much as possible. A survey that offers a comprehensive view of energy-saving solutions in WSNs while taking applications' requirements into consideration is presented in [11].

It is very important to note that in WSN both the network structure and the manner of communication between the nodes decide the energy expenditure. On the plain network, hierarchical structures are generally preferred due to their reliability and improved energy conservation. Clustering is the prominent hierarchical architecture. Cluster formation is one of the early proposed methods for energy efficient operation in WSNs [12].

In clustering, the sensor nodes are divided into different virtual groups according to a set of rules [13]. Some nodes are selected as Cluster Heads (CHs) and the other nodes are called Cluster Members (CMs) [14]. The CHs are responsible for managing the CMs, and being charge of receiving and processing data from them. They are also the nodes having the ability to communicate with the BS directly, while each CM can make a communication just with its own CH (Fig. 1). As a result, CHs consume more energy than their CMs, since they have the responsibility of network organization, data gathering, and long distance data transmissions with the BS [15]. Clustering the nodes in WSNs is performed with different objectives and purposes presented in [16]. The most important and common goal of all these objectives is the energy conservation.

The main contribution of this paper can be summarized as follows: the WSN's clustering in some mission-specific critical situations is not just a single-objective problem, but a multi-objective one; we should consider various aspects of a network concurrently. This optimization is used in several areas related to telecommunication. For example, we site the work presented in [39] where the authors identified a multi-objective dynamic vehicle routing problem (M-DRP) and proposed a Time Seed based solution using Particle Swarm Optimization (TS-PSO) for this problem. We also site the paper [40] aiming at maximizing fault tolerance and minimizing delay in virtual network embedding using Non-Dominated Sorting Genetic Algorithm (NSGA-II). Another approach based on multi-objective optimization is presented in [39], this work deals with a Geocast through Particle Swarm Optimization (GeoPSO) protocol. So, being motivated by the importance of network structure and the manner of communication between the nodes in the energy expenditure under WSN, this work considers jointly those factors (Network structure and communication manner). More precisely, the main objective was to develop a clustering algorithm to solve the energetic constraint in WSNs by the joint minimization of mission and communication costs. In other words, the proposed algorithm aims at ensuring both efficient satisfaction of sensors' mission and improving the quality of communication between them while minimizing jointly the costs of these two operations based on four metrics: $\mathbf{EC}_i$, $\mathbf{DD}_i$, $\mathbf{DC}_i$ and $\mathbf{DM}_i$.

The paper is organized as follows: Section 2 deals with related works. Section 3 is reserved firstly to recall the interest of SGA algorithm in terms of joint minimization of mission and communication costs, secondly to explain and give more details concerning different phases of IMOWCA algorithm, and the final part of this section takes place to show the way to achieve the optimal position of BS using our algorithm BGA, to balance the consumed energy in formed clusters. The numerical result, the possible comparisons, the various analyses and the performances of proposed algorithms are provided in Section 4 which leads to the conclusion and perspectives of our work.

2. Literature review

Many works have been considered for tacking clustering issue and finding good location of nodes in WSNs. For the first challenge, in the last decade, a lot of approaches have been proposed in order to find an energy efficient solution for one of the following clustering problems: Cluster size [17], transmission power load balancing between cluster members [18,19], and CH selection [20,21].

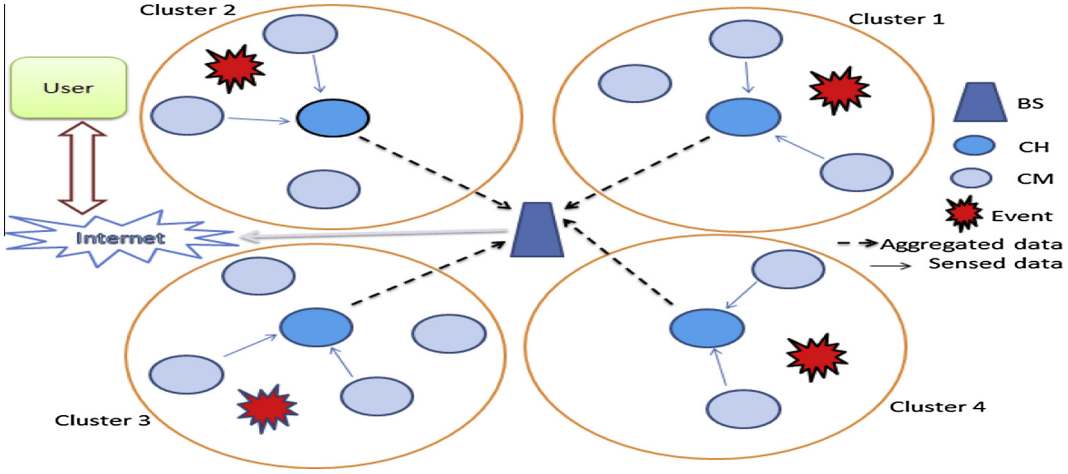

Figure 1 Clustering in WSN.