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Reducing Energy Consumption in Wireless Sensor Networks by CICA Algorithm

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Abstract

A wireless sensor network is a collection of small sensor nodes able to sense its environment and monitor and send data to a base station. One of the main challenges of sensor networks is energy constraint of the nodes because they each have a direct effect on a network's lifetime. Hence, various methods have been employed to optimize power consumption and increase the lifetime of wireless sensor networks. This paper presents a new method called CICA[1] for clustering wireless sensor networks using Imperialist Competitive Algorithm (ICA) that divides sensor nodes according to balanced clusters. Results of simulations show successful performance of this new method for increasing the lifetime of wireless sensor networks.

Keywords: *wireless sensor networks, Imperialist Competitive Algorithm (ICA), reducing energy consumption, clustering, LEACH, HCR.*

1. Introduction

In recent years, advances in telecommunications and electronic technology have resulted in the construction of small and cheap sensors that connect to each other via a wireless network [1]. Wireless sensor networks are applied for extracting data from an environment and monitoring environmental events. Application of such networks is rapidly increasing in domestic, industrial and military fields [2]. Each node in a wireless sensor network consists of three main parts: a sensor, a processor and a wireless transmitter\receiver. Data from the environment such as information on temperature, humidity, pressure, light and motion are received by a node and sent to the base station for processing. The most fundamental challenge in a wireless sensor network is to constrain energy, so development of a method that increases energy efficiency and extends the life of nodes in such a network is of interest to researchers. This paper presents a new method for clustering wireless sensor networks using an Imperialist Competitive Algorithm (ICA). The rest of the paper is as follows: Section 2 reviews related works; Section 3 discusses the proposed algorithm (CICA); simulation results are shown in Section 4 and Section 5 presents the conclusion.

2. Related Works

In the first part of this section, there is a review of some of the most efficient algorithms for energy consumption that extend the lifetime of a wireless sensor network by clustering the network nodes. In the second part, the Imperialist Competitive Algorithm is introduced, on which the CICA is based.

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2.1. Clustering Nodes

The main task of sensor network nodes is to collect information from the environment. Transmission of data is one of the main reasons for energy consumption of the nodes and is directly related to the second (or higher) exponent of distance between the source and the destination in a network. Therefore any plan that shortens the communication distance between nodes in a WSN will reduce its energy consumption and increase its lifetime [3].

The ideal mode of energy consumption in a sensor network is when energy consumption finishes simultaneously in all of the nodes so that the lifetime of a network is maximized. Thus an attempt was made to establish uniform network load distribution in order to minimize the time interval between the death of the first node and the death of the last node. Several communication protocols have been proposed to achieve this goal. To date, protocols based on clustering have reported considerably slowed down energy consumption in networks [4].

Clustering is based on partitioning of an entire network into several independent groups called clusters and each node is located in one of the clusters and one of the nodes in each cluster of nodes is selected as the CH[3].

The duty of all CHs is to collect data from nodes in its cluster and then to send this information either directly, or with data from other CHs, to the BS[4]. Thus, clustering can greatly reduce communications costs.

2.2. LEACH[5] algorithm

This algorithm has been applied to clustering nodes in a sensor network, it was introduced in 2000 and reforms were made in 2002 and 2004. It is one of the best-known and fundamental algorithms for clustering sensor nodes. In this algorithm, information collected by the cluster heads, based on TDMA[6] timing, is sent directly to the BS [5].

In this algorithm, time is divided into intervals called rounds and clusters are formed according to that relationship (2-1). Then each node selects a random number between 0 and 1, if this number is less than the threshold of the relationship (2-1) then that node is selected as the CH for that particular round.

$$T(i) = \begin{cases} \frac{P}{1-p*\left(rmod\frac{1}{P}\right)} if i \in G \\ \\ Potherwise \end{cases} \quad (1)$$

Where (G) is a set of nodes that have not been allocated a CH in previous 1/p rounds, P is the suggested percentage of a CH and r is the current round. In this algorithm, CHs are selected randomly from sensor nodes and all sensors have the same chance of allocation to a cluster head.

2.3. HCR[7]algorithm

HCR algorithm [5] is an extension of the LEACH algorithm [6]. It is a self-organized cluster based approach for continuous monitoring. In HCR, each cluster is managed by a collection of associates and the energy efficient clusters are retained for a longer period of time; the energy efficient clusters are identified using a heuristics based approach. Moreover, in HCR, cluster formation is determined from the base station. A Genetic Algorithm is used to generate energy efficient hierarchical clusters. Simulation results show that HCR is more energy efficient for application in continuous monitoring.

2.4. Imperialist Competitive Algorithm (ICA)

There are several evolutionary algorithms for optimization such as GA[8], PSO[9], SA[10] and some others. Recently, a new algorithm has been introduced called the Imperialist Competitive Algorithm, presented by Atashpaz-Gargari and Lucas in 2007 [6]. The algorithm is based on human political-social developments. Like other evolutionary algorithms, ICA begins with an initial population called a Country. Then a number of countries, showing the best in a population, are selected as imperialist and others are selected as their colonies. Figure 1 shows an overview of the ICA.

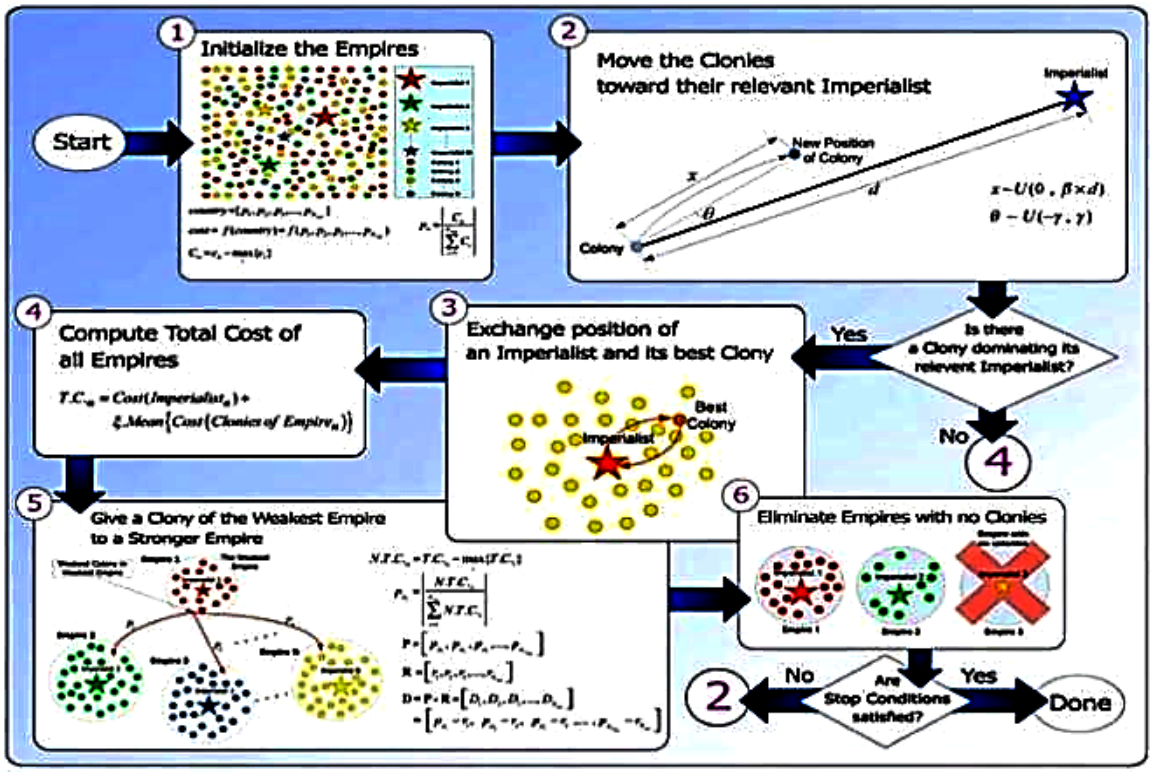

Fig. 1: ICA overview

3. CICA Algorithm

Here we review the CICA algorithm, which is a clustering algorithm applied in WSNs based on the Imperialist Competitive Algorithm. In order to determine optimality, the CICA algorithm was compared to other well-known algorithms in wireless sensor network clustering such as LEACH and genetic based HCR algorithms. Simulation results showed the same parameters in all three algorithms.
Effective parameters in the CICA algorithm are as follows:

- Distance between sensor nodes and cluster heads: the main parameter considered in the CICA algorithm is sum of distance between all nodes of a CH; the more efficient CHs are those with a lower value for sum of distance between all nodes.
- Distance of node to base station: those nodes, for which distance to the base station is less than that of distance from the CH, will send data directly to the CH instead of sending data directly to the BS and this avoids additional energy consumption.
- Remaining energy of a sensor node: when energy of a CH is finished, selection of a CH is done by selecting the node within a cluster that has the highest residual energy.