

Chapter 13

Using Multi-Objective Particle Swarm Optimization for Energy-Efficient Clustering in Wireless Sensor Networks

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ABSTRACT

In this chapter, the authors propose a multi-objective solution to the problem by using multi-objective particle swarm optimization (MOPSO) algorithm to optimize the number of clusters in a sensor network in order to provide an energy-efficient solution. The proposed algorithm considers the ideal degree of nodes and battery power consumption of the sensor nodes. The main advantage of the proposed method is that it provides a set of solutions at a time. The results of the proposed approach were compared with two other well-known clustering techniques: WCA and CLPSO-based clustering. Extensive simulations were performed to show that the proposed approach is an effective approach for clustering in WSN environments and performs better than the other two approaches.

INTRODUCTION

The field of Wireless Sensor Networks (WSNs) has emerged as a very active area of research during the last few years. A WSN consists of autonomous tiny devices that cooperatively monitor physical

or environmental conditions such as temperature, vibration, pressure, motion etc. These tiny devices or sensors have limited battery power, memory and processing capabilities. One of the important challenges of a WSN is the energy-efficient communication which increases the lifetime of the network. Several techniques have been

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proposed to achieve this goal and clustering in WSNs is one of them that can help in providing an energy-efficient solution. Clustering requires the selection of cluster-heads (CHs) for each cluster. Fewer CHs result in greater energy efficiency as these nodes consume more power and energy as compared to non cluster-heads. Several techniques are available in the literature for clustering by using optimization and evolutionary techniques. The main drawback of these techniques is that they handle only one objective at a time. These techniques do not provide a freedom of choice to the user.

A wireless sensor network (WSN) which is a special type of wireless ad hoc network consists of autonomous tiny devices that are capable of cooperatively monitoring physical or environmental conditions. These nodes have limited battery, processing speed, storage, and communication capabilities. These limitations of WSNs bring new problems and challenges for the researchers. Clustering is a technique of organizing objects into meaningful groups with respect to their common characteristics. The objective of clustering in WSNs is to identify the groups of nodes in such a way that the groups are exclusive and any node in the network belongs to a single group. The nodes known as cluster-heads (CHs) are responsible for the formation of clusters, maintenance of network topology, and the allocation of resources to all nodes present in their clusters. Since the configuration of CHs can change frequently due to the mobility of sensor nodes, minimizing the number of cluster-heads becomes an essential component. Optimal selection of CHs is an NP-hard problem. The neighbourhood of a CH is a set of nodes that lie within its transmission range. Since energy-efficiency is an important requirement for a WSN that increases its lifetime, clustering can provide an energy-efficient solution as only a few nodes are involved in doing the main operations in the sensor network such as management, routing, data aggregation etc. Therefore, clustering can

greatly help in achieving an energy-efficient solution for WSNs.

Optimization refers to determining one or more solutions of a given problem which correspond to extreme values of one or more objectives. It has been an active area of research as many real-world problems have become increasingly complex. Therefore, better optimization techniques are always required. Most real world problems consist of several objectives that are needed to be optimized at the same time. Such kinds of problems arise in many applications. While solving multi-objective problems (MOPs) with traditional mathematical programming techniques, a single solution is generated from a set of solutions in one run. Therefore, these techniques are not much suitable for solving multi-objective optimization problems. Evolutionary Algorithms paradigm is very suitable to solve MOPs because they are population-based and can generate a set of solutions in one run (Liang et al., 2006).

In this chapter, we introduce a Multi-objective Particle Swarm Optimization (MOPSO) based clustering algorithm for wireless sensor networks. MOPSO efficiently manages the resources of the network by finding optimal number of clusters in a multi-objective manner. Optimal number of clusters can make the WSN energy-efficient by efficiently managing the resources of the network so that the CHs can do their job in a proper manner. The proposed clustering algorithm takes into account the ideal degree and battery power for selecting the cluster-heads. MOPSO uses the evolutionary capabilities to optimize the number of clusters in a network. Instead of assigning weight to each of the parameters mentioned above, the algorithm deals directly with the multi-objective problem in order to find the Pareto-optimal solutions. The algorithm first finds the cluster-heads and then the neighbours of these cluster-heads. The neighborhood of a CH is a set of nodes that lie within its transmission range. There are some requirements for clustering in WSNs. The clustering algorithm must be distributed since each

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