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OPTIMIZING THE SELECTION OF CLUSTER HEADS IN WIRELESS SENSOR NETWORKS USING SHUFFLED FROG-LEAPING (SFL) ALGORITHM

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ABSTRACT
Because of its many uses, the wireless sensor network is among the most popular wireless networks in the world. Since sensors in this network have limited energy, this article uses the shuffled frog-leaping (SFL) algorithm inspired from the modeling of natural biological evolution. Instead of random selection of cluster heads, this algorithm works on feasible solutions that have a superiority property and higher survivability. The algorithm implementation results indicate increased number of alive nodes, resulting in increased longevity and reduced energy consumption in wireless sensor networks.

KEYWORDS: LEACH algorithm, SFL algorithm, Wireless networks.

INTRODUCTION

Today, the issue of remote control and monitoring systems is one of the most challenging issues in the field of electronics and computer science. Research always seeks solutions to respond to particular circumstances and expectations. In the same condition and quality of work, the methods with lower cost to performance ratio will be more popular. To be aware of changes in the environment or the situation of any set, we need some equipment known as sensors. Sensors present the desired changes (physical or chemical) in the form of an answer in order to discover or measure changes. After gathering the required information, other operations can be performed based on the answer provided. Recent advances in the field of wireless communications have made it possible to use small, inexpensive, low-power and versatile sensors that can establish radio contact with each other over short distances and can be used for things like information collection, and situation identification and monitoring. A sensor network includes a large number of sensors which are densely distributed around the desired environment. In these networks, each node is connected to another node. Each sensor in the network usually consists of a computational unit, a radio receiver or transmitter for wireless communication, a number of sensors to measure the studied environment, and a battery. According to the sensor networks theory, these tiny sensor nodes have equipment for data sensing, processing and transmission. The main difference of sensor networks with other networks is in their data-centric nature and very limited processing and energy resources. That is why the proposed methods for data transfer in other networks and even networks with similar structures cannot be used in these networks. The development trend of these networks is such that surely they will play an important role in our daily life in the near future. Among increasing applications of network sensors, one can point to tracing in broad geographic areas, security systems, monitoring of large structures, monitoring patients with critical conditions, monitoring of environmental parameters in the areas where human presence is dangerous and many others. Indeed sensor networks are the aggregation of a large number of sensor nodes scattered in the environment and each one follows a special purpose autonomously in cooperation with other nodes. Nodes are close to each other and each node can communicate with other nodes and give its data to another node. Finally, the condition of the studied environment is reported to a central node. Techniques and methods used in these networks are highly dependent on the nature of network usage. The network structure and topology, climatic and environmental conditions, and constraints are factors affecting the network's cost and performance parameters. Thus today the wireless sensor network is a very attractive and popular research subject throughout reputable universities and research centers for computer, electronics and especially telecommunications. Many studies and suggestions have been offered on various topics, and the amount of research in this field is still increasing. The main goal of all these efforts and solutions is to have a system with simple, easy and low cost monitoring methods which can respond to our needs

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while standing up against constraints (bandwidth, energy, environmental interventions, etc.) and providing general conditions according to our wants and desires (transfer of large volumes of content information, high survivability and longevity, low cost, etc.). Thus researchers analyze various aspects and try to extract efficient and optimum ideas. These ideas can be inspired from the surrounding environment and can be analyzed by mathematical rules and statistical theories. One of the challenges in sensor networks is how to route and transmit collected data in the nodes of these networks. Since these networks are limited in available energy and processing resources, the methods proposed for other networks cannot be used for sensor networks. The nodes in a sensor network should have low power. The battery life of each node specifies its lifetime. In many applications, batteries are not interchangeable after the end of battery life. For efficient data compression and mix in wireless sensor networks, clustering protocols were proposed which can be used for energy management of wireless sensor networks, among other advantages.

Since this article focuses on the application of meta-heuristic SFL algorithm in the selection of cluster heads in the LEACH protocol, we first review articles relating to the use of meta-heuristic methods in cluster head selection. Hussain *et al*. [Hussain, and Matin, 2009] proposed a new method, using genetic algorithm, to select cluster heads using a cluster-based hierarchical routing. Karimi *et al*. [Karimi and golestani, 2012] increased the network lifetime using the genetic algorithm and the harmony search algorithm in the Partition-LEACH of cluster head selection in the algorithm. In relation to using the imperialist competitive algorithm in clustering algorithms, Ghanavati *et al*. [Ghanavati *et al*., 2011] proposed a method for determining the optimal number of clusters using the imperialist competitive algorithm. This method used a cost function to calculate the cost of each cluster in each round of clustering. Shahvandi *et al*. [Shahvandi, 2011] determined the optimal number of cluster heads using the imperialist competitive algorithm and then selected optimal cluster heads. The method reduces the network's energy consumption. As mentioned, this paper used the SFL algorithm, instead of a random selection of cluster head in the LEACH algorithm, to increase the network lifetime and ultimately increase its efficiency. In fact, in each round of the LEACH algorithm, optimal clusters are selected. After developing the initial network, the SFL algorithm is used for cluster head selection. Next, the LEACH algorithm is executed.

The LEACH (Low-Energy Adaptive Clustering Hierarchy) algorithm

The LEACH method is a self-organizing protocol with dynamic clustering [Heinzelman *et al.*, 2004] which uses a stochastic algorithm to distribute energy consumption among nodes in a balanced way. In this method, nodes organize themselves as local clusters in which a node undertakes the role of a local base station. If the heads of clusters are selected in a fixed manner based on a priority and do not change during the system lifetime, it is evident that the unlucky sensors selected as cluster heads will die soon and the useful period of all the nodes in these clusters will end. Thus, the LEACH algorithm uses the random rotation of cluster heads between energetic nodes so that the battery of a specific node does not drain immediately. In addition, the LEACH algorithm uses data fusion locally to compress the data transmitted from clusters to the base station. This can reduce the energy required to spread information and consequently increase the useful life of the system. At any time, sensors select themselves as local headers. Then these headers broadcast their status to other sensors in the network. Each sensor node determines to which cluster it belongs based on the minimum energy cost needed to communicate. Once all nodes are recognized by the header, each header provides a program for nodes in its cluster. This allows nodes to turn off their radio components, except at the scheduled time, which minimizes the energy consumption of conventional sensors. When a header receives information relating to all other nodes under its coverage, it compresses information and sends the compressed data to the central station. Since the central station may be far from headers, this step will require a lot of energy. However, this will affect a small number of nodes, because the number of headers is small. As we know, the energy resources of a cluster head are quickly discharged. To distribute energy among several nodes, headers are not selected in a fixed way but internally at various time intervals. With this method, nodes that have the highest remaining energy in the network conduct operations that use the highest level of energy consumption. Independently of other nodes in the network, each node decides whether or not to be the cluster head. Therefore, no negotiation is needed to identify cluster heads. In this method, the system can determine the optimal number of clusters based on different parameters such as network topology and the relative cost of communication to computation at each node. Based on the obtained samples, it is appropriate to select 5% of the total number of nodes in the network as headers. Moreover, the amount of energy used in the LEACH algorithm is seven to eight times less than the direct communication method with the central station. The operations of LEACH algorithm are periodically repeated and each round has some steps. Each round begins with the

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initial setup phase and then it enters a stable phase in which data are sent to the central station. To minimize information overhead, the stable phase duration must be longer than the initial setup phase.

THE MOBILE SEARCH SFL ALGORITHM

The SFL algorithm is a memetic algorithm which uses the advantages of collective intelligence and in particular the advantages of Particle Swarm Optimization (PSO) algorithm. This algorithm was developed by Eusuff and Lansey in 2003 [Eusuff and Lansey, 2003]. Its improved version was published by the same persons in 2006. This algorithm combines the features of genetic algorithm and the birds' population algorithm. Therefore, it has higher speed and accuracy compared to the two methods. In this algorithm, each frog represents a solution to the problem. In the given method, the initial population is divided into several groups in which the number of frogs in all groups is equal. Based on this classification, this algorithm has two types of search techniques. The first technique is a local search technique based on which frogs in each group improve their position relative to the food (best solution) with information exchange. The second technique is about information exchange between groups based on which, after each local search in groups, the information obtained between the groups will be compared. To implement this algorithm, the initial parameters for P members of the algorithm are initialized and then an initial population is randomly generated. The merit of each member is calculated, and after sorting the population in descending order, the population is divided into groups, each of which has m members. This division should be such that all groups include n members with higher merits. Then a local search is carried out for leaping of frogs with the worst merit to those with the highest merit. This leaping is done according to relations (1) and (2).

$$D = r\,(Xb - Xw) \qquad (1)$$

$$Xw(new) = Xw + D$$

$$D < Dmax \qquad (2)$$

where Xb and Xw are frogs with the worst and the best solutions, D is the leaping of the weakest frog towards the best member of the group, Dmax is maximum permissible limit for frog leaping and r is a random number in the range [0, 1]. After the above changes, if the new frog has a better solution compared to the worst frog in the group, it will replace it. Otherwise, the same steps are repeated by replacing Xg with Xb. If a more appropriate solution is not found, a solution is randomly generated and replaces the worst member in the group. This process continues for a specified number of repetitions until the stoppage condition of the algorithm is reached. One of the main strengths of the SFL algorithm is its high speed.

SIMULATION AND RESULTS

The proposed algorithm and the LEACH protocol were implemented using MATLAB 2011. The results were obtained using a laptop with a 2 core i CPU and 4GB of RAM. The parameter values considered for simulation are listed in Table 1 [Heinzelman *et al*., 2002].

Table 1. Simulation parameters

Network size	100m
Number of nodes	100
Initial energy	0.5J
Eelec	50nJ/bit
εamp	10pJ/bit
Package size	4000 bits

The send energy and the receive energy are calculated by the following equations:
As seen in Figure 1, alive nodes in 1500 rounds of simulation in the Gases Brownian Motion Optimization algorithm die more slowly than the classical LEACH, thus the network longevity increases.

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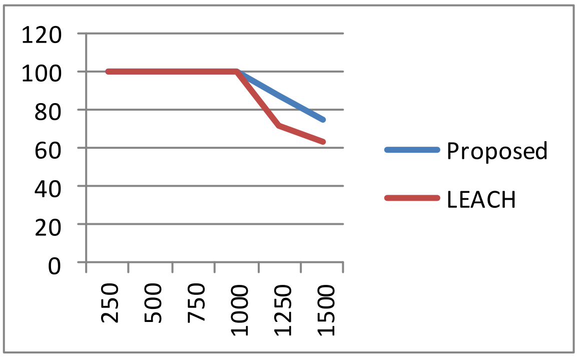

Figure 1. Comparison of the number of alive nodes in the LECH algorithm and the proposed method

Also seen in Figure 2, by selecting an energy merit function for the Gases Brownian Motion Optimization algorithm, the amount of energy used in the above algorithm increased compared to the classical LEACH.

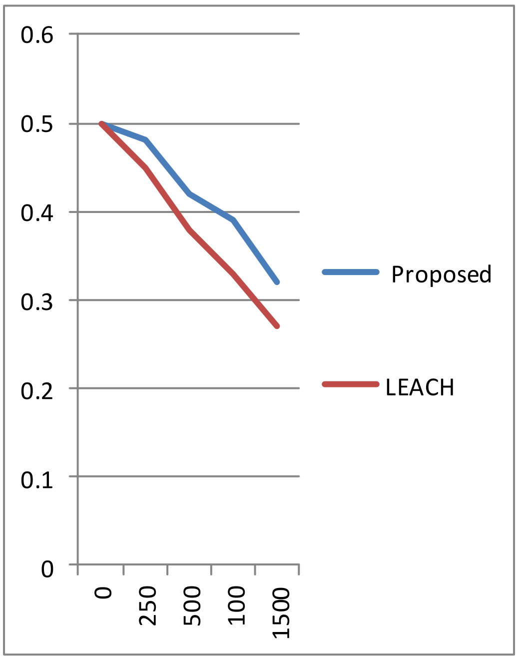

Figure 2. Calculating energy consumption in the LEACH and the proposed algorithm

CONCLUSION

The proper selection of cluster head in wireless sensor networks plays an important role in improving network performance in terms of energy and the number of alive nodes. With the help of SFL algorithm, this paper attempted to improve cluster head selection in the LEACH algorithm. The test results show an improvement in energy consumption and an increase in the number of alive nodes compared to the classical LEACH.

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