pp.195:198

Energy-Saving in Wireless Sensor Networks Based on Optimization Sink Movement Control

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Abstract

A sensor network is made up of a large number of sensors with limited energy. Sensors collect environmental data then send them to the sink. Energy efficiency and thereby increasing the lifetime of sensor networks is important. Direct transfer of the data from each node to the central station will increase energy consumption. Previous research has shown that the organization of nodes in clusters and selection the appropriate cluster head increases the network lifetime. In this study, clustering, determine to cluster heads and the sink movement on the predefined paths has been done with fuzzy method. There are two inputs for the fuzzy model; residual energy of the node and distance from the sink. The output is priority of cluster heads. Sink moves base on the highest priorities on the predefined paths. Then by using genetic algorithm, the number of clusters, shape type and area is optimized. Fitness function is based on network lifetime.

Keywords: wireless sensor network, lifetime, fuzzy method, genetic algorithm, mobile sink

1. Introduction

A large amount of inexpensive sensors is deployed in monitoring fields to sense the physical environments, and a few mobile sinks are involved in collecting sensed data, making decisions, and taking actions. Since sensor nodes are expected to be deployed in harsh environments, which cause great difficulty to recharge or change their battery, the lifetime of a wireless sensor network is limited to the battery lifetime [1-4]. Sensors distributed in a geographic area and lack of access to these sensors causes that they cannot be recharged. Many energy-efficient protocols and schemes have been proposed for data-gathering sensor networks in recent years [5-8]. So researchers have looking to protocols that increase the lifetime of network. Clustering and sink mobility reduces energy consumption. But the number of clusters, shape type and area have fundamental role in the network lifetime. In this paper by using genetic algorithm, the number of clusters, shape type and area is optimal. This reduces energy consumption and increases the lifetime of the network.

2. Related Works

Direct transfer of data from the sensor to the base station can increase energy consumption and therefore reduce the network lifetime. So the clustering method and choosing the appropriate cluster head will increase network lifetime. One of the most basic methods for choosing the cluster head is the LEACH method [9]. Initially, each sensor randomly decided to be the cluster head and take a random number between zero and one, if the number is less than threshold, then sensor is elected as the cluster head. In previous works, usually a fixed number of clusters are considered [10-11]. In some previous researches, base station moves randomly and the others base station moves on predefined paths [12]. The authors in [13] propose deploying multiple, mobile base stations to prolong the lifetime of the sensor network. The method uses an integer linear program to determine new locations for the base stations and a flow-based routing protocol to ensure energy-efficient routing during each round. In [14] Genetic algorithms are used to affect the performance of routing in MANET. Since the fitness function which was used in this method is single value and simply, routing in MANET is different with WSN.

3. Proposed Method

Firstly, clustering is done using fuzzy distance and energy priorities and then sink moves on predefined paths base on fuzzy priorities. Genetic algorithm optimizes the number of clusters, area and the optimal shape to move the sink. Tables 1 and 2 show fuzzy rules.

Table.1.
Fuzzy rules to determine cluster head with the priority of the remaining energy and distance

Distance / Energy	Very near	Near	Medium	Far	Very Far
Very low	M	M	M	L	VL
Low	M	M	M	L	VL
Medium	H	H	M	L	M
High	VH	H	H	M	M
Very High	VH	VH	H	M	M

Table.2.
Fuzzy rules to move sink toward cluster heads with the priority energy and distance

Distance / Energy	Very near	Near	Medium	Far	Very Far
Very low	H	H	VH	VH	VH
Low	M	H	H	VH	VH
Medium	L	M	M	H	H
High	VL	L	M	M	M
Very High	VL	L	VL	L	L

4. Proposed Genetic Algorithm

The algorithm starts with a population of chromosomes which is randomly selected. The fitness of each member of the population is evaluated by an objective function and then after combination and mutation operations, finally a new population is replaced. We briefly review several steps of genetic algorithm.

4.1. Create a random initial population:

Each chromosome is consists of three variables: the number of clusters, path shape and area of the shape.

4.2. Fitness function:

Network lifetime corresponding to each chromosome is expressed as the criterion for evaluating the chromosomes.

4.3. Best chromosome selection:

Best chromosomes selected as the parent for the next generation.

4.4. Renew the population:

The new population is created using a combination and mutant. This generational process is repeated until a termination condition has been reached.

4.4.1. Encoding

We have used the method of binary encoding. This code is shown in Fig.1. Each chromosome is consists of a string of 0 and 1 bits. Each gene in the chromosome gets 0 or 1 bits as well. In this paper, the number of genes is 13 bits, 8 bits to determine the size of the path, 2 bits to specify the path type and 3 bits to determine the number of the clusters.

0	0	1	0	1	0	1	1	1	0

Fig.1. Binary Encoding

4.4.2. Crossover

The most important function of genetic algorithm is marriage or combination operator. The older generation combine to create a new generation of chromosomes. The new generation is expected to be better than the old generation. In this paper, distributed combining method is used, because this method is more suitable for optimization problems, so each offspring chromosome gene is chosen from a parent randomly (Fig.2).

parent1:

1	**0**	**1**	**1**	**0**	**0**	**1**	**0**	**1**	**0**

parent2:

0	0	1	0	1	0	1	1	1	0

Offispring1:

0	0	1	1	1	0	1	1	1	0

Offispring2:

1	0	1	0	0	0	1	1	1	0

Fig.2. Distributed crossover

4.4.3. Mutation

Mutation operator with mutation rates may apply to a bit as a not command. The "one" change to "zero" and the "zero" change to "one".

5. Fitness Parameters

Fitting function is used to minimize energy consumption and increase the lifetime of the network. For this purpose, a number of rounds that the sensor loses its energy are considered as the fitness function. Thus, consideration of appropriate number of clusters, distance between cluster members and cluster head is optimized and energy consumption will be minimized. For moving toward the sink, the size and path shape types have important role in the network lifetime. So these are optimized with genetic algorithm.

Energy model is used to transfer data is as it is shown in equation (1). Energy consumption in order to transfer L bits to “d” distance is named E_{TX} and it is defined in (1).

$$E_{TX}= \begin{cases} E_{elect}*l + E_{fs}*l*d^{2} & \text{if } d < d0 \\ E_{elect}*l + E_{mp}*l*d^{4} & \text{if } d \geq d_0 \end{cases} \qquad (1)$$

E_{TX} = transmission energy
E_{elect}= energy for transceiver circuit
d_0 = threshold

6. Simulation Parameters

Parameters used for simulation are shown in Table..3 and 4. Parameters in Table..3 are used for simulation with genetic parameters and parameters in Table..4 are used for simulation with fuzzy method.

Table.3. Genetic Parameters

Number of nodes	200
Number of population	100
Selection	Roulette wheel
Crossover	Combining distributed
crossover rate	0.1
Reiteration	200

Table.4. Fuzzy Parameters

Network Size	200 X 200
Number of nodes	200
Number of clusters	9
E_0	1J
E_{elect}	50nj
E_{mp}	1.fj3
L	10000
d_0	$d0= (E_{FS}/E_{MP})^2$

7. Simulation Results

Firstly cluster head is determined with fuzzy method by using priorities from Table..1. Then sink moves on predefined path towards the cluster head that has highest priority.

The obtained results have been shown in Table..5 according to the fuzzy rules of Table..2. Then, genetic Algorithm would optimize the number of the clusters, path shapes and size of the paths. Moving sink on triangle path is shown in fig.3. Lifetime rounds are calculated with Matlab software. Lifetime calculated by fuzzy method is 1998 rounds, but optimal lifetime by genetic algorithm is 2500 rounds.

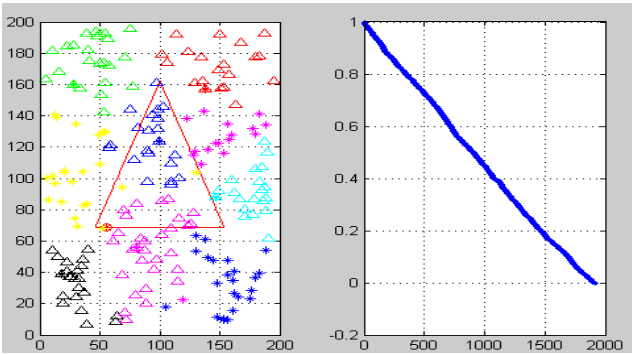

Fig.3 Path Shape for Moving Sink

Table.5.
Simulation Results with fuzzy method and Without Genetic Algorithm

Path Shape For Movable Sink			
lifetime			
Circle	Square	Triangle	Hexagonal
1805	1931	1998	1942

8. Conclusion

The problems of lifetime in sensor network are important. In this paper, clustering is done using fuzzy distance and energy priorities and then sink moves on predefined paths base on fuzzy priorities. Genetic algorithm optimizes number of clusters area and the optimal way to move toward the sink. Fitting function is used to minimize energy consumption in the lifetime of the network. The proposed algorithm in this paper was compared with LEACH, non-fuzzy method and static base station. The results of the stimulation are also shown the better efficiency of proposed method in this paper. Fuzzy rules can be obtained optimally to move the sink on predefined paths to increase the network lifetime.

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