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NETWORK-LIFETIME MAXIMIZATION OF WIRELESS SENSOR NETWORKS USING GENETIC ALGORITHM

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ABSTRACT:

Network lifetime (NL) maximization procedures have pulled in a great deal of research consideration inferable from their significance for expanding the term of the tasks in the battery-obliged remote sensor systems (WSNs). In this paper, a genetic algorithm based method (GABNLM) is proposed to optimize the lifetime of wireless sensor networks. The proposed method is a cluster based approach like LEACH. Genetic algorithm is used to maximize the lifetime of the network by means of rounds. The method has 2 phases which are Set-up and Steady-state phase. In the set-up phase, the clusters are created and are not changed throughout the network. The clusters are not recreated for each round. In each round, there are static clusters with dynamically changing cluster heads. In the simulation, 100 nodes are randomly distributed in 50x50 square meters area. The results show that the proposed method is found to be more efficient than LEACH.

Keyword: *Network Lifetime, Genetic Algorithm, Leach, GABNLM.*

I. INTRODUCTION

Wireless Sensor Network (WSN) [1] is an advanced intelligent network which is organized by amounts of functional sensor nodes. The sensor nodes in Wireless Sensor Network can transmit information and cooperate with each other to accomplish some special functions through implementing the self-organization wireless communication manner. In addition, Wireless Sensor Network can be widely applied in the following areas, such as military, industry, agriculture, medical and environmental monitoring area [2]. To reduce the consumption of energy, the network routing protocol is regarded as a new direction being researched for the energy-constrained wireless sensor network. The idea of cluster-based routing protocol can be realized by the fusion of the information for the nodes in cluster and the decreasing of the throughput and distance of transmitting data in forwarding mechanism through the cluster. As a result, the routing protocol can reduce communication volume and save network energy. Low Energy Adaptive Clustering Hierarchy (LEACH) [3] is the first implemented cluster-based routing protocol and it is also considered as the base of other cluster routing protocols such as PEGASIS [4]、TEEN [5]、LEACH-C、LEACH-F and CEFL [6].

One of the major problems for a WSN is energy consumption during communication between sensor nodes. The longer distance between sensor nodes, the more they consume energy. Therefore to extend the lifetime of the WSN, there are several studies on communication distance of the sensor nodes. Approaches that are cluster-based are useful for environment monitoring [7]. The use of clusters for sensor networks reduces communication distance for most sensor nodes, demanding only few nodes to transmit long distances, e.g., BaseStation (BS). A cluster-based protocol divides the network into a number of clusters. Each cluster has a cluster-head (CH) that collects data from all member nodes in its cluster. These CHs then aggregates the collected data and sends it to the BS. This approach intensely reduces the communication cost of the sensor nodes so that the lifetime of the network greatly expands.

In this work, static clustering with dynamic CH selection is used. At the end of each round a member node, called associate, becomes CH depending on the residual energy of the current CH and the average energy amount of the member nodes in the cluster. And we use genetic algorithm (GA) to minimize the communication distance in the network and maximize the lifetime of the network.

The rest of the paper is organized as follows: Section 2 describes the proposed GABNLM algorithm. Section 3 shows the experimental results and comparison. Section 4 concludes the paper.

II. PROPOSED GABNLM ALGORITHM.

In this work we proposed a Genetic Algorithm based method to optimize the lifetime of WSN. The method is cluster-based approach like LEACH. There are two phases in the proposed method which are set-up phase and steady-state phase.

Set-up Phase:

First phase is the set-up phase and it is performed only one time. In the set-up phase, pre-defined numbers of sensor nodes are chosen as cluster heads. The number of CHs also indicates the number of clusters in the network. Non-CH nodes are assigned to the clusters based on their distances to the CHs. These non-CH nodes join into the clusters.

Steady-state Phase:

In this phase, all nodes start to communicate with their CHs. Each node uses a Time Division Multiple Access (TDMA) schedule to communicate with CH. TDMA is a technology that allows multiple access to share same radio channel and divides each channel into time slots to enable data transmissions. After the CH receives from all member nodes, it fuses the data packets into one packet and sends it to the base station (BS). When all CHs send their data to BS, *a round* is completed. At the end of each round the BS checks the energies of CHs and the member nodes. If the energy of a CH is under the average energy of the member nodes of its cluster, an associate CH is selected from the member nodes of the cluster. The member node which has the highest energy is selected as the new CH and the old CH becomes a member node. The clusters are not recreated as is done in [4] and [9]. The members of each cluster do not change and they are located in the same cluster.

In the proposed method, the clusters that are created in the set-up phase are not changed throughout the network. The selection of the new CH is based on the residual energy of the current CH and its member nodes.

The clusters are not recreated for each round. So in each round, there are static clusters with dynamically changed CHs.

Problem Representation

In the method, GA is used to maximize the lifetime of the network by means of rounds. Binary representation of the network is used and each sensor node corresponds a bit. CHs are represented as “1” and non-CH nodes are represented as “0”. The representation of a network is called a *Chromosome* or *Genome*, a collection of bits. Initially the GA starts with a population, a pre-defined number of chromosomes, consists of randomly generated individuals.

Then GA evaluates each chromosome by calculating its fitness. Fitness of a chromosome depends on some fitness parameters that are explained in Section 3.2. After evaluating the fitness of each chromosome in the population, GA selects the best fit chromosomes by using a specific selection method based on their fitness values and then applies two operators, *Crossover* and *Mutation*, respectively. These operations are carried out to produce a new population better than the previous one for the next generation.

Fitness Function

The aim is to maximize the lifetime of the network. The fitness function has 3 parameters. These parameters are:

R_{FND}: The round which first nodes dies,

R_{LND}: The round which last node dies,

C: The cluster distance.

The cluster distance is the sum of the distances from the member nodes to the CH and the distance from the CH to the BS. For a cluster with k member nodes the cluster distance is denoted as follows [6]:

$$C = \sum_{i=1}^{k} d_{ih} + d_{hs}$$

Where d_{ih} is the distance from node i to the cluster head h and d_{hs} is the distance from the cluster head h to the BS node s.

The fitness function, F, is a function of all parameters described above and used in the genetic algorithm. It is defined as follows:

$$F = \sum_i (f_i \times w_i), \forall f_i \in (R_{FND}, R_{LND}, -C)$$

The w value is an application-dependent weight of a fitness parameter that indicates which parameter is more effective for the function. We can make a fitness parameter more important than the other by changing its weight or we can give them equal importance by setting the weights equal.

Selection

This process determines which of the chromosomes from the current population will create new child chromosomes by doing crossover and mutation. The new child chromosomes join the existing population. The new population with new child chromosomes will be the basis for the next selection. The chromosomes which have better fitness values have bigger chance to be selected. There are a number of selection methods, e.g., Roulette-Wheel selection, Rank selection and Tournament selection [8]. In the proposed method, Roulette-Wheel selection method is used.

Crossover

Crossover is a genetic operator that generates two new child chromosome from two parent chromosome. The easiest way to do this to choose a random crossover point and the two parent chromosomes exchange information after that point. A sample is shown in Figure 1:

Parent 1: **1110 | 0101**

Parent 2: 1011 | 1110

Child 1:**1110** 1110

Child 2: 1011 **0101**

Figure 1. A cross-over example

Crossover is done after the selection process and depends on a probability defined initially before GA starts. The probability that the crossover will take place depends on the crossover rate.

Mutation

After a crossover is performed, mutation takes place. This is to prevent falling all solutions in population into a local optimum of solved problem. Mutation changes every bit of the new child chromosome with a probability called mutation rate as shown in Figure 2.

Original Chromosome: 11100101

Mutated Chromosome: 11000111

Figure 2. A mutation example

III. SIMULATION RESULT

For simulating our proposed GABNLM based protocol, MATLAB R2015a and C language have been used. Considering dBS = 100, we get the number of desired CH = 4 and considering dBS = 85, we get the number of desired CH = 5, having 100 sensor nodes in 100 × 100 m2 sensing region. Simulations have been performed for both 4-cluster and 5-cluster networks. Our proposed GABNLM based protocol has been compared with LEACH-F protocol [3] used in WSN with respect to cluster formation.

Parameters for Simulation

We use similar random 100-node networks and radio models with LEACH. This paper set the following parameters for Simulation:

1) Energy required in sending or receiving 1bit: E_{elec} =50nJ/bit

2) The amount of data sent by nodes each time: k = 200bit.

3) The initial energy of every node: E = 0.5J

4) Compress ratio during data fusion: r = 0.7

5) Energy consumed in every bit data fusion: EA=50pJ/bit

6) Area: 100*100

7) The location of Sink: (5, 5)

8) The percentage of cluster head: p = 0.05

9) The number nodes: n = 100.

Figures and Analysis

The network performance is measured by its life time. Figure 3 shows the system lifetime using the GABNLM based protocol and LEACH-F algorithm. As shown in the figure, nodes in LEACH-F protocol begin to die after about 800 rounds, and almost all nodes die when it comes to 1200 rounds. While in GABNLM -means, nodes begin to die after about 1000 rounds, and all nodes die after 1500 rounds.

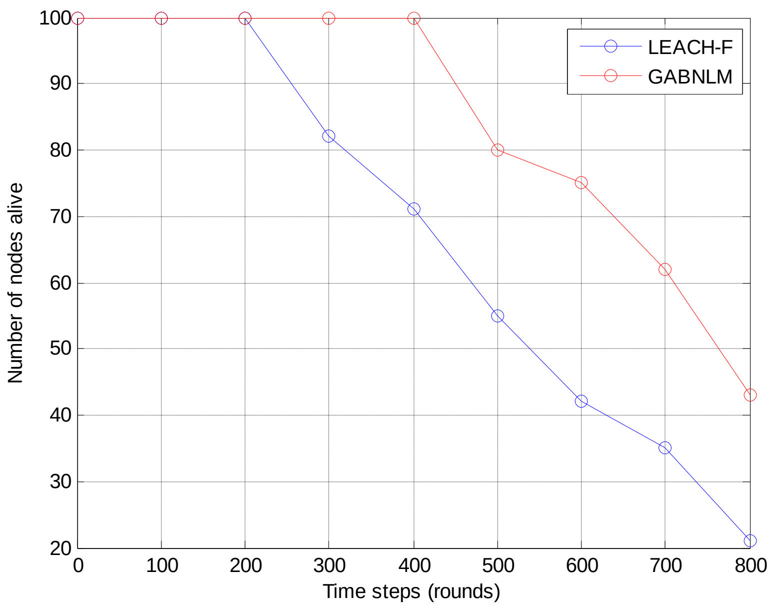

Fig 3: System lifetime

Therefore, the lifetime of GABNLM based protocol has obvious longer than the LEACH-F protocol which proves that the improved algorithm has extended the system lifetime effectively.

IV. CONCLUSION

In this paper, with the research of the LEACH-B protocol, we put forward a novel protocol called GABNLM based protocol. This enhanced algorithm has overcome the shortcoming of the original protocol by taking the node's residual energy into consideration and keeping the constant and near optimal number of cluster heads at each round.

Our simulation result shows that GABNLM based protocol provides better energy efficiency and longer network life span than LEACH-F.

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