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ENERGY EFFICIENT ROUTING AND FAULT NODE RECOVERY ALGORITHM FOR WIRELESS SENSOR NETWORKS

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ABSTRACT

Life time of Wireless Sensor Networks (WSNs) has always been a critical issue and has received increased attention in the recent years. Generally wireless sensor nodes are equipped with low power batteries which are infeasible to recharge. Wireless sensor networks should have enough energy to fulfill the desired requirements of applications. In this paper, we propose Energy Efficient Routing and Fault node Replacement (EERFNR) Algorithm to increase the lifetime of wireless sensor network, reduce data loss and also reduce sensor node replacement cost. Transmission problem and sensor node loading problem is solved by adding several relay nodes and arranging sensor node's routing using Hierarchical Gradient Diffusion. The Sensor node can save some backup nodes to reduce the energy for re-looking the route when the sensor node routing is broken. Genetic algorithm will calculate the sensor nodes to replace, reuse the most available routing paths to replace the fewest sensor nodes.

KEYWORDS: Genetic Algorithm, Hierarchal Gradient Diffusion, Grade Diffusion, Wireless Sensor Networks

INTRODUCTION

Wireless Sensor Network (WSN) is a group of wireless sensor nodes that have small capacities of sensing, processing which are deployed over a geographical area for sensing physical phenomenon. Usually, these sensor nodes send their sensed data to a base station for further processing. They are prepared with low cost small capacity batteries which are, non-rechargeable and irreplaceable. Hence, network lifetime is considered as an important issue for many applications. Several routing algorithms for the wireless sensor network have been sequentially proposed in recent years. C. Intanagonwiwat et al. presented the Directed Diffusion (DD) algorithm [2] in 2003. The DD algorithm aims to reduce transmission counts of data relay and energy consumption. Basically, the DD algorithm is a query driven transmission protocol in which the collected data is transmitted to sink node only if the collected data is matched with the query from the destination node, hence the power consumption of the transmission is reduced. In 2011, H. C. Shih et al. [10] proposed a ladder diffusion algorithm using ant colony optimization for wireless sensor networks (LD-ACO) to solve the routing and energy consumption problem.

Moreover, the LD-ACO algorithm can improve the sensor node's lifetime .The LD algorithm creates the ladder table in each sensor node based on the entire wireless sensor network by issuing the ladder in create packet that is created from the sink node. After the ladder diffusion process, they proposed an improved ant colony optimization algorithm to balancing the data transmission load, increasing the lifetime of sensor nodes. Shengxiang Yang et al. proposed Genetic algorithm with immigrants and memory scheme to solve dynamic routing problem for mobile ad hoc networks. This immigrants and memory-based GAs can quickly adapt to environmental changes (i.e., the network topology changes) and produce high-quality solutions after each change[5]. After the random deployment of sensors in the target area, the problem of finding the largest number of disjoint sets of sensors, with every set being able to completely cover the target area, is nondeterministic polynomial-complete. Xiao-Min Hu et al. proposed a hybrid approach of combining a genetic algorithm with schedule transition operations (STHGA) to solve this problem and construct energy efficient wireless sensor networks[4]. Hong-Chi Shih et al. proposed a fault node recovery algorithm to enhance the lifetime of a wireless sensor network when some of the sensor nodes shut down. The algorithm is based on the grade diffusion algorithm combined with the genetic algorithm[2]. In the wireless sensor network (WSN), reduction of energy consumption is very important for each sensor node because it can extend WSN lifetime. If some sensor nodes can’t work in the WSN, the routing path will break and the detected area will have leaks. Moreover, other sensor nodes can’t transfer event data to the sink node, or they need more sensor nodes to give them assistance. Sensor nodes near the sink node are called “inside node” and others are called “outside node”. We can find that the outside nodes of WSN need inside nodes to give them assistance when outside nodes transfer data to the sink node. Hence, the inside nodes have huge loading, and their energy will be consumed quickly. After the inside nodes are out of energy, there is no sensor node that can transfer data to the sink node, and the WSN will be out of function. In this paper, we proposed a hierarchical gradient diffusion (HGD) algorithm with genetic algorithm (GA) to improve the entire WSN lifetime.

ENERGY EFFICIENT ROUTING AND FAULT NODE REPLACEMENT ALGORITHM

This paper proposes Energy Efficient Routing and Fault Node Replacement Algorithm (EERFNR) algorithm for WSNs based on the Hierarchal gradient diffusion algorithm combined with the genetic algorithm. The flow chart is shown in Figure 1. The EERFNR algorithm creates the grade value, routing table, neighbor nodes, and payload value for each sensor node using the Hierarchal gradient diffusion algorithm. Figure 1, the EERFNR algorithm creates the grade value, routing table, a set of neighbor nodes, and payload value for each sensor node, using the Hierarchical gradient diffusion algorithm. The sensor nodes transfer the event data to the sink node according to the GD algorithm when events appear. If the number of non functioning nodes exceeds the threshold value then genetic algorithm is invoked to replace the nonfunctional nodes by functional nodes and reuse the most available path.

HIERARCHICAL GRADIENT DIFFUSION ALGORITHM

The HGD algorithm adds some RS nodes which are relay nodes of the sink node and they can broadcast the grade creating package as the sink node. Sensor nodes can transfer data to RS nodes or the sink node to balance sensor node loading, reducing the energy consumption and enhancing WSN lifetime according to the HGD algorithm. Moreover, sensor nodes can save some backup nodes in its routing table to reduce the energy for the re-looking routing by our proposed algorithm in case the sensor node’s routing is broken. The RS node is similar to the sink node because it doesn’t have any detection ability; they can just be a data collection center for sensor nodes as well as the sink node.

Moreover, the RS nodes have large transmission scale compared with sensor nodes, and they have enough energy to transfer data to real data collection center (Sink Node). Hence, events can be detected and transferred to RS nodes or the sink node by sensor node. If an RS node receives an event data, the event data will be transferred to the sink node from RS node. Hence, sensor node, RS node, and sink node become a hierarchical structure in the HGD algorithm. In HGD algorithm, the grade creating package will be broadcasted from the sink node and RS nodes. Firstly, the sink node broadcasts grade-creating packages to create a main routing table for sensor nodes. Then, RS node broadcasts grade-creating packages again to create a backup routing table. Moreover, sensor nodes can change their main routing table and backup routing table according to the grade information received from grade-creating packages. Thus, the routing path can be cut down and the transmission loading can be reduced when the routing path from sensor node to RS node is shorter than to sink node. Firstly, the sink node broadcasts the grade-creating package and the package format. In the grade-creating package format, as shown in figure 2, the SRS mean sink node holds the value is 0, otherwise it's a grade value of RS node. The HCP means how many hop counts a sensor can transfer event data to the sink node or RS node. The DN means the destination node, and the destination is the sink node or RS node.

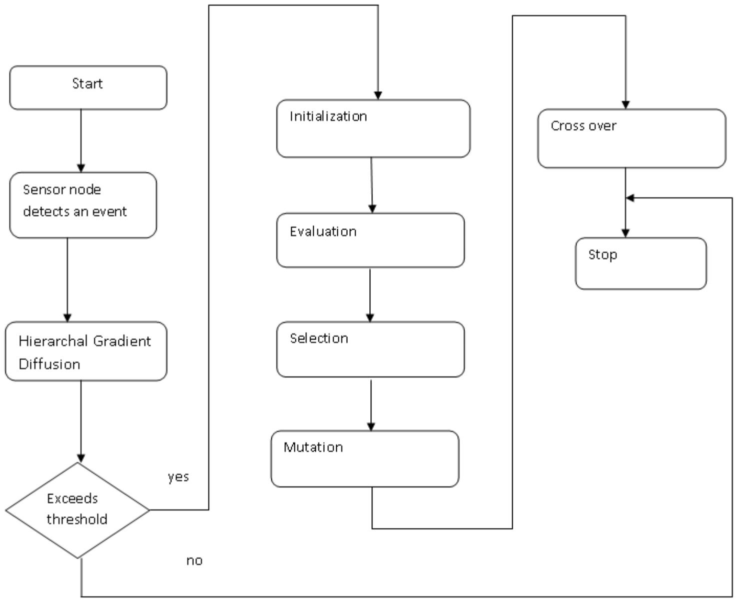

Figure 1: Steps in EERFNR Algorithm

SRS	HCP	DN

Figure 2: Grade Creating Package

GENETIC ALGORITHM

The parameters are encoded in binary string and serve as the chromosomes for the GA. The elements (or bits), i.e., the genes, in the binary strings are adjusted to minimize or maximize the fitness value. The fitness function generates its fitness value, which is composed of multiple variables to be optimized by the GA. At each iteration of the GA, a predetermined number of individuals will produce fitness values associated with the chromosomes. There are 5 steps in the genetic algorithm as described below.

Initialization

In the initialization step, the genetic algorithm generates chromosomes, and each chromosome is an expected solution. The number of chromosomes is determined according to the population size, which is defined by the user. Each chromosome is a combination solution, and the chromosome length is the number of sensor nodes that are depleted or nonfunctioning. The elements in the genes are either 0 or 1. A 1 means the node should be replaced, and means that the node will not be replaced.

Evaluation

In general, the fitness value is calculated according to a fitness function, and the parameters of the fitness function are the chromosome's genes. However, we cannot put genes directly into the fitness function in the EERFNR algorithm, because the genes of the chromosome are simply whether the node should be replaced or not.

In the EERFNR algorithm, the goal is also to reuse the most routing paths and to replace the fewest sensor nodes. Hence, the number of routing paths available if some nonfunctioning sensor nodes are replaced is calculated, and the fitness function is shown as below.

max(Grade)

fn =∑ RPi × TSN

i=1 SNi × TRP *1

where

SNi = the number of replaced sensor nodes and their grade value at i .

RPi = the number of re-usable routing paths from sensor nodes with their grade value at i .

TSN = total number of sensor nodes in the original WSN.

TRP = total number of routing paths in the original WSN.

A high fitness value is sought because the WSN is looking for the most available routing paths and the least number of replaced sensor nodes.

Selection

The selection step will eliminate the chromosomes with the lowest fitness values and retain the rest. We use the elitism strategy and keep the half of the chromosomes with better fitness values and put them in the mating pool. The worse chromosomes will be deleted, and new chromosomes will be made to replace them after the crossover step.

Crossover

The crossover step is used in the genetic algorithm to change the individual chromosome. In this algorithm, we use the one-point crossover strategy to create new chromosomes. Two individual chromosomes are chosen from the mating pool to produce two new offspring. A crossover point is selected between the first and last genes of the parent individuals. Then, the fraction of each individual on either side of the crossover point is exchanged and concatenated. The rate of choice is made according to roulette-wheel selection and the fitness values.

Mutation

The mutation step can introduce traits not found in the original individuals and prevents the GA from converging too fast. In this algorithm, we simply flip a gene randomly in the Chromosome. The chromosome with the best fitness value is the solution after the iteration. The EERFNR algorithm will replace the sensor nodes in the chromosome with genes of 1 to extend the WSN lifetime.

CONCLUSIONS

In this paper, Energy Efficient Routing and Fault Node Replacement (EERFNR) algorithm is proposed for wireless sensor network to increase the life time, reduce data loss and node replacement cost. Grade value, routing table, neighbor nodes, payload value for each node is created by hierarchical gradient diffusion and it also add some relay nodes to reduce the load of internal nodes and reduce data loss due to huge load of internal nodes. Then non functioning sensor nodes are replaced by functioning sensor nodes and most available routing paths are utilized by genetic algorithm to reduce the node replacement cost and data loss.

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