ISSN 23499842(Online), Volume 1, Special Issue 1(NCEE'15), May 2015
International Journal of Innovative Trends and Emerging Technologies

IMPROVING ENERGY EFFICIENCY FOR WIRELESS SENSOR NETWORK USING GENETIC ALGORITHM

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Abstract This project proposes a genetic algorithm to enhance the lifetime of a wireless sensor network (WSN) when some of the sensor nodes shut down either because they no longer have battery energy or they have reached their operational threshold. Using the genetic algorithm can result in fewer replacements of sensor nodes and more reused routing paths. Thus, the algorithm not only enhances the WSN lifetime but also reduces the cost of replacing the sensor nodes. Routing protocols typically identify the optimal path from a source to a sink, based on some heuristic with the ultimate aim of maximizing the lifetime of the network. An energy-aware routing protocol might determine which path uses the smallest amount of energy in routing a message from a source to a sink. The algorithm is based on the grade diffusion algorithm combined with the fault node recovery algorithm. It is important to research the optimization of sensor node replacement, reducing the replacement cost, and reusing the most routing paths when some sensor nodes are nonfunctional. In our simulation, the proposed algorithm increases the number of active nodes, reduces the rate of data loss, and reduces the rate of energy consumption. The Genetic algorithm has ample energy for each grade sensor node because the algorithm can replace the sensor nodes, but it reuses more routing paths compared to using the traditional algorithm.

Keywords- Wireless sensor network, routing protocol, grade diffusion algorithm, fault node recovery algorithm, sensor node, data loss, traditional algorithm.

Introduction

A wireless sensor network is a group of specialized transducers with a communications infrastructure for monitoring and recording conditions at diverse locations. Commonly monitored parameters are temperature, humidity, pressure, wind direction and speed, illumination intensity, vibration intensity, sound intensity, power-line voltage, chemical concentrations, pollutant levels and vital body functions.

A sensor network consists of multiple detection stations called sensor nodes, each of which is small, lightweight and portable. Every sensor node is equipped with a transducer, microcomputer, transceiver and power source. The transducer generates electrical signals based on sensed physical effects and phenomena. The microcomputer processes and stores the sensor output. The transceiver receives commands from a central computer and transmits data to that computer. The power for each sensor node is derived from a battery.

A transducer is an electronic device that converts energy from one form to another. Common examples include microphones, loudspeakers, thermometers, position and pressure sensors, and antenna. Although not generally thought of as transducers, photocells, LEDs (light-emitting diodes), and even common light bulbs are transducers. Efficiency is an important consideration in any transducer. Transducer efficiency is defined as the ratio of the power output in the desired form to the total power input.

OBJECTIVE

This project proposes a genetic algorithm to enhance the lifetime of a wireless sensor network (WSN) when some of the sensor nodes shut down, either because they no longer have battery energy or they have reached their operational threshold. Using the genetic algorithm can result in fewer replacements of sensor nodes and more reused routing paths. Thus, the algorithm not only enhances the WSN lifetime but also reduces the cost of replacing the sensor nodes. The traditional approaches to sensor network routing include the directed diffusion algorithm and the grade diffusion (GD) algorithm. The algorithm proposed in this paper is based on the FNR algorithm, with the goal of replacing fewer sensor nodes that are inoperative or have depleted batteries, and of reusing the maximum number of routing paths. These optimizations will ultimately enhance the WSN lifetime and reduce sensor node replacement cost.

LITERATURE SURVEY

The algorithm proposed in this paper is based on the GD algorithm, with the goal of replacing fewer sensor nodes that are inoperative or have depleted batteries, and of reusing the maximum number of routing paths. These optimizations will ultimately enhance the WSN lifetime and reduce sensor node replacement cost.

[1] C. Intanagonwiwat *et al*. "**Directed diffusion for wireless sensor networking**," presented the Directed Diffusion (DD) algorithm in 2003. DD aims to reduce the data relay to better manage power consumption and is, basically, a query-driven transmission protocol. The collected data are transmitted only if they fit the query from the sink node, thereby reducing the power consumption from data transmission. First, the sink node provides interested queries in the form of attribute-value pairs to the other sensor nodes by broadcasting the interested query packets to the entire network. Subsequently, the sensor nodes only send the collected data back to the sink node if they fit the interested queries.

[2] H. C. Shih *et al.* "**Grade diffusion algorithm**," presented the Grade Diffusion (GD) algorithm in 2012 to improve the ladder diffusion algorithm using ant colony optimization (LD-ACO) for wireless sensor networks. Grade Diffusion algorithm that improves upon the LD-ACO

algorithm to enhance node lifetime, raise transmission efficiency, and solve the problem of node routing and power consumption. The GD algorithm broadcast grade completely and quickly creates packages from the sink node to every node in the wireless sensor network by the LD-ACO algorithm. Then the GD algorithm proposes a routing algorithm to reduce the nodes' average load, enhance the nodes' lifetimes and reduce the nodes' power consumption.

[3] H. C. Shih *et al.* "**A ladder diffusion algorithm using ant colony optimization for wireless sensor networks**," the GD algorithm not only creates the routing for each sensor node but also identifies a set of neighbor nodes to reduce the transmission loading. Each sensor node can select a sensor node from the set of neighbor nodes when its grade table lacks a node able to perform the relay. The GD algorithm can also record some information regarding the data relay. Then, a sensor node can select a node with a lighter loading or more available energy than the other nodes to perform the extra relay operation. That is, the GD algorithm updates the routing path in real time, and the event data is thus sent to the sink node quickly and correctly. Whether the DD or the GD algorithm is applied, the grade creating packages or interested query packets must first be broadcast. Then, the sensor nodes transfer the event data to the sink node, according to the algorithm, when suitable events occur.

ISSUES IN EXISTING SYSTEM

- The WSN may fail due to a variety of causes, including the following: the routing path might experience a break; the WSN sensing area might experience a leak; the batteries of some sensor nodes might be depleted, requiring more relay nodes or the nodes wear out after the WSN has been in use a long period of time.
- The outside nodes transfer event data to the sink node via the inside nodes (the sensor nodes near the sink node) in a WSN illustrate the accommodation measures for non-working nodes. The inside nodes thus have the largest data transmission loading, consuming energy at a faster rate. If all the inside nodes deplete their energy or otherwise cease to function, the event data can no longer be sent to the sink node, and the WSN will no longer function.

PROPOSED SYSTEM

The proposed algorithm increases the WSN lifetime by replacing some of the sensor nodes that are not functioning. In addition to enhancing the active nodes and reducing the data losses, the genetic algorithm reduces the relayed energy consumption by reducing the number of data relayed, as the replaced sensor nodes are usually used the most.

TECHNIQUES

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 a 0 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 FNR algorithm, because the genes of the chromosome are simply whether the node should be replaced or not. In the FNR 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.

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 FNR algorithm will replace the sensor nodes in the chromosome with genes of 1 to extend the WSN lifetime.

Steps in Genetic Algorithm

1. **[Start]**Generate random population of *n* chromosomes (suitable solutions for the problem)
2. **[Fitness]** Evaluate the fitness $f(x)$ of each chromosome x in the population
3. **[New population]**Create a new population by repeating following steps until the new population is complete
    1. **[Selection]** Select two parent chromosomes from a population according to their fitness (the better fitness, the bigger chance to be selected)
    2. **[Crossover]** With a crossover probability cross over the parents to form a new offspring (children). If no crossover was performed, offspring is an exact copy of parents.

    3. **[Mutation]** With a mutation probability mutate new offspring at each locus (position in chromosome).
    4. **[Accepting]** Place new offspring in a new population
4. **[Replace]** Use new generated population for a further run of algorithm
5. **[Test]** If the end condition is satisfied, **stop**, and return the best solution in current population
6. **[Loop]** Go to step **2**

IMPLEMENTATION

A simulation of the genetic algorithm was performed to verify the method. The experiment was designed based on 3-D space, using 100×100 × 100 units, and the scale of the coordinate axis for each dimension was set at 0 to 100. The radio ranges (transmission range) of the nodes were set to 15 units. In each of these simulations, the sensor nodes were distributed uniformly over the space. There are three sensor nodes randomly distributed in 10 × 10 × 10 space, and the Euclidean distance is at least 2 units between any two sensor nodes. Therefore, there are 3000 sensor nodes in the 3-D wireless sensor network simulator, and the center node is the sink node. The data packages were exchanged between random source/destination pairs with 90 000 event data packages. In our simulations, the energy of each sensor node was set to 3600 Ws that is the actual available energy. Each sensor consumed 1.6 Ws when it conducts a completed data transformation ($Rx + Tx$).

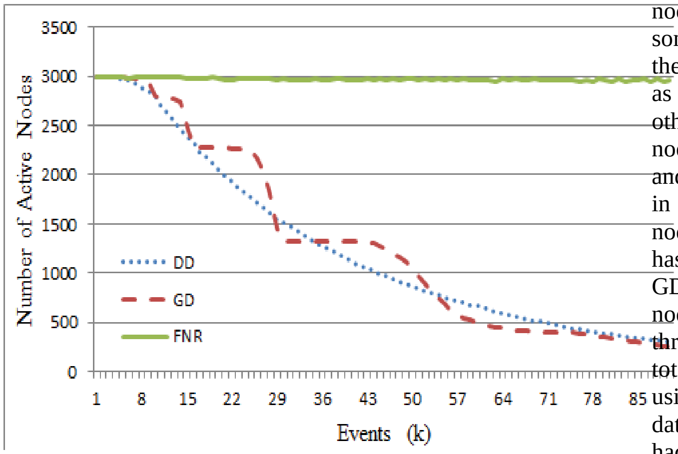

Fig.1. Number of active nodes

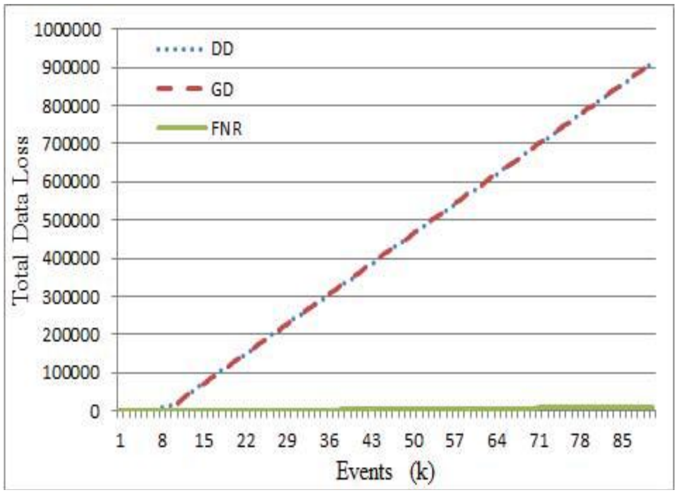

Fig.2. Total data loss.

In the GA algorithm, the population size was 20; the crossover rate was 50%; and the mutation rate was 2%. The FNR, DD, and GD algorithms were implemented. The active sensor nodes and total data loss after 90 000 events are shown in Figs.1 and 2. The active nodes mean that the sensor node has enough energy to transfer data to other nodes, but some sensor nodes can be deleted from the active nodes list if their routing tables do not have a sensor node that can be used as a relay node, or if they are not in the routing table of any other sensor nodes. The FNR algorithm has 2931 sensor nodes available, but the DD and GD algorithms only have 305 and 256 sensor nodes available after 90 000 events, as shown in Fig.1.This new algorithm enhances the number of active nodes by 8.7 and 10.8 times, respectively. The FNR algorithm has the most active sensor nodes compared with the DD and GD algorithms because the algorithm can replace the sensor nodes after the number of nonfunctioning nodes exceeds the threshold, by using the GA algorithm. Fig.2 compares the total data loss using the FNR algorithm to the total data loss using the DD and GD algorithms. In this simulation, event data was destroyed and recorded into the loss count if the data had already been relayed over 20 times. Moreover, sensor nodes might detect the same event when an event appeared and transfer it to the sink node in this simulation setting. Hence, the total data loss might exceed 90 000 events. Therefore, sensor nodes can detect more events and transfer them to the sink node if the WSN lifetime is increased. In Fig. 2, the FNR algorithm exhibits smaller data losses because the algorithm can replace fewer sensor nodes and reuse more routing paths if the number of sensor nodes that are nonfunctioning exceeds the threshold. After the simulation, the FNR algorithm had only suffered 11 025 data losses, but the DD and GD algorithm had suffered 912 462 and 913 449 data losses. This new algorithm can reduce data loss by 98.8% compared to the traditional algorithms.

CONCLUSION

In real wireless sensor networks, the sensor nodes use battery power supplies and thus have limited energy resources. In addition to the routing, it is important to research the optimization of sensor node replacement, reducing the replacement cost, and reusing the most routing paths when some sensor nodes are nonfunctional. This paper proposes a genetic algorithm for WSN based on the grade diffusion algorithm .The genetic algorithm requires replacing fewer sensor nodes and reuses the most routing paths, increasing the WSN lifetime and reducing the replacement cost.

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