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Lifetime Enhancement Using Fault Node Recovery Algorithm For Wireless ad-hoc Network

Aiswarya Sudhakar
Dept of Computer Science and Engineering
KMEA Engg College
Kerala,India

Vidya Hari
Dept. of Information Technology
KMEA Engg College
Kerala,India

***Abstract*-Wireless ad-hoc network contains many wireless nodes. Each node may have a low battery power. When energy of any node is exhausted, the failed nodes cannot relay the data to other nodes during transmission processing. It will cause wireless network leaks. Thus, the other nodes will be burdened with increased transmission processing. It is important to optimization research of replacement of nodes, node replacement cost reduction and reusing the routing paths when some of the nodes becomes nonfunctional. Fault node recovery (FNR) algorithm is used for enhancement of wireless network lifetime when some nodes are shut down. This algorithm is a combination of grade diffusion algorithm and genetic algorithm. It increases the number of active nodes and reduces the rate of data loss.**

We propose a three tier power management schemes in wireless networks to reduce power consumption. To do the same we introduce active, sleep semi-sleep methods. In active mode each node will use its full power and in semi-sleep it uses half of its energy and it will be in off for sleep mode. So combining these three methods the entire system will reduce the total network power consumption.

Keywords- Fault node recovery, directed diffusion , grade diffusion, active node, genetic algorithm, power management.

INTRODUCTION

Wireless networks are always preferred since the beginning of invention due to their natural mobility and scalability. Due to reduced cost and enhanced technology wireless networks have much more preferences than wired networks. Wireless Ad hoc NETwork is a collection of wireless nodes, each mobile node is equipped with a wireless transmitter and receiver they communicate with each other via bidirectional wireless links either directly or indirectly. The major advantage of wireless networks is the data communication between two nodes. However wireless communication is limited to the range of transmitters .That means two nodes cannot communicate with each other when the distance between the nodes is beyond the communication range.

Wireless ad-hoc network contains many wireless nodes. Nodes in wireless network are prone to failure due to energy depletion, hardware failure, communication link errors, malicious attack, and so on. Each node may have a low battery power. When energy of any node is exhausted, the failed nodes cannot relay the data to other nodes during transmission processing. It will cause wireless network leaks. Thus, the other nodes will be burdened with increased transmission processing. It is important to optimization research of replacement of nodes, node replacement cost reduction and reusing the routing paths when some of the nodes becomes nonfunctional.

MOTIVATION

The directed diffusion (DD) algorithm and the grade diffusion algorithm are the two traditional approaches. The proposed FNR algorithm is based on the grade diffusion algorithm, it will replace the non-functioning nodes and it reusing the maximum routing paths. These will enhance the wireless ad-hoc lifetime and reduce the node replacement cost.

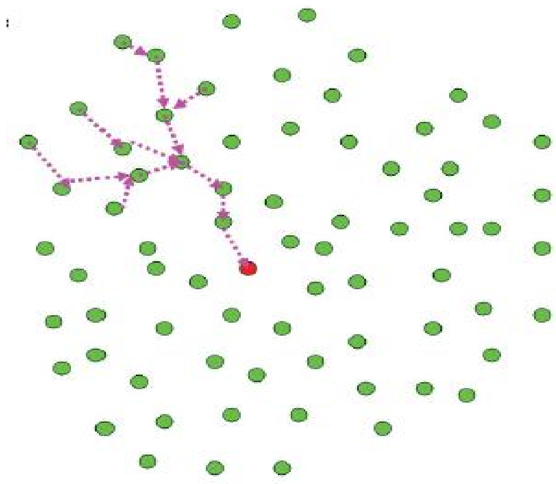
Directed Diffusion Algorithm

There are a series of routing algorithms for wireless ad-hoc networks that have been proposed recent years. C. Intanagonwiwat *et al*. presented the Directed Diffusion (DD) algorithm [9]. The Directed diffusion algorithm is query-driven transmission protocol. For power management the directed Diffusion algorithm reduces the data relay transmission counts. The data is transmitted only when it matches from the query from sink node. The queries from the sink node are in the form of attribute – value pairs, which is broadcasting to all other nodes as query packets. The node with the data that is matches to the query of sink node only sends the data back.

Grade Diffusion Algorithm

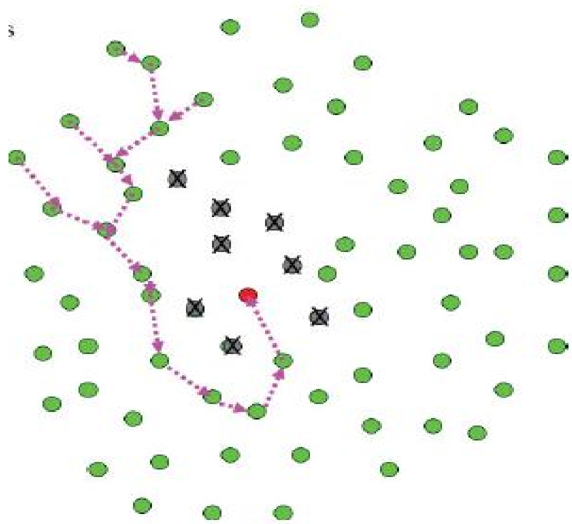
H. C. Shih et al. presented the Grade Diffusion (GD) algorithm, which improves the ladder diffusion algorithm using ant colony optimization (LD-ACO) [6]. GD algorithm creates the routing for all nodes and it identifies set of neighbor nodes for each node to reduce the transmission load. It can also record information about data relay. Each node can select a node with low transmission load and more energy to get extra relay . GD algorithm updates the routing paths for each node in real time and more correctly and quickly the data can send to the sink node.

Wireless ad-hoc network contains many wireless nodes. Nodes in wireless network are prone to failure due to energy depletion, hardware failure, communication link errors, malicious attack, and so on. Each node may have a low battery power. When energy of any node is exhausted, the failed nodes cannot relay the data to other nodes during transmission processing. It will cause wireless network leaks.



Wireless nodes
Sink node

Fig. 1 wireless node routing



Wireless nodes
Sink node

Fig 2. Wireless routing path when some nodes are non-functioning.

Figure 2 shows outside nodes transfer data to the sink node via inside nodes when some nodes are non-functional. Thus the inside nodes have date transmission overload and consume more energy. If all the inside nodes become non-functional, the data cannot sent to the sink node .

Hong-Chi Shih, Jiun-Huei Ho, Bin-Yih Liao, and Jeng-Shyang Pan [1] proposed an algorithm to replace the non-fuctioning node and to reuse the routing paths.

M. Gen and R. Cheng [4] proposed a genetic algorithm based on the natural genetics concept. In this paper it uses FNR algorithm which is based on the grade diffusion algorithm and genetic algorithm. FNR algorithm routing table is created by using grade diffusion algorithm and it replaces the nonfunctioning nodes by genetic algorithm when the number of nonfunctioning node exceeds its threshold. We propose a three tier power management schemes in wireless networks to reduce power consumption. To do the same we introduce active, sleep semi-sleep methods for the same. In active mode each node will use its full power and in semi sleep it uses half of its energy and it will be in off for sleep mode. So combining these three methods will reduce the total network power.

ALGORITHM

FNR algorithm is used in this paper. FNR algorithm is a combination of grade diffusion and genetic algorithm. It creates grade value , neighbour nodes , routing table and payload values by using grade diffusion algorithm. In FNR the number of non-functional nodes are calculated by a parameter bth value.

Bth value is calculated using (1).If the values of bth is greater than zero meanes the genetic algorithm is invoked and it replaces the non-functional nodes by FNR algorithm.

The parameter β is set by the user and must have a value between 0 and 1. If the number of sensor nodes that function for each grade is less than β, *Ti* will become 1, and *B*th will be larger than zero. Then, the FNR algorithm will calculate the nodes to replace using the genetic algorithm.

$$B_{th} = \sum_{j=1}^{\max(Grade)} T_j$$

$$T_j = \begin{cases} 1, & \frac{N_j^{now}}{N_j^{original}} < \beta \\ 0, & \text{otherwise} \end{cases}$$

*N*original =the number of nodes with grade value i
*Ni*now = the number of nodes still functioning at the current time with grade value

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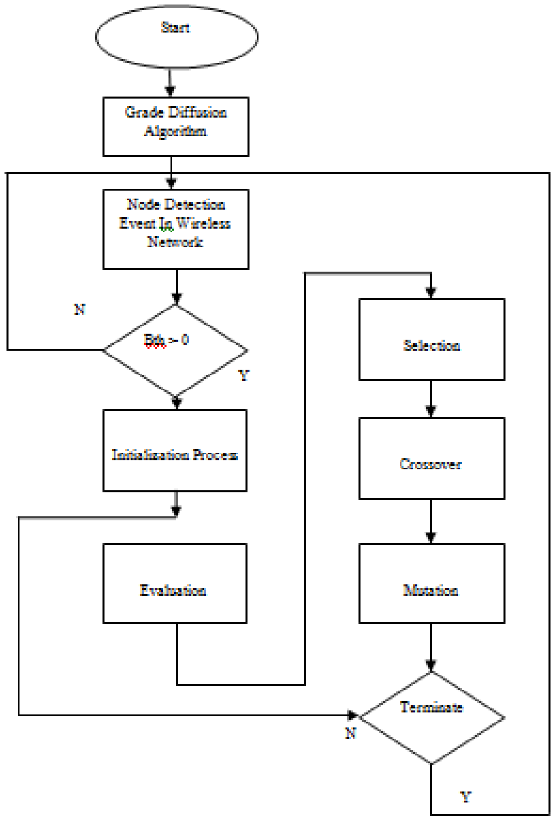

Fig: 3 FNR algorithm flow chart

There are 5 steps in the genetic algorithm: Initialization, Evaluation, Selection, Crossover, and Mutation. Descriptions of the steps follow.

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 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.

9	7	10	81	23	57	34	46	66	70
0	0	1	0	1	1	0	1	1	0

Fig: 4 Chromosome

Evaluation

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 nodes. Hence, the number of routing paths available if some nonfunctioning nodes are replaced is calculated, and the fitness function is shown as fig.

$$f_n = \sum_{i=1}^{\max(\text{Grade})} \frac{P_i \times \text{TP}^{-1}}{N_i \times \text{TN}^{-1}} \times i^{-1}.$$

Ni = the number of replaced nodes and their grade value at i .
Pi = the number of re-usable routing paths from nodes with their grade value at i .
T N = total number of nodes in the original WN.
T P = total number of routing paths in the original WN.

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.

	9	7	10	81	23	57	34	46	66	70
Good	0	0	1	0	1	1	0	1	1	0
	1	0	1	0	1	0	0	1	1	0
	0	0	0	0	1	1	0	0	1	0
	0	1	1	0	1	1	0	1	1	0
	1	1	1	0	1	0	0	0	1	0
f_n	0	1	1	0	1	1	0	1	1	0
	0	0	1	1	1	1	0	1	0	0
	0	1	1	1	1	1	0	0	1	0
	0	0	1	0	1	1	1	1	1	0
Bad	1	1	0	0	1	1	0	0	1	0

Fig: 5 Selection

Crossover

The crossover step is used in the genetic algorithm to change the individual chromosome. Here we use the one-point crossover strategy to create new chromosomes. Two individual chromosomes are chosen 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.

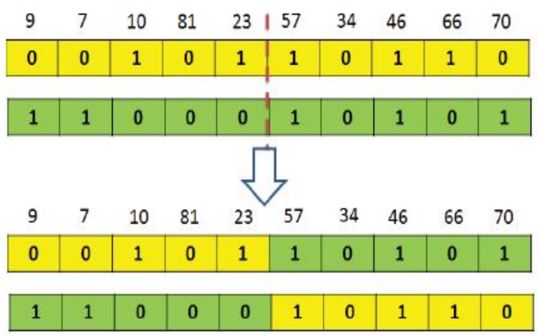

Fig: 6 Crossover

Mutation

The mutation step can introduce traits not found in them 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 nodes in the chromosome with genes of 1 to extend the WN lifetime.

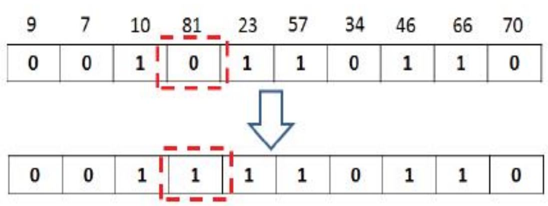

Fig: 7 Mutation

Power management

We will reduce the power consumption by a three tier power management schemes in WNs. To do the same we introduce active, sleep semi-sleep methods for the same. In active mode each node will use its full power and in semi sleep it uses half of its energy and it will be in off for sleep mode. so combining these three methods will reduce the total network power.

SYSTEM ENVIRONMENT

The network simulations are carried out in java simulator. Java is more adaptive and the algorithm modifications can be done in a flexible manner.

SYSTEM DESCRIPTION

The algorithm can be developed in 4 phases Simulation environment creation, initialization , evaluation ,selection, crossover and mutation, power management. In our simulation, the energy of each sensor node was set to 1000 Ws that is the actual available energy. Each sensor consumed 1 Ws when it conducts a completed data transformation. In the GA algorithm, the population size was 20; the crossover rate was 50%; and the mutation rate was 2%.
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.

Simulation Environment creation

The network topology each of the simulation nodes where distributed over the space. We can add 3000 nodes in the simulator. Each having its own range. We can set anyone node as the source node and anyone as destination node. The data packet were exchanged between source to destination randomly. Energy of each node was initially set to 100 Ws that is total available energy of each node. During a complete data transformation each node consume 1 Ws. The population size in GA algorithm was 20. The rate of crossover was 50 % and rate of mutation was 2 %.

Simulation Results

The FNR algorithm increases the WN 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 FNR algorithm reduces the relayed energy consumption by reducing the number of data relayed, as the replaced nodes are usually used the most. Using the proposed scheme , the WN had consumed less power compared to using the GD algorithm.

The number of active nodes shown in Fig. 8. The new algorithm enhances the number of active nodes . The active nodes are the nodes which has enough energy to transfer data to other nodes. The number of active nodes increased by events.

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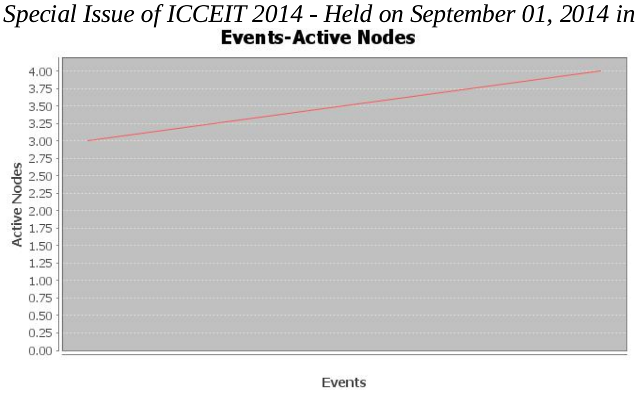

Fig. 8 Number of active nodes

Fig. 9 shows total data loss before node replacement. Data relay through the faults nodes increases data loss. Fig. 10 shows the data loss after node replacement. Data relay through the replaced nodes decreases the total data loss.

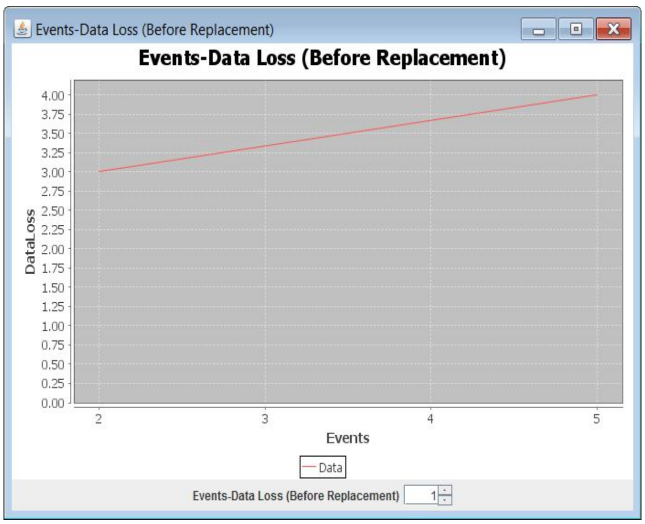

Fig. 9 Total data loss before node replacement

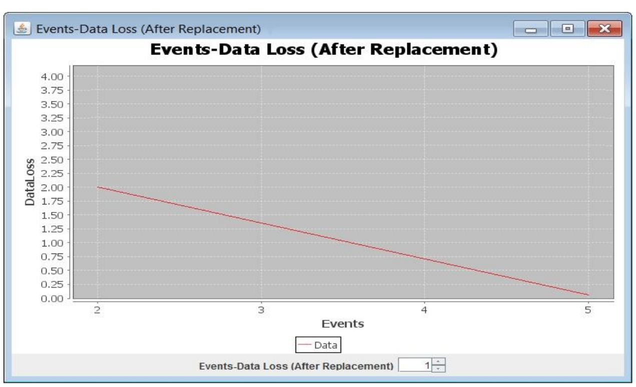

Fig. 10 Total data loss after node replacement

Fig. 9 and Fig. 10 compares the total data loss using FNR algorithm before and after node replacement. Data loss can be reduced by node replacement. In the simulation , event data was detroyed and recorded as loss count if data had already relayed through the nodes many times. If the number of nonfunctioning nodes exceeds the threshold, the FNR algorithm replaces fewer nonfuctioning nodes and reuse more routing paths . So the FNR algorithm exhibits small data losses.

Fig. 11 shows the average energy consumption of wireless network. Existing system consume more energy because the inside nodes are energy depleted nodes but outside nodes continues data transfer to sink node through inside nodes until the nodes are depleted.

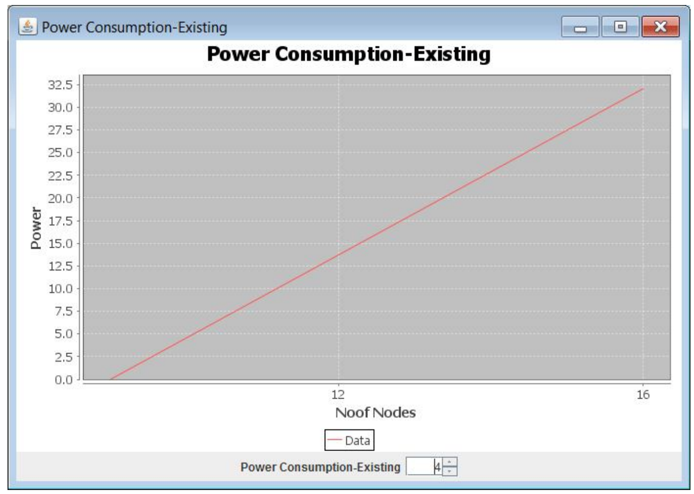

Fig. 11 Average enegry consumption of existing system

Fig. 12 shows the Total number replaced nodes. . The proposed system uses three tier power management scheme and it reduces the power consumption by a three tier power management schemes in WNs. To do the same we introduce active, sleep semi-sleep methods for the same. In active mode each node will use its full power and in semi sleep it uses half of its energy and it will be in off for sleep mode. so combining these three methods will reduce the total network power. After the replacement of the nonfunctiong nodes FNR algorithm generates a new path . proposed scheme enables the nodes which are on the routing paths as active mode nodes , the remaining nodes are the semi sleep mode nodes and the faults nodes are in sleep mode.

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nodes were recovered, and the FNR algorithm continues to run for iterations after some events. In the simulation, the algorithm replaced, on average, approximately 32 nodes for each calculation, extending the lifetime of the WN.

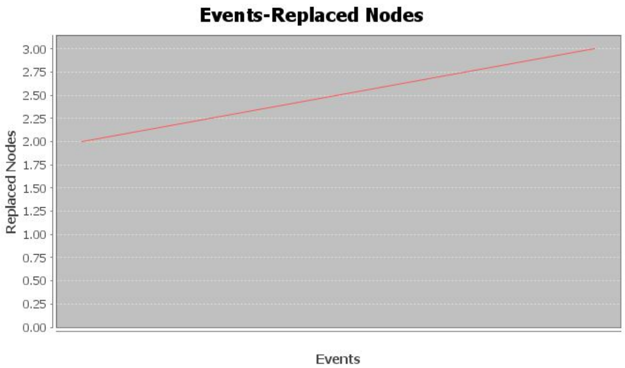

Fig. 12 Total number replaced nodes.

CONCLUSION

In real wireless networks, the nodes use battery power supplies and thus have limited energy resources. In addition to the routing, it is important to research the optimization of node replacement, reducing the replacement cost, and reusing the most routing paths when some nodes are nonfunctional.

We proposes a fault node recovery algorithm for WN based on the grade diffusion algorithm combined with a genetic algorithm. The FNR algorithm requires replacing fewer nodes and reuses the most routing paths, increasing the WN lifetime and reducing the replacement cost.

We reduces the power consumption by a three tier power management schemes in WNs. To do the same we introduce active, sleep semi-sleep methods for the same. In active mode each node will use its full power and in semi sleep it uses half of its energy and it will be in off for sleep mode. so combining these three methods will reduce the total network power.
In the simulation, the proposed algorithm increases the number of active nodes. The algorithm reduces the rate of data loss and reduces the rate of energy consumption .Therefore, the FNR algorithm not only replaces nodes, but also reduces the replacement cost and reuses the most routing paths to increase the WN lifetime.

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