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FNDRA: Failure or Dead Node Detection and Recovery Algorithm for Wireless Sensor Networks

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ABSTRACT: Recently large numbers of applications are developed in wireless sensor networks with more numbers of portable sensor nodes to increase the quality of service of such applications. The failure occurred in sensor nodes typically affects the quality of service of WSNs.This algorithm is a combination of discrete round trip delay & round trip path algorithm and genetic algorithm. The combination of these algorithms are used to preventing traffic in networks and also provides better performance improvement, less delay and less packet loss rate. The simulations are done in network simulator 2 and results shows that this method provides better performance compared with existing systems.

Keywords: QoS, Round trip path, Round trip delay, genetic, chromosome.

I. INTRODUCTION

Recently, the geographical areas are spread over large amount of sensors with wireless sensor networks. Due to the spreading of large number of sensors there is a possible for fault occurrences in networks. Such faults are affects the communication as well as quality of service [1], [2], [3]. The detection of fault node is very essential for efficient communications. In wireless sensor networks, failures are not preventable because of careless monitoring and non-uniform deployment. The faults in sensor node may occur because of connection-less with network, hardware or software failures [4]. There are lots of works are done for detection and prevention of faulty nodes. Most of literatures have proposed round trip delay time and path calculations to detect fault node present in the network. When a node fails, all processes running on that node will fail. If there was any process running by using that failure node, entire process will fail.

The current process running on particular node failed, the process running on other nodes that weren't communicating with process on the failed node will continue to run without a problem. In [1], the failure node is detected by using discrete round trip path analysis algorithm. In this the round trip path is formed with minimum three nodes. The round trip delay time and threshold is calculated first after that the threshold is compared with round trip delay time of each path. The delay time is greater than the threshold means that node is considered as malfunctioning node. Suppose the value of delay time is equal to infinity means then the node is considered as failure node. In this a fault or dead node detection and recovery algorithm is proposed to detect the failure node and recovering the failure node to improve quality of service. This algorithm is the combination of discrete round trip path algorithm and genetic algorithm. The failure or dead node is detected based on discrete path of round trip algorithm and the detected failure node is recovered using genetic algorithm.

II. RELATED WORKS

Navanath Duche and Nisha et al. [1] have proposed discrete round trip paths analysis for detecting fault nodes. The round trip times of discrete round trip paths are compared with threshold time to determine failed or malfunctioning sensor node. But this scheme addresses only the detection of fault node and it does not address recovering process of failure node. But the proposed scheme will detect and recover the faulty node. Pinak S. Patel et al. [2] have proposed ARX-based spike fault detection method which does not require the system input information or *a* priori establishment of reference sensors is proposed for LTI physical systems. The method is based on pair-wise relationships of sensors, and these relationships are learned online when the system is functioning normally. Ameer et al. [3] have proposed Least-Disruptive topology Repair (LeDiR) algorithm. LeDiR relies on the local view of a node about the network to relocate the least number of nodes and ensure that no path between any pair of affected nodes is extended relative to its prefailure status. LeDiR is a localized and distributed algorithm that leverages existing route discovery activities in the network and imposes no additional prefailure communication overhead. Guowei Wu et al. [4] have proposed a dynamical jumping real-time fault-tolerant routing protocol namely DMRF. Each node utilizes the remaining transmission time of the data packets and the state of the forwarding candidate node set to dynamically select the next hop. PrasenjitChanak et al. [5] have proposed a fault tolerant routing which involves fault recovery process with fault detection scheme, referred to as energy efficient fault tolerant multipath routing scheme for wireless sensor network (FTMRS). In FTMRS technique every sensor node transmits its data to a base station through shortest path. If data or node fault occurs in the network, these are recovered very fast. The data are transmitted to base station with minimum time and energy loss. Smita Jangale et al. [6] have proposed ad

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hoc on demand distance vector routing algorithm is used to create wireless sensor network. The proposed fault detection algorithm is based on the spatio-temporal correlations among the sensor measurement series in WSNs. Shuo Guo et al. [7] have proposed FIND, a novel sequence-based detection approach for discovering data faults in sensor networks, assuming no knowledge about the distribution of readings. In particular, this scheme is interested in Byzantine data faults with either biased or random errors, since simpler fail stop data faults have been addressed sufficiently by existing approaches.

III. PROPOSED APPROACH

Round trip delay and paths analysis for failure node detection

Due to the fault sensor node the round trip delay time of the round trip path may change. The round trip delay may be infinity or higher than threshold value. Failure in sensor node is detected by measuring the round trip delay for each round trip path after that compare the round trip delay time of round trip path with threshold value. The sensor node common to specific RTPs with infinity round trip delay time is detected as failed. If this round trip delay time is higher than the threshold value then this senor node is detected as dead node.

Round Trip Delay Time Estimation mainly depends upon the numbers of sensor node present in the round trip path and the distance between them. The round trip path in WSNs is formed by grouping minimum three sensor nodes. Hence the minimum round trip delay time (τ_{RTD}) of RTP with three sensor node is given by,

$$\tau_{RTD} = \tau_1 + \tau_2 + \tau_3 \qquad (1)$$

where τ_1, τ_2 and τ_3 are the delays for sensor node pairs (1,2), (2,3) and (3,1) respectively. In this the circular topology is formed with twenty one sensor nodes is considered. Three consecutive sensor nodes in each RTP are almost at equidistance because of circular topology. As a result sensor node pair delays τ_1, τ_2 and τ_3 will be equal. Let 'τ ' be the uniform time delay for all sensor node pairs in RTPs i.e. $\tau = \tau_1 = \tau_2 = \tau_3$. Round trip delay time for RTP with uniform sensor node pair delay is obtained by referring equation (1) as

$$\tau_{RTD} = 3\tau. \qquad (2)$$

This is the minimum RTD time of an RTP in WSNs. It is determined by the sensor node pair delay (τ), which is decided by particular application of WSNs, as it depends upon the distance between the sensor nodes. Hence the efficiency of this method can be improved only by reducing the RTPs in WSNs.

Faulty sensor node is detected by comparing the specific RTPs to which it belongs. More numbers of sensor nodes in the round path will reduce the RTPs created. But due to this individual sensor node will be present in more RTPs. While detecting faults, comparisons of all such RTPs become necessary. This will delay the fault detection process. The numbers of RTPs formed with 'm' sensor nodes is given by

$$P = N(N - m) \qquad (3)$$

where P is the numbers of RTPs. Analysis time of fault detection method is the time required to measure the RTD times of all RTPs in the WSNs. It is the addition of all RTD times. The equation for analysis time with P numbers of RTPs is given by,

$$\tau_{ANL}(M) = \tau_{RTD-1} + \tau_{RTD-2} + \cdots + \tau_{RTD-P} \qquad (4)$$

$$\tau_{ANL} = \qquad (5)$$

RTD time of RTP will increase for additional numbers of sensor nodes. Referring (2), optimum value of RTD time of RTP is obtained by considering only three sensor nodes.

Failure Node recovery

Genetic Algorithm

- **Chromosome:**

A chromosome is a collection of genes and each chromosome represent a number of nodes or genes in the given network. Chromosome of the GA consists of sequences of positive integers that represent the ID's of nodes. The variable length of the chromosome is represented as the total number of nodes or genes in the network. The length of the chromosome should not exceed the maximum length (total number of nodes in the network).

- **Population(P)**

A population is a collection of chromosomes, where a family of 'r' chromosomes is represented as P = (c1, c2 ... cr). In which as the number of nodes increases, then size of the chromosome structure increases. For the initial population the number of chromosomes structures is generated with presence of faulty nodes. Selection of two chromosomes is based on roulette wheel selection for finding better chromosomes for fault tolerance in the network. In which gene index that represent the position of the nodes (as shown as 1, 2, 3, 4, 5, 6, 7, 8, 9, 10…..) and gene value provides the nodes identification number (ID).

- **Fitness function**

Each chromosome is evaluated by fitness function. The proposed fitness function is designed to increase the fault tolerance of the system. It preserves the historically obtained best chromosomes with fitness value. In this work the fitness function is considered as the following parameters to recover each node in the network on the basis of energy, and link efficiency, which eliminates the faulty nodes from the network. The energy of each node should be more than threshold level energy (THLEN), and the link efficiency between the nodes will be more than threshold level link efficiency (THLeff). The fitness function of the proposed scheme is formulated as follows:

Fitness(Chromosome) =

$$\sum_{x=1}^{N} E \sum_{x=1}^{N} L_{eff} * Path * fault \quad (1)$$

Where E= energy of each node(Joules)

L_{eff}=Link efficiency

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Path is a variable, which depends upon whether there is an existing path between source and destination or not but there is no cycle in the path

$$\text{Fault}=\begin{cases} fault & = -1 \\ not\ fault & = 1 \end{cases}$$

Finally there are two parent chromosomes are selected which are having lowest fitness value.

- **Crossover and Mutation:**

The two-point crossover (CT) method is used to create new chromosomes. Two individual chromosomes are chosen from the mating pool or population with lowest value to produce two new offspring. Crossover process exchanges the genes of two parent chromosomes. Mutation acts that first a random number between 1 and the number of nodes is produced, and then this value is placed in a random cell within chromosome.

The following are the steps involved in failure or dead node detection and recovery algorithm. This algorithm is the combination of discrete round trip delay, round trip path algorithm and genetic algorithm. The number of nodes as randomly deployed in some bounded region. After the deployment of nodes the parameters are initialized for each node. They are id of the sensor, energy and link efficiency. Then the round trip path is formed by grouping three nodes.

For calculating the round trip path and round trip delay for each nodes deployed in network. Select any sensor node K_X from WSN with N sensor nodes. The values of X varies from 1, 2, 3, …….. N (K_1<=K_X<=K_N). The round trip path is formed by following sequences such as K_x-K_{x+1}-K_{x+2}. Then calculate the round trip delay time RTD_X of each round trip path. First the round trip delay time of each path are calculated. Among that delay time the maximum round trip delay time is taken as threshold value.

The threshold value is compared with each round trip delay time of path. The value is equal to the threshold value means increase the sequence of the round trip path from k_x by 3(i.e k_x to k_{x+3}). If the value is equal to infinity then the node is considered as failed otherwise it is considered as malicious node. After that the delay time is compared with next sequences this process continued till correct failure node is detected. After detecting the failure nodes chromosomes are formed with genes. Chromosome is nothing but a gene that containing some length. Here the length of the gene is 10.

The chromosome gene value having the value either 1 or -1 sensor id. 1 represents the node be good and -1 represents the node to be failure. Then fitness function is calculated. The chromosomes with lowest fitness function is selected and applied to cross over process. In this two chromosomes are selected and the value of that is selected by using selection and mutation process. Finally the mutation process provides which failure must be recovered. After that the failure node must be recovered and the data will be transmitted without any loss.

IV. PERFORMANCE ANALYIS

In this section, failure or dead node detection and recovery diffusion algorithm is implemented and simulations are done through Network Simulator-2. The nodes are uniformly deployed under the bounded region of 1500 x 1500 sqm. 21 nodes are formed with circular topology. Here the MAC layer protocol we use is IEEE 802.11 for WLANs and the simulated traffic is Constant Bit Rate. The parameters such as throughput, packet loss, delay are calculated.

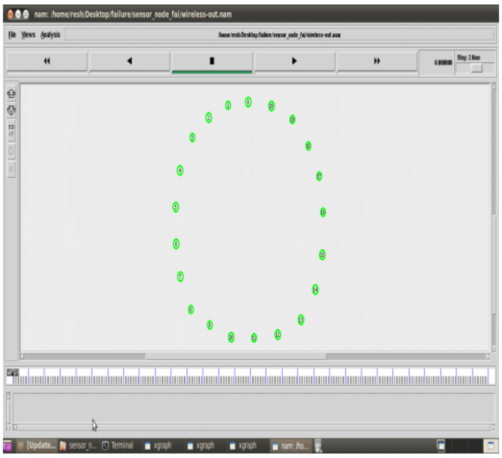

Fig 1 Network Formation

Fig 1 shows that formation of network with circular topology. Here the nodes are deployed under the bounded region of 1900 x 1700. Under the bounded region 21 nodes are formed. The protocol here used for routing is ad hoc on demand distance vector routing and medium access control here used is 802.11. Omni directional antenna is used for transmission purpose.

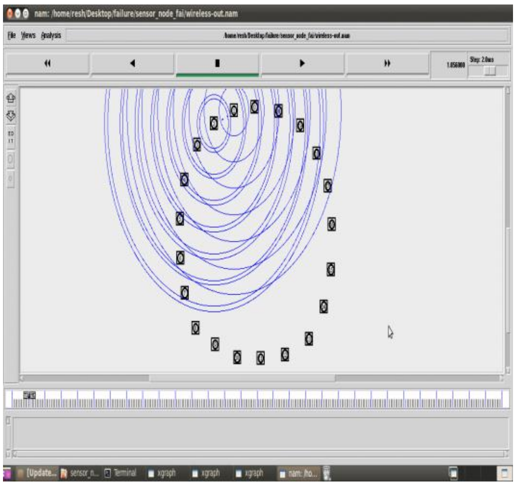

Fig 2 Round trip time calculation

Fig 2 shows that calculation of round trip time. The round trip path is formed by grouping minimum three nodes. Here 21 nodes are formed and total numbers of possible round trip paths are 378. The round trip time is the time taken for data packet send from sender to receiver plus the time taken for the acknowledgement send from receiver to sender. Here three nodes grouped to form the round trip path and round trip time is calculated for all round trip paths.

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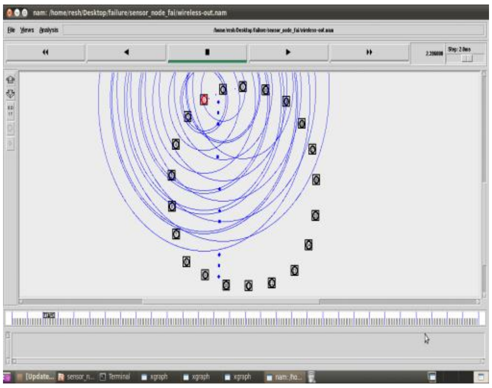

Fig 3 Packet loss due to failure node

Fig 3 shows that packet loss due to failure node. The node can fail for any of a variety of reasons, e.g., broken node hardware, a broken network, software bugs, or inadequate hardware resources. Here the failure node is detected by calculating the round trip time. The failure node drops the packet due to malicious activities of node. The failure node is detected by comparing the round trip delay time of sensor node.

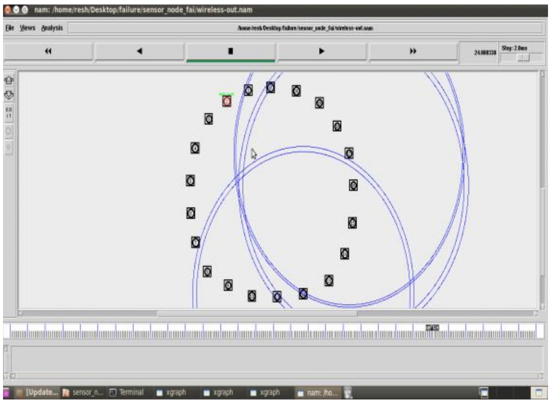

Fig 4 Failure node detection

Fig 4 shows that the failure node detection. Here the failure node is node number 2. It is detected by using round trip time. Because it takes more times to transmit the packet as well as it drops the packet. The failure node is detected by comparing the round trip delay time of this path with threshold value. By comparing this delay time with threshold it value is greater than the threshold value. So, the node 2 is failure node.

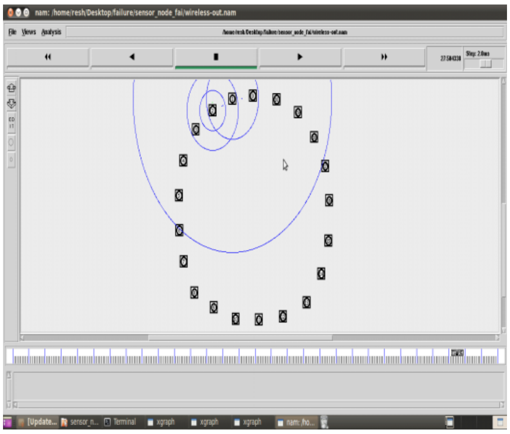

Fig 5 Failure node recovery and data transmission

Fig 5 shows that the failure node recovery and data transmission of the node. The failure node 2 is detected and recovered using genetic algorithm. After recovering a node the transmission is done without any data packet loss and it must take less round trip time than first. The data is transmitted without any disturbing to quality of service.

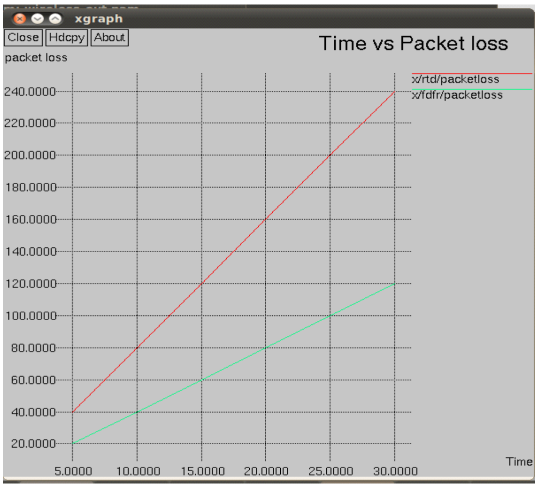

Fig 6 Packet loss

Packet loss is the failure of one or more transmitted packets to arrive at their receiver. Fig 6 shows that packet loss graph. Here the graph is plotted between the times versus packet loss. From fig we can see that the packet loss of proposed scheme (represented in green color) is less compared to existing scheme (represented in red color).

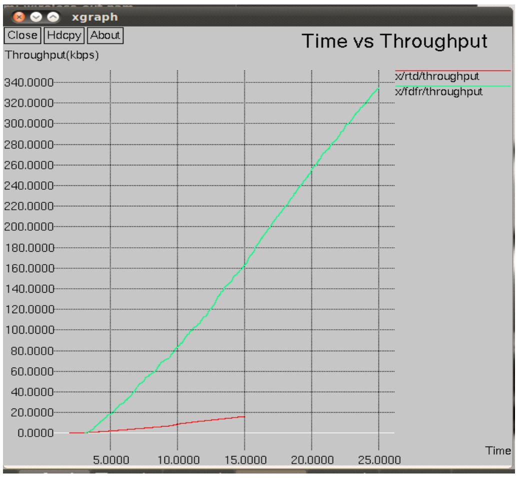

Fig 7 Throughput

Throughput is measure of number of packets received by the destination during the communication process. Fig 7 shows the throughput graph. From fig we can see that the proposed scheme (represented in green color) throughput is higher than that of the existing scheme (represented in red color).

Delay is the measure of amount of time taken by the packet to reach the receiver. Fig 8 shows that delay graph. From fig we can see that the delay of the proposed scheme (represented in green color) is lower than that of the existing scheme (represented in red color).

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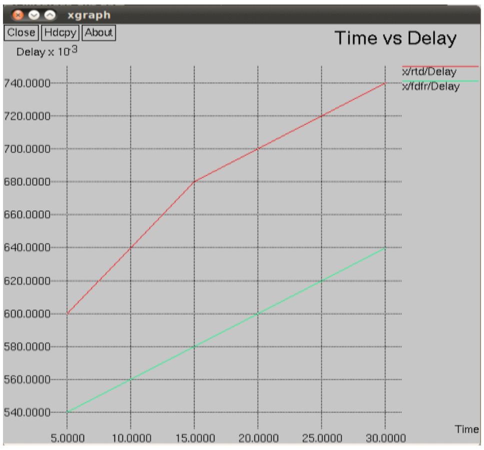

Fig 8 Delay

Table 1 shows the simulation parameters.

Table 1 Simulation Parameters

No. of nodes	21
Area	1500 x 1500
Simulation Time	30
MAC	802.11
Traffic Source	CBR (Constant Bit Rate)
Transmitting Power	0.5w
Receiving Power	0.35w
Initial Energy	500 J
Data Rate	512 Kb
Routing Protocol	AODV

V. CONCLUSION

Fault or dead node detection and recovery algorithm is presented. This algorithm is a combination of discrete round trip path algorithm and genetic algorithm. These combinations of algorithms works well and provide better fault detection accuracy and replace the node efficiently. The simulations are done in network simulator 2. The results show that the proposed algorithm provides better throughput, less delay and packet loss. This system can recover from a single node failure at a time. Generally, simultaneous node failures are very improbable unless a part of the deployment area becomes subject to a major hazardous event In the future, we plan to investigate this issue. This future plan also includes factoring in coverage and ongoing application tasks in the recovery process and developing a tested for evaluating the various failure recovery schemes.

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BIOGRAPHIES

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