ISSN (Online) : 2319 – 8753
ISSN (Print) : 2347 - 6710

International Journal of Innovative Research in Science, Engineering and Technology

An ISO 3297: 2007 Certified Organization, Volume 3, Special Issue 1, February 2014

International Conference on Engineering Technology and Science-(ICETS'14)

On 10th & 11th February Organized by

Department of CIVIL, CSE, ECE, EEE, MECHNICAL Engg. and S&H of Muthayammal College of Engineering, Rasipuram, Tamilnadu, India

An Efficient Detection and Recovery of Fault node in Wireless Sensor Networks

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Abstract—This paper proposes an efficient detection and recovery algorithm to identify a fault node efficiently and to recover the Wireless Sensor Networks by replacing only few sensor nodes along with often used alternative routes. This algorithm is a combination of bootstrapping algorithm, grade diffusion algorithm and genetic algorithm.

Keywords— grade diffusion, genetic algorithm, bootstrap algorithm

I. INTRODUCTION

The Wireless sensor network is a collection of sensors that are spread over large geographic area. Since sensors are widely spread and large in number, the occurrences of faults in the network are also more. Hence to detect the fault node and to replace the fault node an efficient algorithm is proposed. Besides the sensors have many issues related to energy, routing, security, coverage, etc., and so the proposed efficient detection and replacement algorithm takes these issues in to account and performs the fault detection and recovery mechanisms.

II. RELATED WORKS

Failures are unavoidable in Wireless Sensor Networks due to the lack of monitoring and unattended deployment. There are many issues related to energy, memory and computational ability of a sensor node. The occurrences of faults are mostly due the presence of faulty sensor nodes [1]. To identify a fault node and to replace it, many techniques are proposed.

Song Jia et al. proposed a recovery algorithm [1] in 2013 based on minimum distance redundant node. By numerical algorithm, the sink node gets the centre of the "coverage hole", and then wakes up a redundant node, which has the minimum distance to the centre, to recover the hole. By choosing appropriate number of redundant nodes, this algorithm will have great recovery accuracy and coverage quality; also achieve the purpose of prolonging the lifecycle of WSNs.

W. Guowei et al. Proposed a Dynamical Jumping Real-time Fault-tolerant Routing Protocol (DMRF) [2]. When a node fails, network congestion or void region occurs then the transmission mode will switch to jumping transmission mode leading to reduced transmission delay and guarantees the data packet to be sent to its desired destination within the specified time limit. Each node can dynamically adjust the jumping probabilities to increase the ratio of successful data transmission by using feedback mechanism. This mechanism results in reduced effect of failure nodes, congestion and void region and reduced transmission delay, reduced number of control packets and higher ratio of successful transmission.

Ameer A. Abbasi et al. proposed a Least-Disruptive topology Repair (LeDiR) algorithm [3] in 2013. LeDiR relies on the local view of a node about the network to devise a recovery plan that relocates the least number of nodes and ensures that no path between any pair of nodes is extended. LeDiR is a localized and distributed algorithm that leverages existing route discovery activities in the network and imposes no additional pre failure communication overhead.

In Wireless Sensor Network all sensor nodes have the equal probability to fail and therefore the data delivery in sensor networks is inherently faulty and unpredictable. Most of the sensor network applications need reliable data delivery to sink instead of point-to-point reliability. Therefore, it is vital to provide fault tolerant techniques for distributed sensor network applications. Rehena, Z. et al. in 2013 presented a robust recovery mechanism of nodes failure in a certain region of the network during data delivery. It dynamically finds new node to route data from source nodes to sink. The proposed algorithm is integrated easily in data delivery mechanisms where area failure in a certain geographical region is not considered. This recovery mechanism is focused on multiple-sink partitioned network. It is found that it quickly selects alternative node from its 1-hop neighbor list when there are no forwarding nodes available and establishes route from source to sink [4].

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Rajashekhar Biradar [5] in 2013 proposed an Active node based Fault Tolerance using Battery power and Interference model (AFTBI) in WSN to identify the faulty nodes using battery power model and interference model. Fault tolerance against low battery power is designed through hand-off mechanism where in the faulty node selects the neighboring node having highest power and transfers all the services that are to be performed by the faulty node to the selected neighboring node. Fault tolerance against interference is provided by dynamic power level adjustment mechanism by allocating the time slot to all the neighboring nodes. If a particular node wishes to transmit the sensed data, it enters active status and transmits the packet with maximum power; otherwise it enters into sleep status having minimum power that is sufficient to receive hello messages and to maintain the connectivity.

Fault tolerance mechanisms either consume significant extra energy to detect and recover from the failures or need to use additional hardware and software resource. Meikang Qiu et al proposed a novel energy-aware fault tolerance mechanism for WSN, called Informer Homed Routing (IHR). In this IHR, non cluster head (NCH) nodes select a limited number of targets in the data transmission. Therefore it consumes less energy [6].

Ting Yang et al. in 2013 proposed the novel rectification algorithms [7] (greedy negative pressure push algorithm and dynamic local stitching algorithm) is proposed to cooperatively repair broken transmitting paths in Wireless Sensor Networks. Using adjacency information, Greedy negative pressure push algorithm can efficiently grow the transmitting path to achieve the minimum energy consumption for relays model. These algorithms only stitch broken fragments of the original path.

The main challenge in wireless sensor network is to improve the fault tolerance of each node and also provide an energy efficient fast data routing service. [8] An energy efficient node fault diagnosis and recovery for wireless sensor networks is referred as fault tolerant multipath routing scheme for energy efficient wireless sensor network (FTMRS).The FTMRS is based on multipath data routing scheme. One shortest path is use for main data routing in FTMRS technique and other two backup paths are used as alternative path for faulty network and to handle the overloaded traffic on main channel. Shortest path data routing ensures energy efficient data routing.

By introducing new network equipments [9], the traditional distributed hierarchical management structure can be improved. The equipment can quickly locate the failure and analyse the cause of the failure. A new low-energy fault management protocol is also introduced which can quickly respond to failures.

Hong-Chi Shih et al. proposed a fault node recovery algorithm [10] 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. The algorithm can result in fewer replacements of sensor nodes and more reused routing paths.

TABLE I
COMPARISON OF DIFFERENT FAULT TOLERANT MECHANISMS

Title	Techniques Employed	Benefits
An Efficient Recovery Algorithm for Coverage Hole in WSNs [1]	Node Self Detection by History data and Neighbors (NDHN) algorithm and Fault Detection Technique based on Clustering (FDTC)	Great recovery ,accuracy and coverage quality, prolong the lifecycle of WSNs
Dynamical Jumping Real-Time Fault-Tolerant Routing Protocol for Wireless Sensor Networks [2]	Dynamical Jumping Real-time Fault-tolerant Routing Protocol (DMRF)	Reduced effect of failure nodes, congestion and void region and reduced transmission delay, reduced number of control packets
Recovering From a Node Failure in Wireless Sensor-Actor Networks With Minimal Topology Changes [3]	Least-Disruptive topology Repair (LeDiR) algorithm	Relocates least number of nodes
Handling area fault in multiple-sink Wireless Sensor Networks [4]	robust recovery mechanism (dynamically finds new node to route data)	Quickly selects alternative node from its 1-hop neighbor list
Fault tolerance in wireless	Active node based Fault Tolerance using	Fault tolerance against low

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sensor network using hand-off and dynamic power adjustment approach [5]	Battery power and Interference model, Dynamic power level adjustment mechanism	battery power
Informer homed routing fault tolerance mechanism for wireless sensor networks [6]	Energy-aware fault tolerance mechanism - Informer Homed Routing (IHR)	Consumes less energy
DLS: A dynamic local stitching mechanism to rectify transmitting path fragments in wireless sensor networks[7]	Greedy negative pressure push algorithm and Dynamic local stitching algorithm	Consumes less energy
Fault –Tolerant multipath routing scheme for energy efficient Wireless Sensor Networks[8]	Fault Tolerant Multipath Routing Scheme for energy efficient wireless sensor network (FTMRS)	Energy efficient data routing
A Fault Management Protocol for Low-Energy and Efficient Wireless Sensor Networks[9]	Network equipments, Low-energy fault management protocol	Quick Response to Failures
Fault Node Recovery Algorithm for a Wireless Sensor Network[10]	Fault node recovery algorithm (Grade Diffusion and Genetic Algorithm)	Fewer replacements of sensor nodes and more reused routing paths

Fault management for WSNs [12] is different from traditional networks. Recent research has developed several schemes and techniques that deal with different types of faults at different layers of the network. The comparison of different fault tolerant mechanisms is given in TABLE I. All these techniques consider only few issues of WSNs. An Effective Fault Management system or model must consider maximum issues or kinds of faults.

III. EXISTING SYSTEM

Hong-Chi Shih et al. proposed a fault node recovery algorithm[10] 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. The algorithm can result in fewer replacements of sensor nodes and more reused routing paths.

A. Drawbacks in Existing System

Nodes in WSNs are prone to failure due to energy depletion, hardware failure, communication link errors, malicious attack, [12] and so on. The Fault Node Recovery algorithm detects a fault node when ever some of the sensor nodes shut down, either because they no longer have battery energy or they have reached their operational threshold, but it fails to detect a malicious node or unauthorized node. The presence of these malicious nodes [13] may lead to data seize, malfunction of sensor, depletion of battery etc.

Further Grade Diffusion algorithm [10] selects a particular group of sensors to form a routing table and hence there is a chance for the unauthorized or malicious node to get included in the routing path.

In the presence of malicious node [13], the Fault Node Recovery algorithm fails to effectively detect and replace fault node.

IV. PROPOSED SYSTEM

The presence of unauthorized node is detected by Bootstrapping algorithm. Bootstrapping [16] the sensor network refers to the discovery of deployed sensors and establishing direct Communication links between each gateway and sensors that are reachable to it. Bootstrapping can be very challenging while dealing with sensor networks because human intervention to setup and administer the network is not possible in a major portion of the applications that sensors are used for. Bootstrapping is an efficient way to monitor the sensor network. It is achieved by introducing mobile robots [15]. Here a mobile robot is used to connect with group of sensors so that nodes can directly link with this robot and communicate. The mobile robots check the group of sensor parameters and exchange secret keys and verify their identities. Upon new inclusion, a node has to collect enough authorizations from its neighbors so that its privilege can be accepted by the sink. Mean while each sensor node independently makes authorization decisions by itself based on the information it composed directly from its neighborhood. Ensuring that the sensor network is secure with boot strapping algorithm, grade diffusion and genetic algorithm is employed.

The Grade Diffusion algorithm [10] 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.

When the number of sensor nodes that are not functioning exceeds the threshold, Genetic algorithm [10] is used for replacement. There are 5 steps in the genetic algorithm: Initialization, Evaluation, Selection, Crossover, and Mutation.

Initialization: Here chromosomes are generated. Each Chromosome is an expected solution. The number of chromosomes depends on number of sensors to be replaced.

Evaluation: The Number of routing path available if some non functioning sensors are replaced is evaluated based on fitness value. This fitness value is calculated with number of sensor nodes grade values, number of reusable routing paths, total number of sensor nodes in original wsn, and total number of routing paths in original WSN.

Selection: Here chromosomes with lowest fitness values are eliminated.

Cross over: Two individual chromosomes are selected and compared and a part of it is replaced with the other to produce new offspring.

Mutation: Here a single gene is replaced after comparison.

V. EXPECTED RESULT

The Efficient Fault detection and recovery algorithm combines bootstrapping algorithm and the fault node recovery algorithm. The FNR algorithm [10] can result in fewer replacements of sensor nodes and more reused routing paths. The Bootstrapping [16] is an efficient way to detect and to monitor the sensor network.

VI. CONCLUSIONS

The Efficient fault detection and recovery algorithm will not only identify a fault node when some of the sensor nodes shut down, either because they no longer have battery energy or they have reached their operational threshold but also when an unauthorized sensor got included in the network. Since it makes use of grade diffusion and genetic algorithm, only few sensor nodes have to be replaced. The accuracy of fault node identification will be improved with bootstrapping algorithm. Results to be reflected that the proposed system will efficiently find all possible faults compared to existing fault tolerant techniques

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