Available online at http://www.journalijdr.com

International Journal of
DEVELOPMENT RESEARCH

ISSN:2230-9926

International Journal of Development Research
Vol. 4, Issue, 4, pp. 898-901, April, 2014

Full Length Research Article

A SURVEY ON FAULT NODE IDENTIFICATION

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ARTICLE INFO

Article History:
Received 11th January, 2014
Received in revised form
07th February, 2014
Accepted 30th March, 2014
Published online 23rd April, 2014

Key words:
Wireless Sensor Networks (WSNs),
Sensors, Network Lifetime,
Fault diagnosis,
Energy-efficiency.

ABSTRACT

In recent years, Wireless Sensor Networks (WSNs) are widely used in different applications for information gathering and monitoring purpose. Large numbers of sensor nodes are deployed in the environment to increase the quality of service (QoS). A critical issue found in Wireless Sensor Network is node failure. Failure of nodes occurs due to various reasons like hardware failure, energy depletion, harsh environment, malicious attack, etc. To increase the Quality of service, it is important to identify the failure node and take necessary actions to avoid further ruin of the service. The current research work is based on learning different techniques used to identify and recover the failure node which spontaneously improves the Quality of Service.

INTRODUCTION

Wireless network technology improved in designing a new device called sensor nodes. Sensor nodes are smaller in size, lightweight, inexpensive and battery powered. This device is furnished with limited data processing, wireless communication, detecting capabilities. It is usually deployed in the sensing area to monitor events, gather the information about the environment and transmit the collected information to the base station (BS). Currently, Wireless Sensor Networks have attracted to various applications such as traffic surveillance, health care, environmental conditions like temperature, pressure, motion etc. In WSN, we use large number of sensor nodes, so formation of topology will be dynamic because of the various factors like destruction of environmental factors, addition of new node in the network, sensor node failure, location change of sensor nodes, communication link failure and out of coverage area.Sensor nodes are deployed in the sensing area either in grid or in random manner. Despite of the location of sensor nodes, faults occurs frequently at different levels. Though a node becomes failure, it can still monitor and able to communicate but the sensed data will be incorrect. Faulty nodes should be removed from the network permanently or else it should be diagnosedto free from fault without allowing to generate erroneous data. Fault tolerance issue is widely considered as a key part of network management due limited energy and communication link failure (ShuoGuo *et al*., 2009). To address this issue, many fault tolerance mechanisms are proposed. Fault tolerance mechanisms vary in form of architecture, detection decision fusion algorithms, protocols, detection algorithms. To increase the quality of service (QoS) and also to obtain accuracy, large number of portable wireless sensors are deployed in the environment. But, the accuracy and QoS will be affected due to failure of sensor nodes. Sensor nodes failure is not only due to energy depletion but also owing to various other factors like environmental changes, failure of links, out of coverage area and so on. This causes the certain part of the network to stop functioning properly and it leads to reconstruction of new topology, network partitioning and connectivity loss. In these situation, data loss will be more and QoS will not be obtained.

To maintain the better QoS even under the situation of nodes failure, it is indispensable in most WSN applications to identify the faulty nodes available in the networks.We have classified our paper into four different sections where we have presented the general introduction about the Wireless Sensor Networks in Section I. We also specify why failure occurs in sensor nodes and due to what reasons the sensor node becomes a fault node. Section II is about the related works done for the identification of fault nodes. In Section III, we also specify the different kinds of fault identification techniques present to detect the fault node present in the wireless sensor network

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using various algorithms. Finally, we conclude our paper by comparing various techniques for fault identification in Section IV.

RELATED WORKS

WSN are prone to failure, these failure nodes will degrades the quality of Service (QoS) of the entire network. To improve the Quality of services, one important parameter is to have a complete knowledge about fault detection methods due to the following reasons (Peng Jiang, 2009; VenniraSelvi and Manoharan, 2013):

- In some high security application like monitoring of nuclear reactor, identifying fault node should be given more importance.
- The sensor node fails because of deploying low-cost sensors in uncontrollable environment so failure of nodes occurs more frequently.
- Energy depletion is another major problem faced in sensor nodes since they are battery-powered with limited energy that causes failure.
- Failure of links due to dynamic changes of networks will cause sensor node to fail permanently or temporarily.
- Congestion occurs in sensor node due to overload and traffic that results in packet loss and node failure.
- The Sensor node becomes fault due to hardware failure during fabrication process.
- Failure of nodes cannot be examined manually to determine the proper functioning of nodes.

Control center cannot find whether the information received is correct because erroneous data will be produced by failed nodes.

In general, fault occurs in sensor network can be classified into two types. They are function faults and data faults. Function fault normally refers to abnormal behaviors of the sensor node and this leads to network failure or breakdown of a node shown in Fig 1. Whereas in data fault, node behave as a normal node but they sense wrong information when compared to other nodes in the network. This type of fault is difficult to identify because there will not be any change in behavior of the node expect the sensor reading it produces. These fault readings would degrade the performance of the network significantly; therefore thesesensor should be corrected or removed from the network. One significant way to solve this problem is to map faulty reading with correct ones (Balzano and Nowak, 2007). The parameters of mapping function are obtained in different ways, so additional assumptions like sensor model (Feng *et al*., 2003), dense deployment (Feng*et al*., 2003), similarity of readings between neighboring nodes (Bychkovskiy *et al*., 2003) are needed.

Ding *et al*. (2005) proposed a technique to detect fault node by finding the difference between the fault node reading and its neighbors node readings is above the threshold with an assumption that neighboring nodes have similar readings. Krishnamachari *et al*. (2004) proposed a distributed bayesian scheme for detecting and correcting by taking the possibility of sensor measurement faults. An approach of weighting the neighbor's measurement and characterize the difference between sensor measurement by using weighted median fault detection scheme (WMFDS) and finding the spatial correlation of sensor measurements to detect faults in WSN (Gao *et al*., 2007). In the later section we will learn some more new algorithms to find the faulty node in the network.

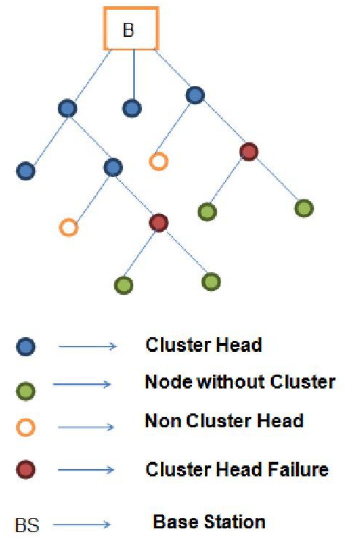

Fig. 1. Failure detection in cluster tree

FAULT DETECTION TECHNIQUES

In this section, we discuss about various algorithms and protocols that are used to provide the quality of service by identifying the fault node available in the Wireless sensor network, Failure of nodes occurs frequently due to various reasons and because of this failure nodes in some security application will lead to major problems, to avoid this situation a survey is done on various existing techniques. Some techniques are Cluster Heed Failure Recovery algorithm, Distributed Fault Detection algorithm, Energy-Efficient Fault-Tolerant Protocol (EFP), Decentralized Fault Management Mechanism for Cluster based WSNs (DFMC) and Round Trip Delay and Paths Analysis, etc.

Cluster Heed Failure Recovery Algorithm

This algorithm (Akbari *et al*., 2011) is mainly used to maintain the cluster structure when failure occurs due to energy-drained nodes. Initially cluster is used to group the neighbor nodes to maximize the energy of the nodes. The nodes which have maximum residual energy in the cluster will be nominated as cluster heed and the secondary cluster heed will be the second maximum residual energy. Cluster members will be aware of cluster heed and secondary cluster heed. When the energy in the cluster heed drops below the threshold value, a message will be send to other cluster members and also to secondary cluster head as an indication for the secondary cluster head to act as a new cluster head. The existing cluster heed will becomes as a member in the cluster. All the member will follow the secondary cluster heed as the new cluster head. Therefore, this algorithm uses a backup secondary cluster heed to replace the cluster heed in the case of failure. The advantage of this algorithm is to increases energy efficiency by frequently rotating the cluster heed among sensor nodes with equal probability.

Distributed Fault Detection Algorithm

The Distributed Fault detection algorithm (VenniraSelvi and Manoharan, 2013) is used to detect the failure nodes by comparing the result of the sensing information with the neighboring nodes to enhance the accuracy of diagnosis. Some faults in communication and sensor reading may happen which can be tolerated to some extend by using time redundancy. To reduce the delay in time redundancy the interval in the sliding window is increased. Sensor nodes that are permanently failed in the network are identified with high accuracy. This algorithms works well if the node is permanently failed.

Energy-Efficient Fault-Tolerant Protocol (EFP)

Energy-Efficient Fault-Tolerant Protocol (EFP) is a power adaptive protocol (ZohreArabi and RoghayehParikhani, 2012) to decrease energy consumption of sensor nodes. In this protocol cluster head will be chosen randomly in the first phase which is similar to LEECH protocols. The residual energy and distance to the base station is calculated for the randomly chosen cluster head. These two parameters are compared with other nodes. If any node has high residual energy and dimension then that particular node will become the cluster-head and the remaining nodes will reselect this node as the main cluster-head.This protocol is a best fault tolerant method where the cluster head is selected based on power and dimension and there is more efficient and trustworthy communication is guaranteed between the sending and receiving sensor node. This energy driven technique is to monitor the node status for detecting energy that is dissipated from each sensor node.

Decentralized Fault Management Mechanism for Cluster based WSNs (DFMC)

The Decentralized Fault Management Mechanism for Cluster based WSNs (DFMC) is used for detecting failure sensor node (VenniraSelvi and Manoharan, 2013). Here we classify the sensor nodes into three kinds namely Cluster head observer, Cluster head, and Cluster member. The main work done by Cluster head observer is to find the fault cluster head from the cluster that provides incorrect data to the base station. The cluster manager is responsible for sending a query message to the cluster head periodically and receives the acknowledgement message. If the reply message is not received from cluster head then it is assumed to be failure node for that cluster. The Cluster head observer selects a new sensor node as cluster head to replace the failed cluster head in that cluster. This recovery mechanism helps in improving the throughput of the Wireless Sensor Network.

Fuzzy Based Algorithm

In Fuzzy based algorithm (Barati *et al*., 2012), the results will be more accurate for detecting faulty nodes when compared to other algorithms that is used for the same detection of failure nodes. Here in this algorithm, an effective fuzzy interface system is used to overcome the localization problem and fault node detection. The experimental analysis results in the reduction of computational complexity of two nodes and there is an increase in the accuracy by decreasing the energy consumption of each node in the network. To attain better efficiency with low energy consumption, the adaptive fuzzy interface system is used to detect faulty nodes. When there is a difference in the sensed value of two nodes, there fault occurs and that corresponding value can be used as a linguistic variable in fuzzy logic to detect the fault. This value can be represented as low, medium or high using fuzzy logic method.

Zone-Based Fault-Tolerant Management Architecture (ZFTMA)

In ZFTMA (Muhammad Zahid Khan *et al*., 2010), to form a network as fault tolerant all sensor nodes are formed as multiple clusters to perform efficient fault management. ZFTMA divides the network into four zones to reduce energy consumption, and selects a resourceful node as Zone Manager (ZM). Each zone will have Zone manager (ZM) for monitoring the management task throughout the network thereby reducing the message which are moving between sink and nodes. This Zone Manager is placed at one-hop distance to the Central Manager (CM) for direct communication. Here, a two- dimensional plane is used to represent the sensor nodes. Normally in Cartesian Coordinate System, the X-coordinates are placed in horizontal position and the Y-coordinates in vertical position. By using Cartesian coordinate system, the sensor network plane is divided into four zones with Central Manager in the center of the field. Therefore, the advantage is that CM will be placed in equal distance to all the Zone Managers. Thus, the Cluster head is selected in the random process and almost 5% of nodes in the network will be elected as Cluster head. This method finds the optimal solution for the fault tolerance and fault management.

Fault Tolerant, Energy Efficient, Distributed Clustering (FEED)

In FEED (Mohammad Mehrani *et al*., 2011), the entire network are divided into clusters with cluster heads, pivot cluster heads and some supervisor nodes. The cluster head is chosen by considering four different parameters like density, energy, centrality and distance. A cluster head is chosen to be the head of the cluster like other algorithm. A pivot cluster head (PCH) contains additional capabilities than cluster head. All the PCH nodes in the network will be acting as routers. To increase the network lifetime every cluster has a supervisor node and pivot cluster head. The supervisor node are used for detecting and replacing the failed cluster head and pivot cluster head and also try to achieve fault tolerant clustered network. By selecting three types of cluster head to handle a fault cluster head the energy consumption of FEED can be increased.

Round Trip Delay and Path Analysis

Round Trip Delay time (RavindraNavanathDuche and Nisha P. Sarwade, 2014) measurement of RTPs will be changed due to faulty sensor nodes. The RTD value will be compared with the already calculated Threshold value for determining the failed or malfunctioning sensor nodes. If the value is greater than the threshold value, then the node is identified as malfunctioning. If the value is infinity, then the node is detected as faulty node.RTD Time Estimation depends mainly on number of sensor nodes present in the RTP and the distance between each sensor nodes. By reducing the number of sensor nodes, we can reduce the RTD time of RTP so that the accuracy will be more efficient for detecting failure nodes. We can group four consecutive sensor nodes for finding the Round Trip Path (RTP) and the minimum Round Trip Delay (RTD) time for these four sensor nodes is given as

$$\tau RTD = \tau 1 + \tau 2 + \tau 3 + \tau 4$$

where τ1,τ2, τ3 and τ4 are the delays for sensor node pairs (1,2), (2,3), (3,4) and (4,1) respectively.In Evaluation of RTP, the faulty sensor nodes are identified by comparing RTP time of specific path with already calculated Threshold value. If there is delay in the value of RTP of specific path, we define that there is delay due to fault node in that path. When there is more number of nodes in a path, there will be reduction in the RTPs. If there is 'm' number of sensor nodes, then the RTP value can be calculated as follows:

P =N (N−m)

where P is the numbers of RTPs.

Now we need to optimize the RTPs to speed up the process for detecting fault nodes. In Optimization of RTPs, the fault nodes are detected from analyzing more number of RTPs that requires much time and also affects the performance. To analyze maximum number of RTPs, we can either follow Linear selection or Discrete selection of RTPs. In Linear selection of RTPs, only few paths are analyzed for detecting fault nodes and this will not optimize in case of large number of nodes are used. In Discrete selection of RTPs, we reduce the number of RTPs by selecting only discrete RTPs from sequential number of Linear RTPs. By using Discrete RTPs, time will be saved and detection of fault will be more efficient even though large number of sensor nodes are used.

Conclusion

In our paper, a survey was made on various fault detection algorithms. Each method for finding faulty nodes uses a specific algorithm to find that failure node. In Cluster Heed Failure mechanism, we need a secondary cluster heed when the cluster heed is about to be failed, so a backup recovery node is needed for this method. In Distributed Time Redundancy mechanism, it detects fault nodes by comparing the data sensed by itself with the neighbor node and tolerates only the transient faults in sensor reading. In Energy-Efficient Fault-Tolerant Protocol (EFP), cluster head will be selected randomly based on power and dimension. This method is fault tolerant and energy driven technique to monitor the energy dissipated from each sensor node. In the Decentralized Fault Management Mechanism for Cluster based WSNs (DFMC), when the cluster head fails to send acknowledgment to cluster head observer, then another new node is selected as cluster head for that cluster with increase in throughput. Fuzzy based algorithm uses an effective or adaptive fuzzy interface system to overcome localization and fault detection problems with better efficiency. In Zone-Based Fault-Tolerant Management Architecture (ZFTMA), the sensor node field is divided into four zones with Zone Manager and a Central Manager at the center of the plane. This methods provides optimal solution for fault tolerance and management. By considering four parameters, a cluster head is selected in Fault Tolerant, Energy Efficient, Distributed Clustering (FEED). In this method, supervisor node will detect the fault node and also tries to achieve fault tolerant by increasing energy consumed. When compared to these methodologies, we suggest that Round Trip Path and Paths analysis method is efficient and accurate for finding fault nodes. Here in this method, Round Trip Time (RTT)is measured which is useful to find the optimized way for sending packets from source to destination node without loss of data.

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