IJISET - International Journal of Innovative Science, Engineering & Technology, Vol. 4 Issue 4, April 2017
ISSN (Online) 2348 – 7968 | Impact Factor (2016) – 5.264
www.ijiset.com

A Study on Fault Tolerance Methods in Wireless Sensor Networks

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Abstract

Wireless sensor networks (WSN) have received a more noteworthy enthusiasm for applications such as area monitoring, health care monitoring, industrial monitoring and environmental sensing. In WSNs sensor nodes are expected to work in unattended mode and conceivably in huge number. Faults are something which itself is undesirable and it prompts to undesirable outcomes.WSNs are failure prone due to reasons such as malicious attack, hardware failure, energy depletion, communication error and so on. Adaptation to fault tolerance is one of the basic issues in WSNs. This paper addresses this issue by surveying existing fault tolerance approaches in WSNs.

Keywords: Wireless sensor networks, Sensor nodes, Fault tolerance, Quality of service (QoS), Fault detection, Energy.

1. Introduction

Wireless sensor networks (WSNs) also known as wireless sensor and actuator networks (WSANs) which are spatially distributed autonomous sensors to monitor physical and environmental conditions such as temperature, pressure, moisture. WSNs collect data and cooperatively pass through the network to the main station. Innovations of scaling down the span of low cost electronic machines have boosted the vision to produce the convenient sensor nodes at low cost with sensitivity and accuracy. A node might vary in size from that of a shoebox down to the size of a grain of dust, although functioning “motes” of genuine microscopic dimensions are yet to be created [2]. Depending on the complexity and size, cost of the sensor node is variable. The network Quality of service (QoS) increases with increase in number of sensor nodes. Hence to increase QoS of the WSNs, large number of portable sensor nodes can be deployed. Probability of getting failure nodes increases with expanding the hubs in the networks. To keep better QoS under failure conditions, Identifying and replacing such nodes are important. Sensor nodes can be imagined as small computers, extremely basic in terms of their interfaces and their components [2]. Due to small dimension sensory nodes have strong restrictions on its software and hardware, in terms of memory storage, processing capacity, and energy supply. This power cannot be rechargeable so reduction in life time of battery leads to nodes fault. When the energy of the sensor depleted, failed nodes will not transfer data [3]. This paper focus on different faulty node detection approaches, to investigate the current state of fault detection in WSNs .For this we address this by surveying different existing methods and providing an overview of fault detection in WSNs

2. Faults in WSNs

Faults are something which itself is undesirable and it leads to undesirable results [4].Due to reasons such as malicious attack, hardware failure, energy depletion, communication errors and so on WSNs are failure prone. It effects vary from nothing to the aggregate breakdown. Node faults in the WSNs mainly divided into two types. First one is hard fault and second one is soft fault. In hard fault a sensor node cannot communicate with other nodes because of failure of a certain module like energy depletion of nodes, And in soft fault failed nodes can continue to work and communicate with other nodes but the data sensed or transmitted is not correct [4].Importance of fault detection methods as follows.

- ✓ Nodes have non rechargeable batteries as its power supply, so due to battery depletion faults may occur.
- ✓ Due to harsh situations sensor node failure occur more than in another systems.
- ✓ Faulty nodes can produce unwanted or error data which may leads to destroy the network.
- ✓ The manual examination of the sensory nodes is not so practical.
- ✓ In the case of high security regions like nuclear reactor monitoring fault detections are really important.

3. Fault Detection

Fault detection methods used to find out faulty nodes in the network system. The goal of fault detection is to verify that the services being provided are functioning properly, and in some cases to predict if they will continue to function properly in the near future [5]. The basic approach is direct visual observation and if any faulty node detected manually remove them from the network.

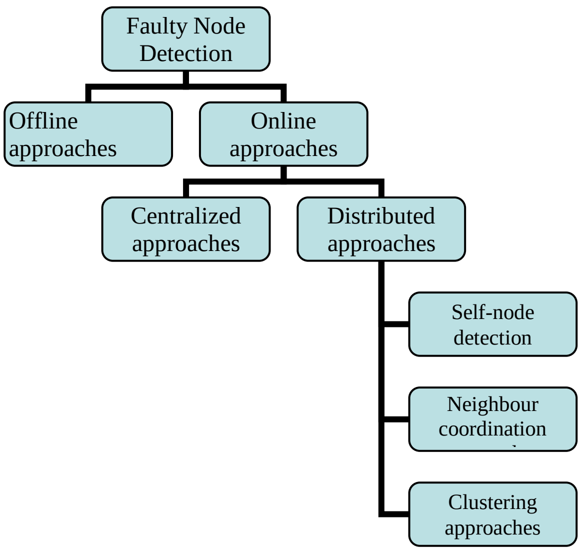

Fig. 1 Classification of faulty node detection method

Direct visual observation offers downsides, human communication prompts to mistakes, it has a high cost and it is not productive. Consequently automatic fault detection techniques are used for WSNs. Faulty node detections basically classified into offline and online approaches. Online approaches are generally used and it is mainly classified into two centralized and distributed approaches. In offline approaches first, data are collected and later only those data can analyze. The main disadvantage of this method is during runtime fault cannot detected. So this is not an efficient method. This drawback can be overcome using online approaches. By this method fault can be detect during system runtime. Online approaches are surveying in detail in the following section.

3.1 Centralized Approaches

Centralized approach is a typical answer for distinguish and restrict the reason for failures in WSNs. For the most part; a geologically or consistently centralized sensor node takes liability for tracing and monitoring failed nodes. An active detection model will adopted by central node to recover conditions of the network performance and individual sensor nodes by periodically injecting requests into the network [4]. It breaks down this data to recognize and limit the fizzled or suspicious nodes. Furthermore, the central manager gives a centralized approach to detect the fault by comparing the present or verifiable conditions of sensor nodes against the general network data models. As a synopsis, the centralized approach is productive and exact to recognize the network failures in certain ways. Xin Miao, Kebin Liu, Yuan He, Dimitris Papadias, Qiang Ma, and Yunhao Liu (2013) found an online lightweight failure detection approach called Agnostic diagnosis (AD), AD is motivated by the fact that the system metrics like radio on time, number of packets transmitted of sensor nodes usually exhibit certain correlation patterns. Infringement of such examples shows potential failures in the nodes. The experimental results by Xin Miao et al. (2013) demonstrate the advantages of AD to discover silent failures, effectively expanding the capacity and scope of WSN diagnosis. But this approach cannot be used in a distributed manner. Jessica Staddon, Dirk Balfanz, and Glenn Durfee (2002) demonstrate that the topology of the network can be efficiently conveyed to the base station allowing for the quick tracing of the identities of the failed nodes with the moderate communication overhead. Failed nodes efficiently traced by simple divide and conquer strategy. When a base station ceases to receive measurements from a region of nodes it can't immediately determine whether this is because of the destruction of all the nodes in that region or merely the result of the failure of a few nodes bearing much of the routing load [7]. This technique helps to solve this problem.

3.1 Distributed Approaches

Distributed approach encourages the concept of local decision making, which evenly distributes fault management into the network [4].Before communicating with the central node it allows node to make decision at certain level. It trusts the more choice a sensor can make; the less data should be conveyed to the central node. In the other word, the control focus ought not to be educated unless there is truly a failure happened in the network.

3.1.1 Self node detection

Self-node detection method is used to screen the malfunctioning of the physical components in the sensor node. This is a straight forward technique. Each sensory node observes its own binary outputs and compare with the predefined values. S Harte, A Rahman, and K M Razeeb (2005) designed a flexible circuit using accelerometers that acts as a sensing layer around a node, which will be capable of sensing the physical condition of the node. Using accelerometer, software analysis can be performing on the raw data to determine impacts and orientation. This information helps to evaluate the damage probability. After detecting that a node is not healthy, the effect this has on the whole sensor network is looked at [8]. We investigate the progressions that can be required such as regarding sensor readings as invalid. At the network level, the directing convention ought to be made aware of faulty nodes to conform that faulty nodes are steered around. B.R. Tapas Bapu, K. Thanigaivelu, A.Rajkamar (2006) discussed about various self-node detection methods. Observing battery discharge curve and current discharge rate we can estimate death time of battery, by this battery exhaustion faults can be predict.

3.1.2 Clustering Approaches

This approach utilizes a hierarchical network topology. Node with maximum priority will elect as a cluster head. This cluster head monitor remaining normal nodes. The cluster head it's self-monitored by base station. Transfer of cluster head and data loss problems are main design issues of this approach. Abolfazl Akbari, Arash Dana, Ahmad Khademzadeh, and Neda Beikmahdavi (2011) designed that initially, node with the maximum residual energy in a cluster becomes cluster head and node with second maximum residual energy becomes second cluster head. On the basis of residual energy availability cluster head will selected among them. Abolfazl Akbari et al. (2011) focus on technique to maintain cluster structure in the event of failure caused by energy drained nodes. Algorithm proposed has data loss problems due to transfer of cluster head. M.Asim, H.Mokhtar, and M.Merabti (2008) proposed new fault management architecture, the network is partitioned into virtual grids of cells which support scalability and perform fault detection and recovery locality with minimum energy consumption.

3.1.3 Neighbor coordination approaches

Neighbor coordination is another approach to find out failure nodes in wireless sensor networks. Nodes arrange with their neighbors to recognize and distinguish the system flaws before counseling with the central node. In most case, the central node is not aware about any fault unless something is accepted to not be right with high certainty by means of node coordination conclusion. This design reduces network correspondence message, and subsequently conserve node vitality. Jinran chen, Shubha Kher, and Arun somani (2006) proposed and evaluated a localized falt detection algorithm to identify the faulty sensors. The execution complexity of the algorithm is low and probability of right diagnosis is high even in the presence of huge number of faulty nodes. On the basis of localize fault detection algorithm check whether diagnosis consistent with the test results [14]. Consistency proves that that diagnosis is valid. In the event that there is no sensor being analyzed, every one of its neighbors are either not analyzed or are analyzed as faulty. Peng jiang (2009) proposed an improved distributed fault detection scheme to checks out the failed nodes by exchanging data and mutually testing among neighbor nodes in the network. This approach is an improved version of distributed fault detection algorithm proposed by Jinran chen et al. (2006).

4. Conclusion

This paper gave an intensive examination of faults that happened in genuine WSN arrangement. By concentrating just on the faults, the lessons gained from the different classification can be utilized by any application regardless of the possibility that the explored trial had an alternate research focus. This paper proposed scientific classification to arrange failures and faults that happen in WSN. It is possible to compare different fault detection methods and their strong and weak points by this classification approach. This helps to select proper techniques suitable for particular applications.

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