A Short Survey on Fault Diagnosis in Wireless Sensor Networks

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Abstract. Fault diagnosis is one of the most important and demandable issues of the network. It makes the networks reliable and robust to operate in the normal way to handle almost all types of faults or failures. Additionally, it helps sensor nodes to work smoothly and efficiently till the end of their lifetime. This short survey paper not only presents a clear picture of the recent proposed techniques, but also draws comparisons and contrasts among them to diagnose the potential faults. In addition, it proposes some potential future-work directions which would lead to open new research directions in the field of fault diagnosis.

Keywords: Wireless Sensor Networks · Fault diagnosis · Reliability

1 Introduction

Wireless Sensor Networks (WSNs) consist of a large number of low-cost, spatially distributed, small-in size, limited computation, storage and communication power sensor nodes that are deployed across the monitoring area. These nodes perform sensing, processing, communication and coordination of information with each other to achieve the common objectives autonomously. Due to recent advancement in wireless communication and electronics, micro-electro-mechanical system (MEMS) enables the resource constrained multi-functional sensor nodes to untetheredly communicate with each other in short distances. These constraints on the network makes it different form the other existing wireless networks. In WSNs, each small sensor node is composed of the following main components such as: (a) processing (b) communication (c) computation (d) power source (e) external memory (f) one or more sensors.

2 Fault Diagnosis Approach

According to the architecture, fault diagnosis model in WSNs consists of the following three types of approaches to handle faults: (i) Model-based or Centralized (ii) Model-less or Distributed (iii) Model-based distributed or Hybrid

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approaches, each one of which is explained in detail with the help of most recent relevant work available in the literature, see in Fig. 1.

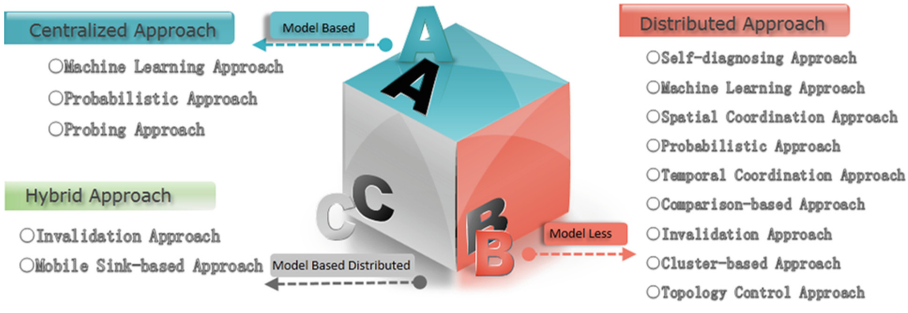

Fig. 1. Fault diagnosis categorization and approaches

2.1 Model-Based or Centralized Approach

As name indicates, an ultra-reliable centralized sensor node called sink node, with large storage, interrupted power supply and high computational power, is placed logically or geographically in the center. The base station or sink node periodically injects health requests or queries messages to determine the state of each sensor node deployed in the field. There are many techniques available in the literature of WSNs which have followed the centralized approaches for the purpose of fault detection and diagnosis.

2.2 Model-Less or Distributed Approach

Unlike model-based or centralized approach, each sensor node in model-less or distributed approach takes decision about their health status by gathering and analyzing diagnostic response results from the neighboring nodes. Then it updates the BS accordingly. Therefore, the model-less approaches transfer a little information to the BS that helps in prolonging the lifetime. It further reduces a lot of traffic overhead, and minimizes the end-to-end delay over the network. There are many recent techniques in the literature which have followed the distributed approaches for fault diagnosis and detection.

2.3 Distributed Model-Based or Hybrid Approach

It combines the advantages of both centralized (model based) and distribute approach (model-less), and avoids the limitations of both. According to literature, the model based distributed approaches are preferred in terms of reliability, robustness, energy efficiency, and minimizes traffic overhead. So these approaches

Table 1. Analysis with respect to different fault diagnosis parameters

Author	Year	Diagnosis network			Diagnosis view			Fault persistence		Fault type		Approach
		Distributed	Centralized	Hybrid	Local	Global	Permanent	Intermittent	Transient	Hard	Soft	
Shahram et al. [3]	2013	✓			✓	✓	✓		✓	✓	✓	Self-diagnosing
Miao et al. [16]	2013		✓			✓		✓	✓		✓	Machine learning
Kulla et al. [12]	2013	✓			✓			✓	✓	✓	✓	Machine learning
Banerjee et al. [4]	2014			✓	✓	✓	✓	✓	✓	✓	✓	Spatial-temporal coordination
Chanak et al. [5]	2013	✓			✓		✓		✓	✓	✓	Spatial coordination
Alessandra et al. [7]	2013	✓			✓			✓	✓		✓	Probabilistic
Dima et al. [10]	2013	✓			✓		✓	✓	✓	✓	✓	Spatial coordination
Bill et al. [13]	2014		✓			✓		✓	✓		✓	Probabilistic
Arunanshu et al. [15]	2014	✓			✓		✓	✓		✓	✓	Comparison-based
Manmath et al. [21]	2014	✓			✓		✓	✓		✓	✓	Spatial coordination
Mehdi et al. [2]	2014	✓			✓		✓	✓	✓	✓	✓	Cluster-based
Yu et al. [25]	2014		✓			✓	✓	✓	✓	✓	✓	Model-based
Arunanshu et al. [15]	2013	✓			✓		✓	✓	✓	✓	✓	Invalidation
M. Panda et al. [18]	2015	✓			✓		✓	✓	✓	✓	✓	Self-diagnosing
Yuan et al. [26]	2015	✓			✓			✓			✓	Probabilistic
Zafar et al. [27]	2015			✓	✓	✓		✓	✓		✓	Invalidation
Dhal et al. [8]	2015		✓			✓		✓	✓		✓	Topology control
Gong et al. [9]	2015		✓			✓		✓	✓		✓	Probing
Meenakshi et al. [19]	2015	✓			✓			✓	✓		✓	Majority voting
Lo et al. [14]	2016			✓	✓	✓		✓	✓		✓	Spatial coordination
Chafig et al. [23]	2015	✓			✓	✓		✓	✓		✓	Probabilistic
Jin et al. [11]	2015		✓		✓	✓		✓	✓		✓	Model-based
Mohammed et al. [1]	2015			✓		✓	✓	✓	✓	✓	✓	Mobile sink-based
Christopher et al. [17]	2016		✓			✓		✓	✓		✓	Topology control
Panigrahi et al. [20]	2016	✓			✓			✓	✓		✓	Spatial coordination
Zhen et al. [29]	2016		✓			✓		✓	✓		✓	Model-based
Hongsheng et al. [24]	2016	✓			✓		✓	✓	✓	✓	✓	Spatial coordination
Zhang et al. [28]	2016	✓			✓	✓	✓	✓	✓	✓	✓	Spatial coordination
Tang et al. [22]	2016	✓			✓	✓		✓	✓		✓	Machine learning
Chanak et al. [6]	2016			✓	✓	✓	✓	✓	✓	✓	✓	Mobile sink-based
Chanak et al. [5]	2016	✓			✓		✓	✓		✓	✓	Probabilistic

bridge the gap between the centralized, and distributed approaches. There are a few techniques available in the literature based on the subject cited above.

Table 1 presents some of the most important and recent protocols, which have been presented in the literature, are classified on the basis of different parameters of fault diagnosis. It would help the researchers to find the current trends of the protocols. It also illustrates the advantages and limitation of each. In order to contribute a more demanded-able protocol to be robust, reliable, energy-efficient for the domain.

3 Open Research Challenges

WSNs have steadily become a cutting edge technology of the 21^{st} century for the development of wireless sensor applications. It is the most important area because its applications applying to almost all walks of life. Due to its importance, a lot of work has been performed in last one decade, nevertheless the area still demands more work to be done in order to fulfill the current requirements. The followings are some challenges listed below which need be focused:

1. More intelligent algorithms are required for the purpose of fault diagnosis and detection
2. Nodes are required to be diagnosed while performing their usual task simultaneously
3. The network must be prepared for load balancing efficiently specially in the case of multi-media sensor nodes
4. It is required to be adaptive to dynamics changes occurring such as topology, transmission ranges etc.
5. Intelligent movable robot needs to be proposed for diagnosis and detection
6. QoS-based fault diagnosis needs to be concentrated on network energy consumption and link quality
7. Malicious activities and threats are required to be tracked in order to operate uninterruptedly
8. Damaged link diagnosis and detection need to be addressed in large scale WSNs
9. After diagnosing the faulty nodes, they are required to be recovered or reused as much as possible (communication, storage, computation)
10. A cross layer approach to deal with the reliability and robustness of the network

4 Conclusion

This short survey provides a big picture of promising techniques for fault diagnosis and detection existing till date. It also elaborates their strong and weak points. It is believed that this survey will be appreciated, helpful in proposing more robust, reliable, scalable, real-time, mobile, energy-efficient, and intelligent protocols in the near future.

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