Chapter 12
Centralized and Distributed Approach:
A Comparative Analysis of Fault Diagnosis Approaches in Wireless Sensor Networks

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ABSTRACT

This Chapter presents a comparative analysis of two predominant fault diagnosis approaches, centralized and distributed, in WSNs. Fault diagnosis is paramount for maintaining network reliability and performance in diverse applications. Centralized fault diagnosis involves collecting and analyzing data at a central location, offering simplified management and efficient localization but potentially suffering from scalability issues. In contrast, distributed fault diagnosis leverages collaborative processing among sensor nodes, enhancing fault tolerance and scalability but requiring coordination and potentially incurring higher communication overhead. Factors such as network size, topology, resource constraints, and application requirements influence the choice between centralized and distributed approaches. This Chapter serves as a valuable resource for guiding decision-making processes and informing the selection of fault diagnosis methodologies in WSN deployments, contributing to

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the advancement of fault-tolerant and resilient wireless sensor networks.

4.1 INTRODUCTION

Wireless Sensor Networks (WSNs) have emerged as essential components in various domains, including environmental monitoring, healthcare, industrial automation, and smart cities. WSNs consist of a large number of tiny, resource-constrained sensor nodes that collaborate to collect, process, and transmit data from the physical environment to the end-users. However, due to their deployment in harsh and dynamic environments, WSNs are susceptible to various faults, including sensor node failures, communication errors, environmental disturbances, and malicious attacks. Faults in WSNs can disrupt data collection, compromise system performance, and lead to inaccurate or unreliable data transmission, impacting critical decision-making processes and applications. Therefore, effective fault diagnosis is paramount for maintaining the reliability, robustness, and performance of WSNs.

Fault diagnosis in WSNs involves the detection, localization, and mitigation of faults to ensure the continuous operation of the network. By promptly identifying and addressing faults, fault diagnosis mechanisms enable WSNs to adapt to changing environmental conditions, recover from disruptions, and maintain data integrity. Moreover, fault diagnosis facilitates proactive maintenance and management of WSNs, allowing for timely interventions to prevent catastrophic failures and optimize resource utilization. In mission-critical applications such as environmental monitoring, healthcare monitoring, and industrial automation, the accuracy and reliability of data collected by WSNs are of utmost importance. Faulty sensor readings or communication errors can lead to erroneous conclusions, jeopardizing the effectiveness and credibility of the entire system (Miao, X. et al., 2013). Therefore, robust fault diagnosis mechanisms are essential for ensuring the trustworthiness and utility of data generated by WSNs.

Centralized and distributed fault diagnosis approaches represent two fundamental strategies for detecting and mitigating faults in WSNs, each with its advantages, limitations, and implications. Centralized fault diagnosis involves collecting data from sensor nodes and analysing it at a central location, while distributed fault diagnosis leverages collaborative processing among sensor nodes to detect and diagnose faults collectively (Wan, S. 2016). The choice between centralized and distributed approaches significantly impacts fault detection, localization, and mitigation strategies in WSNs, making it essential to compare and evaluate their effectiveness.

Comparing centralized and distributed fault diagnosis approaches provides valuable insights into their relative strengths, weaknesses, and suitability for different WSN deployments. Centralized approaches offer centralized control, simplified