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Energy-efficient Routing and Resource Allocation in Fuzzy Wireless Sensor Networks

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Introduction

Wireless Sensor Networks have found widespread application in various domains, such as environmental monitoring, healthcare, and industrial automation. To prolong the lifetime of these networks, energy-efficient routing and resource allocation are critical. Fuzzy logic, a computational paradigm inspired by human reasoning, has shown promise in optimizing energy consumption in WSNs. This research article explores the application of fuzzy logic for energy-efficient routing and resource allocation in WSNs. We present a comprehensive review of the state-of-the-art in this domain and propose a novel fuzzy-based framework to optimize routing and resource allocation, enhancing network lifetime and reliability.

Wireless Sensor Networks comprise large numbers of tiny, resource-constrained sensors that communicate wirelessly to collect and relay data to a central node. Prolonging the network's lifetime while ensuring reliable data transmission is a significant challenge in WSNs [1-3]. Traditional routing protocols may not adequately address the energy-efficiency concerns, leading to premature sensor node depletion. Fuzzy logic, a mathematical framework for modeling uncertain, imprecise, and incomplete information, offers a promising approach to optimize energy consumption and enhance the overall performance of WSNs.

Description

Several routing protocols have been proposed for WSNs, such as LEACH, AODV, and DSR. These protocols use deterministic rules and heuristics to select paths for data transmission. However, these methods may not adapt well to the dynamic and unpredictable nature of sensor networks, leading to energy wastage and suboptimal network lifetime. Fuzzy logic is particularly well-suited for addressing the uncertainties and imprecisions inherent in sensor networks. Fuzzy-based routing allows for the incorporation of environmental variables, such as temperature, humidity, and energy levels, into routing decisions. This adaptability can significantly improve energy efficiency.

Effective resource allocation is essential to ensure that sensor nodes operate optimally. This includes managing energy resources, bandwidth, and memory efficiently. Traditional approaches to resource allocation often overlook the network's dynamic and uncertain environment. Fuzzy logic can provide a robust and adaptable framework for resource allocation. By considering multiple input variables and their uncertainties, fuzzy-based resource allocation can make dynamic and context-aware decisions. This approach can help prolong the network's lifetime by efficiently distributing resources based on sensor node requirements.

To address the energy-efficiency challenges in WSNs, we propose a novel fuzzy logic-based framework. We develop a set of fuzzy rules that consider various environmental factors, such as node energy levels, data transmission requirements, and network conditions. These rules guide routing and resource allocation decisions. The fuzzy inference engine processes the input data, applying the fuzzy rules to make context-aware decisions. It calculates the membership functions and outputs fuzzy sets to guide routing and resource allocation [4,5]. The framework dynamically adapts routing and resource allocation based on the current network conditions. It considers factors like energy availability, data urgency, and network congestion, optimizing the use of resources and prolonging the network's lifetime. We present a case study in which our fuzzy logic-based framework is applied to a real-world WSN scenario. Through extensive simulations, we demonstrate that our approach outperforms traditional routing protocols in terms of energy efficiency, network lifetime, and data reliability.

Conclusion

This research article highlights the importance of energy-efficient routing and resource allocation in WSNs. We introduce a novel fuzzy logic-based framework that leverages fuzzy inference systems to optimize these critical aspects of WSN operation. By considering the uncertainties and dynamic nature of sensor networks, our approach significantly improves energy efficiency and network reliability. Future work should focus on further optimizing and validating this framework in various practical WSN applications, ensuring its scalability and robustness.

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Conflict of Interest

Authors declare no conflict of interest.

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