



RESEARCH ARTICLE

Optimized Multi-Criteria Routing Algorithm for Durable Wireless Sensor Networks

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ABSTRACT

The Internet of Things and the Fourth Industrial Revolution (IR 4.0) rely on Wireless Sensor Networks (WSNs) as their underlying infrastructure. WSNs have recently attracted significant attention due to their crucial applications, such as monitoring applications. Geographic routing algorithms are widely used in WSNs because event location is often more critical than node identification. However, these algorithms still face challenges, such as workload imbalance and high energy consumption. Energy consumption is particularly vital in WSNs due to the sensor nodes' limited power resources. This work proposed an enhanced geographic routing algorithm based on the Technique for Order of Preference by Similarity to Ideal Solution (TOPSIS), a robust Multi-Criteria Decision-Making technique. The proposed TOPSIS-based method simultaneously incorporates four critical criteria, thereby addressing the limitations of conventional shortest-path approaches that depend solely on distance or residual energy. By integrating these carefully selected criteria, the proposed approach significantly improves network lifetime and overall performance, providing a more balanced and efficient routing strategy than previous methods. Simulation experiments were conducted to validate the proposed routing algorithm's performance compared to the EAEDR and FTR algorithms, which served as benchmarks. The results show that the developed algorithm significantly improved over the baseline algorithms regarding packet error rate, network lifetime, packet delivery ratio, and average energy consumption.

Keywords: Geographic routing, Internet of Things, Multi-criteria decision making, TOPSIS, Wireless sensor networks

Introduction

The rapid and exponential expansion of the Industry Revolution 4.0 (IR4.0) and the notion of the Internet of Things (IoT) serve as a crucial framework for future industrial innovations.^{1–3} WSNs are the foundation of the IoT and smart cities.^{4,5} WSNs are often characterized as multi-hop network systems consisting of a diverse range of intelligent sensor nodes.^{6–8} Sensor nodes have characteristics dispersed in an auto-organizing manner and are limited by en-

ergy constraints.^{9,10} Every sensor node can gather data necessary for a particular application from the surrounding environment.¹¹ It may also act as a data forwarder to guarantee that the data has been successfully transmitted to its intended destination.¹² The autonomous and adaptable character of WSN operations is highly sought after in several important and time-sensitive application situations, such as monitoring earthquakes, volcanic activity, and forest fires.^{13,14}

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