Commentary

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# Energy-Efficient Routing Protocols for Wireless Sensor Networks Using Genetic Algorithms

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## Introduction

Wireless Sensor Networks (WSNs) have become an integral part of modern communication and monitoring systems, finding applications in environmental monitoring, healthcare, agriculture, and industrial automation. These networks consist of numerous sensor nodes that collect and transmit data to a central base station. However, one of the major challenges in WSNs is energy consumption. Since sensor nodes are typically battery-powered and often deployed in remote or inaccessible areas, extending their lifetime through energy-efficient routing becomes critical. Traditional routing protocols often fail to balance energy consumption across nodes, leading to premature node failures and reduced network performance. In recent years, bio-inspired algorithms particularly Genetic Algorithms (GAs) have emerged as powerful optimization tools for designing energy-efficient routing protocols [1].

## Description

Genetic Algorithms are evolutionary computation techniques inspired by Darwin's theory of natural selection, where the fittest individuals are chosen to reproduce and evolve toward optimal solutions. In the context of WSNs, a GA-based routing protocol encodes potential routing paths as chromosomes, with each gene representing a node or communication link. The algorithm evaluates these paths using a fitness function, which considers parameters such as residual energy, distance between nodes, signal strength, and network lifetime. Through iterative operations selection, crossover, and mutation the algorithm evolves generations of solutions until the most energy-efficient routing pattern emerges. This process helps identify paths that minimize total energy consumption while avoiding overuse of specific nodes, thereby balancing the energy load across the network. For instance, nodes with higher residual energy can be prioritized for data forwarding, reducing the risk of network partitioning [2].

Additionally, GAs are capable of adapting to dynamic changes in network topology, such as node mobility or failure, making them suitable for real-world WSN applications. Moreover, GA-based routing protocols can be integrated with clustering techniques to further enhance energy efficiency. In clustered WSNs, sensor nodes are grouped, and a cluster head is selected to aggregate and transmit data to the base station. Genetic Algorithms can optimize the selection of cluster heads based on energy levels, communication costs, and proximity, ensuring balanced energy distribution within clusters [3].

Hybrid models combining GAs with other computational intelligence methods such as fuzzy logic or particle swarm optimization have also demonstrated improved performance by refining the decision-making process in route selection. These protocols can significantly reduce communication overhead, delay, and energy wastage associated with redundant data transmission. Despite the computational complexity of GAs, advancements in lightweight algorithm design and distributed processing enable their efficient implementation even in resource-constrained WSN nodes. Furthermore, the scalability of GAs allows them to handle large and dense sensor deployments without compromising on performance, making them ideal for next-generation Internet of Things (IoT)-enabled sensor networks [4,5].

## Conclusion

In conclusion, the application of Genetic Algorithms for developing energy-efficient routing protocols in Wireless Sensor Networks presents a robust and intelligent approach to prolonging network lifetime and optimizing data transmission. By continuously evolving optimal routing paths through adaptive learning and natural selection mechanisms, GA-based systems effectively balance energy consumption across nodes, enhance network stability, and ensure reliable communication. Their flexibility, adaptability, and scalability make them a promising solution for modern sensor network challenges, particularly in dynamic and large-scale environments.

## Acknowledgement

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## Conflict of Interest

None

## References

1. Torres JJ, Pantic L, Kappen HJ (2002) Storage capacity of attractor neural networks with depressing synapses. Phys Rev E 66: 061910

2. Hopfield JJ, Tank DW (1985) “Neural” computation of decisions in optimization problems. Biol Cybern 52: 141–152

3. Sun Y, Xue B, Zhang M, Yen GG, Lv J (2020) Automatically designing CNN architectures using the genetic algorithm for image classification. IEEE Trans Cybern 50: 3840–3854

4. Krotov D, Hopfield J (2018) Dense associative memory is robust to adversarial inputs. Neural Comput 30: 3151–3167

5. Aryapratama R, Pauliuk S (2022) Life cycle carbon emissions of different land conversion and woody biomass utilization scenarios in Indonesia. Sci Total Environ 805: 150226