

# Recent Advances in Wireless Sensor Networks: Challenges, Opportunities, and Future Directions

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**Abstract:** *Wireless Sensor Networks (WSNs) have emerged as a key technology for the Internet of Things (IoT) era, enabling distributed sensing and monitoring across numerous application domains. This paper provides a comprehensive review of recent advances in WSN technologies, focusing on energy efficiency, security, scalability, and integration with emerging paradigms such as edge computing and machine learning. We analyze current challenges facing WSN deployments and propose directions for future research. Our findings indicate that while significant progress has been made in extending WSN lifespan and security, substantial challenges remain in areas of standardization, heterogeneous network integration, and sustainable energy harvesting. The paper concludes with recommendations for future research to address these gaps.*

**Keywords:** Wireless Sensor Networks, Energy Efficiency, Network Security, Edge Computing, Internet of Things

