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Unified Approach to Energy and Data Security in Wireless Sensor

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Abstract: *Wireless Sensor Networks (WSNs) are the backbone of many contemporary applications in fields like environmental monitoring, precision agriculture, battlefield monitoring, and healthcare. As IoT technologies have spread, the requirement for WSNs to be energy-efficient and secure has become a top priority. Yet, energy limitations and increasing cybersecurity threats present serious challenges to their deployment and viability. This survey gives an overall overview of cutting-edge solutions addressing the twin issues of energy efficiency and security in WSNs. It investigates methods such as homomorphic encryption for privacy-enhanced data aggregation, fault-tolerant routing for robustness, dynamic data availability for longer network lifetime, and light-weight cryptographic models that are suitable for resource-limited settings. The work categorizes the existing approaches into four thematic pillars: security-focused mechanisms, energy efficiency methods, fault tolerance and reliability frameworks, and hybrid combined models. Additionally, it critically evaluates the computationally incurred overhead, communication expense, privacy assurance, and resilience against faults. The survey ends by outlining open research issues and suggesting a coherent architectural vision that spans energy-security interdependencies, and thus serving as a good reference for intelligent and sustainable WSN deployments' future research.*

Keywords: Wireless Sensor Networks, Energy Efficiency, Data Security, Homomorphic Encryption, Fault-Tolerant Routing

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