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EAMLOF: An Energy-Aware Multi-Layer Optimization Framework for Battery-Operated IoT Devices in Smart Environments

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Abstract: *The exponential growth of Internet of Things (IoT) ecosystems has resulted in a vast deployment of battery-powered sensor nodes across diverse application domains, including healthcare, smart cities, agriculture, and environmental monitoring. These devices often operate in energy-constrained and inaccessible settings, where battery replacement or maintenance is impractical. Addressing this critical challenge, this paper introduces EAMLOF (Energy-Aware Multi-Layer Optimization Framework), a novel cross-layer framework designed to optimize energy utilization in battery-powered IoT networks. Unlike conventional protocols such as PEGASIS and APTEEN, which offer limited adaptability, EAMLOF integrates adaptive sleep/wake scheduling, intelligent data filtering, energy-aware routing, and context-sensitive sampling. The framework employs lightweight edge intelligence to assess node energy levels, data variability, and environmental conditions, enabling dynamic adjustment of communication strategies. This significantly reduces redundant transmissions and energy waste. Simulation results conducted on a network of 1000 nodes using the First-Order Radio Model demonstrate that EAMLOF consistently outperforms existing benchmarks in terms of energy efficiency, network lifetime, packet delivery, and node survivability, showcasing its suitability for long-term and large-scale deployments. EAMLOF presents a scalable, intelligent, and sustainable approach to energy conservation in IoT systems, contributing to the realization of robust, green, and autonomous smart environments.*

Keywords: Battery-operated IoT devices, Energy Efficiency, Smart Environments, Edge Intelligence, Adaptive Scheduling, Multi-layer Optimization, EAMLOF, PEGASIS, APTEEN, Energy-Aware Routing, Green IoT.

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