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(57) Abstract :
The proliferation of Internet of Things (IoT) devices and latency-sensitive applications has driven the adoption of edge computing as a decentralized computing paradigm. However, powering edge clusters sustainably remains a challenge, as conventional grid-based energy supply increases both operational costs and environmental impact. Solar-powered edge clusters have emerged as a promising solution, but their reliance on intermittent and variable renewable energy sources introduces new complexities in resource allocation and task scheduling. This work addresses the problem of energy-aware task scheduling for solar-powered edge clusters, with the goal of achieving a balance between performance, energy efficiency, and sustainability. The proposed framework integrates predictive solar energy modeling with adaptive task scheduling algorithms. By forecasting solar energy availability using historical irradiance patterns and weather data, the system proactively adjusts task assignment strategies. Tasks are scheduled based on their priority, deadline sensitivity, and computational requirements while considering the dynamic energy budget. A hybrid scheduling approach is employed, combining energy-aware heuristics with reinforcement learning to optimize resource utilization in real time. To ensure service quality, critical and delay-sensitive tasks are given priority during energy-constrained periods, while non-urgent tasks are deferred or migrated across cluster nodes with surplus energy. Simulation and experimental analysis demonstrate that the proposed scheduling method significantly reduces task deadline violations, minimizes energy wastage, and enhances the utilization of harvested solar energy compared to traditional load-balancing or performance-centric schedulers. Furthermore, the framework extends the operational lifetime of edge clusters during off-grid operation, making them more resilient and sustainable. This research contributes to the advancement of green edge computing by aligning computational efficiency with renewable energy utilization, paving the way for eco-friendly and cost-effective deployment of next-generation IoT and edge services.

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