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Energy-Efficient Resource Scheduling in Cloud Computing Environments: Techniques and Performance Evaluation

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Abstract

The rapid growth of cloud computing has resulted in increasing demand for computational resources, leading to substantial energy consumption in data centers. Energy-efficient resource scheduling has therefore emerged as an important research area for reducing operational costs, improving resource utilization, and minimizing the environmental impact of cloud infrastructures. This study examines various techniques for energy-efficient resource scheduling in cloud computing environments and evaluates their performance based on key parameters such as energy consumption, execution time, resource utilization, throughput, and quality of service. Traditional scheduling approaches often prioritize performance and load balancing without adequately considering energy requirements. In contrast, energy-aware scheduling techniques incorporate factors such as workload characteristics, virtual machine allocation, server utilization, dynamic voltage and frequency scaling, task migration, and server consolidation to achieve improved energy efficiency. The study explores heuristic, metaheuristic, and artificial intelligence-based approaches that dynamically allocate resources according to changing workload conditions. Performance evaluation of these techniques can help identify suitable scheduling strategies for different cloud environments and application requirements. Particular attention is given to the trade-off between energy savings and service-level agreement requirements, as excessive consolidation or resource reduction may negatively affect application performance. The analysis suggests that intelligent and adaptive scheduling mechanisms can significantly reduce unnecessary energy consumption while maintaining acceptable levels of performance and reliability. The study highlights the need for scalable, workload-aware, and sustainable scheduling frameworks capable of responding to the dynamic nature of cloud workloads. Energy-efficient resource management can ultimately contribute to greener, cost-effective, and more sustainable cloud computing infrastructures.

Keywords: Cloud Computing, Resource Scheduling, Energy Efficiency, Virtual Machines, Data Centers, Server Consolidation, Load Balancing, Green Computing, Resource Utilization, Quality of Service.