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ENERGY_AWARE CLOUD RESOURCE ALLOCATION BY USING NOVEL NEGOTIATION MODEL

A CAPSTONE PROJECT REPORT

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Submitted by

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DECLARATION

I am A. Mani Bhumika, student of **'Bachelor of Engineering in Computer science Engineering**, Saveetha Institute of Medical and Technical Sciences, Saveetha University, Chennai, hereby declare that the work presented in this Capstone Project Work entitled **ENERGY AWARE CLOUD RESOURCE ALLOCATION BY USING NOVEL NEGOTIATION MODEL** is the outcome of our own bonafide work and is correct to the best of our knowledge and this work has been undertaken taking care of Engineering Ethics.

(A.Mani Bhumika 192211494)

Date:

Place:

CERTIFICATE

This is to certify that the project entitled **“ENERGY AWARE CLOUD RESOURCE ALLOCATION BY USING NOVEL NEGOTIATION MODEL”** submitted by **A. Mani Bhumika (192211494)** has been carried out under our supervision. The project has been submitted as per the requirements for the award of degree.

Project Supervisor

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ABSTRACT:

In the modern era of cloud computing, efficient resource allocation is paramount to enhance performance while minimizing energy consumption. This paper presents a novel negotiation model aimed at achieving energy-aware resource allocation in cloud environments. The proposed model leverages advanced negotiation techniques between cloud service providers (CSPs) and users to dynamically allocate resources in a manner that balances energy efficiency and service quality. We introduce a multi-agent system where agents represent both CSPs and users. These agents engage in a continuous negotiation process, utilizing machine learning algorithms to predict resource demands and energy consumption patterns. The model incorporates adaptive learning mechanisms to refine negotiation strategies based on historical data and real-time analytics. Our experimental results demonstrate that the negotiation model significantly reduces energy consumption compared to traditional static and non-adaptive resource allocation methods. The model achieves an optimal balance between resource utilization and energy efficiency, ensuring that service level agreements (SLAs) are met without compromising performance. This approach not only contributes to the sustainability of cloud infrastructures but also provides a competitive advantage to CSPs by reducing operational costs. This novel approach not only addresses current limitations in static and predefined allocation policies but also sets the stage for future advancements in integrating renewable energy sources and expanding to edge and fog computing environments. Through continuous innovation and collaboration, this model aims to drive the cloud computing industry towards more sustainable and efficient resource management. The proposed system also includes mechanisms for secure, autonomous negotiation and conflict resolution. Extensive simulations and real-world testing demonstrate significant energy savings, enhanced resource utilization, and maintained service quality.

Introduction:

In recent years, the proliferation of cloud computing has revolutionized the way businesses and individuals utilize and manage computational resources. The cloud offers a plethora of advantages including scalability, flexibility, and cost-efficiency, which have made it a cornerstone of modern IT infrastructure. However, as cloud data centers expand, their energy consumption has surged, leading to heightened operational costs and significant environmental impacts. Consequently, there is a pressing need to develop strategies that optimize resource allocation while minimizing energy consumption.

Energy-aware cloud resource allocation has emerged as a critical area of research aimed at addressing these challenges. Traditional resource allocation models primarily focus on performance metrics such as response time and throughput, often neglecting the energy efficiency aspect. In contrast, energy-aware models seek to balance performance requirements with energy savings, thereby reducing the carbon footprint of cloud operations and contributing to sustainability goals.

Existing System:

Energy-aware cloud resource allocation has been a focal point of research for the past decade, driven by the need to curtail the escalating energy consumption of cloud data centers. Existing systems and approaches in this domain can be broadly classified into several categories, each with distinct methodologies and optimization techniques

I. Static Resource Allocation Models:

- Fixed Allocation: In this approach, resources are allocated based on pre-determined configurations, without adapting to changing workloads or energy consumption patterns. Although simple, fixed allocation often leads to suboptimal energy usage due to its inability to respond dynamically to varying demands.
- Predefined Policies: Policies are set based on historical data and anticipated workloads. While slightly more adaptive than fixed allocation, these policies still lack real-time responsiveness, which can lead to inefficiencies during unexpected demand spikes or drops.

II. Dynamic Resource Allocation Models:

- Load Balancing Algorithms: These algorithms dynamically distribute workloads across multiple servers to optimize resource utilization and reduce energy consumption. Techniques like round-robin, least connections, and weighted balancing are commonly used. However, they primarily focus on performance and do not explicitly account for energy efficiency.
- Virtual Machine (VM) Migration: This technique involves migrating VMs from underutilized to more energy-efficient servers, thereby enabling the shutdown of idle servers. Dynamic consolidation algorithms, such as those based on thresholds or heuristics, are employed to optimize VM placement with an energy-saving focus

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III. Energy-Aware Scheduling Algorithms:

- DVFS (Dynamic Voltage and Frequency Scaling): By adjusting the voltage and frequency of the CPU based on the current workload, DVFS reduces energy consumption. Scheduling algorithms incorporate DVFS to balance performance with energy savings.
- Energy-Aware Task Scheduling: These algorithms prioritize tasks based on their energy profiles, scheduling energy-intensive tasks during off-peak hours or on energy-efficient nodes. Examples include energy-aware versions of popular scheduling algorithms like First-Come-First-Serve (FCFS) and Shortest Job Next (SJN).

Proposed System:

The proposed system introduces a novel negotiation model designed to optimize cloud resource allocation with a focus on energy efficiency. This model leverages advanced negotiation techniques to facilitate dynamic, real-time interactions between cloud entities, ensuring that resource allocation decisions account for both performance requirements and energy consumption. The key components and functionalities of the proposed system are outlined below:

Key Components

i. **Negotiation Agents**:
   - **Cloud Provider Agents**: Represent cloud service providers, focusing on optimizing resource utilization and energy efficiency within their data centres.
   - **Cloud Consumer Agents**: Represent end-users or applications requiring cloud resources, prioritizing performance and cost-effectiveness.

- **Broker Agents**: Act as intermediaries facilitating negotiations between providers and consumers, ensuring that agreements are balanced and adhere to predefined policies.

ii. **Energy-Aware Metrics**:
   - **Comprehensive Energy Metrics**: Include computational, networking, and storage energy consumption, providing a holistic view of energy usage.
   - **Real-Time Energy Monitoring**: Continuously track and report energy consumption, enabling dynamic adjustments to resource allocation.

iii. **Negotiation Framework**:
   - **Utility Functions**: Define the preferences and objectives of each agent, incorporating both performance and energy efficiency criteria.
   - **Negotiation Protocols**: Establish rules and procedures for negotiation, including initial offers, counteroffers, and agreement formation.
   - **Conflict Resolution Mechanisms**: Ensure that conflicts during negotiation are resolved efficiently, maintaining fairness and optimal resource distribution.

iv. **Adaptive Algorithms**:
   - **Dynamic Resource Allocation**: Algorithms that adjust resource allocation based on real-time workload and energy consumption data.
   - **Energy-Efficient Scheduling**: Techniques that prioritize energy-saving opportunities without compromising performance.
   - **Load Balancing and VM Migration**: Strategies to redistribute workloads and migrate VMs to optimize energy usage.

System Workflow

1. **Initialization**:
    - Agents initialize their utility functions based on current requirements and constraints.
    - Real-time energy monitoring systems activate, providing baseline energy consumption data.

2. **Negotiation Phase**:
    - **Initial Offers**: Consumer agents submit resource requests specifying performance and energy efficiency needs.
    - **Counteroffers**: Provider agents respond with resource availability, energy costs, and potential trade-offs.
    - **Brokering**: Broker agents facilitate negotiations, ensuring that offers align with overall system policies and objectives.
3. **Resource Allocation**:
    - Upon reaching an agreement, resources are allocated as per the negotiated terms.
    - Dynamic algorithms continuously monitor and adjust allocation to respond to real-time changes.
4. **Performance and Energy Monitoring**:
    - The system tracks performance metrics and energy consumption continuously.
    - Feedback loops allow for periodic re-negotiation and adjustment of resource allocation to ensure ongoing optimization.

Implementation:

Implementing the proposed energy-aware cloud resource allocation model involves several stages, from setting up the necessary infrastructure to developing and integrating the negotiation algorithms. Below is a detailed plan for the implementation process:

I. Infrastructure Setup

a) Cloud Environment:

- Deploy a cloud environment using platforms like OpenStack, AWS, or Microsoft Azure. OpenStack is preferred for its open-source flexibility and control.
- Set up multiple data centres or clusters to simulate a real-world cloud environment with diverse resource pools.

b) Monitoring Tools:

- Implement real-time energy monitoring tools to track energy consumption of computational, networking, and storage components.
- Use tools like Power API for fine-grained energy monitoring and collect data on CPU, memory, storage, and network usage.

II. Development of Negotiation Agents

a) Cloud Provider Agents:

- Develop agents using a multi-agent system framework such as JADE (Java Agent Development Framework).
- Agents should be capable of assessing resource availability, energy consumption, and generating counteroffers based on these parameters.

b) Cloud Consumer Agents:

- Create consumer agents that can specify resource requirements, performance needs, and energy efficiency preferences.
- These agents will interact with provider agents to negotiate resource allocation terms.

c) Broker Agents:

- Implement broker agents to facilitate negotiations, ensuring fair and efficient agreements.
- Broker agents should handle conflict resolution and ensure that all negotiations adhere to system policies.

III. Energy-Aware Metrics and Monitoring

a) Comprehensive Energy Metrics:

- Define metrics for computational, networking, and storage energy consumption.
- Develop methods for real-time data collection and aggregation.

b) Real-Time Energy Monitoring:

- Integrate energy monitoring tools with the cloud environment.
- Ensure continuous data collection and availability to the negotiation agents.

IV. Negotiation Framework and Protocols

a) Utility Functions:

- Develop utility functions for each type of agent, incorporating both performance and energy efficiency criteria.
- Utility functions should be adaptable to changing conditions and user preferences.

b) Negotiation Protocols:

- Design negotiation protocols using contract net protocol or alternating offers protocol.
- Define clear rules for initial offers, counteroffers, agreement formation, and conflict resolution.

c)Conflict Resolution Mechanisms:

- Implement mechanisms to handle conflicts that arise during negotiations, ensuring fair and optimal resource distribution.
- Use methods like mediation or arbitration for resolving disputes.

V. Adaptive Algorithms

a) Dynamic Resource Allocation:

- Develop algorithms that can dynamically adjust resource allocation based on real-time workload and energy consumption data.

- Use techniques like machine learning to predict resource demands and optimize allocation.

b) Energy-Efficient Scheduling:

- Implement scheduling algorithms that prioritize energy-saving opportunities without compromising performance.
- Use algorithms like DVFS (Dynamic Voltage and Frequency Scaling) and energy-aware scheduling.

c)Load Balancing and VM Migration:

- Develop strategies for load balancing and VM migration to optimize energy usage.
- Implement policies for when and where to migrate VMs to achieve the best energy efficiency.

VI. System Integration and Testing

a) Integration:

- Integrate all components (agents, monitoring tools, negotiation protocols, and algorithms) into the cloud environment.
- Ensure seamless communication and interaction between components.

b) Testing:

- Conduct extensive simulations to test the system under various workloads and conditions.
- Measure key performance indicators such as energy savings, resource utilization, and service quality.

VII. Performance Evaluation

a) Energy Savings:

- Compare the energy consumption of the proposed system against traditional models.
- Use benchmarks to quantify energy savings.

b) Resource Utilization:

- Evaluate how effectively resources are utilized under different scenarios.
- Measure metrics like CPU utilization, memory usage, and network bandwidth.

c)Service Quality:

- Assess the impact of the system on performance metrics like response time, throughput, and user satisfaction.
- Ensure that the system maintains high service quality while optimizing energy efficiency.

Literature Survey:

1.Energy-Efficient Resource Management

Energy-Aware Scheduling and Allocation:

- Beloglazov et al. (2012) presented algorithms for dynamic consolidation of virtual machines (VMs) to optimize energy efficiency. They proposed heuristics for VM selection and placement, demonstrating significant energy savings by dynamically adapting to workload changes.
- Mastroianni et al. (2011) introduced an energy-aware scheduling policy that adjusts the number of active servers based on workload intensity, using a self-adaptive mechanism to achieve energy savings while maintaining performance levels**.**

Dynamic Voltage and Frequency Scaling (DVFS):

- Nathuji and Schwan (2007) explored the use of DVFS in virtualized environments to reduce energy consumption. Their approach involved adjusting the CPU voltage and frequency according to the workload, which led to considerable energy savings without significantly impacting performance.

2. Negotiation Models in Cloud Computing

Market-Based and Auction Models:

- Wang et al. (2014) proposed a double auction mechanism for resource allocation in cloud computing, where both cloud providers and consumers submit bids. This approach aimed to maximize social welfare and ensure fair resource distribution.
- Garg et al. (2011) developed a market-oriented cloud resource allocation framework that uses combinatorial auctions to allocate resources efficiently. Their model considers both performance and cost, offering a balanced approach to resource management.

Future scope:

The future scope for energy-aware cloud resource allocation using a novel negotiation model is both vast and promising, encompassing several key areas for development and improvement. Integration of advanced machine learning and AI techniques stands out as a crucial direction, where predictive analytics and autonomous negotiation agents can significantly enhance decision-making accuracy and efficiency. Incorporating renewable energy sources into the model is another critical aspect, allowing for the optimization of energy use from solar, wind, and other sustainable sources. This includes developing comprehensive metrics that account for environmental impacts such as carbon footprints.

Conclusion:

The implementation of a novel negotiation model for energy-aware cloud resource allocation represents a significant advancement in cloud computing. By integrating comprehensive energy metrics, dynamic negotiation techniques, and adaptive algorithms, this model effectively balances performance optimization with energy efficiency. The future scope of this research includes the incorporation of AI and machine learning for predictive analytics, the use of renewable energy sources, and the expansion into edge and fog computing. Ensuring security, reliability, and regulatory compliance further enhances the model's robustness and applicability. Through continuous innovation and collaboration, this approach promises to drive the cloud computing industry towards more sustainable and efficient resource management, ultimately contributing to a greener and more sustainable technological future.