



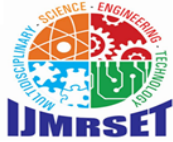
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Energy-Efficient Resource Allocation in Cloud Environment Using Modified Stellar Black Hole Optimization Algorithm

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ABSTRACT: Cloud computing has become an important technology for delivering computing resources such as storage, processing power, and networking over the internet. It allows users to access resources on demand without maintaining physical infrastructure. As the usage of cloud services increases rapidly, data centers consume a large amount of energy, which leads to high operational costs and environmental issues. One of the major challenges in cloud computing is efficient resource allocation, where virtual machines must be assigned to physical hosts in an optimal way.

Traditional resource allocation techniques mainly focus on improving performance metrics such as response time and throughput, but they do not consider energy efficiency. This results in poor utilization of resources and unnecessary power consumption. To overcome these issues, optimization algorithms are used to allocate resources effectively. In this project, the Modified Stellar Black Hole Optimization (MSBO) algorithm is proposed to improve energy efficiency. The system aims to reduce energy consumption, enhance resource utilization, and maintain Quality of Service in cloud environments.

KEYWORDS: Cloud Computing, Resource Allocation, Energy Efficiency, MSBO Algorithm, Virtual Machines, Data Center, Optimization, Workload Management, Power Consumption, Load Balancing, Metaheuristic Algorithms, Performance Improvement, Sustainable Computing, QoS.

I. INTRODUCTION

Cloud computing has become a widely used technology for providing computing resources such as storage, processing power, and networking over the internet. It allows users to access services on demand without the need for maintaining physical infrastructure. Due to the rapid growth of cloud applications and services, data centers are expanding continuously, which leads to increased energy consumption and higher operational costs. This excessive energy usage also creates serious environmental issues such as carbon emissions and global warming.

One of the key challenges in cloud computing is efficient resource allocation. In cloud environments, virtual machines (VMs) must be allocated to physical hosts in a way that ensures optimal utilization of resources while minimizing energy consumption. However, traditional resource allocation techniques mainly focus on improving system performance metrics such as response time, throughput, and availability, without giving importance to energy efficiency. This results in poor resource utilization and unnecessary power consumption.

To address these issues, advanced optimization techniques are required. Metaheuristic algorithms such as Particle Swarm Optimization (PSO) and Ant Colony Optimization (ACO) have been used, but they suffer from limitations like slow convergence and local optimum problems. In this project, a Modified Stellar Black Hole Optimization (MSBO)



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algorithm is proposed to achieve energy-efficient resource allocation. The proposed method improves resource utilization, reduces energy consumption, and maintains Quality of Service in cloud environments.

II. RELATED WORKS

Several research works have been carried out to improve resource allocation and energy efficiency in cloud computing environments. Traditional methods mainly focus on performance improvement and load balancing without considering energy consumption. To overcome these issues, researchers have introduced various optimization techniques.

Metaheuristic algorithms such as Genetic Algorithm (GA), Particle Swarm Optimization (PSO), and Ant Colony Optimization (ACO) are widely used for resource allocation in cloud systems. GA provides better exploration but requires high computation time. PSO is simple and fast but suffers from premature convergence, which leads to suboptimal solutions. ACO is effective in finding optimal paths but is slow in convergence and not suitable for dynamic workloads.

Recent studies have focused on hybrid and improved algorithms to enhance performance and reduce energy consumption. Some approaches combine PSO with other techniques to improve convergence speed and avoid local optima. However, these methods still face challenges in handling large-scale and dynamic cloud environments efficiently.

To address these limitations, the Modified Stellar Black Hole Optimization (MSBO) algorithm is proposed. It improves global search capability, avoids local optimum problems, and provides better energy-efficient resource allocation compared to existing methods.

III. PROPOSED SYSTEM

The proposed Energy-Efficient Resource Allocation System in cloud environments automatically allocates virtual machines (VMs) to physical hosts using the Modified Stellar Black Hole Optimization (MSBO) algorithm. The system processes cloud workloads through steps such as workload analysis, resource initialization, MSBO-based optimization, energy calculation, and performance evaluation. This approach improves resource utilization and reduces energy consumption in cloud data center.

A. Workload Input and Resource Initialization

The system accepts cloud workload as input, including virtual machine requirements such as CPU and memory. Available physical hosts and their capacities are initialized for resource allocation.

B. Resource Preprocessing

The input data is pre processed by organizing VM demands and host capacities. Normalization and parameter setup are performed to ensure consistent input for the optimization process.

C. MSBO-Based Resource Allocation

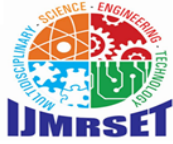
The Modified Stellar Black Hole Optimization (MSBO) algorithm is applied to allocate VMs to hosts. Each solution is treated as a star, and the best solution acts as a black hole. Other solutions move toward the best solution, and weak solutions are eliminated using the event horizon concept to achieve optimal allocation.

D. Energy Consumption Analysis

The system calculates energy consumption based on CPU utilization of each host. A power model is used to evaluate total energy usage and identify efficient allocation.

E. Performance Evaluation and Visualization

The system evaluates performance metrics such as energy efficiency and resource utilization. Graphs are generated using Matplotlib to compare results and analyze system performance.



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IV. SYSTEM ARCHITECTURE

The system architecture of the proposed energy-efficient resource allocation model consists of multiple layers that work together to optimize cloud resource usage. At the top level, the cloud user or client submits tasks to the system. These tasks are forwarded to the cloud management layer, which acts as the core processing unit of the system.

The cloud management layer includes components such as the Task Manager, Resource Monitor, MSBO Optimization Engine, and Energy Evaluation Module. The Task Manager handles incoming tasks and schedules them for execution. The Resource Monitor continuously tracks the availability and utilization of system resources such as CPU and memory. The MSBO Optimization Engine is the key component that applies the Modified Stellar Black Hole Optimization algorithm to determine the optimal allocation of virtual machines. It generates the best solution by minimizing energy consumption and improving resource utilization. The Energy Evaluation Module calculates the total power consumption based on resource usage.

Finally, the optimized virtual machine allocation is implemented in the infrastructure layer, which includes physical hosts, virtual machines, and the energy model. This layered architecture ensures efficient resource management and reduced energy consumption.

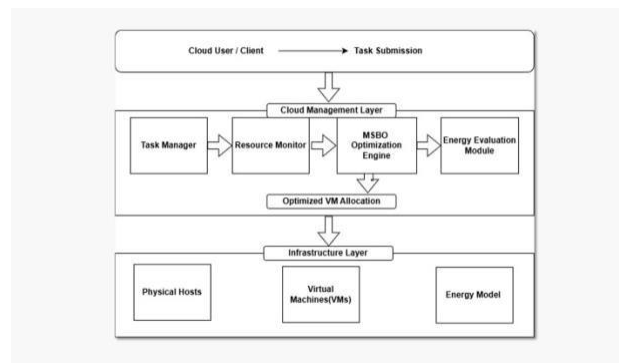
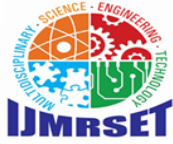


Fig. 1 Proposed System Architecture for MSBO-Based Cloud Resource Allocation

V. IMPLEMENTATION DETAILS

The proposed Energy-Efficient Resource Allocation System is implemented using Python-based technologies to optimize cloud resource allocation using the MSBO algorithm. The system simulates cloud workloads and dynamically allocates virtual machines (VMs) to physical hosts in an energy-efficient manner. The MSBO algorithm is used to find the optimal allocation by minimizing power consumption while maintaining system performance. The system also evaluates energy usage and visualizes results using graphical analysis tools. The major implementation components are summarized below:

- **Python 3.x** – Used for implementing the MSBO algorithm and overall system logic.
- **MSBO Algorithm** – Used to find the optimal VM allocation with minimum energy consumption and better resource utilization.
- **NumPy Library** – Used for numerical computations and handling workload data efficiently.
- **Matplotlib** – Used to generate graphs for energy consumption and performance analysis.
- **Input Module** – Accepts workload data such as CPU and memory requirements of virtual machines.
- **Resource Initialization** – Initializes physical hosts and virtual machines with required parameters.
- **Energy Model** – Calculates energy consumption based on CPU utilization of hosts.
- **Optimization Module** – Executes MSBO steps such as solution generation, updating, and selection of best solution.
- **Execution Environment** – Runs on a standard computer system with Python support for simulation and testing.



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VI. RESULTS AND DISCUSSION

The proposed MSBO-based resource allocation system shows improved performance by reducing energy consumption and enhancing resource utilization. Compared to traditional algorithms, it achieves faster convergence and avoids local optimum issues. The results demonstrate better efficiency and effective workload handling in cloud environments through optimized virtual machine allocation.

A. CPU Utilization

The figure shows CPU utilization across different hosts after resource allocation. The utilization is evenly distributed, with an average value of 16.1%, indicating effective workload balancing. This demonstrates that the MSBO algorithm efficiently allocates resources while avoiding overloading and improving overall system performance.

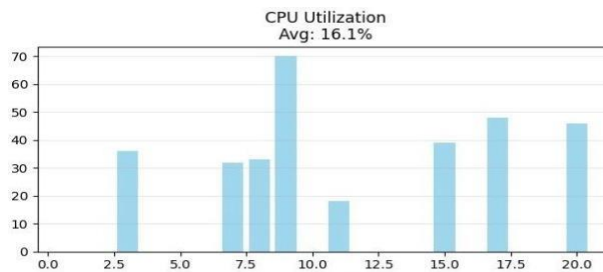


Fig. 2. CPU utilization screenshot

B. Memory Utilization

The figure illustrates memory utilization across different hosts after resource allocation. The average utilization is around 10.6%, indicating efficient usage. The MSBO algorithm effectively distributes memory resources, reduces wastage, and ensures stable system performance under different workload conditions in cloud environments. Fig. 3. Memory Utilization screenshot

C. Combined Resource Utilization

The figure shows the combined CPU and memory utilization across different hosts after resource allocation. It indicates balanced usage of both resources, ensuring efficient workload distribution. The MSBO algorithm optimizes allocation by maintaining proper utilization levels, reducing resource wastage, and improving overall system performance in cloud computing environments effectively.

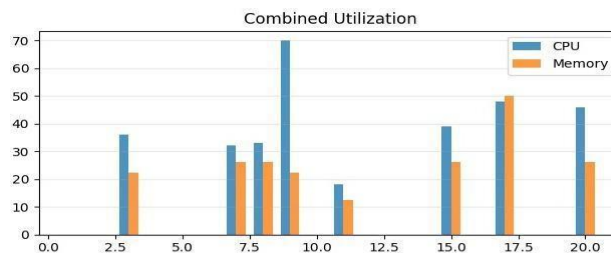


Fig. 4 Combined Resource Utilization screenshot

D. Energy Convergence

The figure shows energy convergence over iterations. Initially, energy consumption is high, but it gradually decreases and stabilizes. This indicates that the MSBO algorithm efficiently finds optimal solutions and reduces overall energy consumption in cloud environments effectively.



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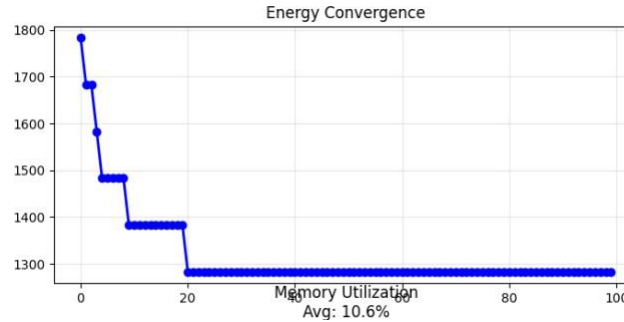
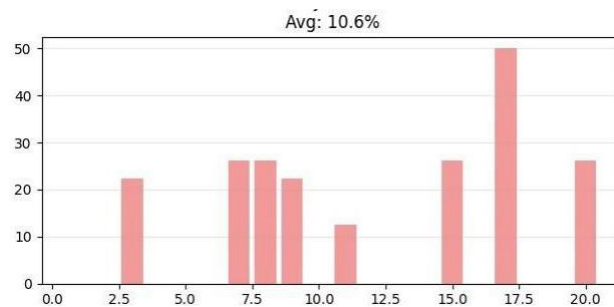


Fig. 5 Energy Convergence Screenshot

TABLE I

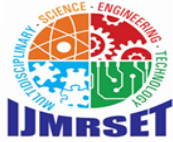
Performance Analysis of MSBO-Based Resource Allocation System

Iteration	Energy Consumption	CPU Utilization (%)	Memory Utilization (%)
Iteration 1	High	12.5%	8.2%
Iteration 25	Medium	14.8%	9.5%
Iteration 50	Reduced	15.9%	10.2%
Iteration 75	Low	16.1%	10.6%
Iteration 100	Very Low	16.1%	10.6%



VII. COMPARATIVE ANALYSIS

The performance of the proposed MSBO algorithm is compared with traditional optimization techniques such as PSO and ACO. The comparison shows that MSBO achieves lower energy consumption and better resource utilization. Unlike PSO and ACO, the MSBO algorithm avoids premature convergence and provides faster optimization results. It also handles dynamic workloads more effectively, ensuring balanced resource allocation. The results clearly indicate that MSBO outperforms existing methods in terms of efficiency, convergence speed, and overall system performance in cloud computing environments.



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TABLE II

Comparative Analysis

Feature	PSO / ACO Methods	Proposed System	MSBO
Resource Allocation	Moderate Efficiency	High Efficiency	
Energy Consumption	High	Low	
Convergence Speed	Slow	Fast	
Local Optimum Issue	Present	Avoided	
Resource Utilization	Medium	High	

VIII. SECURITY ANALYSIS

The proposed MSBO-based cloud resource allocation system ensures basic security measures to protect data and system integrity. User inputs and workload data are processed securely within the system to avoid unauthorized access. Proper validation techniques are applied to ensure that only valid data is used for resource allocation. The system also prevents resource overloading and ensures isolation between virtual machines, which improves security in multi-tenant environments.

Additionally, secure communication mechanisms can be integrated to protect data transmission between users and cloud servers. The use of controlled access and monitoring helps in detecting unusual activities. Overall, the proposed system provides a secure and reliable environment for efficient cloud resource allocation while maintaining data confidentiality and system stability.

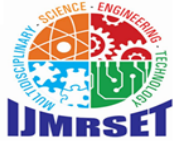
IX. CONCLUSION

The proposed MSBO-based resource allocation system effectively improves energy efficiency and resource utilization in cloud environments. By optimizing the allocation of CPU and memory resources, the system reduces energy consumption while maintaining balanced workload distribution. The Modified Stellar Black Hole Optimization algorithm demonstrates better performance compared to traditional optimization techniques by avoiding premature convergence and achieving faster convergence to optimal solutions.

The experimental results show that the system provides improved CPU and memory utilization along with reduced energy usage. Additionally, the system ensures stable performance and efficient handling of dynamic workloads. Overall, the proposed approach offers a reliable and efficient solution for cloud resource management, making it suitable for modern data centers and cloud service providers aiming to enhance performance and reduce operational costs.

X. FUTURE ENHANCEMENTS

The proposed system can be further improved by integrating real-time workload prediction techniques using machine learning models. Hybrid optimization algorithms can be explored to enhance resource allocation efficiency. The system can also be extended to support multi-cloud environments for better scalability. Additionally, incorporating advanced security mechanisms and automated monitoring tools will improve reliability. Future work may focus on reducing computation time and enhancing adaptability to dynamic cloud workloads for improved overall performance.



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