

International Conference On Advanced Computing Technologies (ICoACT-2025)

Paper Title:

**Hybrid K-Means and Firefly Algorithm-Based Load Balancer for
Dynamic Task Scheduling in Fog Computing for Postoperative
Healthcare Systems**

Paper ID: ICoACT-435

Presenter Name: Tharun Kumar C



Table of Contents

- 1. Introduction**
- 2. Problem Statement**
- 3. Proposed Solution**
- 4. Hybrid K-Means and Firefly Algorithm-Based Load Balancer**
- 5. Cluster Validation Techniques**
- 6. Firefly Algorithm Optimization for Task Scheduling**
- 7. Integration of K-Means and Firefly Algorithm**
- 8. Experimental Setup & Results**
- 9. Conclusion**
- 10. Q&A**

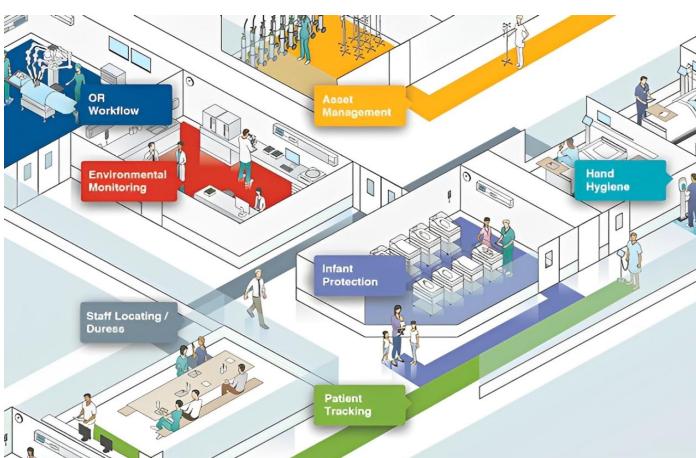


Introduction



Fog computing enables real-time healthcare by reducing latency and network congestion through localized data processing. Traditional cloud systems face high latency and bandwidth issues, making them inefficient for critical applications.

This paper presents a hybrid load balancing approach using K-Means clustering and the Firefly Algorithm (FA). K-Means groups tasks based on computational needs, ensuring balanced workload distribution. FA dynamically optimized task scheduling, improving response time, energy efficiency, and overall healthcare system performance.



Problem Statement

Challenges in Postoperative Healthcare Monitoring:

Traditional cloud systems introduce latency and bandwidth issues, making real-time patient monitoring inefficient. A faster, localized processing solution is needed for timely medical intervention.

Load Balancing Issues in Fog Computing:

Fog computing reduces latency but struggles with uneven workload distribution, leading to inefficiencies. An effective load balancing strategy is required to optimize resource utilization and performance.

Limitations of Existing Techniques:

Static and threshold-based load balancing methods fail to adapt to changing workloads. These limitations result in resource underutilization, overloading, and reduced efficiency in real-time healthcare.



Proposed Solution

Hybrid Approach

Combines K-Means clustering and Firefly Algorithm for optimization.

Efficient Task Allocation

Groups tasks based on computational needs for efficiency.

Dynamic Load Balancing

Distributes workload effectively across fog nodes.



Optimized Performance

Reduces response time, makespan, cost, and energy consumption.

Healthcare Application

Enhances postoperative monitoring in fog-based healthcare systems.

Hybrid K-Means and Firefly Algorithm-Based Load Balancer



Efficient Task Clustering

K-Means groups tasks based on computational needs for better allocation. This reduces delays and enhances resource utilization in fog computing.

Dynamic Load Balancing

The Firefly Algorithm optimizes task distribution to minimize response time. Light intensity guides allocation, improving energy efficiency and performance.

Healthcare Optimization

Enhances real-time postoperative monitoring with reduced latency. Improves makespan, cost, and energy efficiency for better patient care.

Cluster Validation Techniques



Elbow Method

Determines the optimal number of clusters by analyzing variance. The "elbow point" indicates where adding more clusters has minimal benefit.



Silhouette Score

Measures how well tasks fit within their assigned clusters, with a higher score indicating better-defined and well-separated clusters.



Within-Cluster Sum of Squares

Calculates the compactness of clusters based on task distances, with lower WCSS values.



Inter-Cluster Distance

Evaluates the separation between different clusters for clear boundaries, with greater distances ensuring distinct and non-overlapping task groups.



Firefly Algorithm Optimization for Task Scheduling



Nature-Inspired

Uses firefly behavior to optimize task scheduling efficiently in fog computing environments.



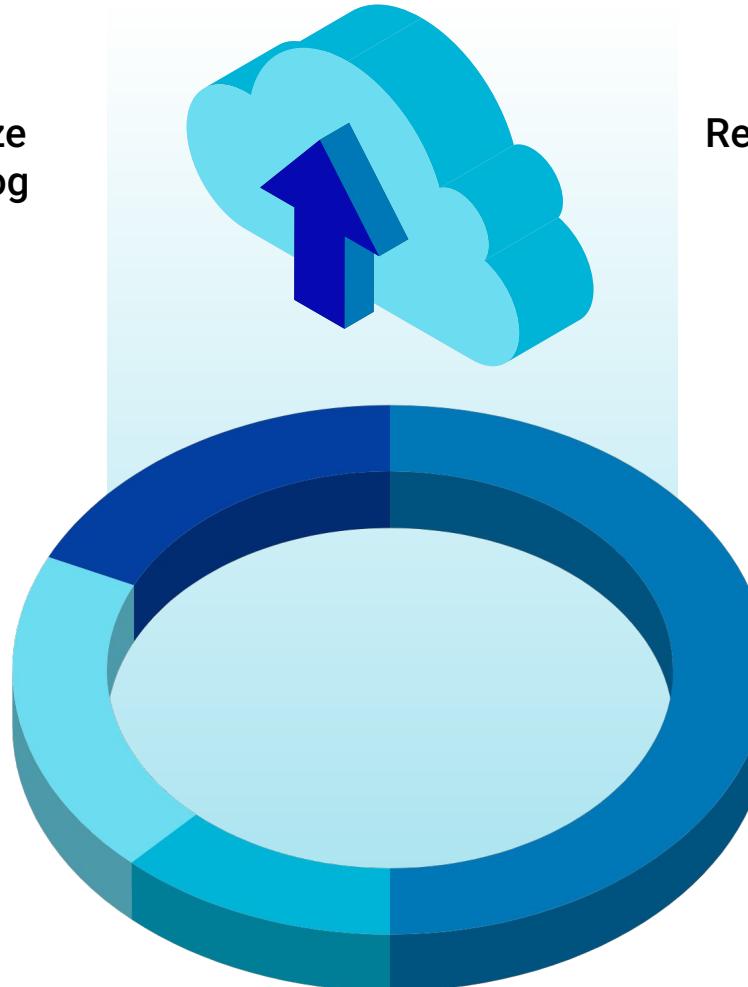
Load Balancing

Dynamically distributes tasks across fog nodes to prevent overload and improve system performance.



Light Intensity Factor

Guides task allocation by evaluating fitness based on workload, response time, and efficiency.



Energy Efficiency

Reduces power consumption while maintaining high computational performance and resource utilization.



Response Time Optimization

Minimizes execution delays for real-time healthcare applications requiring instant processing.

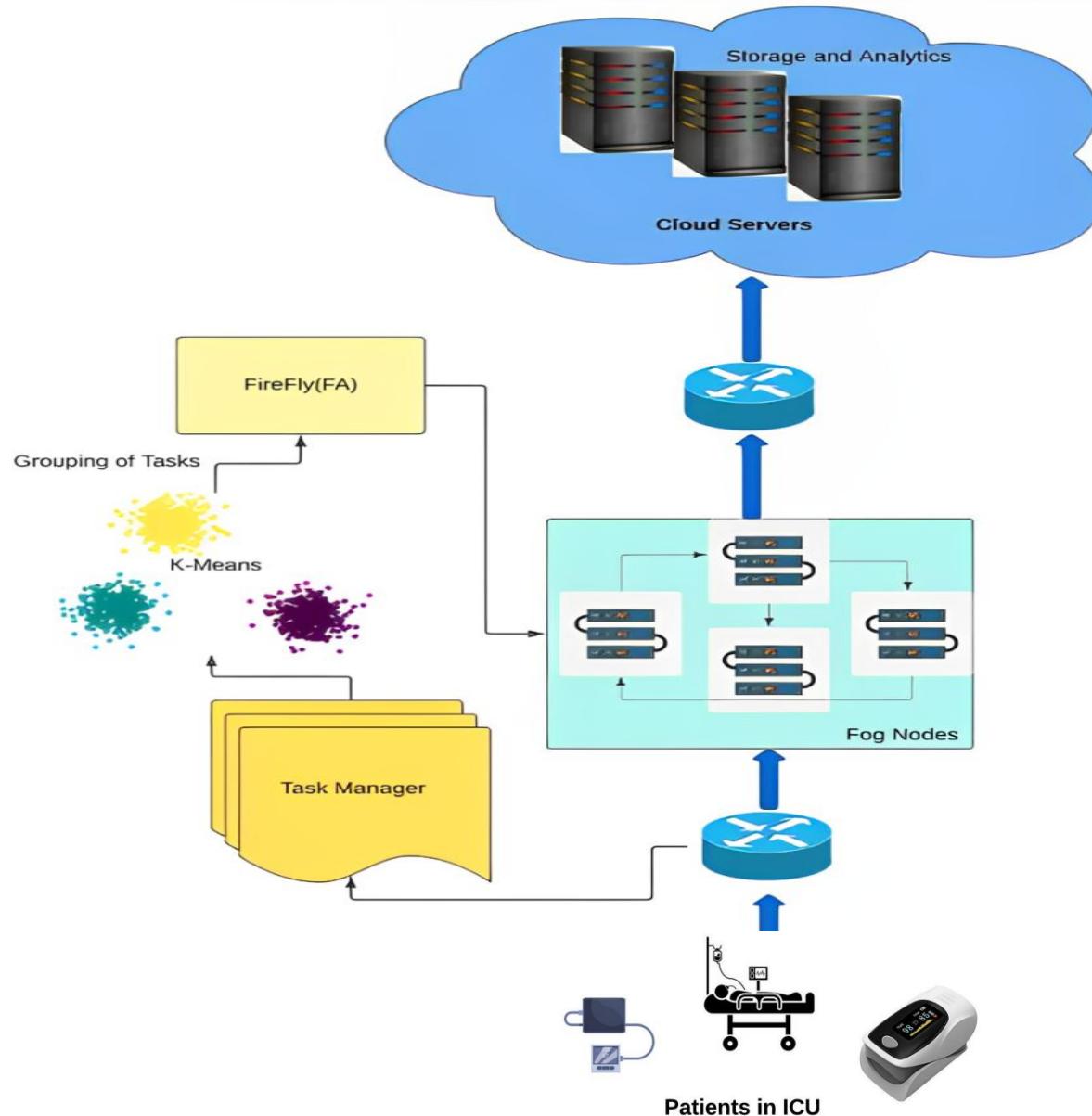


Enhanced Performance

Improves makespan, cost, and task scheduling efficiency in fog computing.



Integration of K-Means and Firefly Algorithm



Initialization



K-Means clusters tasks based on workload and priority, creating an initial task allocation.

Memory Update



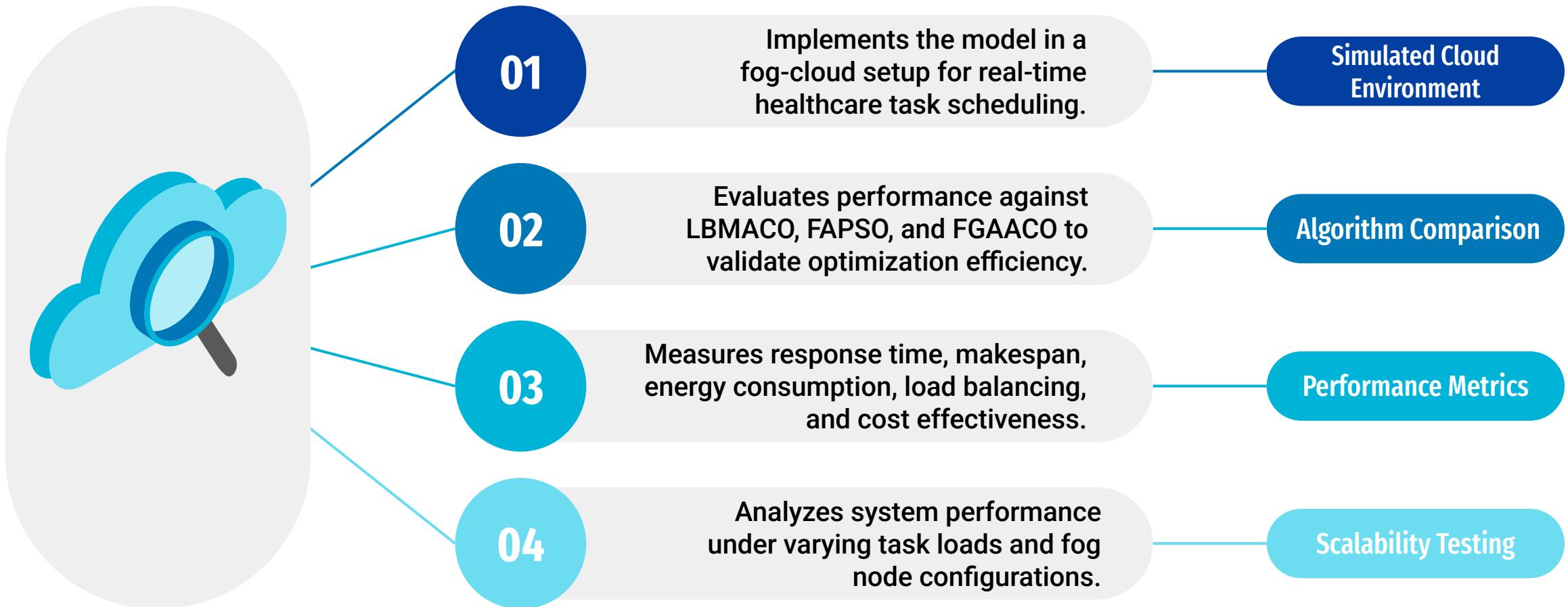
Firefly Algorithm refines cluster assignments by evaluating fitness using light intensity variations.

Position Update

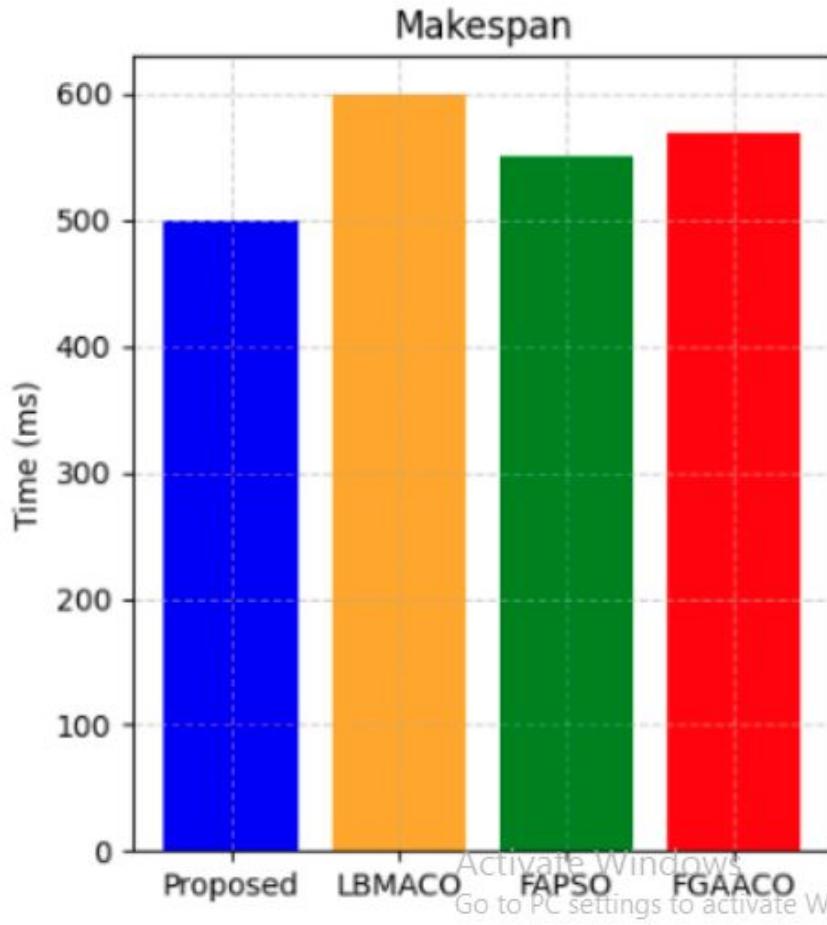
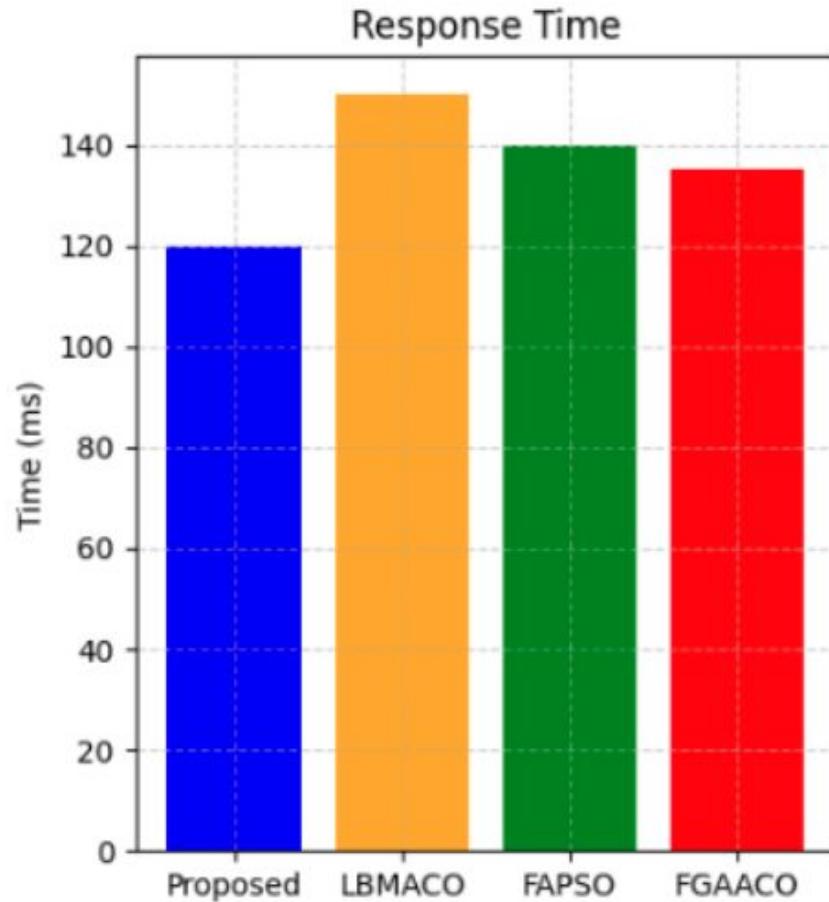


Tasks are dynamically assigned to optimal fog nodes, improving load balancing and efficiency.

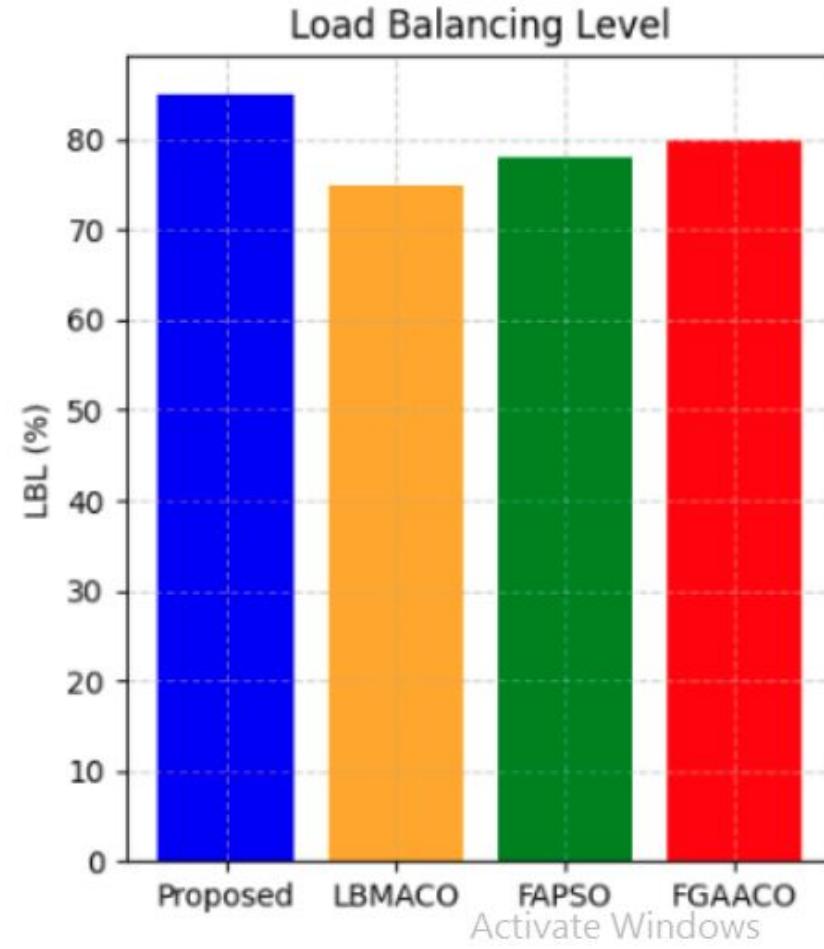
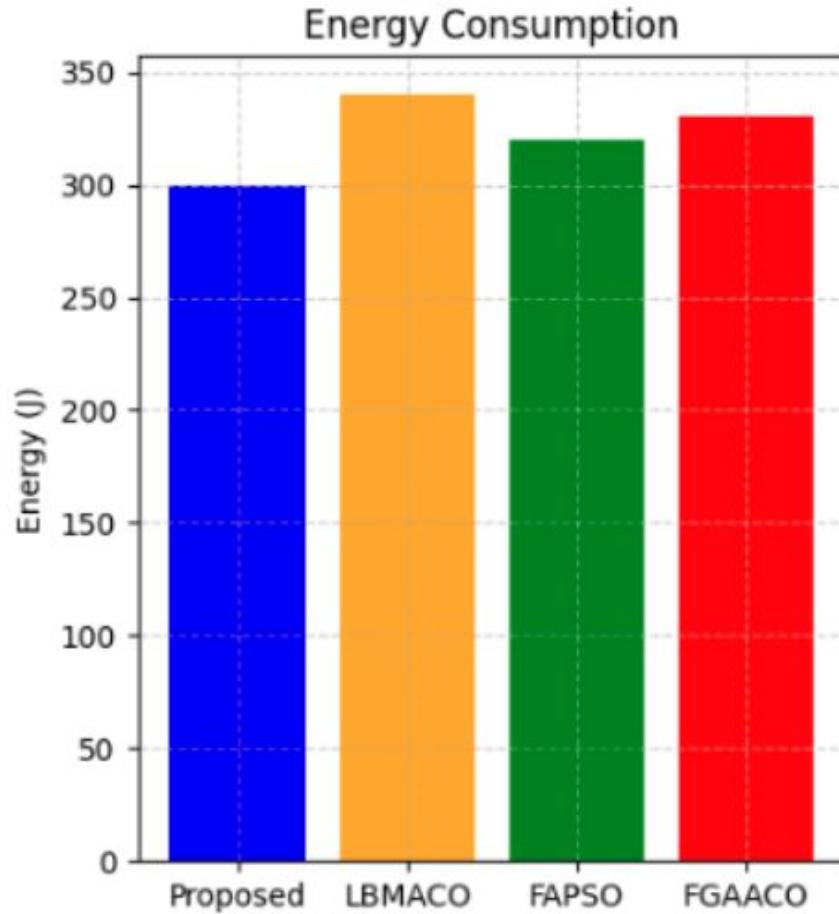
Experimental Setup



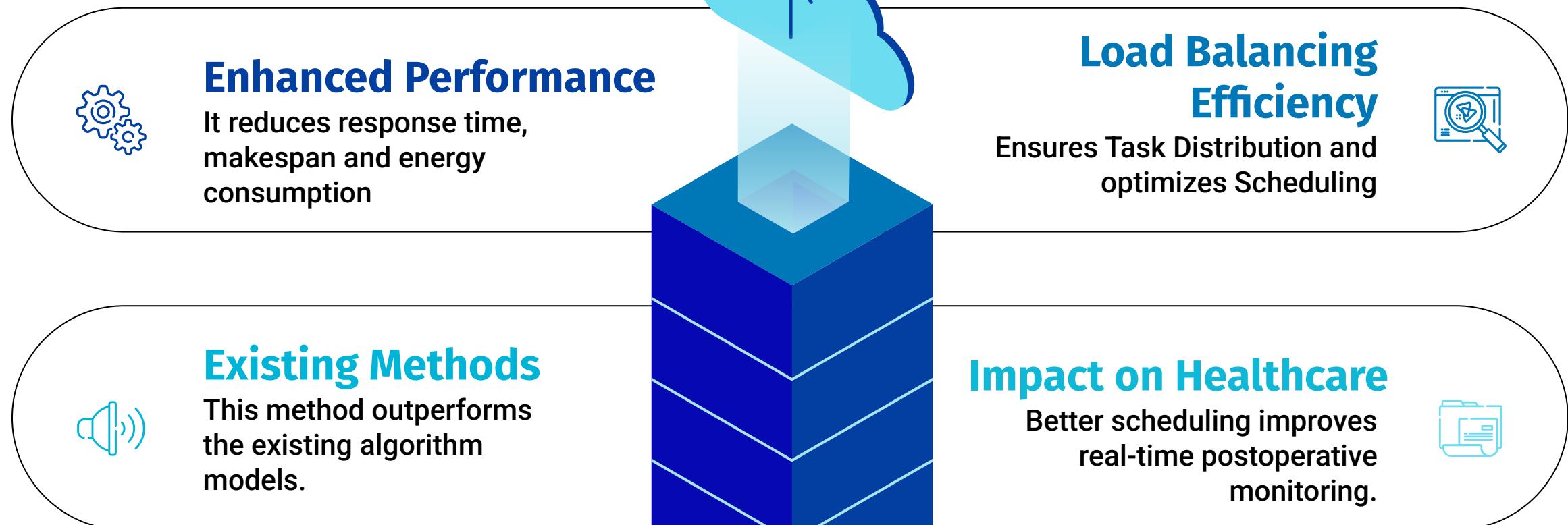
Performance metrics across the models for response time and Makespan



Performance metrics across the models for Energy consumption, load balancing, and Makespan.



Results & Discussion



Conclusion



References

- [1] W. Chongdarakul and N. Aunsri, "Heuristic Scheduling Algorithm for Workflow Applications in Cloud-Fog Computing Based on Realistic Client Port Communication," in IEEE Access, vol. 12, pp. 134453- 134485, 2024.
- [2] M. Hosseinzadeh et al., "Task Scheduling Mechanisms for Fog Computing: A Systematic Survey," in IEEE Access, vol. 11, pp. 50994-51017, 2023.
- [3] A. Ali et al., "Multiobjective Harris Hawks Optimization-Based Task Scheduling in Cloud-Fog Computing," in IEEE Internet of Things Journal, vol. 11, no. 13, pp. 24334-24352.
- [4] K. Cui, W. Sun, B. Lin and W. Sun, "Load Balancing Mechanisms of Unmanned Surface Vehicle Cluster Based on Marine Vehicular Fog Computing," in 2020 16th International Conference on Mobility, Sensing and Networking (MSN), Tokyo, Japan, 2020, pp. 797-802.
- [5] P. K. Mishra and A. K. Chaturvedi, "State-Of-The-Art and Research Challenges in Task Scheduling and Resource Allocation Methods for Cloud-Fog Environment," in 2023 3rd International Conference on Intelligent Communication and Computational Techniques (ICCT), Jaipur, India, 2023, pp. 1-5