INTERNATIONAL JOURNAL OF COMPUTERS AND APPLICATIONS
https://doi.org/10.1080/1206212X.2025.2550736

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Adaptive load-balancing multi-criteria scheduling algorithm for fog computing systems

Shahid Sultan Hajam [a], Iraq Ahmad Reshi [b], Irfan Rasool [b], Afaq Alam Khan [a] and Mohammad Ahsan [c]

[a]Department of Information Technology, Central University of Kashmir, Ganderbal, Jammu and Kashmir, India; [b]Department of CSE, Islamic University of Science and Technology, Awantipora, Kashmir, Jammu and Kashmir, India; [c]Artificial Intelligence Cluster, School of Computer Science, UPES, Dehradun, Uttarakhand, India

ABSTRACT

Fog nodes with multi-processor provides an efficient framework for processing time-sensitive tasks. However, scheduling the tasks in such systems involves challenges: distribution of tasks evenly among fog nodes and also among the processors within each fog node. To tackle these challenges, this paper presents an Adaptive Load-Balancing Multi-Criteria Scheduling Algorithm (ALB-MCSA). The algorithm is designed to incorporate the load balancing algorithm alongside multi-criteria optimization in order to minimize the completion time, energy consumption, and operational cost. The algorithm ensures optimal resource utilization and increased performance by adjusting the weights and evenly distributing the load among the processors. Simulation results depict improved performance in terms of completion time, energy efficiency, operational cost and load distribution. Furthermore, a comparative analysis with conventional algorithms such as FCFS, PRIORITY, and EDF demonstrates the superior performance of the proposed approach across key evaluation metrics.

ARTICLE HISTORY
Received 18 June 2025
Accepted 14 August 2025

KEYWORDS
Scheduling; multi-processor; fog computing; load balancing; resource management; fog computing

1. Introduction

The Internet of Things (IoT) has increased the demand for low-latency computing systems. Fog computing has emerged as a transformative paradigm to address this need by extending the cloud computing capabilities closer to the IoT devices nearer to the network edge. It addresses the limitations of cloud including latency, network congestion, response time, bandwidth and so on [1–3].

The decentralized approach of fog computing enables real-time processing, improved response time, and bandwidth conservation, making it suitable for latency-sensitive applications of IoT. Managing and scheduling tasks among fog nodes presents a significant challenge.

The diversity of fog nodes with diverse processing capability, resource availability, and network connectivity requires adaptive scheduling policies. Furthermore, dynamic nature of tasks requires dynamic strategies for efficient resource utilization [4]. In addition, there is a need to optimize multiple objectives such as energy consumption, latency, and monetary cost in order to enhance the performance of the system. Parallel processing within multi-processor fog nodes requires efficient intra-node task scheduling so as to maximize the resource utilization and minimize the latency [5,6]. Recent research has explored various scheduling policies such as heuristic, meta-heuristic and machine learning based [7–9]. However they often fail to integrate load-balancing mechanisms into multi-criteria optimization frameworks, leading to resource bottlenecks, high energy usage, and uneven task distribution. Moreover a little focus has been given to inter-node task scheduling within multi-processor nodes in fog network [10,11].

This paper presents the Adaptive Load Balancing Multi-criteria scheduling algorithm, an approach designed to schedule the tasks in fog networks. The algorithm optimizes both inter-node and intra-node task scheduling by considering multiple objectives simultaneously including completion time, energy consumption, and monetary cost. The algorithm aims to optimize the system performance and hence improve resource utilization, minimize completion time, energy consumption, and monetary cost. To validate its effectiveness, a comprehensive comparative analysis is conducted against traditional scheduling algorithms such as First Come First Serve (FCFS), PRIORITY, and Earliest Deadline First

CONTACT Shahid Sultan Hajam shahid.sultan@cukashmir.ac.in, shahid.nit002@gmail.com Department of Information Technology, Central University of Kashmir, Tulmulla, Ganderbal 191131, Jammu and Kashmir, India Iraq; Ahmad Reshi rshiraq333@gmail.com Department of CSE, Islamic University of Science and Technology, Awantipora, Pulwama 192122, Jammu and Kashmir, India; Irfan Rasool da.irfanrasool@gmail.com, da.irfanrasool@iust.ac.in Department of CSE, Islamic University of Science and Technology, Awantipora, Pulwama 192122, Jammu and Kashmir, India

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