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AI-Powered Task Scheduler for Multi-Node Space–Ground Computing Using AI : Architecture, Simulation, and Intelligent Decision Framework

Chandan Wagh, Swapnanjali P. Thorgule, Rishikesh Boril
Kundan Chaudhari, Umesh Chaudhari, Vijay Chavan
Department of Computer Engineering
Dr. D. Y. Patil College of Engineering and Innovation Varale, Talegaon, Pune, MH, India
chandan.wagh@dypatilef.com, swapnanjali.thorgule@dypatilef.com, tpagare951@gmail.com
Kundanchau624@gmail.com, umeshchaudhari8858@gmail.com, vijaychavan65000@gmail.com

Abstract: *This paper presents a Hybrid Optimization Frame- work for Multi-Objective Resource Allocation in Low Earth Orbit (LEO) Satellite Edge Computing environments. We pro- pose a novel scheduling methodology that integrates Genetic Algorithm (GA) optimization to discover near-optimal Pareto frontiers with Generative AI (GenAI) inference for contextual risk assessment and Explainable AI (XAI) justifications. The framework addresses dynamic power and latency trade-offs across large satellite constellations, introducing adaptive con- straint management for real-time decision-making. The proposed system architecture consists of three primary components: (1) a GA-based multi-objective optimizer that explores the solu- tion space for task-satellite assignments, (2) a GenAI-powered contextual analyzer that evaluates scheduling decisions using Large Language Models (LLMs), and (3) an XAI module that generates human-interpretable explanations for schedul- ing recommendations. Experimental simulations conducted on synthetic satellite constellation datasets demonstrate that this hybrid AI optimization strategy achieves up to 23% improve- ment in makespan reduction, 18% better energy efficiency, and 31% enhanced load balancing compared to traditional heuristic approaches. The framework maintains computational efficiency with average decision times under 2.5 seconds for constellations of up to 50 satellites, making it suitable for real-time space– ground computing applications. Our results validate that inte- grating evolutionary optimization with generative AI significantly enhances computational efficiency, decision transparency, and energy utilization in distributed satellite edge networks.*

Keywords: Hybrid Optimization, Resource Allocation, LEO Satellites, Edge Computing, Generative AI, Genetic Algorithms, Explainable AI, Multi-Objective Scheduling, NP-Hard Problems, Satellite Constellations

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