Hybrid Grey Wolf Optimizer and Elitism Genetic Algorithm for Multi-objective IoT Service Placement in Fog Computing Environment

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ABSTRACT

In response to the expanding use of the Internet of Things (IoT), fog computing was created to enhance cloud computing services and meet the requirement to process and store enormous volumes of newly created data. In this environment, we address the service placement problem by proposing a new hybrid meta-heuristic algorithm that combines the Grey Wolf Optimizer and the Elitism Genetic Algorithm. The iFogSim simulator is used to evaluate the performance of the proposed approach. The results were compared to metaheuristics from the literature: Elitism Genetic Algorithm and Grey Wolf Optimizer. Simulation results show that the proposed algorithm is more efficient than both the Grey Wolf Optimizer and the Elitism Genetic Algorithm in terms of execution time and total cost.

Keywords: Fog computing, IoT service placement, Meta-heuristic Algorithms

1 Introduction

The rapid proliferation of the Internet of Things (IoT) has ushered in a new era of digital connectivity, with billions of devices continually generating vast volumes of data. To efficiently manage this data deluge, Fog computing has emerged as a pivotal solution. Fog computing bridges the gap between traditional cloud computing and edge devices, offering an agile and decentralized resource pool [1]. The growth of IoT devices shows no signs of slowing down, with forecasts predicting over 500 billion connected devices by 2030 [1]. This staggering expansion has given rise to complexities in the placement of IoT services within Fog computing environments. Optimizing service placement has become a central concern, directly impacting the efficient utilization of computational resources, minimization of latency, and management of costs [2]. To tackle the multifaceted service placement problem in Fog computing, researchers have turned to various heuristic and meta-heuristic techniques [2], including the Grey Wolf Optimizer (GWO) [3] and Genetic Algorithms (GA) [2]. In this paper, we introduce a novel hybrid meta-heuristic approach, harnessing the synergies of the Grey Wolf Optimizer and the Elitism Genetic Algorithm (GWOEGA) to tackle the intricate problem of IoT service placement in Fog computing environments.

2 Methodology

We present our approach to address IoT service placement in fog computing. We propose a mathematical model to map IoT services onto fog nodes while considering resource constraints and costs. Beginning with a service set (S) encompassing diverse IoT services with distinct CPU, RAM, and bandwidth requirements, we allocate these services to fog and cloud nodes (denoted as F). We calculate execution times for each node to determine the total execution time and costs. To balance execution time and cost, we introduce a fitness function utilizing a weight factor (α). By adjusting α, we prioritize either objective. The optimization process aims to minimize this function, finding the optimal service-to-node mapping. Ultimately, our goal is to achieve a balance between speedy execution and cost-effectiveness, customizable to specific system requirements.

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The proposed GWOEGA algorithm is designed to optimize IoT service placement in heterogeneous distributed fog computing environments by combining the strengths of GWO and EGA. This algorithm follows a series of stages to achieve its objective.

1. Initialization: A random population representing service mappings.
2. Fitness Evaluation: The generated population is evaluated by the fitness value
3. Selection of Leaders: The best three individuals (α, β, and δ).
4. Grey Wolf Optimization: The three selected leaders are used to generate new individuals
5. Elitism: Select top-performing individuals for the next generation.
6. Crossover and Mutation: New offspring are produced through crossover and mutation
7. Iterative Optimization: Steps 2 to 6 are repeated iteratively until a satisfactory result is achieved.

3 Results and Discussion

Figure 1 illustrates a comparative evaluation of IoT service placement algorithms. It showcases the performance metrics of fitness value, execution time, and overall cost for the proposed GWOEGA algorithm in contrast to traditional meta-heuristic algorithms, EGA, and GWO. The graph depicts GWOEGA consistently outperforming both EGA and GWO in terms of fitness value, execution time, and total cost showcasing its superior optimization capability for the same number of IoT services.

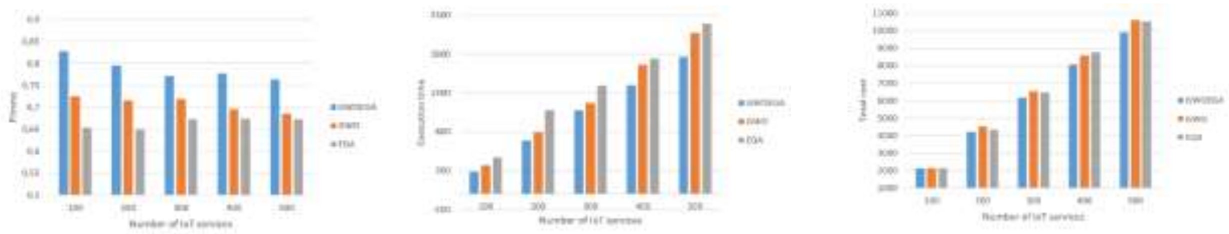

Figure 1: *Comparative Evaluation of IoT Service Placement Algorithms*

4 Conclusion

In conclusion, our research presents the GWOEGA algorithm as an effective solution for optimizing IoT service placement in Fog computing environments. The algorithm's ability to balance exploration and exploitation, adapt to varying user needs, and outperform existing meta-heuristic algorithms demonstrates its potential for practical applications. While acknowledging its limitations, we believe that the GWOEGA algorithm represents a significant step forward in addressing the challenges of IoT service placement in Fog computing.

How to Cite

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