Analysis ofResource Scheduling algorithms for optimization in IoT-Fog-Cloud System

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Abstract

Resource planning is one of the critical problem in the IoT-Cloud-Fog system due to the resource-constrained.Data processing in the cloud system is creating headache because the amount of IoT devices is increasing rapidly.The problem of delay, and network bandwidth arises in the cloud environment due to the increase in IoT devices. To overcome the arises problem in the cloud system, the Fog layer introduces.The fog layer is established on edge of the network and communication between the IoT devices and storage, Computation system reduces. Many Researches introduced optimization algorithms like Min-Min, Max-Min, PSO, ACO, FCFS, Roundrobin, GA, etc., Which results in an improvement in makespan, time, cost, and energy in IoT-Fog-Cloud System. In this paper, we have evaluated and discussed Round Robin, Max-Min, Min-Min, PSO, and GA Scheduling algorithms on parameters Time, makespan, Energy, and costby simulation setup. The simulation result has shown the performance of optimization algorithms is better on IoT-Fog-Cloud system in comparison toonly-Cloud, and only-Fog, the Min-Min algorithm is performing better in comparison to Max-Min and Round Robin Scheduling algorithm, and GA is still showing better results over PSO on some parameters.

Keywords

Resource Scheduling, Optimization, Fog, Cloud, Task scheduling.

1. Introduction

In today's Scenario, manyhuman life trends are becoming dependent on IoT devices.IoT devices are spreading in various fields like in healthcare, industries, home-based electronics things, and vehicles[1].That's why the amount of IoT devices is increasing rapidly. As an estimate by the year 2025, the number of IoT devices will be reached to approximately 1 Trillion [2]. Various types of applications like healthcare systems, traffic management, smart home, and spatial data management are based on IoT devices [3,4]. All these applications are required on-time response to provide effective processing to users [5]. By using the storage and computation capabilities of the Cloud, these applications are functioning for users. But the distance between IoT devices and the cloud is creating the problem of delay-tolerant, network bandwidth, and latency [6]. To overcome the problems of cloud by some extent the Fog system has been introduced [7].

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The Fog layer is placed between the IoT devices and the cloud layer. So that real-time processing for IoT devices could be improved.The Fog system is a combination of various fog nodes like routers, switches, base stations, and smartphones [8,9]. Each Fog node is having limited processing capabilities and storage. All Fog nodes are connected through the network with IoT devices as shown in **Figure 1**.

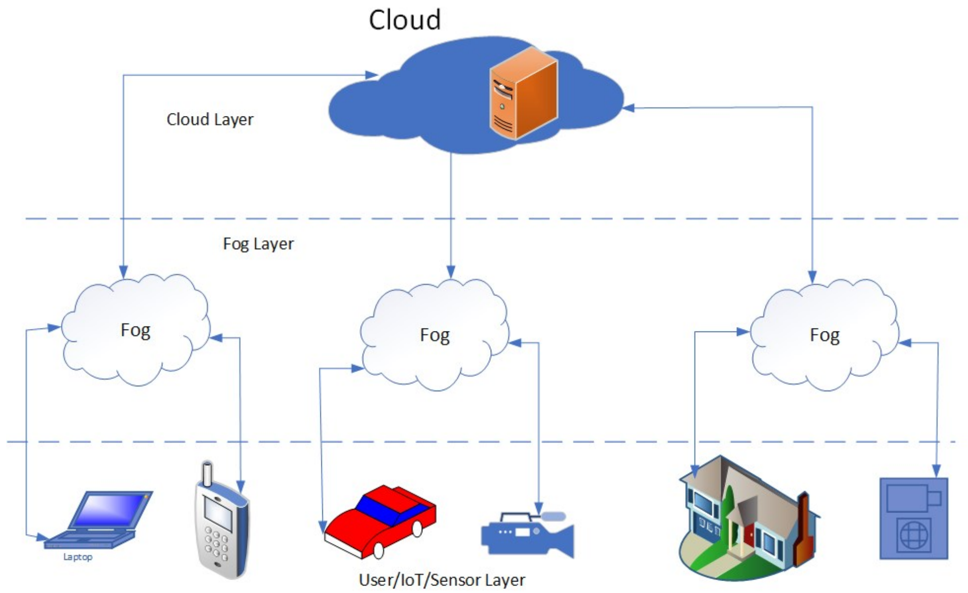

Figure 1: IoT-Fog-Cloud Architecture

At the Fog layer, fog nodes are varying in terms of storage & computation capabilitiesand, applicationsare competing for resources to provide efficient processing to the users. For providing resources to IoT devices effectively, Resource Scheduling is required in the IoT-Fog-cloud system[10].

Scheduling of resources is one of the headache in the System because of the limited number of available resources in the Fog layer. If available resources are allocated to IoT devices efficiently then parameters like response time, makespan, cost, and network bandwidthcould be optimal [11].Hence many optimization algorithms like Min-Min, Round robin, Max-Min, FCFS,PSO, ACO, etc. have been implemented for optimal QoS in the IoT-Fog-cloud system [12,13].

1.1 Contribution/Outline and goal of this paper

In this paper, we have evaluated and discussed various Scheduling algorithms like Round Robin, Max-Min, Min-Min, PSO, and GA on parameters Time, makespan, Energy, and cost. The main contributions for this paper are as follow:

1. How Resource utilization is affected on platforms-on fog, on Cloud, and IoT-Fog-Cloud.
2. In Min-Min, Max-Min, and Round Robin, which is performing better on IoT-Fog-Cloud System for parameter time and cost.
3. Evaluation of PSO and GA on parameters makespan, energy consumed, and cost on IoT-Fog-Cloud System

1.2 Organization

The rest of the paper is enlightening as follows: section 2 gives a discussion on existing work related to the resource scheduling technique in contrast to task scheduling and resource allocation. The discussion on heuristic optimization algorithms is described in Section 3. Section 4 describes a simulation setup of the IoT-Fog-Cloud system.In the end, the paper is concluded in section5.

2. Related Work

In this segment, some existing resource scheduling techniques which are implemented for optimal QoS in the Fog paradigm have been discussed. Many researchers have done resource scheduling through task scheduling and resource allocation techniques. The main agenda of all the researchers were to minimize the cost, minimize the makespan, effective utilization of network bandwidth, and minimize energy consumption. But most researchers have worked on two to three parameters out of these mentioned parameters.

SniahRehman et al.[14] proposed the Min-Min algorithm for managing resources utilization efficiently. The researcher calculated the completion time of tasks and by following the property of the Min-Min algorithm, resources were assigned to those tasks which havethe lowest execution time. In this paper, the Researcher has worked on only cost and makespan parameters. Seema et al. [15] proposed hybrid algorithms LJFP-PSO and MCT-PSO on the cloud environment and made a comparison of proposed algorithms with the PSO algorithm. The researcher has successfully shown parameters cost, makespan, and total energy consumption has been reduced in comparison to PSO. Bushra Jamil et al. [16]proposed a new approach for reducing energy and delay consumption in fog system and made a comparison with the proposed approach with the FCFS approach and effectively shown the proposed approach has reduced delay and energy consumption in comparison to the FCFS approach.The author implemented the proposed approach in the healthcare system.MarwaMokniet al. [17] proposed a technique of multi-agent-based genetic algorithm for reducing makespan, cost, and response time. The researcher made the comparison of the proposed approach with fog and cloud on parameters cost, makespan, and response time and achieved improvement in the proposed approach.Salim Bitam et al.[18] proposed a Bees life optimization algorithm for efficient utilization of resources. Researchers reduce parameters memory utilization and CPU execution timeto some extent.Mostafa Ghobaei-Arani et al.[19]suggesteda moth-flame optimization algorithm for effective utilization of resources. Senthil Kumar et al.[20] proposed a firefly and crow algorithm for reducing makespan and in return helpful to maximize throughput of thesystem.T. Choudhari et al.[21]proposeda cuckoo optimization algorithm for reducing response time and cost by utilizing the offloading process in the system.

3. Heuristic algorithms for optimization

Heuristic and Metaheuristic algorithms are problem-solving algorithms. For finding an estimated optimal solution for a given problem like resource utilization in our case. Various optimization algorithms [22,23] had provided by researchers. Heuristic algorithms are problem-dependent. On the other hand, metaheuristic algorithms are problem-independent.Heuristic algorithms are categorized into heuristic and metaheuristic [24].Likewise, Min-Min, Max-Min comes under a heuristic algorithm. Round Robin is a type of Hyper-heuristic& PSO, ACO, and Genetic algorithms are Metaheuristic type algorithms. Many researchers have worked on resource scheduling problems in the IoT-Fog-cloud system to provide optimal solutions on parameters cost, time, makespan, and energy [25,26,27].

4. Simulation Setup

For evaluating the results, we have used the Fog Workflow sim toolkit[28,29]. The toolkit was run on Windows 7-64-bit system having a Core i3 processor (2.40Ghz), and 8GB RAM.The entire evaluation was run on setup having 5 Cloud Server with MIPS 1600, 10 fog devices with MIPS 1300, and 50 IoT devices with MIPS 1000.All evaluation was scheduled for 40 and 100 tasks. For the result evaluation, various Scheduling algorithms like Min-Min, Max-Min, Round Robin, PSO, and GA were run on the Fog workflow Sim toolkit for parameters makespan, time, energy, and cost.

Min-Min scheduling algorithm was evaluated on only Fog system, only Cloud System, and IoT-Fog-cloud System for parameter makespan, Energy consumed, and cost as shown in **Figure 2 and Figure 3**. Comparison for all these platforms was contrasting to show how resource utilization is affected on different platforms. All three parameters are less in the fog system as a comparison to the cloud system as shown in **Figure 2 and Figure 3**. But when the simulation was run on a complete IoT-Fog-Cloud system, results are getting better in comparison to only Fog and only cloud system. Because resources of both the fog system and cloud system were utilized in combination in a single simulation.

Evaluation of Min-Min, Max-Min, and Round Robin was done in a simulation environment for parameters Time and cost as shown in **Figure 4 and Figure 5**. As mentioned, simulation was run for 40 and 100 tasks. For 40 tasks, the Min-Min algorithm is performing better in comparison to Max-Min and Round Robin Scheduling algorithm. But for 100 tasks, the Round Robin scheduling algorithm is a little bit closer for cost parameter with the Min-Min Scheduling algorithm. The Max-Min algorithm is failed to show performance in comparison to both algorithms.

Makespan, Energy consumed and cost parameters made a base for contrasting comparison between PSO (particle swarm optimization) and GA (Genetic algorithm) as shown in **Figure 6 and Figure 7**. For PSO simulation setup constants like Number of particles=20, Number of iterations=30, Learning factor c1=1.37, Learning factor c2=1.37, inertia weight=0.37 and Repeated Experiment=2 was set.and for GA, constants like population size=20, Number of iterations=30, crossrate=0.8, Mutation rate=0.01, and repeated experiment=2 was set. For 40 tasks performance of GA is better on all three parameters. But for 100 tasks, the makespan of both the algorithms is almost the same. But for the cost and energy consumed factor GA is still showing better results over PSO.

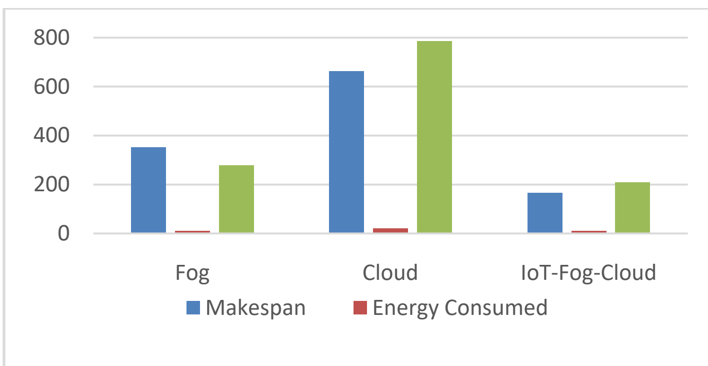

Figure 2: Min-Min Scheduling For 40 Tasks

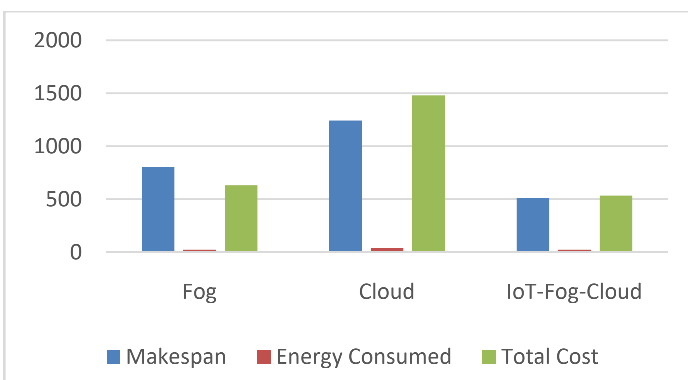

Figure 3: Min-Min Scheduling For 100 Tasks

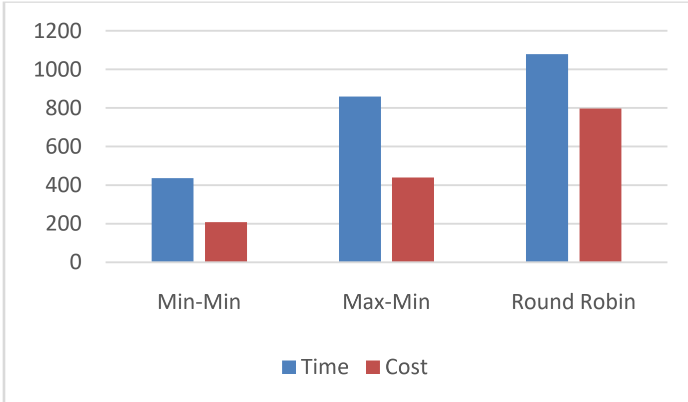

Figure 4: Comparison of Scheduling Algorithms on IoT-Fog-Cloud System for 40 Tasks

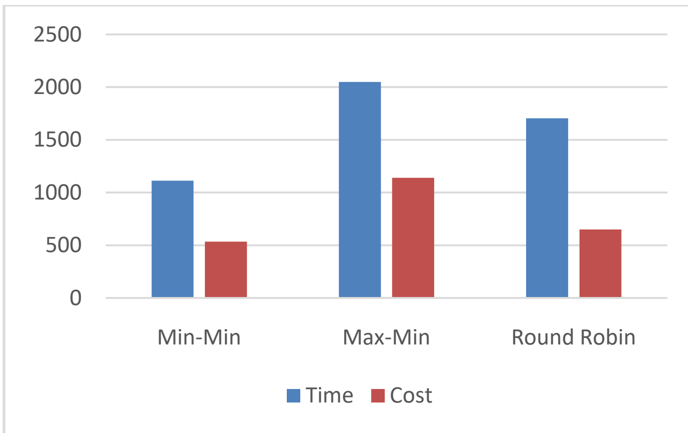

Figure 5: Comparison of Scheduling Algorithms on IoT-Fog-Cloud System for 100 Tasks

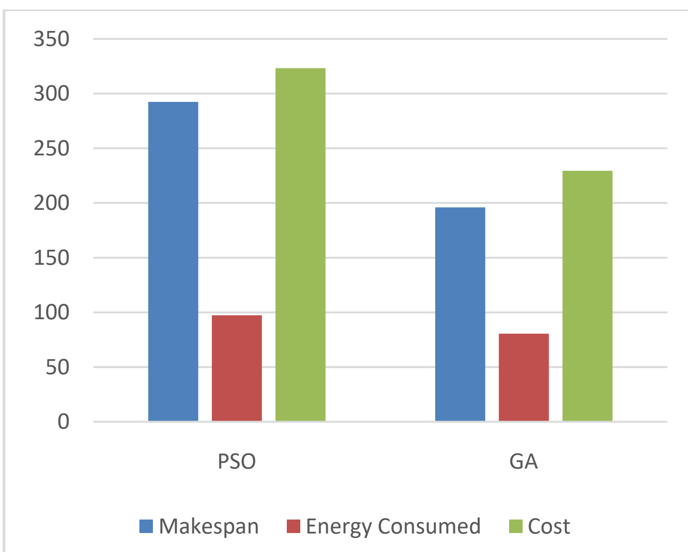

Figure 6: Comparison of PSO and GA on 40 Tasks

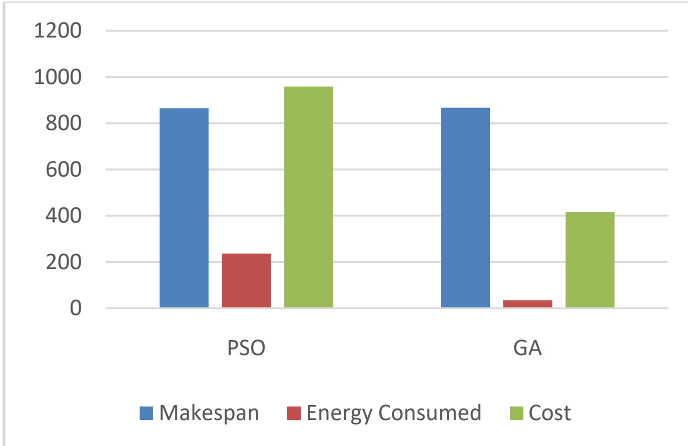

Figure 7: Comparison of PSO and GA on 100 Tasks

5. Conclusion and Future work

For an increasing number of IoT devices,the problem of latency, network bandwidth, and delay arises.QoS in the IoT-Fog-Cloud system is determined by resource scheduling strategy. In this paper, a discussion on various heuristic optimization algorithms has been done.For evaluating the result, the simulation was done on the Fog workflow sim toolkit for various optimization algorithms like Round Robin, Max-Min, Min-Min, PSO, and GA on parameter Time, cost, makespan, and energy.The simulation result shows QoS parameters, on the Fog system are better in comparison to the only cloud system and, Min-Min algorithms shows better result comparison to Max-Min & Round robin algorithm. Simulation result of PSO and GA shows, Genetic algorithm performance is better in IoT-Fog-cloud system on parameter makespan, energy consumed, and cost.
In the Future, the simulation environment will be determined on some latest optimization algorithms like the Black widow, Cat swarm, Antlion,and Monarch Butterfly optimization algorithms.

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