Reliability aware Resource Scheduling based on Fuzzy Cuckoo Search (FCS) Technique for IaaS Cloud

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Abstract. Resource scheduling assigns the precise and accurate tasks to CPU, network, and storage. The aim behind this is the optimum usage of resources. However, well-organized scheduling is needed for both cloud providers and cloud users. Several resource scheduling algorithms have been discussed in the literature, but there are little emphases to reliability aware resource scheduling. In this research article, an innovative technique is proposed that is known as the Fuzzy Cuckoo Search (FCS) technique based on the fuzzy theory and cuckoo search algorithm to solve real-time optimization problematic issues. The FCS technique is used to address the reliability aware resource scheduling problems in IaaS Cloud. An experiment has been carried out on the CloudSim simulator and results of FCS techniques are compared with the Genetic Algorithm (GA), Honey Bee (HB) and Particle Swarm Optimization (PSO) scheduling algorithms. Finally, computational results demonstrate that the FCS technique is produced 39.21% better optimal solutions than the best solutions obtained by the comparison algorithms in terms of failure rate. It specifies that the FCS technique is more appropriate for reliability aware resource scheduling for IaaS Cloud.

1. Introduction

In Cloud Computing, the business and IT resources such as applications, processors, networks, servers, storage and VMs dynamically provision to the cloud users' needs and workloads. These resources are metered and cloud users pay according to their usage. It also supports the fluctuation of cloud users' demand and availability of resources, without affecting the performance and any restriction. The main reasons for the need and use of cloud computing are accessibility and reliability [1]. Scheduling of cloud resources is a critical problem for Infrastructure as a Service (IaaS) in the CC environment. Efficient scheduling is the optimal mapping of cloudlets/tasks to the required virtual resources. In the IaaS cloud, cloud users always want the ideal virtual resources from the thousands of cloud resources provided by cloud providers. However, it is not possible to schedule all these

resources manually and an optimized resource scheduling algorithm or technique is required to deal with this critical problem in the IaaS cloud [2].

Reliability is one of the main criteria or parameters in planning or making decisions for maintaining the cloudlets/tasks in the IaaS cloud. Reliability is the ability to ensure the strength of cloud computing and considered to be an essential part of the IaaS cloud [3]. Hence, the guarantee of reliability is one of the important characteristics of resource scheduling, which requires advanced reliability as an essential standard. As a result of the extensive usage of cloud resources, enhancing the reliability helps reduce the physical and financial risks for IaaS in IaaS Cloud.

In this research article, we formulate an innovative Fuzzy Cuckoo Search (FCS) technique for reliability aware resource scheduling for the IaaS cloud. It enhances the Quality of Service (QoS), to allocate the specific cloudlets to the explicit Virtual Machines (VMs) by enhancing the availability and reliability with less failure rate for fulfilling the demands of accurately and improving the resource utilization for cloud providers. In conclusion, this research article analyzes the risk to cloud based resource scheduling for the distribution of IaaS resources achieving the reliability and availability of traditional deployment. Also, it makes opportunities and the proposed FCS technique to improve reliability and availability with less failure rate for resource scheduling problems in the IaaS cloud. The main contributions of this research study are chronicle as follows:

- An inventive Fuzzy Cuckoo Search Optimization (FCS) technique is developed for reliability aware resource scheduling in the IaaS cloud.
- Comparative analysis of the FCS technique with existing meta-heuristic algorithms for resource scheduling in the IaaS cloud.
- Performance evaluation of the FCS technique as a comparison to the surviving meta-heuristic algorithms by considering the mediums of failure rate.

The rest of this research article's sections are consistently organized as follows: In the next section, the existing comparison studies and related works are reviewed for reliability aware resource scheduling problems in the IaaS cloud. Further, a comprehensive description of the FCS algorithm is provided. The simulation setup, results and discussion demonstrate the experimental simulation for the performance evaluation. The last section includes the details of the conclusion and recommendations.

2. Related Works

In this section, the existing and current studies are reviewed for reliability-based resource scheduling problems within the IaaS cloud. Frequently studies are concentrated on heuristics, meta-heuristics and hybrid algorithms for resource scheduling in the IaaS cloud. Cloud users' demands are fluctuating according to their need for required resources. Problems in terms of availability, reliability and overload are found in a heterogeneous and dynamic cloud environment.

To solve all these problems, Kumar and Patel [4] propose an ANN-PSO model based on Artificial Neural Network (ANN) and Particle Swarm Optimization (PSO) algorithm to analyze the estimated time of users' requests, performance analysis and utilization of resources. Makespan and cost fitness functions are used as the objective function. Further, Charity and Hua [5] propose a pro-active method that tolerates the problem based on processing, memory and network to increase resource reliability.

For this purpose, the first proposed method calculates the reliability of each VM with the help of the success rate of task execution and after that mapping the task on a more reliable VM. Moreover, Sun, et al. [6] propose a comprehensive theoretical model for calculating energy consumption, performance and reliability of multi-agent cloud computing. It requires a genetic algorithm in developing global request scheduling methods, which gives significant results between performance and energy consumption.

Similarly, Kumar and Raza [7] suggest the PSO algorithm for VM scheduling to reduce the wastage of resources and servers in the IaaS cloud. Simulation results show that for VMs allocation, the PSO algorithm performs better than Best-Fit, First-Fit and Worst-Fit algorithm by considering the performance and scalability. Hence, Kumar, et al. [8] propose an innovative Resource Allocation and Adaptive Job Scheduling algorithm for enhancing the reliability of resource accessibility and reduce the execution time which indirectly improves the QoS for cloud users. However, Hung, et al. [9] present a task scheduling strategy by considering bandwidth speed and cost to condense the recovery time in case of failure in improving the availability and reliability of cloud services. Likewise, Gupta and Ghrera [10] propose fault and load aware Honey Bee (HB) algorithm for resource scheduling in the IaaS cloud in order to load and failure rate, thus enhancing the QoS and performance. Also, Guddeti and Buyya [11] recommend a bio-inspired hybrid algorithm that is a hybridization of modified PSO and Cat Swarm Optimization (CSO) algorithms to allocate a task to VMs for improving the reliability, response time and resource utilization.

In the same way, Zavvar, et al. [12] design an algorithm based on fuzzy logic for resource scheduling to improve the reliability, turn-around time and waiting time. Moreover, Awad, et al. [13] enhance the PSO algorithm by hybridization of Load Balancing Mutation (LBM) and develop the LBMPSO algorithm for resource availability, reschedule the failure task. Hence, Sharma, et al. [14] identify the importance of energy and reliability aware resource allocation and scheduling policy to enhance the availability of the cloud services by minimizing the consumption of energy. Among the most popular meta-heuristics performed to resolve reliability awareness of resource scheduling problems includes the Honey Bee and PSO algorithms in the IaaS cloud. The analysis of the related works is revealed that most of the studies are based on PSO, while HB and GA meta-heuristic algorithms are also used for reliability-based resource scheduling in the IaaS cloud.

3. Methodology

Fuzzy CuckooSearch (FCS) technique is a composition of a fuzzy logic approach and cuckoo search algorithm. The FCS technique applies fuzzy logic to filter out the population and then applies the cuckoo search for refining the population for resource scheduling in the IaaS cloud. A fuzzy approach at the first level is used for controlling diversification and intensification. Cuckoo is also has a distinct member of a population, so this population is competent as a second level of control, which is reorganized by introducing a new form of smarter cuckoos and more effective in the search solutions. For this purpose, a fuzzy approach selects the best population according to Figure 1.

The population is represented as $x_i = (x_1, x_2, \dots, x_d)$ which includes the cloud resources. The index of the whole best population is g and after selection represented as $\Delta x_i = (\Delta x_1, \Delta x_2, \dots, \Delta x_d)$ and calculated with the help of Equation 1. Let $f(x)$ be arbitrary reference set, the characteristic function of each normal sub-set of x. $\mu_f(x): R \rightarrow (0,1)$is defined in Equation 1. For each $x \in R$; $\mu_f(x)$, it will

take only one of the values 0 and 1. This behavior serves as an inspiration for creating a new kind as known as smart cuckoos. It has the capability to select the alternative host resource during breading and avoids abandonment's eggs. These cuckoos use the pre and post breading mechanisms for observing the host resource to select either the nest is the best option or not, which is considered to be a much better choice for the cloudlet.

For simplicity, the adopted search mechanism is divided into two main steps: by the new fraction of cuckoos in the proposed FCS technique. (a) Firstly, a smart cuckoo moves with the help of Levy flights in the direction of a new solution. (b) From the existing solution, the smart cuckoo looks for a new better solution in the same search space. These two steps are directly introduced so that the population of FCS technique is organized in terms of three kinds of cuckoos' searches:

- A smart cuckoo searches the best resource that includes the new solution, which is more superior than the random solution selected from the initial population.
- A fraction*pc* of smart cuckoo looks for solutions from the current position and tries to enhance them. It moves from one area to another with the help of Levy flights for finding the best solution in all regions, without being stuck in the local optima.
- A fraction*pa* of smart cuckoo finds the new solutions distant from the best solution.

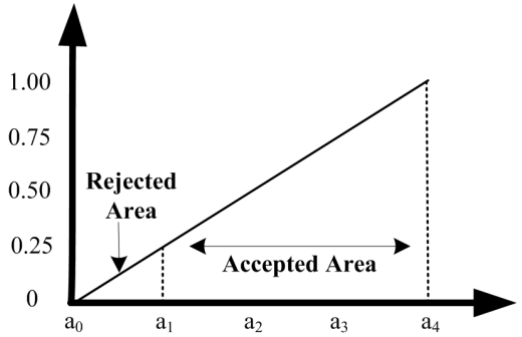


Figure 1. Fuzzy Accepted and Rejected Area

$$\mu_f(\mathrm{x}) = \begin{cases} 0 & a_1 \le x < a_1 \\ 1 & a_1 \le x \le a_4 \, a\epsilon \, R, \\ 0 & x > a_4 \end{cases} \qquad 0 \le x \le 1 \tag{1}$$

The aim of this development is to strengthening the intensive search for the best solution from the population. At the same time, randomization is precisely applied for exploring the new areas by using Levy flights. Fuzzy approach and the smart cuckoo make it possible for the FCS technique to achieve more professionally. It gives better resistance in local optima and avoids all prospective traps in the case of reliability aware resource scheduling in the IaaS cloud. Figure 2 presents the flowchart of the FCS technique design.

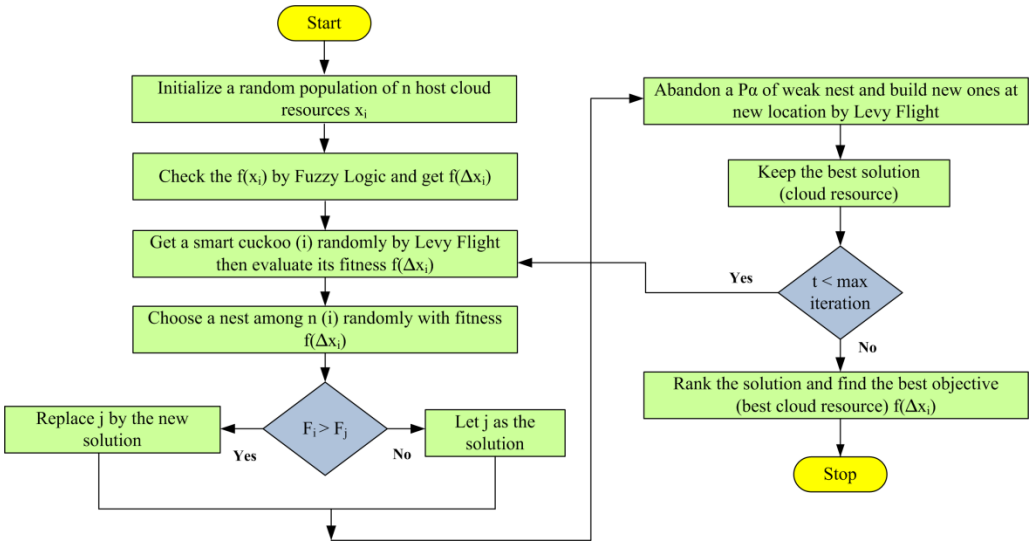


Figure 2. Flow Chart of Fuzzy Cuckoo Search (FCS) Technique for Reliability aware Resource Scheduling

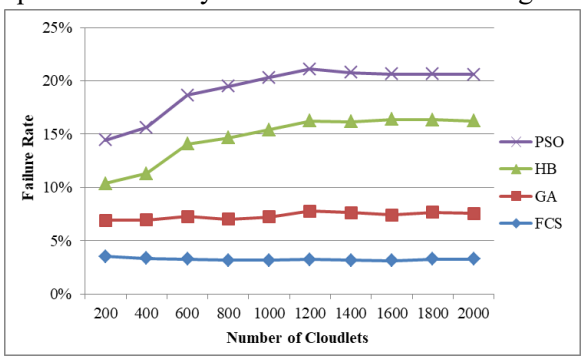
4. Simulation Setup

In this section, the simulation setup is designated for the computational simulation's results and significance analysis attained after the execution of the Fuzzy Cuckoo Search (FCS) technique, and current selected meta-heuristic algorithms for reliability aware resource scheduling in IaaS cloud. The simulation has been implemented on an Intel CoreTM i5 processor, 3.20 GHz processor speed, 1 TB hard disc drive and 4 GB memory. The experimental simulations are implemented with 2 datacenters with 35 hosts, each containing 50 VMs, 100 users and 200-2000 cloudlets under the CloudSim simulation environment. The parameter settings of the cloud simulator are based on [15-17]. All meta-heuristic algorithms are executed in the CloudSim simulator [18] by using the workload traces as HPC2N (High-Performance Computing Center North) [19], NASA Ames iPCS/860 [20] and SDSC (San Diego Supercomputer Center) [21], respectively. The failure rate is used as performance metrics by the help of Equation 2 that is the ratio of the sum of total failed cloudlets in the proposed FCS technique to the sum of total failed cloudlets in other comparison algorithms. The proposed FCS technique will enhance the failure ratio if it is less one [17].

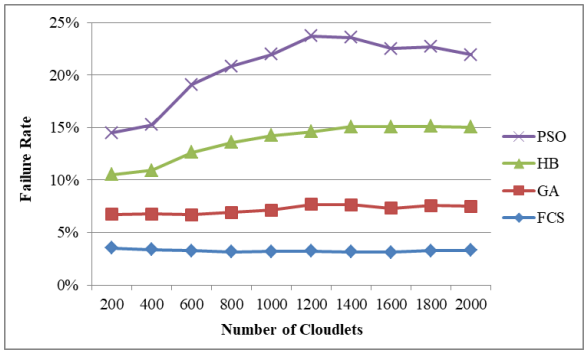
$$Failure\ Rate = \frac{\sum_{i=0}^{n} total\ failed\ tasks\ (FCS)}{\sum_{i=0}^{n} total\ failed\ tasks\ (other\ algorithms)} * 100 \quad (2)$$

5. Results and Discussion

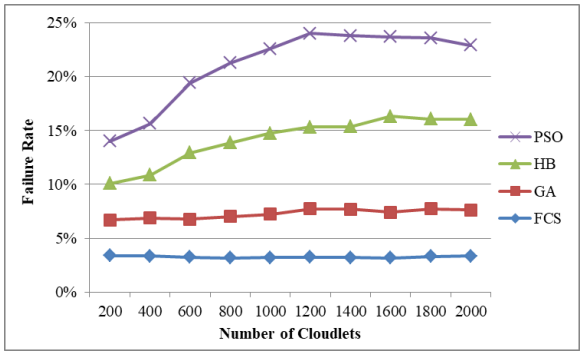
This section identifies and discusses the computational simulations' results to obtain the performance of the proposed FCS technique for reliability aware resource scheduling for the IaaS cloud.



(a) HPC2N



(b) NASA



(c) SDSC

Figure 3. Failure Rate for Resource Scheduling Comparision by using the (a) HPC2N, (b) NASA, (c) SDSC

Figure 3 (a), (b) and (c) illustrate the performance based on the failure rate of the FCS technique. The proposed FCS technique is compared with three resource scheduling algorithms (GA, HB and PSO) for the IaaS cloud. In Figure 3 (a), (b) and (c), it can be noted that the failure rate of resource scheduling algorithms is slightly the same as growing the number of cloudlets. However, the FCS technique is able to minimize the failure rate as compared with GA, HB and PSO algorithms, specifically as increases the cloudlets instances. The consequences of these outcomes are that the FCS technique would enhance the number of cloud users, support economize for saving more money and significantly improve the users' QoS while using the IaaS cloud.

The results show the proposed FCS technique improves the quality of solutions during the search process, making them more efficient and reliable for cloud resource scheduling. Since the arrival of demands in the IaaS cloud are unpredictable in sizes, where large computing workloads are said to arrive at the cloud datacenter, IaaS cloud requires scheduling schemes that can handle the fluctuating demands. The FCS algorithm can adapt the scalability and reliability of cloud environments since it is capable of scheduling huge cloudlets and can meet customers' expectations by improving the reliability and throughput while reducing the failure rate.

6. Conclusion

FCS technique is proposed for reliability aware resource scheduling by using the Fuzzy approach with Cuckoo Search (CS) algorithm for the IaaS cloud. The FCS algorithm is designed to handle resource scheduling while the execution is still ongoing. The purpose of the FCS technique is to address the problem of reliability aware resource scheduling in the IaaS cloud by paying special attention to execute the scheduling of resources without any interruption and local trap. The simulation outcomes demonstrate that the proposed FCS technique provides better quality in terms of failure rate as compared to the GA, HB and PSO algorithms by returning less failure rate. The results indicate that the FCS technique is more applicable for reliability aware resource scheduling in the IaaS cloud. In the future, additional cases, performance metrics and comparison of the proposed technique are required in a real cloud environment.

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