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Task scheduling in the cloud computing using an improved cuckoo search algorithm

Parminder Kaur
kaurparminder317@gmail.com
Adesh Institute of Engineering and Technology, Faridkot, Punjab

Sarabjeet Kaur
sarb7316@gmail.com
Adesh Institute of Engineering and Technology, Faridkot, Punjab

ABSTRACT

Cloud computing is an advanced internet resources network that is used by many users remotely. The resources include software, hardware, and various applications. The main challenge in cloud computing is task scheduling due to numerous requests are generated simultaneously from remote locations. To overcome this challenge, task scheduling algorithms are designed that appropriately arrange the tasks. In the literature, metaheuristic algorithms have been deployed for optimal task scheduling. The most popular algorithms are genetic algorithm, particle swarm, and cuckoo search algorithm. However, if the initial population of these algorithms is properly not defined then it is easily trapped into the local optimal solution and causes low precision. In this paper, we have overcome this issue and designed an improved cuckoo search algorithm. In the proposed method, the initial population is defined using the chaotic map algorithm and after cuckoo search algorithm is applied to determine optimal task scheduling. The experimental results show that the proposed method is superior in terms of convergence rate, makespan, average waiting time, and average turnaround time as compared to the existing algorithm.

Keywords— *Cloud Computing, Chaotic Map, Cuckoo Search Algorithm, Task Scheduling.*

1. INTRODUCTION

In the digital world, a large number of businesses are directly dependent on cloud computing such as e-commerce and online payment methods. Cloud computing can be defined as the perfect business software that offers a large number of business resources with accuracy and with high performance. It is user-friendly and facilitates variable pay-per-use services to many users. Users can get these services in the form of software like software as a service (SaaS), Security as a service ((SECaaS), big data as a service (BDaaS), infrastructure as a service (IaaS), and platform as a service (PaaS), etc [1]. Nowadays, most of the business has turned online and is dependent on cloud computing. Also, there are a large number of companies that provide these services which are cost-effective as well as better in quality [2]. Despite that, because of heady diversion towards the application of cloud computing in the technology field, cloud computing is being considered very loaded with heavy numbers of users. So, it is necessarily important to apply the intelligent way to handle cloud resources that is profitable for the service providers. The scheduled technique is one of the main ways for ensuring the submitted tasks to the available cloud resources that are to be executed [3]. In brief, we can say, cloud computing should have a routine information system with hosts that are represented in below figure 1 [4].

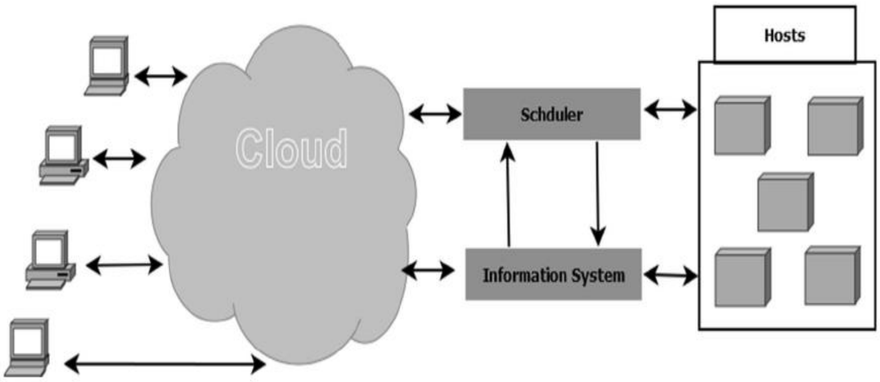

Fig. 1: Scheduling Model of Cloud Computing System [1]

In the figure, the Scheduling process consists of different individual components and each of these has some specific task. Among all, the scheduler and the information system are the main responsible component in the scheduling process. The strategies of the scheduling process are controlled by the scheduler whereas the collection of informative data that are necessary for the scheduling process is controlled by the information system. This data includes information about the tasks, namely, the total number of tasks, their size, required processing power, and memory. After collecting all information, its information is communicated to the scheduler for further processing. The scheduler applies a scheduling algorithm to assign each task to the suitable virtual machine to be executed. This process involves the series of collected information data, details of each task such as the size of the task, memory required, and the processing power. Similarly, available resources and details regarding each of them like capacity, memory, and the number of processing units available. Then finally, these data are sent to the scheduler where it is analyzed using an algorithm for the execution of data by the virtual machine. In the same figure, hosts create the virtual machine and also show the linking between each component of the cloud computing process. The complete system performance and resource utilization are affected by the scheduling technique that sets inside the scheduler. The performance of cloud computing systems is fully dependent on the scheduling process and if it is not implemented carefully, the overall system losses most of its time in analyzing instead of computing the required operations [5].

Presently, many advanced innovations have been developed for resolving the scheduling process that improves the performance of cloud computing systems [6]. Although, these techniques are not sufficient and efficient to resolve the complete problem. The results obtained from each technique are applied for the generation of a new solution and the sustainable function is to be used to study the new solution [7]. The present study shows that that the well-known cloud computing system developed for scheduling are: genetic algorithm (GA), Particle swarm optimization (PSO), and cuckoo search (CS) algorithm. From these techniques, the cuckoo search (CS) algorithm is the most powerful and applicable technique in comparison to other techniques. This algorithm is strongly based on the reproduction process of the birds, mainly cuckoo birds as cuckoo birds search for others' nests to lay their eggs. If each egg in the nest shows the solution, then the cuckoo bird shows a new and different solution. Similarly, if the bird of that nest can able to identify the cuckoo egg then may break and destroy the egg or leave the nest [8]. So from this, it is cleared that this computing algorithm can be easily trapped and causes less precision which is less precise if the initial number of eggs of the host nest is not properly determined [9].

This research paper deals with the proposed cuckoo search algorithm that helps to schedule tasks in a cloud computing system. For this, the chaotic map is used in the generation of the initial population. It is a good and precise way for more diverse change compares to the available cuckoo optimization technique. This proposed technique is accepted globally as it prevents falling into the local optimal solution. After all, the cuckoo search algorithm is considered for the scheduling of tasks. Apart from a specific aim, we have also made a multi aimed suitable system to acquire the optimal solution. Finally, the performance of the proposed algorithm is listed with the help of the available algorithm based on different factors. Hence the results represent that the proposed algorithm is better and suitable as compared to the present existing algorithms.

The remaining research paper is divided into the following sections. In section 2, we have discussed the cuckoo search algorithm, logistic chaotic map, and the essentials for hybridization. Section 3 deals with the proposed technique and section 4 illustrate the results and finally, section 5 shows the conclusion and future scope of the proposed cloud computing system.

2. RELATED WORK

In this part of the paper, for the comprehensive understating of the proposed technique algorithm such as cuckoo search and chaotic map are discussed. Later in this paper, the requirement of Hybridization is also discussed.

2.1 Cuckoo Search Algorithm

For a better understanding of the CS algorithm, it is important to understand the breed behavior of the species of cuckoo. After reviewing this behavior, we will then draft a framework of the step-by-step procedure of the CS algorithm [10].

2.1.1 Breeding Behavior of Cuckoo: Cuckoos are in the category of entrancing birds, and the reason for this is not only its mesmerizing vocal sound of this bird but the strategy of reproduction of these birds. A part of the cuckoo species such as guira and ani, use the common nests for laying the eggs. However, they tend to remove the eggs of other birds to enhance the chances of hatching for their eggs. Many species are involved in this type of brood parasitism in which they use nests of other birds of different species for laying the eggs. Brood parasitism can be broadly categorized into three basic types i.e. cooperative breeding, intraspecific brood parasitism and nest capturing. Sometimes the intruding cuckoos face conflict from the host birds. It is common that the host birds find out the eggs from another species, in that case, the host birds toss these eggs out of their nests or leave the nest and create a new one on some other place. Some of the species of cuckoos, for example, the new brood-parasitic Tapera have been advanced to an extent that they became experts in imitating the exact features of the eggs resembling some of the host species. This minimizes the chances of identifying the eggs by host birds and enhances the reproductivety of the cuckoo species. It is also interesting to know that the scheduling of the egg-laying process is also remarkable. Parasitic cuckoos time their eggs in such a way that it almost matches the timing of the host bird egg-laying process. It general, the hatching duration of the cuckoo eggs is slightly less than the host eggs. After the hatching of the first cuckoo, they tend to toss the host eggs out of the nest, which maximizes the food portion of the cuckoo chicks from the host bird. It is also observed and identified from the different studies that, the cuckoo chicks imitate the call of host chocks to increase the chances of feeding prospect.

2.1.2 Levy flights: In widespread nature, it is observed that various creatures look around for food in a different manner that can be based on random or quasirandom techniques. Normally, the creatures follow a random path, and the selection of the next move is dependent upon the present state or location as well as the transition probability of the location where they want to go. The selection and planning of the direction are dependent on the probability that can be designed mathematically. For example, it is observed by various studies that the behavior of flight for insects and animals can be characterized based on the Levy Flight. These behaviors are being adapted for optimization. In the initial finding, this shows optimum results for the optimal search.

2.1.3 Cuckoo Search Algorithm: In order to describe the CS method in a simple manner [4], three standard rules are adopted that are as follows:
- Each cuckoo lays a single egg at once and used a randomly selected nest for this purpose.
- The best nests that have superior quality eggs are responsible for the next generation of cuckoos.
- The count of the available host nest is known, and the probability that the host identifies the alien egg is Pa ε[0, 1]. After identifying the alien egg, the host can leave the nest and create a new nest on some other location or toss out the alien eggs from their nests.

In order to easily understand the concept, the last assumption of probability is taken in fraction Pa of the n nests that can be left by the host. To get the maximum, it is considered that the fitness of the solution is directly affected by the objective function. Another type of fitness can also be derived in such a way the fitness function is derived in the case of GA. On the basis of these three assumptions, the basic steps of the CS are outlined as follows:

For generating a new solution termed as $x^{(t+1)}$ for cuckoo, they are dependent on the Levy flights.

$$x_i^{t+1} = x_i^{(t)} + \propto \oplus \, Levy(\lambda) \tag{1}$$

In which the $\propto > 0$ is considered as the step size that is directly associated with the requirement of the problem of interest. Commonly we can consider $\propto = O(1)$. The Levy flights specifically give the random walk, while the random steps are derived on the basis of the Levy distribution for large steps.

$$Levy \sim u = t^{-\lambda}, (1 < \lambda < 3) \tag{2}$$

That has an infinite mean with the infinite variance. In this, the sequential steps of the cuckoo bird are considered as the random walk that is based on the power-law step length distribution with the consideration of a heavy tail. The pseudocode for the cuckoo search algorithm is demonstrated in Fig. 2.

2.2 Chaotic Map Algorithm

The logistic map showing the chaotic trend is taken among the nonlinear chaotic discrete system (DCS). The 1DCS can be termed in the equation shown below [11]:

$$X_{n+1} = \mu X_n (1 - X_n) \tag{3}$$

In which the μ signifies the chaotic factor and n signifies the count of the iteration.

2.3 Need for Hybridization

As per the three rules discussed above for the standard CS, the host nest is considered as the possible solution in the multi-dimensional space. Random selection of the location of the new nest minimizes the capability of the global search. This makes the standard cuckoo search algorithm bad for consideration. This is the reason for using the local optimal solution.

3. PROPOSED METHOD

The proposed method is simple and provides efficient task scheduling as compared to the existing algorithm. Figure 2 depicts the flowchart for the proposed method. Initially, the number of processes is defined and its execution time is randomly generated. After that, the cuckoo search algorithm parameters are defined. The initial position of the cuckoo search is generated using the chaotic map algorithm. Next, the fitness evaluation is done on the basis of the objective function in order to identify the best solution. In the proposed algorithm, a multi-objective function is defined and average turnaround time and average waiting time parameters are taken under consideration. Next, the initial population is updated by considering the cuckoo search algorithm operations. The whole process is iterated for a defined iteration. In the end, task scheduling is performed by considering the optimal solution.

4. EXPERIMENTAL RESULTS

This section shows the experimental results were performed for the proposed method. The initial parameters were defined for the cuckoo search algorithm are shown in Table 1.

Table 1: Initial Parameters considered for the Cuckoo Search Algorithm

Parameters	Value
Processes	100
Coun of the Nests	25
Count of Iterations Performed	100

The convergence rate to achieve the optimal solution for the proposed method is shown in Figure 3. The graph is plotted between iterations vs fitness function. Further, the comparative analysis of the convergence rate of the proposed method compared to the existing cuckoo search algorithm is shown in Figure 4. The results show that the proposed method quickly convergence in the initial iterations as compared to the cuckoo search algorithm.

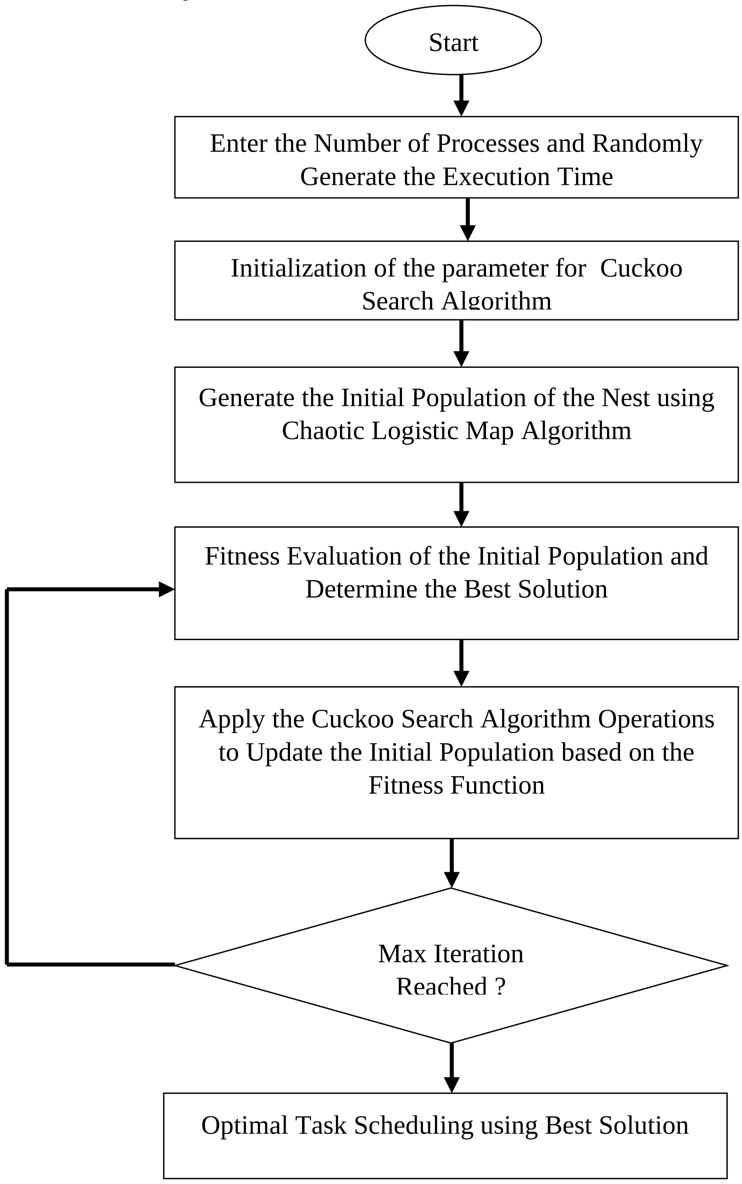

Fig. 2: Flowchart of the Proposed Method

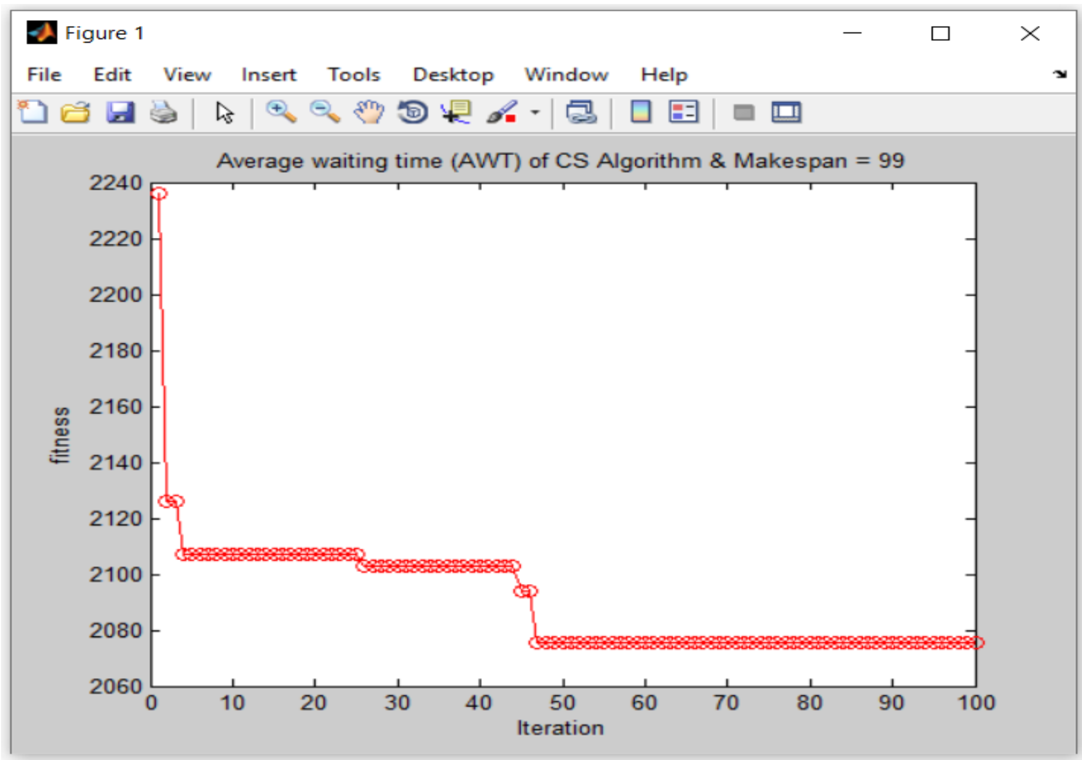

Fig. 3: Iteration vs Fitness Function for the Proposed Method

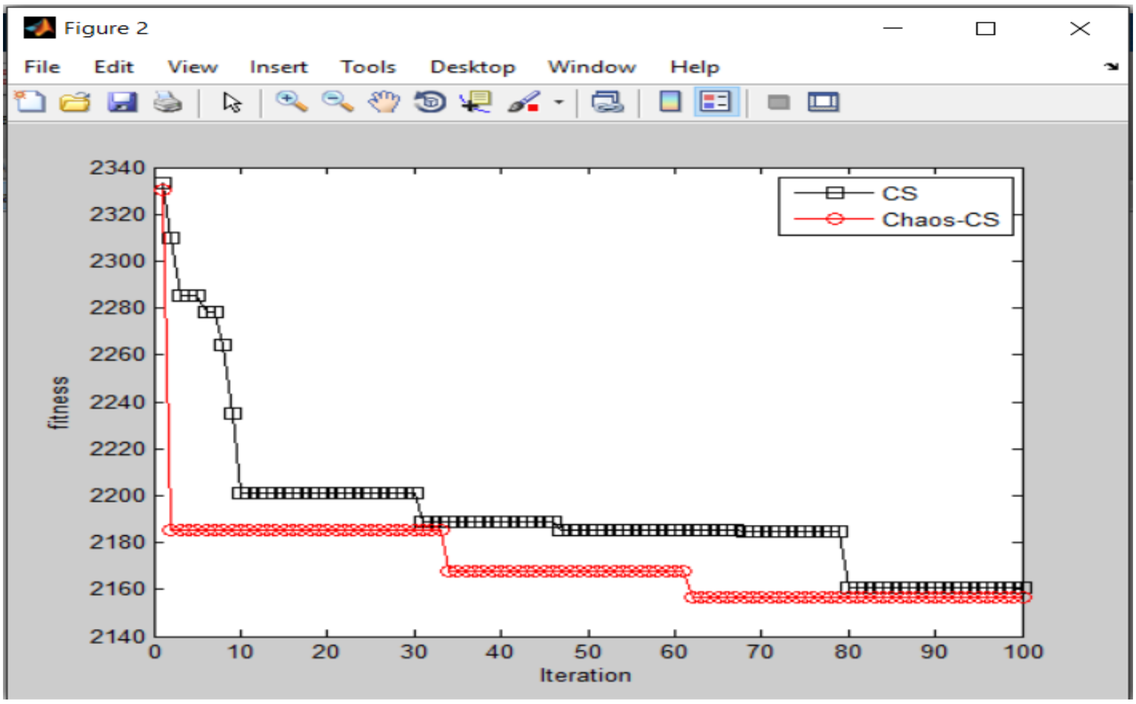

Fig. 4: Comparative Analysis of Proposed Method with the Existing Cuckoo Search Algorithm

In this study, we calculated various important parameters such as Average Wating Time, makespan, and Average Turnaround time.

4.1 Makespan

Makespan signifies the time taken to completely execute the last task. In order to effectively optimize it is important to reduce the makespan as much as possible as it is important to execute the process as fast as possible for any application.

$$\text{Makespan}=max_{i\epsilon tasks}\{F_i\} \tag{4}$$

In the above equation, F_i signifies the finishing time for the task taken as *i*.

Figure 5 depicts the comparative analysis of the proposed method (chaotic-CS) in comparison to the existing makespan parameter-based cuckoo search algorithm. The analysis indicates that the proposed method has the makespan time at a higher end compared to the existing method.

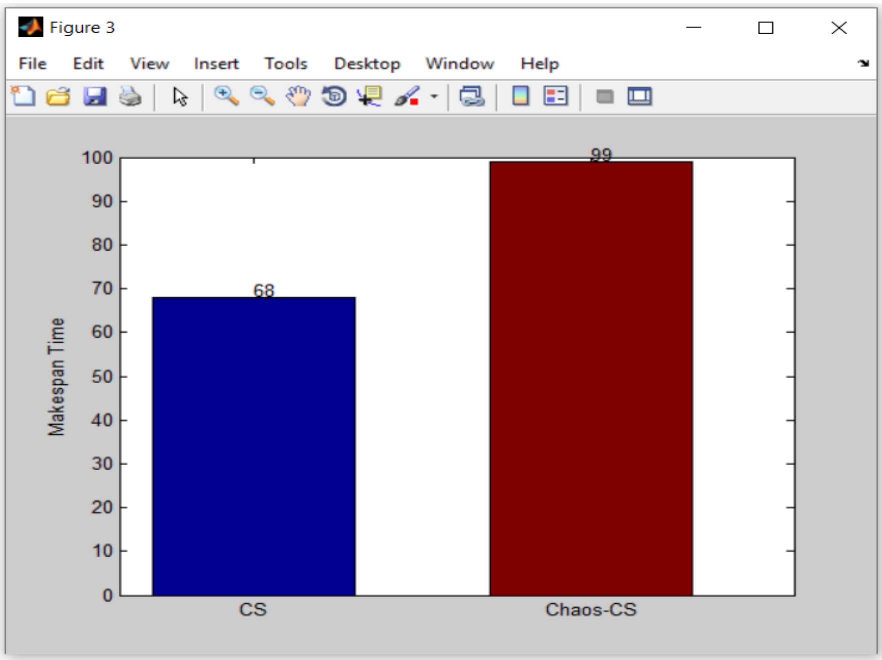

Fig. 5: Comparative Analysis based on the Makespan

4.2 Average Turnaround Time (ATT)

The time between the completion and initialization of the process is termed as the turnaround time. Turnaround time is the overall time period spent in the wait to enter in the memory, hold time in the ready queue, processing time by the CPU, and performing the Input/Output Process. Figure 6 depicts the comparative analysis of the proposed method (chaotic-CS) in comparison to the existing ATT parameter-based cuckoo search algorithm. The analysis indicates that the proposed method minimizes the utilization of ATT compared to the existing method.

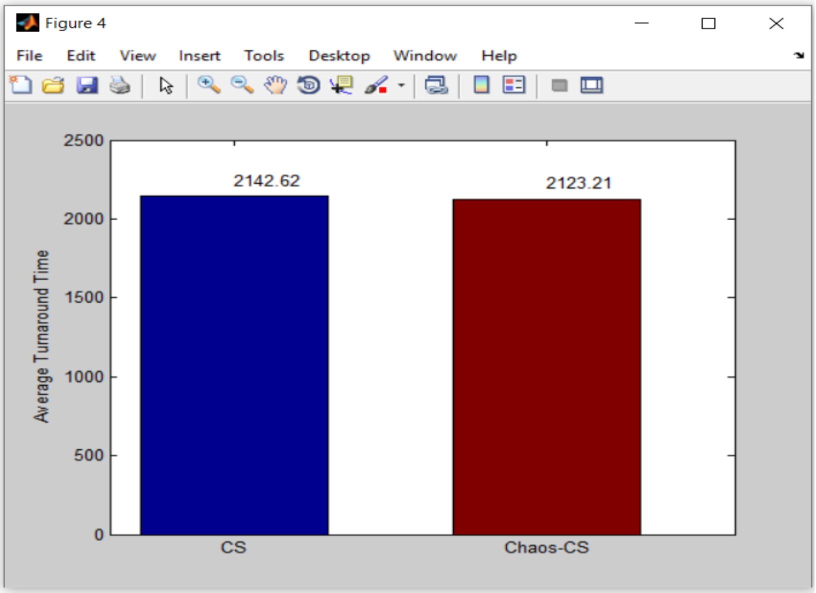

Fig. 6: Comparative Analysis based on the Average Turnaround Time (ATT)

4.3 Average Waiting Time (AWT)

Average waiting time shows the average of waiting time for the process that is actually in the queue, in wait of their term to be picked up for the processing. Figure 7 depicts the comparative analysis of the proposed method (chaotic-CS) in comparison to the existing AWT parameter-based cuckoo search algorithm. The analysis indicates that the proposed method minimizes the utilization of AWT compared to the existing method.

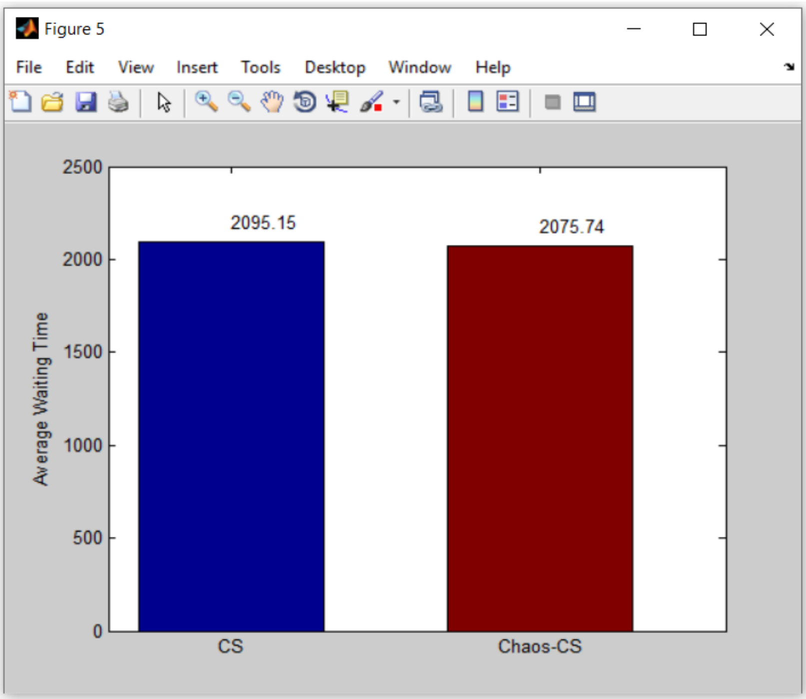

Fig. 7: Comparative Analysis based on the Average Waiting Time (AWT)

5. CONCLUSION AND FUTURE WORK

In this research paper, we tried to develop an improved method of cuckoo search algorithm considering the existing fallback of this algorithm. In order to accomplish the goal, we implemented the cuckoo search algorithm after defining the initial population based on the chaotic map in order to identify the task scheduling optimal solution. After the implementation, the performance analysis is carried out based on a different parameter that includes makespan, average waiting time, and average turnaround time. Based on these comparisons, it is identified that the proposed method shows improved results in comparison to the exsisting cuckoo search algorithm. In the future, other metaheuristic algorithms will be explored that provide a fast convergence rate.

6. REFERENCES

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