ISSN: 1992-8645 www.jatit.org E-ISSN: 1817-3195

NEW HYBRID ALGORITHM FOR TASK SCHEDULING IN CLOUD COMPUTING

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ABSTRACT

The theory of task scheduling in cloud computing systems is gaining increased attention with the rising popularity of the Cloud. In general, task scheduling is the process of assigning tasks to available resources based on the characteristics and general conditions of the tasks. This is an important aspect of efficient cloud functioning. Task scheduling is also perceived to be a real problem for managers. In this paper, we will present some concepts and research papers that have proposed improvements or solutions to this challenge and we will propose a hybrid Cat swarm optimization (CSO) Combined with Tabu Search (TS) for solving Task scheduling problems. CloudSim was used to implement the suggested hybrid algorithm (TS-CSO). The proposed algorithm's performance is compared to the performance of the PSO and FCFS algorithms on the Makespan parameter. The implementation results proved that the proposed algorithm (TS-CSO) outperforms the other algorithms.

Keywords: *Cloud computing, Task Scheduling, Tabu Search, CSO, Cloud Sim*

1. INTRODUCTION

Cloud computing [1] is an infrastructure in which computing power and storage are managed by remote servers that users connect to via a secure Internet link. Desktops, laptops, mobile phones, touch tablets and other connected devices become access points to run applications or view data that is hosted on servers. The cloud is also known for its adaptability, allowing vendors to automatically adapt computing power and storage capacity to users' needs.

Cloud computing offers the ability to use computing and storage resources on a measured basis and reduce investment in a computing organization [2]. This is a combination of several existing technologies (virtualization, storage . . .)

The scheduling of cloud computing tasks consists of distributing computing tasks over the grouping of resources between different resource users' according to certain resource usage rules under given cloud conditions. Currently, there is no universal uniform standard for scheduling tasks in the cloud. Resource management and task scheduling are key cloud computing techniques that play a critical role in the effective management of cloud resources [3].

The scheduling algorithm must be sufficiently capable of dealing with resource allocation problems such as resource contention, digitization of resources, over-provisioning of resources and fragmentation of resources. When the number of tasks in question, to be performed is large, scheduling becomes difficult, so an effective scheduling algorithm is a necessity and compulsory.

Among the main algorithms of tasks scheduling, Among the main algorithms of tasks scheduling, there are:

Particle Swarm Optimization (PSO) is global optimization method for finding the global minimum of an objective function. PSO is proposed in [4] schedules applications to cloud resources that take into account the costs of computing and data transmission. The average computation cost is calculated for each task from all resources. This is calculated by executing tasks in an application. It is assumed that the input sizes and output data of every task is known. If communication cost increases, the time diminishes and vice versa.

The optimization of ant colonies (ACO), proposed in 1992 by Marco, is a technique to solve optimization problems reduced in finding good paths. In the parameters sweep experiment with task priorities, the authors utilize ACO to reduce weighted flow time [5]. The new scheduler is based on the previously mentioned technique to execute Parameter Sweep Experiments by taking into account task priority in the cloud.

The First Come First Served (FIFO) algorithm [6] is one of the simplest algorithms. The idea is to add each available task and resource in a queue and run each task and resource in order of arrival. This algorithm is implemented in the CloudSim simulator [7], [8].

Round Robin is one of the oldest and most commonly algorithms used in tasks scheduling. Each process is assigned a certain interval of time, called quantum, during which it is given the opportunity to execute.

If the process is still operating at the end of the quantum, the CPU resource is taken away from it and given to another process. Of course, if a process enters a blocked state or exits before the time slice expires, then the CPU switches to another process at that very moment. The cyclic scheduling algorithm is not difficult to implement [9].

The genetic algorithm [10] is, first of all, an evolutionary algorithm, in other words, the main feature of the algorithm is crossing (combining). As you might guess, the idea of the algorithm is impudently taken from nature, since it will not sue for it. So, by enumeration and, most importantly, selection, the correct "combination" is obtained.

The algorithm is divided into three stages: Crossbreeding, Selection and Formation of a new generation. If the result does not suit us, these steps are repeated until the result begins to satisfy us.

The heuristic algorithm Cat Swarm Optimization is based on the social behavior of cats. Cat swarm optimization (CSO) has proved quicker than particle swarm optimization in terms of speed and convergence [11]. Although directly applying the real version of CSO to the task scheduling problem may raise complexity, the search capacity of CSO may still be enhanced to solve the job scheduling problem in the cloud. For each iteration, its global search and local search are carried out independently and its velocity and position are also modified. A very high computing time is needed for this.

Most research concentrated on Makespan criterion. It has defined as the completion time at which all tasks complete processing. A good planning algorithm is still trying to minimize Makespan.

In this study, we incorporated the tabu search approach into the local search of cat swarm optimization to get a new hybrid algorithm and ultimately minimize Makespan. The remainder of the paper is organized as follows: Section 2 provides a review of the literature and presents necessary background information for the study. The proposed methodology is carefully explained in Section3. The results and discussion are given in Section 4. The last section summarizes the work and concludes the paper.

2. BACKGROUND AND RELATED WORK

The scheduling problem is a persistent old issue, as we know, it is the action of assigning tasks to resources for processing them. To solve it, a variety of methods have been proposed.

In [12], authors use Cuckoo's algorithm to perform one of these checks. The reason for the proposed technique is to achieve an order of processing units such that the response time to tasks is minimized. The Cuckoo algorithm uses the range of virtual machines and the variety of tasks. By examining many of these machine controls, the proposed approach allocates hosts to tasks appropriately. This algorithm uses the Cuckoo algorithm for load balancing in Cloud computing due to the ability of general and local sample flight search to perform simultaneously. Therefore, the processing time of the system is reduced.

In [13], cost savings are compared using PSO and the existing "Best" algorithm Resource Selection" (BRS). The findings revealed that PSO achieves 3 times more cost savings than BRS and a proper workload allocation of resources.

Simulated Annealing for multi-criteria scheduling of Bag-of-Tasks systems on heterogeneous interconnected Clouds is proposed in [14]. The scheduling heuristic takes several criteria into account when planning applications and tries to optimize performance and costs, while the heterogeneity of virtual machines. Simulation indicates that the use of heuristic has an impact on performance while ensuring a good compromise cost-performance.

A novel job scheduling algorithm in cloud environment based on basic Genetic Algorithm (GA) combined PSO for the task scheduling is proposed in [15]. In this approach bandwidth is used as fitness condition for verifying the fitness of the scheduling results. In order to improve the resource utilization most cloud resources are considered in this approach. The allocated VMs are partitioned based on their CPU priority to improve the allocation process. The cloud resources such as execution time, deadline, node requirement and bandwidth are applied in the hybrid algorithm to obtain the optimized scheduling scheme.

In [16], the authors presented an improved genetic algorithm for task scheduling problem in the cloud computing. The proposed algorithm was simulated using Cloud Sim simulator and the results showed reduced cost, improvement in resource utilization, increased speedup, and higher ratio for algorithm efficiency when compared with default RR and GA algorithms.

Based on this review, it is evident that there is no effective technique to optimize task scheduling in CC that takes into account all issues and parameters. For examples, some consider the performance and costs for solving combinatorial optimization problems [5]; cost savings, a proper workload allocation of resources [13]; optimization of performance and costs [14], and improvement of the resource utilization [15]. Recent study [16] was simulated using Cloud Sim simulator and the results showed reduced cost, improvement in resource utilization, increased speedup, and higher ratio for algorithm efficiency when compared with default Round Robin and GA algorithms.

We choose to investigate the performance of the CSO and TS algorithms for task scheduling in CC for several reasons. The main reason is that CSO is a robust and powerful metaheuristic swarm-based optimization approach that has received very positive feedback since its emergence. It has been tackling many optimization problems [17]. We used the local heuristic method TS to enhanced CSO's local search to meet the latter's limitations. The proposed algorithm (TS-CSO) is a more viable alternative for the standard CSO and promising results regarding the Makespan.

3. RESEARCH METHOD

Tabu Search algorithm is a neighborhood search algorithm which employs intelligent search and flexible memory technique. It is designed to guide other algorithms to escape from the trap of local optimally. Therefore, it is applied to tackle task scheduling problems. So, the Tabu Search algorithm has been Combined with the CSO algorithm to avoid being trapped at the local optimum and speed up the search process.

The design and pseudocode for the original algorithms (CSO and Tabu), as well as the suggested hybrid search algorithm, has been demonstrated in this section.

3.1 Scheduling Problem

Every fraction of a second, a cloud environment receives a significant number of tasks from its apps' users. These jobs build up in multiple queues before being dispatched to task schedulers. The task schedulers are in charge of allocating these tasks to virtual machines (VMs) for execution [18].

Assuming that there are n tasks, each of them has a specified execution time on each processing unit, and that they should be processed using m computational resources. The number of tasks is considered more than the number of resources, and tasks cannot be assigned to different resources. Among the aims of task scheduling, is minimizing the tasks execution time.

To formulate the problem, take into account that $Ti = \{1,2,...,n\}$ is the set of tasks, where n is the number of tasks and $Rj= \{1,2,...,m\}$ is the set of computational resources. Suppose that CTij is the execution of task i on VM j, the Makespan is calculated using Equation (1)[19]:

$$\text{Makespan}=CTmax(i,j),\quad i\in T,\quad i=1,2,\ldots,n \text{ and } j\in VM,\ j=1,2,\ldots,m \qquad (1)$$

Where CTmax is the maximum time for completing task i on a virtual machine j.

3.2 Cat Swarm Optimization

Cat swarm optimization (CSO) algorithm was introduced by Chu and Tsai [20]. is inspired by cat behaviors to solve optimization problems. It is like other algorithms for swarm optimization such as Artificial Bee Colony Optimization Algorithm or particle swarm optimization. The CSO is divided into two modes which are the tracing mode and seeking mode. The seeking mode introduces a cat's rest mode in real life, where it spends most of its lifespan and the tracing mode when the cat chasing a prey or any moving object. Each cat is defined by its own velocity, Position and flag to decide if the cat is in search mode or tracing mode.

3.2.1 Seeking mode:

This mode is a moment to reflect and deciding about the next move. It has four parameters (1) "Seeking Memory Pool "(SMP), (2) "Seeking Range of selected Dimension" (SRD), (3) "Count of Dimensions to Change" (CDC) and "Self-Position Consideration" (SPC), the role of each one is:

(1) Make j copies of **Cat$_k$** current position, where j=SMP. If the SPC value is true, put j = (SMP – 1), retain the Cat as one of the candidates.
(2) Generate a random SRD value
(3) Calculate all candidate points' fitness values (FS). If not, all FS are equal, calculate each candidate point probability by:

$$P_i = \frac{|FS_i - FS_b|}{FS_{max} - FS_{min}}$$

And each candidate's default probability value is 1. If the goal of the fitness is to find the minimum solution, **$FS_b = FS_{max}$** , otherwise, **$FS_b = FS_{min}$** .
(4) Choose the point to move to from the candidate points randomly, and replace the **Cat$_k$** position.

3.2.2 Tracing Mode:

This mode corresponds to a local search technique for the optimization problem. In this mode, cats wish to trace targets and food. This section is devoted to describing the process and the parameters used in this mode.

Tracing mode process:

1. Compute and update **Cat$_k$** velocity using new velocity in Eq. 2:

$$V_{k,d} = V_{k,d} + (c1 \times r1 \times (Xbest_d - X_{k,d})), \quad d = 1, 2, \ldots, M \quad (2)$$

where c is the constant acceleration value and r is a uniformly distributed random integer between 0 and 1. For each iteration, Eq. 2 is used to update the velocity.

2. Add new velocity by computing the current (new) position of the **Cat$_k$** using Eq. 3:

$$X_{k,d} = X_{k,d} + V_{k,d} \quad (3)$$

3. Calculate the fitness values of all cats.
4. Update and return best cats with the best fitness.

3.2.3 The flowchart of CSO algorithm

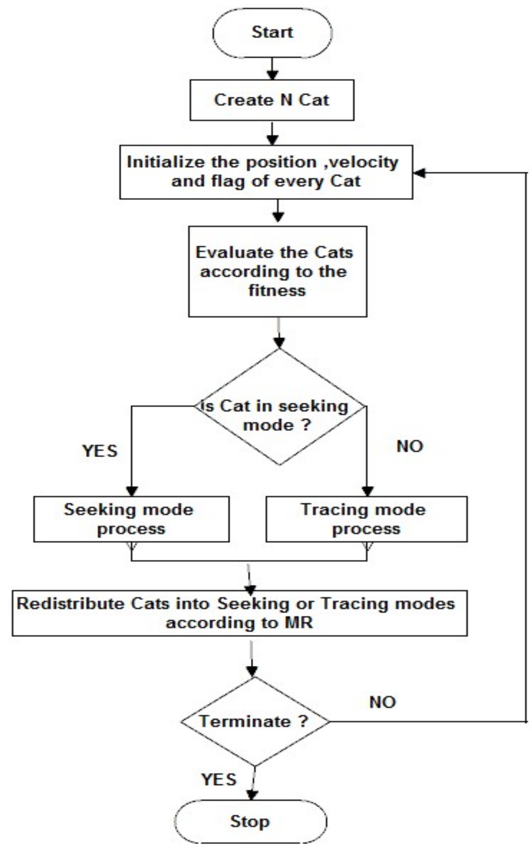

Figure 1: flowchart of CSO

3.2.4 Cat Swarm Optimization Limitations in Solving the Cloud Task Scheduling Problem

[21] claims that the CSO approach is more efficient than PSO in terms of computation time and convergence speed. However, it may need to be improved to tackle the complicated task scheduling optimization problem in cloud computing. The global search optimization process of the CSO is very promising. However, without the support of the local search optimization process, the global search cannot arrive at an optimal solution.

The number of cats going into seeking mode (global search) all the time always exceed the ones with tracing mode (local search). The thing that has made CSO suffer from falling into a local trap while the global solution feature is preserved. This may cause the mutation process of the CSO at tracing mode local search, to impact efficiency and does not achieve an optimum solution for task scheduling optimization problem in cloud computing. Similarly, for each iteration, the seeking mode (global search) and the tracing mode (local search) of the CSO were executed independently, resulting in a similar process of updating its velocity and position.

As a result, a very high computation time is unavoidable [22]. Therefore, a local search optimization algorithm integrated with CSO's local search is sufficient to meet its limitations.

3.3 Tabu search

The Tabu search is a heuristic local search method used to solve complex problems. Tabu search was proposed by Fred Glover in 1986 [23]. Since then, the method has become very popular, thanks to its success in solving many problems. The intention of the author was to devise a method of Smart research. The method uses a memory (or several memories) which are updated and exploited during the search. when a potential solution is determined, it is marked "Tabu" so that the algorithm does not visit it anymore. A local/neighborhood search procedure is changed from a solution x to a solution x' in the neighborhood of x, until a stop criterion is met. to explore regions of the search space that would not be explored by the local search procedure.

The Tabu search is based on:

1. The use of flexible memory structures allowing full exploration of evaluation criteria and search history.

2. A control mechanism based on the alternation of the conditions that restrict (Tabu restriction) and those that free (aspiration criterion) the search process.

3. Integration of strategies for intensification and diversification of research:

- The scaling-up strategy uses medium-term memory, and serves to strengthen regional search for the best recently found solutions.

- The diversification strategy uses long-term memory and is used to search for new regions.

3.3.1 Standard Algorithm of Tabu Search

We present below the standard Tabu Search algorithm:

1) Put an initial solution (initialization).

2) Creating a list of movements for candidates.

3) select the best candidate. This selection is based on Tabu constraints and aspiration requirements.

This provides an alternative, which will only be registered if it is better than the previous solution.

4) termination criterion satisfied?

Non: change the eligibility candidates (Restriction and aspiration criteria tab). Go to 2.

Yes: Going to diversification and intensification strategies

3.3.2 The flowchart of Tabu search algorithm

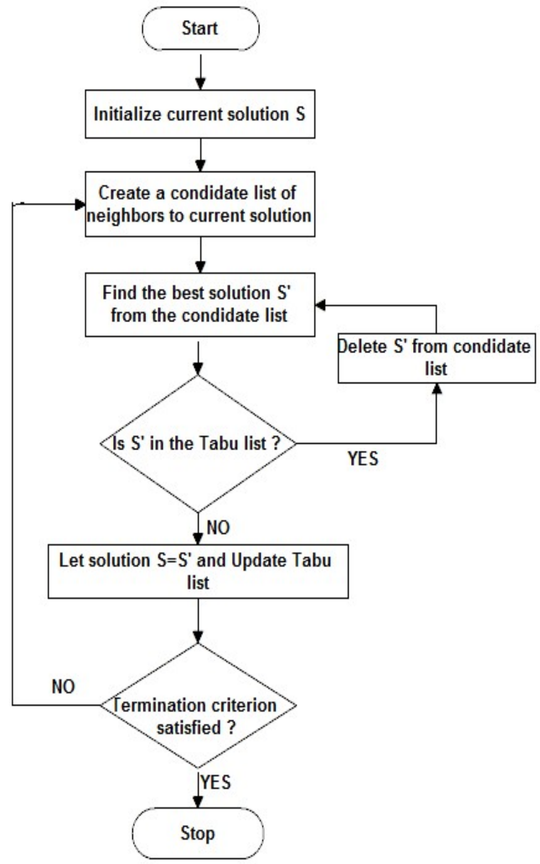

Figure 2: The flowchart of Tabu search algorithm.

3.3.3 The proposed algorithm

In this subsection, we outlined our proposed TS-CSO method that solved the task scheduling problem presented in Sect. 3.1. The goal is to create an effective scheduling pattern that could ensure that all jobs planned on vms are completed in the shortest amount of time possible.Algorithm 1 shows our proposed TS-CSO tracing mode.

3.3.4 Algorithm 1: TS-CSO tracing mode

the algorithm is represented as follows:

1. Compute and update $\mathbf{Cat_k}$ *velocity using new velocity in Eq (2):*

2. Add new velocity by computing the current (new) position of the $\mathbf{Cat_k}$ *using Eq. (3):*

2. Calculate the fitness values of all cats.

3- The cat population was updated by TS. Each cat searches the local best solution.

4-Update the best position and TL.

5-Repeat Step 2-Step 4 until the termination criterion was met.

6- return best cats with the best fitness.

4. RESULTS AND DISCUSSION

In this section we will explain the simulation configuration and the results obtained after the execution of the task scheduling algorithms in CloudSim [24] simulator. These algorithms on the Makespan parameter are compared to each other. The simulation parameter setting of CloudSim is shown in Table 2.

Table 1: Simulation parameters setting of CloudSim.

Entities	Parameters	Values
User	“No of users”	15
Cloudlet	“No of cloudlets”	100–500
	“Length”	1000
Host	“No of Host”	2
	“RAM”	2048MB
	“Storage”	1000000
	“Bandwidth”	10000
Virtual Machine	“No of VMs”	40
	“Type of Policy”	Time Share
	“RAM”	512MB
	“Bandwidth”	1000
	“MIPS”	1000
	“Size”	10000
	“VMM”	Xen
	“Operating System”	Linux
	“No of CPUs”	1
Data Center	“No of Data Centers”	1

A comparison between the FCFS, PSO and TS-CSO algorithms by the Makespan parameter is presented in the figure below. The number of cloudlets is represented on the x axis, and the Makespan time is indicated by the y axis.

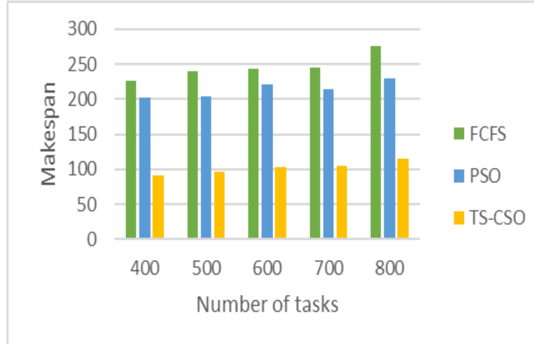

Figure 3: Average Makespan with different number of tasks

The analysis of findings clearly demonstrate that the Makespan of TS-CSO is better when compared with the other two algorithms.

5. CONCLUSION

The scheduling problem is a persistent old issue. As known, it is the action of assigning tasks to resources for processing them. In this paper, we presented some concepts and research papers that have proposed improvements or solutions to task scheduling issue. Our experiments depict that even if both FCFS and PSO algorithms show acceptable results, it can be said that, by and large, PSO algorithm shows better results than FCFS but TS-CSO algorithm outperforms these two algorithms from minimizing makespan point of view. This algorithm can be used in cloud computing environment for efficient scheduling of tasks on existing resources, so that the completion time of tasks becomes minimized.

Future work focuses on improving the execution cost and resource utilization.

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