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SCHEDULING BASED ON HYBRID PARTICLE SWARM OPTIMIZATION WITH CUCKOO SEARCH ALGORITHM IN CLOUD ENVIRONMENT

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ABSTRACT

Cloud computing provides a centralized pool of configurable computing resources and computing outsourcing mechanisms that enable different computing services to different people in a way similar to utility based systems. Job scheduling algorithm achieves a high performance computing and the best system throughput. The scheduling problem can be solved by enumeration method, heuristic method or approximation method. In this work, a heuristic method is proposed for optimizing scheduling in cloud. Particle Swarm Optimization (PSO) refers to a population-based meta-heuristic algorithm that is inspired by the social behavior of populations with collaborative properties. Cuckoo Search (CS) is a new and efficient population-based heuristic evolutionary algorithm for solving optimization problems. CS has the advantages of simple implementation and few control parameters. In this paper, scheduling is performed based on hybrid PSO with CS algorithm. Results show that the proposed method performs better in terms of average schedule length and ratio of successful execution.

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KEY WORDS

Cloud computing, Job scheduling, hybrid Particle Swarm Optimization (PSO) with Cuckoo Search (CS) algorithm, average schedule length and ratio of successful execution.

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INTRODUCTION

Cloud computing refers to a model of processing information, storing it as well as delivery wherein physical resources are provided to clients on demand. Instead of purchasing actual physical devices servers, storage, or any networking equipment, clients lease these resources from a cloud provider as an outsourced service. It can also be defined as "management of resources, applications and information as services over the cloud (internet) on demand". Cloud computing is a model for enabling convenient and on demand network access to a shared group of computing resources that can be rapidly released with minimal management effort or service provider interaction [1]. The goal of cloud computing is to provide on-demand computing service with high reliability, scalability, and availability [2]. Cloud Computing is rapidly spreading out at an excellent pace amongst IT enterprises because of the incredible saving of costs in infrastructure as well as decrease in the costs of IT management.

This is a vast domain and has several aspects on which efficacy is dependent on, one major aspect being scheduling. Scheduling is an important factor requiring attention within the domain of cloud computing. Quantity of energy utilized, costs incurred for providing services over the cloud, execution time are all important concerns and improving task scheduling assists in their minimization. Plenty of research has been carried out in this domain.

Job scheduling [3] is an important activity that is carried out in all computational environments. Cloud computing is emerging rapidly to become one of the most useful latest technologies. For effectively increasing the functioning of cloud computing environments, task scheduling is carried out for gaining most amount of profit. The aim of scheduling algorithms within distributed systems is the spreading of load on processors as well as the maximization of their usage and the minimization of total task implementation time. Task scheduling, a popular optimization issue, is key in improving flexible as well as dependable models. The major purpose is the scheduling of tasks to adaptable resources as per adaptable time, which includes discovering proper sequences in which tasks may be implemented

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under transaction logic constraints. There are two major groups of scheduling algorithms: Static scheduling algorithm and Dynamic scheduling algorithms. Both of them have their own benefits as well as limitations. The latter possesses better performance over the former, although it also has more overheads in comparison.

Scheduling process in cloud can be generalized into three stages: 1.Resource discovering and filtering: Datacenter Broker discovers the resources present in the network system and collects status information related to them. 2. Resource selection: target resource is selected based on certain parameters of task and resource which is deciding stage. 3. Task submission: task is submitted to resource selected.

Optimization problems are in Class NP-hard [4]. These issues may be resolved through enumeration, heuristic or approximation methods. In the first approach, optimal solutions may be chosen if all feasible solutions are enumerated and contrasted one by one. When quantity of instances is huge, extensive enumeration is not possible for scheduling issues. In this case, the second approach, the heuristic is the next best way to obtain reasonably good solutions in a short amount of time. The last kind of algorithms is approximation algorithms that are utilized to discover approximate solutions for optimized solutions. The algorithms are later utilized for issues wherein exact polynomial time algorithms are known. Improving task data locality in huge scale data processing models is critical to complete the tasks. Almost all methods for improving data locality are greedy or ignore global optimization or even suffer from high computational complexities. This issue is handled through a heuristic task scheduling model.

Task scheduling in cloud computing is an NP-hard problem, PSO as one of the heuristic algorithms has been applied in solving scheduling problem and other NP-hard problems, it is relatively easy to implement compared with the ant colony optimization algorithm and genetic algorithm. PSO has been utilized in workflow scheduling issue in cloud computing environments. However, PSO has some disadvantages, such as poor local search ability and not suitable for problems in discrete areas. This study proposes a workflow scheduling strategy in cloud computing based on hybrid particle swarm algorithm with Cuckoo Search algorithm (HPSOCS) in order to solve these shortages.

PSO has several advantages, such as fast convergence speed, but it also has some defects, such as premature convergence, and it easily falls into local optima. CS has several advantages, such as few control parameters and high efficiency, but it also has some defects, such as slow convergence speed and low accuracy. A PSO and CS hybrid algorithm should be developed as a hybrid algorithm with an outstanding performance because of the complementation of PSO and CS. In this study, HPSO-CS is proposed to improve the performance of scheduling in cloud. Section 2 explains the literatures that are related to this study, section 3 explains the techniques and algorithms, section 4 discusses about the obtained results and section 5 explains the conclusion of this study.

LITERATURE SURVEY

Masdari et al [5] presented a comprehensive survey and analysis of scheduling schemes in the cloud computing and provides a classification of the proposed schemes based on the type of scheduling algorithm applied in each scheme. Beside, each scheme was illustrated and a complete comparison of them was given for illustrating their aims, properties as well as their limitations. In the end, conclusion as well as indicators for future research is provided.

Tsai et al [6] presented a novel heuristic scheduling algorithm, called Hyper-Heuristic Scheduling Algorithm (HHSA), to find better scheduling solutions for cloud computing systems. The diversity detection and improvement detection operators were employed by the proposed algorithm to dynamically determine which low-level heuristic has to be used to find better candidate solutions. To evaluate the performance of the proposed method, this study compares the proposed method with several state-of-the-art scheduling algorithms, by having all of them implemented on CloudSim (a simulator) and Hadoop (a real system). The results show that HHSA can significantly reduce the makespan of task scheduling compared with the other scheduling algorithms, on both CloudSim and Hadoop.

Guo et al [7] formulated a model for task scheduling to minimize the cost and proposed a PSO model that has its basis in small position value rules. Through comparison of PSO with PSO embedded in crossovers as well as mutations and in local research, experimental evaluation reveals that PSO not only converges more rapidly but also runs quicker than the other two on a large scale. Experimental results proved that PSO was more suitable to cloud computing.

The scheduling of dependent tasks is a NP-complete problem and has become as one of the most challenging problems in cloud environment. There is a need of specifying a sequence of execution of these tasks to satisfy the user requirements in terms of QoS parameters such as cost, execution time, etc. The workflow scheduling is considered to be difficult, when it becomes a multi-objective optimization problem. Dutta&Aggarwal [8] presented a comprehensive description of the existing approaches based on meta-heuristics for workflow scheduling. On the basis of the related works, it was found that the Genetic algorithm as the best method for scheduling. A GA searches the problem space globally and therefore, scholars have investigated combining GAs with other meta-heuristic methods to resolve the local search problem. There is a scope of using hybrid meta-heuristics approach that combines Artificial Bee Colony algorithm and Genetic Algorithm (ABC-GA) for scheduling workflows in Cloud computing. Cross-over and mutation operators of GA can be embedded into ABC to improve scheduling strategy.

Ramezani et al [9] developed a comprehensive multi-objective model for optimizing task scheduling to minimize task execution time, task transferring time, and task execution cost. However, the objective functions in this model are in conflict with one another. Considering this fact and the supremacy of PSO algorithm in speed and accuracy, we design a multi-objective algorithm based on Multi-objective PSO (MOPSO) method to provide an optimal solution for the proposed model. To implement and evaluate the proposed model, Jswarm package was extended to Multi-objective Jswarm (MO-Jswarm) package. Also extend the Cloudsim toolkit applying MO-Jswarm as its task scheduling algorithm. MO-Jswarm in Cloudsim determines the optimal task arrangement among VMs according to MOPSO algorithm. The simulation results reveal that the suggested technique has the ability to find optimal trade-off solutions for multi-objective task scheduling problems that represent the best possible compromises among the conflicting objectives, and significantly increases the QoS.

Durgadevi&Srinivasan [10] focused on Meta-heuristic Swarm Optimization Algorithms (MSOA) which handles issue of VM placements as well as task scheduling in cloud environments. MSOA are simple, parallel algorithms which may be employed in several ways for resolving task scheduling issues. The suggested model is regarded as a combination of SO as well as CS algorithms called MSOACS. The proposed algorithm was tested with CloudSim simulator. The outcomes confirmed the decrease in makespan as well increase in utilization ratio of the suggested MSOAC as opposed to SOA or RA algorithms.

Xue& Wu [11] presented a QoS-based Genetic Hybrid Particle Swarm Optimization (GHPSO) for scheduling applications to cloud resources. Crossovers as well as mutations are embedded into PSO, in GHPSO, so that it can play a role in the discrete problem, in addition, variability index, changing with the number of iterations, was suggested for ensuring that populations can have better global search capacity in earlier stages of evolution, with no premature phenomena. Hill climbing algorithms are also introduced into PSO for improving local search capacity as well as for maintaining diversity of population. Simulation outcomes reveal that GHPSO attains greater performance than standard PSO used in minimizing costs in a specified execution time.

Scheduling refers to tasks that are carried out for obtaining maximum profit for increasing cloud computing workload efficacy. The objective is to utilize resources in an adequate manner as well as the management of loads between resources with minimal execution time. Extreme transmissions costs are incurred in clouds prevent task schedulers from being employed in huge scale distributed environments. Sridhar &Babu [12] proposed a hybrid Particle Swarm Optimization (PSO) which performs better in execution ratio and average schedule length.

Bittencourt et al [13] introduced the scheduling problem in hybrid clouds presenting the main characteristics to be considered when scheduling workflows, as well as a brief survey of some of the scheduling algorithms used in these systems. To assess the influence of communication channels on job allocation, proposed method compared and evaluated the impact of the available bandwidth on the performance of some of the scheduling algorithms.

Babukarthik et al [14] presented a Hybrid algorithm, on the basis of ACO as well as Cuckoo Search that effectively resolves the task scheduling issue that decreases total implementation time Within ACO, pheromones are chemical substances which are deposited by ants when they walk. For resolving optimization issues, it behaves as if it lures artificial ants. For performing local searches, proposed method use Cuckoo Search where there is essentially only a single parameter apart from the population size and it is also very easy to implement.

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The issue of scheduling in a cloud is an NP-hard optimization problem. Maintaining a load balance between processing units in the system is of great significance in cloud technology. When a set of tasks arrive at the cloud, the system is supposed to respond to all of them as it manages to achieve the shortest possible time. Branch [15] used Cuckoo algorithm to perform such a management. The purpose of the proposed method achieved an order of processing units such that the time of responses to queries was minimized. The input to cuckoo algorithm is the number of virtual machines and the number of tasks. By examining various orders of these machines, the proposed method allocates hosts to tasks in a proper way. Simulation results show that using Cuckoo algorithm for the intention of reaching the best order of processing units leads to improve performance parameters. In addition, simulations reveal that if tasks are scheduled without any primary information about the resources, the results will not be satisfying enough.

METHODS

In this work, scheduling is performed based on hybrid PSO with CS algorithm.

PARTICLE SWARM OPTIMIZATION (PSO)

Particle swarm optimization (PSO) is a non-traditional, modern optimization method. It is population based, it is inspired by the natural behavior of animals or insects e.g., bird flocking, fish schooling. PSO was formulated for resolving non-linear optimization issues, but recently the algorithm has been utilized in several domains, including real world application issues. It is a significant tool of swarm intelligence and it owes its inspiration to the natural activity of birds as well as fish and their movements. Regard this scenario; if flocks of birds are looking for one from one location to another, there is no leader present for that flock. All birds follow that one bird that is nearest to food source and they transmit the data to one another. The flock attains its best position toward the food source through transmissions with the member nearest to it. The procedure is iterated till food source is identified. To find optimal solutions, PSO algorithm follows the exact same procedure [16].

Each individual in the swarm is represented as a particle in a D –dimensional space. Each particle is represented by its position (X_i) and velocity (V_i). The particle's personal best location is specified by $P_i = \{p_{i1}, p_{i2}, \ldots\ldots, p_{in}\}$ and the Global best of all particles is given by $G = \{\mathrm{g}_1, \mathrm{g}_2, \ldots\ldots, \mathrm{g}_n\}$. The algorithm begins with a set of particles whose location as well as velocity is set arbitrarily. All particles' fitness values are computed. Fitness values of all particles are recorded as personal best (pbest) values. Best fitness values as got so far by all particles is considered as the global best (g best). Once these two values are obtained, then each particle will updates its position and velocity using the two equations (1):

$$V_{id}(t) = wV_{id}(t) + \mathrm{c}_1 r_1[\mathrm{x}_{id}(t) - p_{id}(t)] + \mathrm{c}_2 r_2[\mathrm{x}_{id}(t) - g_d(t)]$$
$$X_{id}(t) = X_{id}(t) + V_{id}(t) \quad (1)$$

Where c_1 and c_2 are the Cognitive factors r_1 and r_2 are the values randomly chosen between 0 and 1 and w is the cognitive weight factor.

BINARY PARTICLE SWARM OPTIMIZATION (BPSO)

Binary Particle Swarm Optimization (BPSO) is possible with a modification of the PSO version. In a binary version, particle's personal best and global best are updated as in a typical version [3]. The difference between BPSO and PSO is that relevant variables (particles velocities and positions) are defined regarding the change of probabilities. Particles are formed by integers in {0, 1}. A logistic Sigmoid transformation function $s(v_{ij}^k)$ limits velocity in the interval [0, 1].

$$s(v_{ij}^k) = 1/(1 + \mathrm{e}^{-V_{ij}^k}) \quad (2)$$

Thus, real velocity is digitized (1/0) by logistic functions for binary space. The BPSO's update equation is done in 2 steps. First, the equation is used to update particle velocity. Second, the particle's new position is obtained using equation (3) [30]

$$X_{ij}^k = \begin{cases} 1: if \quad rand() \le s(v_{ij}^k) \\ 0: \quad otherwise \end{cases} \quad (3)$$

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Where, v_{ij}^{k} is a velocity of jth dimension in it hparticle, X_{ij}^{k} is current position of jthdimension in ith particle at iteration k.rand( ) is a uniform random number in a range [0, 1]. The scheduling algorithm is given as:

1. *Set particle* dim*ension as equal to the size of ready tasks in* $\{t_i\} \in T$
2. *Initialize particles position randomly from PC* $= 1, \ldots, j$ *and velocity* v_i *randomly.*
3. *For each particle, calculate its fitness value*
4. *If the fitness value is better than the previous best pbest, set the current fitness value as the new pbest.*
5. *After Steps* 3 *and* 4 *for all particles, select the best particle as gbest.*
6. *For all particles, calculate velocity and update their positions*
7. *If the stopping criteria or* max*imum iteration is not satisfied, repeat from Step* 3.

CUCKOO SEARCH (CS) ALGORITHM

The CS is an optimization algorithm proposed by Yang and Deb. Cuckoo search [17] is a search algorithm based on the natural behavior of blood parasitism of cuckoo birds. Cuckoo birds display aggressive breeding behavior. They do not build their own nests, rather they lay their eggs in the nests of other hosts. Host birds are typically not aware of cuckoo eggs because the color as well as pattern is imitated. Cuckoo eggs are hatched at an earlier stage than host eggs. When hosts discover that the eggs do not belong to it, they throw away the foreign eggs or destroy them and rebuild their nests elsewhere. This behavior of cuckoos helps in several optimization issues. CS has its basis in three assumptions: Every cuckoo lays only one egg at a time and the eggs are arbitrarily placed into any nest, the nest containing eggs of better quality will be passed to the subsequent iteration and the quality of host nest is static and cannot be changed.

L´EVY FLIGHTS

As it is well-known, random searching [18] is crucial importance in meta-heuristic algorithms. The L´evy flight is a random process which consists of taking a series of consecutive random steps [36]. From the mathematical point of view, two consecutive steps need to be performed to generate random numbers with L´evy flights: **[Figure-1]**

- The generation of steps and
- The choice of a random direction. To do this, one of the most efficient methods is to use the so- called Mantegna algorithm where the step length can be determined as in equation (4):

$$L = \frac{u}{|v|^{1/\beta}} \tag{4}$$

Where β the scale parameter and its recommended range is [1, 2].

Step (0): Initialization
Objective function f (x), x= {x1, x2,……. xd}
Generate an initial population of n host nests xi, i=1, 2,…., n
Step (1): Updation loop
While(Termination Criterion)
Choose a cuckoo bird (i) arbitrarily using levy Flights
Find the Fitness function Fi Choose a nest (j) arbitrarily among n
If(Fitnessi>Fitnessj) Replace j by i
End
A Probability (Pa) of worst nest is removed.
Build the new nest
Record the best solutions
Sort these solutions and find current best
End While
Pass the Best solution to next iteration
End

Fig: 1. Pseudo code for Cuckoo Search (CS) Algorithm

HYBRID PSO WITH CS

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To improve the performance of CS, PSO [19] is introduced in the update process of CS. Thus, a PSOCS hybrid algorithm is developed. PSOCS first uses Lévy flights in the search space to search, and then it uses the position of the PSO update mode to accelerate the particles to the optimal solution convergence. At the same time, the random elimination mechanism of CS can successfully escape local optima, thereby improving the performance of searching for the optimal solution. **[Figure-2]** shows the flowchart for hybrid PSO-CS.

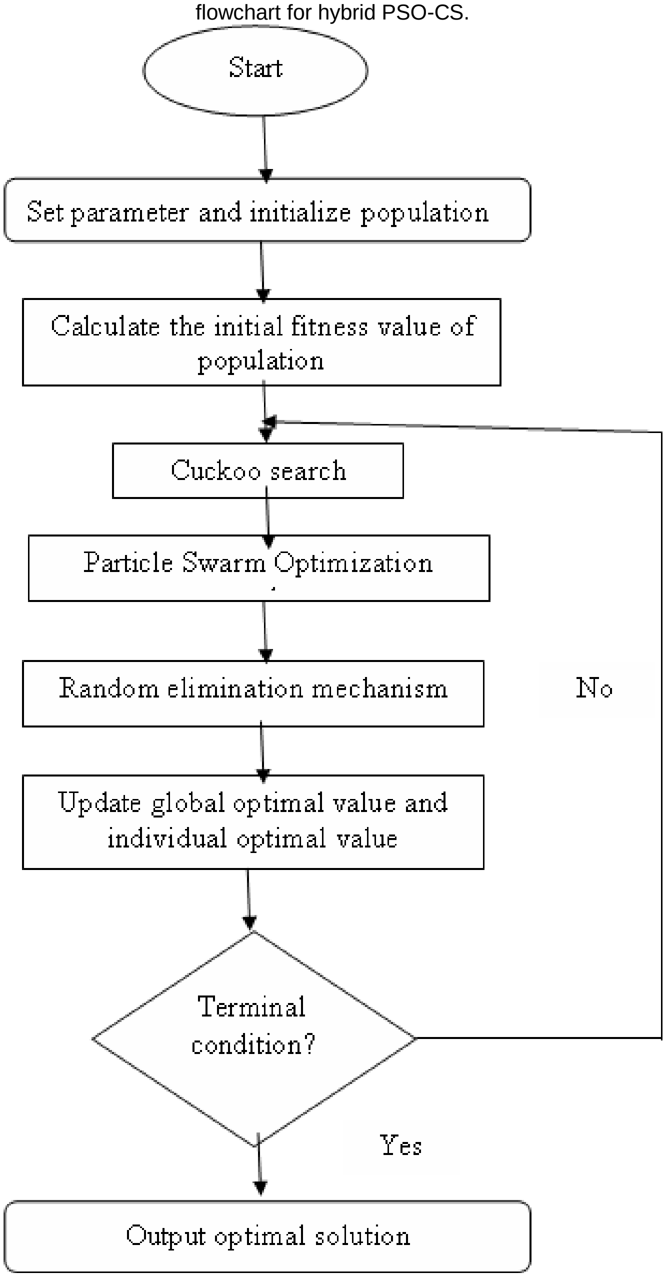

Fig: 2. Flowchart for Hybrid PSO-CS algorithm

RESULTS AND DISCUSSION

For experiments, the numbers of tasks used are 100, 300, 500, 700 and 900. PSO and HPSO with CS is applied for scheduling. **[Table -1], [Table -2]** and **[Figure-3], [Figure-4]** shows the result table and graph for average schedule length and ratio of successful execution respectively.

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Table: 1. Average Schedule Length

Number of tasks	PSO	HPSOCS
100	324	321
300	1014	989
500	1712	1665
700	2354	2339
900	3044	2953

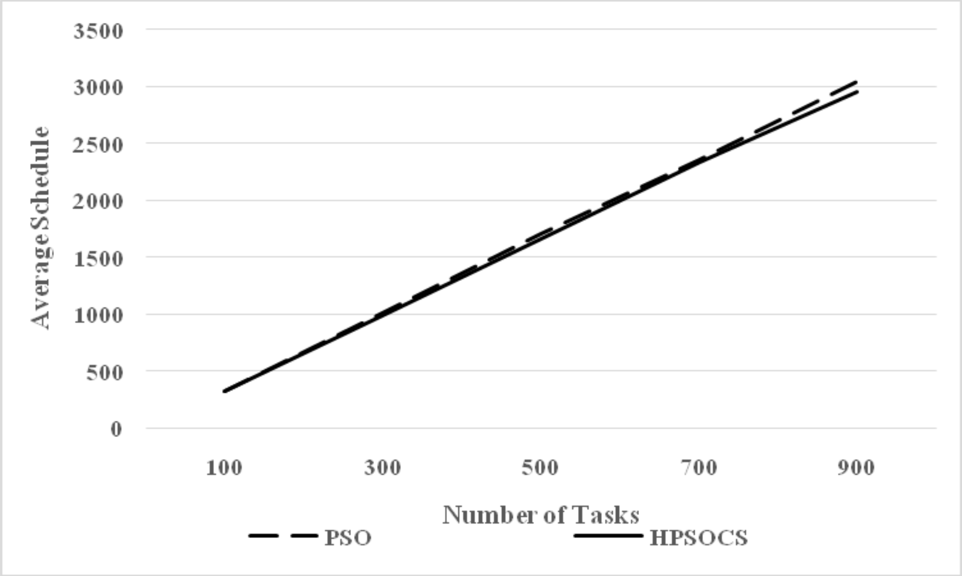

Fig: 3. Average Schedule Length

It is observed from **[Table -1]** and **[Figure -3]** that the average schedule length of proposed HPSOCS performs better by 0.93% than PSO at number of task is 100 and by 3.03% than PSO at number of task is 900. The average schedule length is increased when the number of tasks increases.

Table: 2. Ratio of Successful Execution

Number of tasks	PSO	HPSOCS
100	0.85	0.88
300	0.83	0.86
500	0.82	0.84
700	0.81	0.81
900	0.8	0.81

It is observed from **[Table -2]** and **[Figure -4]** that the ratio of successful execution of proposed HPSOCS performs better by 3.5% than PSO at number of task is 100 and by 1.24% than PSO at number of task is 900. The ratio of successful execution gets decreased when the number of tasks increases.

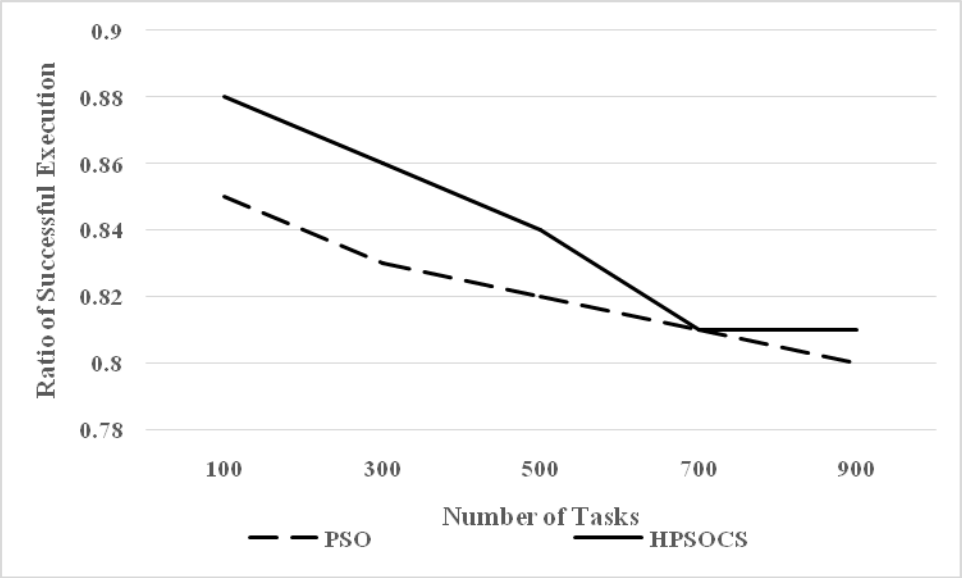

Fig: 4. Ratio of Successful Execution

CONCLUSION

Cloud computing has become an important platform for companies to build their infrastructures upon. Scheduling is one of the most important task in cloud computing environment. Results shows that the average schedule length of proposed HPSOCS performs better by 0.93% than PSO at number of task is 100 and by 3.03% than PSO at number of task is 900. The average schedule length is increased when the number of tasks increases. Also the ratio of successful execution of proposed HPSOCS performs better by 3.5% than PSO at number of task is 100 and by 1.24% than PSO at number of task is 900. The ratio of successful execution gets decreased when the number of tasks increases.

CONFLICT OF INTEREST

The authors declare no conflict of interests.

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The authors report no financial interests or potential conflicts of interest.

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