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Optimum Selection of Virtual Machine Using Improved Particle Swarm Optimization in Cloud Environment

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Abstract – Nowadays, Cloud Computing acts a major role in every field. These days, more large data centers are in service and many small cloud data centers are enlarging all over the universe. Cloud Computing is a catchword in the domain of HPC and offers on-demand services to the resources on the internet. The VMs (Virtual Machines) specified in the cloud data centres may have different specifications and instable resource usage, which causes imbalanced resource utilization within servers. Thus, it leads to performance degradation. Hence to achieve efficient selection of VM, these challenges must be addressed and solved by using meta-heuristics algorithms. In order to process the data, the VMs are placed on the PMs (Physical Machines). There will be multiple and dynamic request of input in the IaaS(Infrastructure as a Service) framework, hence the system's responsibility is to create a VMs without knowing the types of tasks. Therefore, the fixed tasks scheduling is not right for this system. The most important research area that needs to be addressed is its performance in scheduling. The best and optimal solution is to find out in the cloud environment. Metaheuristics-based algorithms provide the near-optimal solution. In this paper, we proposed an Improved Particle Swarm Optimization algorithm to reduce the makespan and improve the throughput. We have compared our results with adaptive three-threshold energy-aware (ATEA) algorithm and PSO. The investigational results display the proposed Improved PSO algorithm will schedule and balance the load in the dynamic cloud environment better than the other approaches.

Index Terms – Particle Swarm Optimization, Task Scheduling, Cloud Computing, Virtual Machine, Virtualization, Load Balancing.

1. INTRODUCTION

The aspects of everyday human life are been altered and transformed by this creative and innovative digital solution. Cloud computing is a distributed pattern which delivers the resources like servers, software, database, storage over the internet. The digital era changes daily. Cloud computing is a new development where all companies have started to turn to it. The term cloud computing means the resources are managed by the third-party provider. The end-user doesn't want to worry about the hard drives or software.

With the expansion of cloud computing, virtualization technology is moving towards growth by underlying attention by the industry. The virtualization technology increases the security of cloud computing. The digital version of physical computer is named as VM. This software VM have the ability to run programs and OS, store data, connectivity to the network. But this requires maintenance to update and to monitor the system. The single machine probably server, can carry multiple VMs which can be managed using virtual machine software.

The growing resource utilization of the CDCs (Cloud Data Centers) is increasing faster because of the expansion of the cloud centers with the support of massive internet services. The utilization of the Central Processing Unit, Storage, and Memory resources in the cloud data center comprises 45% of the operating costs. Hence the cloud service providers are in the situation to reduce the operational cost, thereby reducing energy utilization. Based on the SLA (Service Level Agreement) between the providers and the users, the resources required by the users are packed as Virtual Machine and placed in different hosts [1].

To improve resource consumption, virtualization techniques are helpful to run several VMs on the same physical machine.

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The other approach used to reduce energy consumption is on-demand resource allotment. Yet, migration of VMs introduces other costs like reconfiguration cost, creation and destruction of VMs. Hence, the number of migrations of VMs should be reduced. The active consolidation of VMs is the approach used to reduce energy consumption. The VMs are periodically reallocated to diminish the number of active hosts that use live migration [2]. Cloud Computing can be categorized into four main types. They are private, public, hybrid, and community cloud. These four types of cloud are applied in any field of life. Cloud computing architecture consists of many layers. The application layer comprises cloud applications. This is the top level in the hierarchy and it is directly connected with the end-users. SMTP, FTP, email clients, and many other functions are available at this layer. The next level layer is the platform layer. This layer has the operating system. This layer reduces the complexity of the development of the application. The infrastructure layer consists of a pool of resources need for the virtualization technique. This layer allows the customer to get the resources with the help of a VM. The hardware layer is accountable for the organization of the physical resources [3]. The Load Balancing(LB) means to distribute the excess amount of workload evenly across all the nodes in a dynamic fashion. This definitely leads to higher user satisfaction which eventually better resource utilization. The poor load balancing system can allocate the resources in an improper manner leading to wastage of resources. Hence suitable work LB technique is required which decreases the resource utilization [4]. Figure 1 shows the Structure of Cloud Computing.

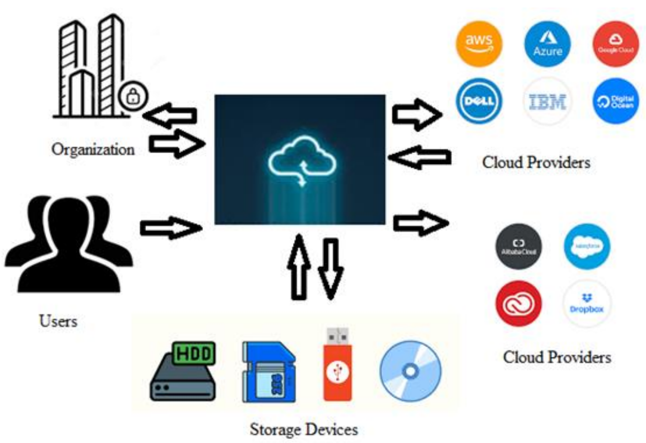

Figure 1 Structure of Cloud Computing

1.1. Objectives and Scope

1.1.1. Objectives

1. To develop the algorithm named improved ACO (Ant Colony Optimization) for the optimal selection of virtual machine.

2. To design an improved PSO algorithm for the load balancing in the cloud environment.

3. To compare and analyse the performance measures of improved ACO and improved PSO for the VM selection and load balancing in the cloud.

1.1.2. Scope

This model brings outs the best VM selection algorithm in the Data Center of cloud environment. To achieve best load balancing, the improved PSO is adopted. The improved ACO and improved PSO guarantee the optimization which leads to maximum resource utilization and reduction in execution time and makespan time. This model beats the already existing VM selection algorithm with betterment in the experimental results. Thereby, the improved PSO achieves better result compared to improved ACO. Table 1 shows the Meta-heuristics algorithm with year of introduction.

S.No	Meta-heuristic algorithms	Year
1	Random Optimization	1965
2	Evolutionary Optimization (EO)	1966
3	Genetic Algorithm	1975
4	Ant Colony Optimization	1992
5	Multi-objective GA (MOGA)	1993
6	Particle Swarm Optimization (PSO)	1995
7	Artificial Bee Colony Optimization	2005
8	Firefly Algorithms (FA)	2008
9	Cuckoo Search (CS)	2009
10	Gravitational Search Algorithm	2009
11	Bat Algorithm	2010m
12	Swallow Swarm Optimization	2013
13	Water Wave Optimization	2015

Table 1 Meta-Heuristics with Year of Introduction

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The rest of the paper is organized as: Section-2 gives the related work has been done and motivated us for this work. In section-3, the proposed system model is explained. Section-4, explains the proposed Improved PSO algorithm for task scheduling. The experimental analysis and results are presented in section-5. Finally, conclusion is given in section-6 with some future enhancements.

2. RELATED WORKS

The internet along with cloud computing technology makes the new era of computing. Cloud computing depends on the internet for the faster and more reliable transmission of data. The resources are shared among the users simultaneously. The resources are pooled in a centralized place, where these can be accessed by the users at any time with the help of the internet.

Chaudhary et al presented that the scheduling arrangement can be static or dynamic. Static scheduling is not in use due to the advancement in technology. The bio-inspired algorithms are used for the implementation of scheduling the load balance in dynamic techniques. The static algorithms acquire low operational costs when compared to dynamic meta-heuristics algorithms [5].

One of the most famous meta-heuristic algorithms is Particle Swarm Optimization (PSO) is presented by the author Kennedy et al. The flock of birds' pattern is used to transfer from one source to another.

A constraint-based PSO scheme is proposed by Kennedy et all, which allocated the tasks in sequence mode. The particle's best current position and universal best position yield the velocity of the particle. This paper shows that it decreases the total cost of computation [6].

Garg and Buyya stated the study deployed PSO to schedule the VMs in cloudsim. Gravitational Search Algorithm (GSA) is the searching mechanism adopted by this author. The size of the particle is computed by the fitness value. Based on the velocity and the existing particle place, the secondary particle location is captured [7].

Binary Gravitational Search Algorithm (BGSA) is proposed for the optimization in scheduling operation by Rashedi et al. The repulsive and attractive forces are the main factors to determine the optimization issue in the cloud environment [8].

The authors Higang Hu et al proposed an Adaptive Three-Threshold Energy-Aware algorithm. The hosts are categorized as hosts with a small load, light load, moderate load, heavy load. The heavy-loaded VMs are shared with small load VMs. The Cloudsim toolkit is used for the experimental setup. This gives a better reduction in energy consumption [9].

In PSO, the objective function of the search space is evaluated at its current location. The previous history and the best location of the swarm members are used to determine the movement. The flock of birds i.e swarm moves towards the fitness function.

Three dimensional vectors are there in the particle swarm. The current position is denoted by $\underset{o_i}{\rightarrow}$, previous best position is denoted by $\underset{p_i}{\rightarrow}$ and the velocity as $\underset{q_i}{\rightarrow}$.

{set of coordinates which describes a point in space} -> current position

If the best place is found by the swarm, then the current position is changed to the previous best position. i.e $\underset{o_i}{\rightarrow}$ -> $\underset{p_i}{\rightarrow}$

A single particle cannot find the best solution. The best solution can be found when it interacts with the other particle. Bidirectional edges connecting pairs of particles is the topology that can be applied to connect every particle with its neighborhood.

Based on LB, the SWIM ACOTS LB is presented by Li et al. The proposed Ant Colony (ACTS LB) algorithm is good than outdated ACO algorithm, PSO and min-min algorithm. The experiment is conducted by using NS-3 simulator. This simulation shows better result than other load balancing algorithms. This is not actually simulated in large SWIM environment in real time [10].

Mishra et al structured the LB method by imitating the characteristics of a group of birds named as BSO-LB algorithm. Here, the jobs are equalled to birds and the VMs are equalled to food particles. The datasets measured by the authors are taken from GoCJ which is executed in cloudlets. The response time is reduced by the authors thereby achieving the balanced workload. The proposed system is compared with max-min, FCFS(First Come First Serve), SJF(Shortest Job First) and RR(Round Robin). The proposed approach achieves improvement in the utilization of the resource and the reduction in the makespan time [11].

Ashutosh Kumar Dubey et al proposed efficient ACO and PSO built framework for classifying the data and for pre-processing in big data. The classification correctness achieved with PSO-Simple Adaptive Weight is 98%, ACO-Simple Adaptive Weight is 95% [12].

Gupta et al used MATLAB for simulating the results. The ACO and PSO are used by the author to calculate the distance. This brings the shortest path between the two vertices. The value of square of error 0.2 in 80 iterations achieved for ACO while 6.8 in 400 iterations for PSO. The ACO achieves minimum value of square of error [13].

Azad et al examined the GA(Genetic Algorithm), ACO and PSO. ACO is used for the continuous domain and PSO is used for DE to improve the presentation of ANFIS models to simulate the magnitude of the monthly rainfall. The experimental results are conducted with input (3) and applied on 5 models. Based on the experiments, the hybrid model gives better accuracy than ANFIS model [14].

The fault diagnosis methods proposed by Wu Deng et al outperforms well compared to existing fault diagnosis methods. The improved PSO algorithm optimizes the least square parameters of LS-SVM. The experimental results are applied to the motor bearing. This article gives a new fault diagnosis of rotating machinery [15]. The summary is represented in Table 2.

Year	Author Name	Title	Description	Methodology	Limitations
2014	E. Rashedi and A. Zarezadeh	Noise filtering in ultrasound images using GSA (Gravitational Search Algorithm)	Scheduling arrangement can be static or dynamic. Static scheduling is not in use due to the advancement in technology.	Bio-inspired algorithms	The static algorithms acquire low operational costs when compared to dynamic meta-heuristics algorithms
1995	Kennedy J and Eberhart R.	Particle Swarm Optimization	The particle's best current position and universal best position yield the velocity of the particle.	Constraint-based PSO scheme	Decreases the total cost of computation
2013	Garg, S.K., Versteeg, S. and Buyya, R	A Framework for Ranking of Cloud Computing Services	Gravitational Search Algorithm (GSA) is the searching mechanism adopted by this author. The size of the particle is computed by the fitness value.	Gravitational Search Algorithm	Implementation cost is high.
2014	E. Rashedi and A. Zarezadeh	Noise filtering in ultrasound images using GSA (Gravitational Search Algorithm)	The repulsive and attractive forces are the main factors to determine the optimization issue in the cloud environment.	Binary Gravitational Search Algorithm	Response Time is high
2016	Zhou, Z., Hu, Z. and Li, K	Virtual Machine Placement Algorithm for Both Energy-Awareness and SLA Violation Reduction in Cloud Data Centers	The hosts are categorized as hosts with a small load, light load, moderate load, heavy load. The heavy-loaded VMs are shared with small load VMs	Adaptive Three-Threshold Energy-Aware algorithm	Better reduction in energy consumption
2019	Li, G. and Wu, Z	Ant colony optimization task scheduling algorithm for SWIM based on load balancing	The proposed Ant Colony (ACTS LB) algorithm is good than outdated ACO algorithm, PSO and min-min algorithm.	Ant Colony (ACTS LB) algorithm	This is not actually simulated in large SWIM environment in real time
2021	Mishra, K. and Majhi, S. K	A binary Bird Swarm Optimization based load balancing algorithm for cloud computing environment	The response time is reduced by the authors thereby achieving the balanced workload.	BSO-LB algorithm	The proposed approach achieves improvement in the utilization of the resource and the reduction in the makespan time

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2021	Dubey, A. K., Kumar, A. and Agrawal, R	An efficient ACO-PSO-based framework for data classification and preprocessing in big data	ACO and PSO built framework for classifying the data and for pre-processing in big data	ACO and PSO	Better response time
2020	Gupta, A. and Srivastava, S.	Comparative Analysis of Ant Colony and Particle Swarm Optimization Algorithms for Distance Optimization	The value of square of error 0.2 in 80 iterations achieved for ACO while 6.8 in 400 iterations for PSO.	ACO and PSO	The ACO achieves minimum value of square of error
2019	Azad, A. et al.	Comparative evaluation of intelligent algorithms to improve adaptive neuro-fuzzy inference system performance in precipitation modelling	ACO is used for the continuous domain and PSO is used for DE to improve the presentation of ANFIS models to simulate the magnitude of the monthly rainfall. The experimental results are conducted with input (3) and applied on 5 models.	Genetic Algorithm), ACO and PSO	The hybrid model gives better accuracy than ANFIS model
2019	Deng, W. et al	A novel intelligent diagnosis method using optimal LS-SVM with improved PSO algorithm	The improved PSO algorithm optimizes the least square parameters of LS-SVM.	Improved PSO algorithm	Minor problems may occurred during migration

Table 2 Summary of the Literature Review

3. EVOLUTIONARY ALGORITHM: PSO

The efficiency in discovering the optimum solution of the evolutionary algorithm pays way to the enrichment in the research field. This is bio-inspired evolution. The mutation, combination methods will take place in the problem space. The main characteristics of EAs are population-based, recombination technique is there to attain a new solution [16].

In PSO, the particles are positioned arbitrarily in search space and the fitness or quality of the particle is evaluated at that particular position. Each particle changes to a new position a predefined number of times to yield better fitness than the previous location. This is attained based on the communication among the particles. The velocity and location of the particle are updated for every iteration [17].

3.1. Fundamentals of PSO Algorithm

The PSO algorithm comprises a swarm with ‘m’ particles and the position of each particle which is represented in D-dimensional search space [18].

The equations used to calculate the speed and position of every particle are as follows.

$$V_{id}^{k+1} = WV_{id}^{k} + const_1 rand_1^k (pbest_{id}^k - x_{id}^k) + const_2 rand_2^k (gbest_{id}^k - x_{id}^k) \quad (1)$$

$$x_{id}^{k+1} = x_{id}^{k} + v_{id}^{k+1} \quad (2)$$

x_{id}^{k+1} denotes position of ith particle at d-dimension in kth iteration.

V_{id}^{k} denotes velocity

$pbest_{id}^k$ denotes personal best position

$gbest_{id}^k$ denotes global best solution.

w represents inertial weight

$const_1$ and $const_2$ denotes acceleration constants

$rand_1^k$ and $rand_2^k$ denotes random numbers in the range[0,1]

Figure 2 shows the iteration 0 to m.

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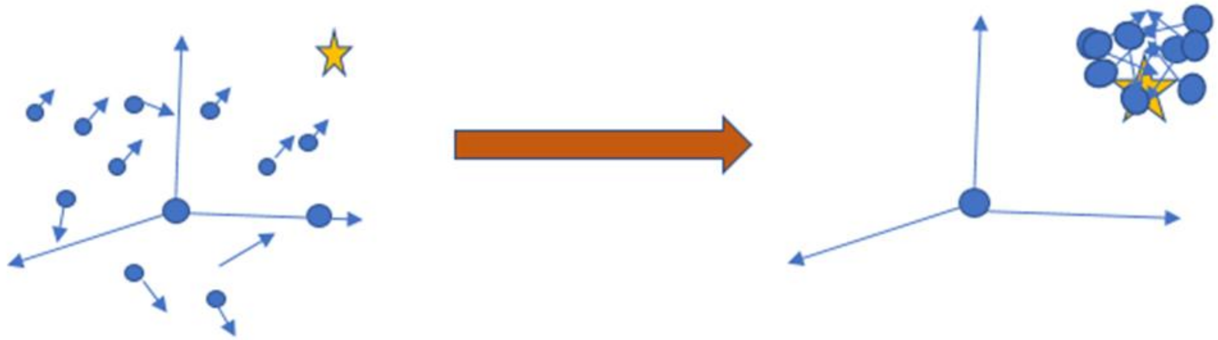

Figure 2 Iteration 0 to Iteration m

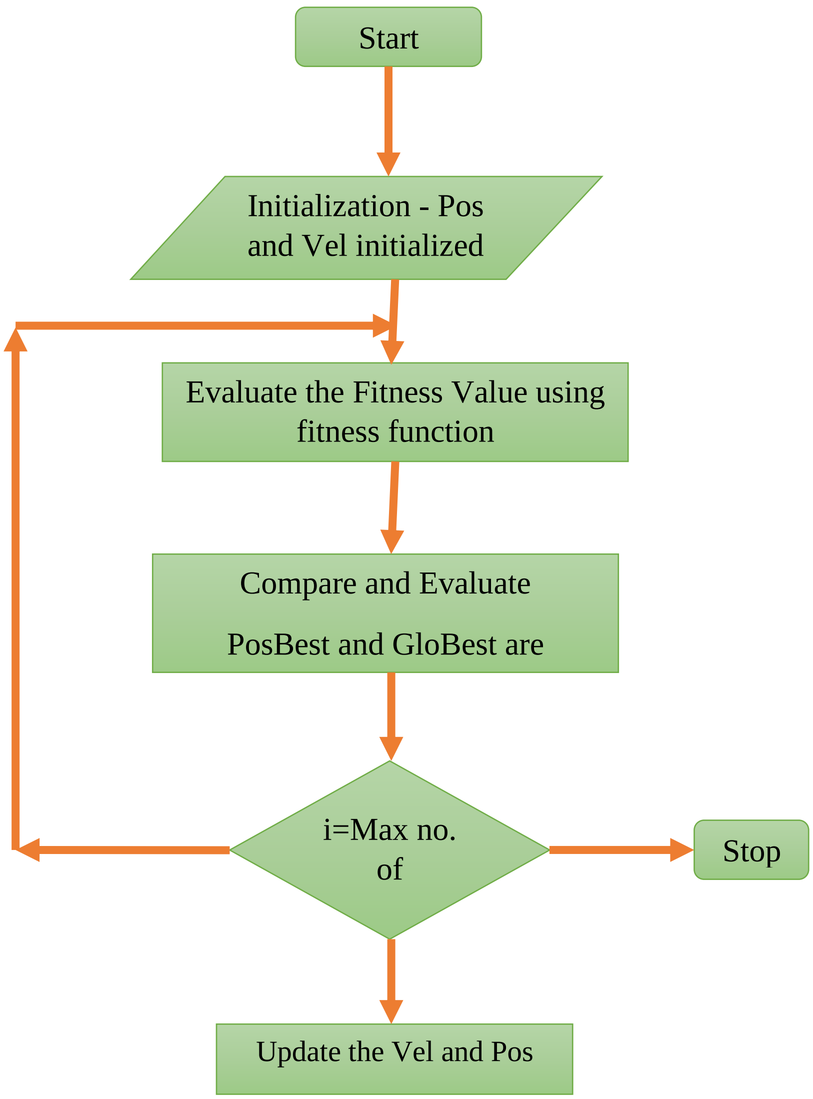

Figure 3 Flowchart of Particle Swarm Optimization

In PSO, the objective function of the search space is evaluated at its current location. The previous history and the best location of the swarm members are used to determine the movement. The flock of birds i.e swarm moves towards the fitness function [19].

Three dimensional vectors are there in the particle swarm. The current position is denoted by $\underset{o_i}{\rightarrow}$, previous best position is denoted by $\underset{p_i}{\rightarrow}$ and the velocity as $\underset{q_i}{\rightarrow}$.

{set of coordinates which describes a point in space} -> current position

If the best place is found by the swarm, then the current position is changed as previous best position. i.e $\underset{o_i}{\rightarrow}$ -> $\underset{p_i}{\rightarrow}$

A single particle cannot find the best solution. The best solution can be found out when it interacts with the other particle. Bidirectional edges connecting pairs of particles is the topology that can be applied to connect each and every particle with its neighbourhood [20].

The Figure 3 displays the flowchart of Particle Swarm Optimization.

4. TASK BASED SCHEDULING USING PSO

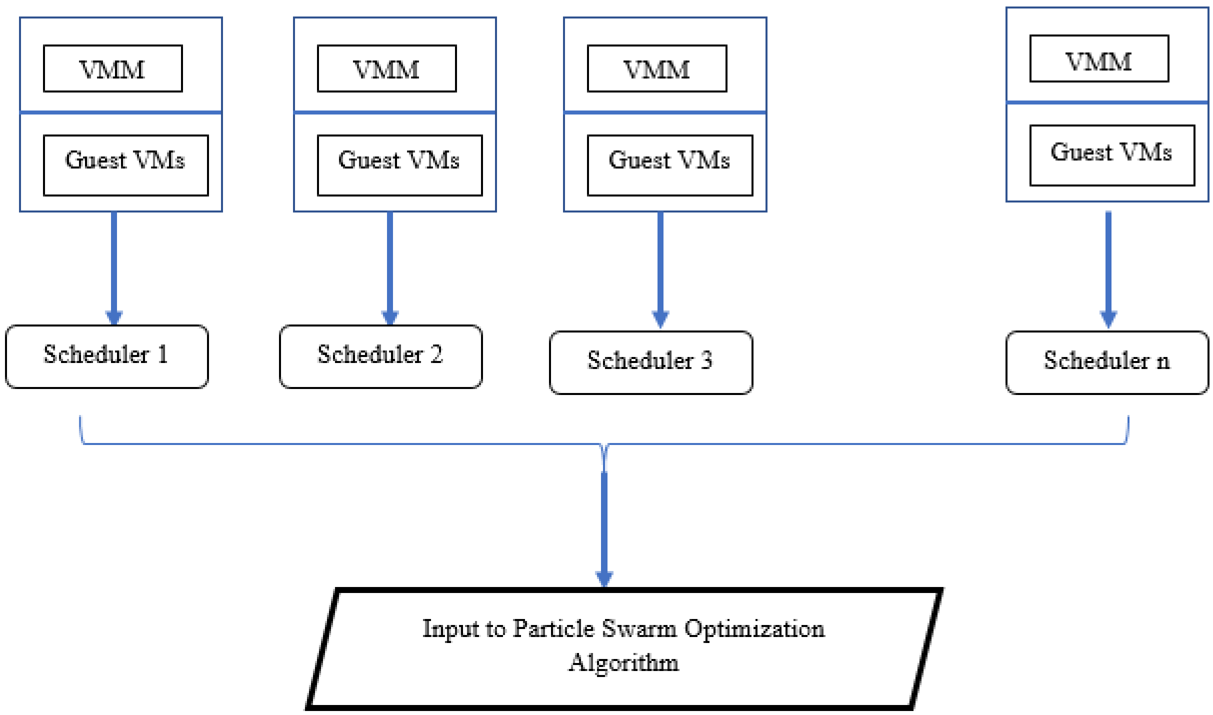

Figure 4 A Conceptual Model of the Proposed Work

The tasks can be migrated from the overloaded VMs to other idle or non-overloaded machines based on the PSO algorithm which achieves load balancing. In the case of data-intensive tasks, bandwidth is the important factor to reduce the data movement. Rather in the case of computing-intensive tasks, the number of CPUs on the host VMs is the major parameter to be considered.

The Task-based scheduling consists of a board where the VMS can publish the status like overloaded, underloaded, and task execution. Moreover, the idle VMs are not utilized for the new physical machine which consumes high energy [21].

The time taken for relocation from a fully loaded virtual machine is computed on the origin of the balance workload capacity of a VM. The formula is as follows [22]

$$VM_{rem\ work} = VM_{workload} - VM_{exec\ tasks}$$

Here, $VM_{workload}$ represents VM workload

$VM_{exec\ tasks}$ represent quantity of executing jobs in the VM

Figure 4 shows the conceptual model of the proposed work. The arrival tasks will be directed to another alike VM for completing the task when the particular VM is overloaded where

$$0 \leq VM_{rem\ work} \leq 1$$

The steps involved in the improved PSO algorithm is depicted in the Algorithm 1.

Input: The information of VMMs, VMs, PMs and SLA

VM : CPU, Execution tasks , Time of Task execution, Resources required

PM: Processors count, Processors speed, PM status (idle or active)

SLA information

1: Monitoring the information associated with workflow of VM, task execution, overloaded, execution time

2: Finding the new hosts as VM for the execution of the tasks in overloaded VMs.

3: Set the maximum particle size

4: Set each particle position and velocity in random manner

5: Set const1, const2, rand1, rand2, n, nmax

6: do

7: For (each particle location)

8: Fitness value update fitsum

9: For End

10: If (fitsum is less than or equal to personalbest)

11: Increase personalbest value

12: Increase personalbest vector

13: End if

14: End for

15: For (each location particle)

16: Increase globalbest to the min personalbest value

17: Increase globalbest vector

18: Increase particle velocity vector v_i^k

19: Increase particle position vector x_i^k

20: End for

21: While(stop condition)

22: Update the task exec time, Time to transfer.

23: Transfer the task and the data to mentioned host VM

24: Update the board according to step 4.

Algorithm 1 Improved PSO Algorithm

Therefore, the following equations can be used to calculate the task execution time on VM

$$Taskexe_k = \sum_{i=1}^{n} x_{ik} * \frac{Data_{ik}}{VM_{mem\,k} * VM_{cpu\,k}} \tag{3}$$

Here Task exe_k – task execution time

x_{ik} =1 if task i is mapped to VM_k

$Data_{ik}$ – total data where task i mapped to VM_k

$VM_{mem\,k}$ – amount of memory of VM_k

$VM_{cpu\,k}$ – number of CPUs of VMs.

The total task execution is executed as

$$Task_{exe} = \sum_{k=1}^{m} Taskexe_k \tag{4}$$

5. PERFORMANCE EVALUATION

The proposed work is carried out with the help of cloudsim simulator. Cloudsim is used to model and pretend the cloud computing environments. The number of VMs is 100 in the data center. At the initial stage, the various number of resources are requested by the different types of VMs which can be changed based on the VM workload [23].

The proposed work is compared with an adaptive three-threshold energy-aware (ATEA) algorithm to assess the effect of the proposed work. The number of iterations used in the Improved Particle Swarm Optimization algorithm is determined by running experiments with 25 to 1000 tasks and 150 iterations [24]. Both makespan and throughput reached a constant value after 150 iterations. As a result, our proposed method will have 150 iterations.

Parameter	Value
Population size	100
Count of iterations	150
Count of executions	500
Const1	1
Const2	1.1
Rand1, rand2	[0,1]
α1, α2	0.4
α3	0.2

Table 3 PSO Algorithm Parameters

To find the features of VMs in the experiments, Table 3 parameters are helpful. The main goal of this research work is to decrease the makespan of the application, balancing the load to utilize the resources.

The initial population assumed here is 100.

Parameter	Value
No. of tasks	25-1000
VMs count	16
MIPS	250-1500
BW	250-1500 (mbps)
Number of processors	4

Table 4 Parameters Used for Simulation

Table 4 shows the parameters used for simulation. Figure 5 shows the Comparison of Makespan Time for ATEA, PSO

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and Improved PSO (10 VM). Makespan time for ATEA, PSO, and Improved PSO is mentioned as a graph in Figure 6. The figure shows that the improved PSO performs in minimum makespan time compared to ATEA and PSO.

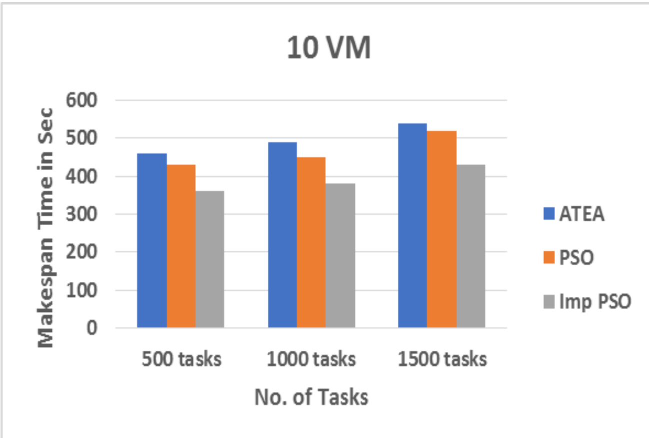

Figure 5 Comparison of Makespan Time for ATEA, PSO and Improved PSO (10 VM)

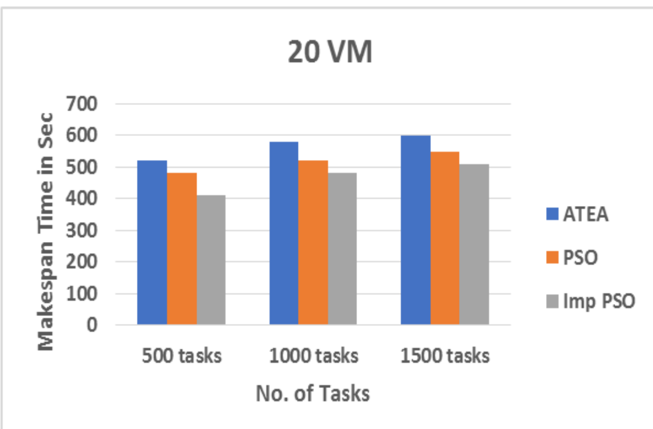

Figure 6 Comparison of Makespan time of ATEA, PSO and Improved PSO (20 VM)

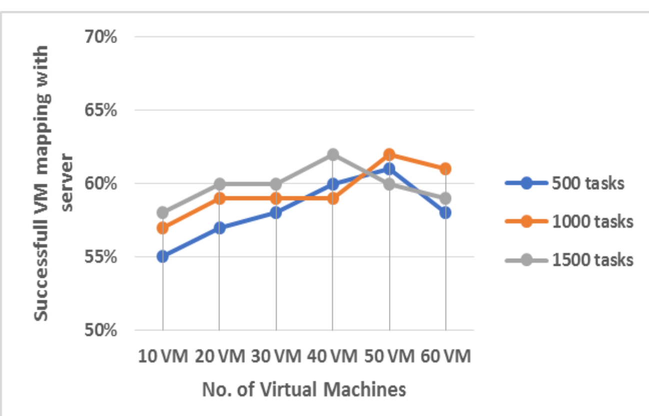

Figure 7 Throughput Based on Number of Virtual Machines

The overall performance of cloud computing depends on the throughput, Response Time [25]. The makespan time is mentioned in Figures 6 & 7 to denote the response time. To show the throughput of the cloud environment, the count of VM mapped with the server is shown in Figure 8.

Figure 9 shows the average execution cost on different tasks. This shows that the proposed improved PSO gives a minimum execution time than other ATEA and PSO algorithms.

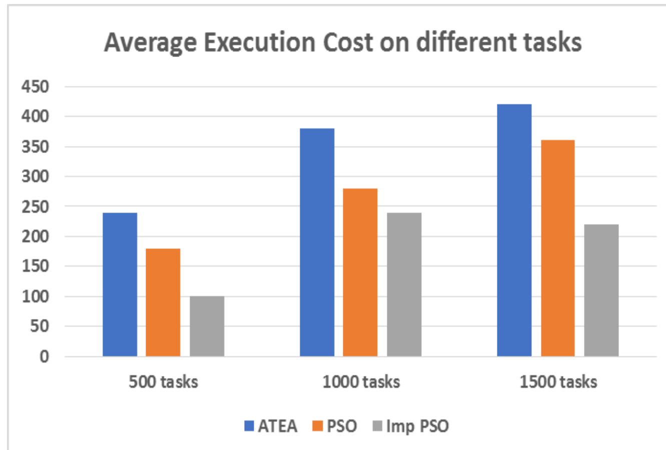

Figure 8 Average Execution Cost on Different Tasks

6. CONCLUSION AND FUTURE WORK

In this research article, an improved PSO algorithm is projected and executed in the cloudsim simulator. Here, the proposed improved PSO algorithm is compared with ATEA and PSO algorithms. To ensure a fair workload in the VMs, the execution of tasks and execution tasks are considered. The improved PSO algorithm selects the VM host with minimal workload to share the data of the overloaded VM. The proposed improved PSO achieves minimum execution cost and makespan time compared to other algorithms.

In the future, this research work can be extended to do with one data center and more in a heterogeneous environment. In addition, the Genetic Algorithm along with Particle Swarm Optimization (PSO) can be applied to check for the betterment of the result.

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