Hybrid Genetic Algorithm and Modified-Particle Swarm Optimization Algorithm (GA-MPSO) for Predicting Scheduling Virtual Machines in Educational Cloud Platforms

https://doi.org/10.3991/ijet.v17i07.29223

Supreeth S[1,2](✉), Kirankumari Patil[3]
[1] Research Scholar,VTU, Belgaum, India
[2] School of CSE, REVA University, Bengaluru, India
[3] Department of CSE, REVA ITM, Bengaluru, India
supreeth.s@reva.edu.in, supreeth1588@gmail.com

Abstract—Cloud Computing is expanding gradually as the number of educational applications rapidly increases. Therefore, Internet connectivity is essential to get the Educational Cloud services, and Cloud Environment uses one of the critical technologies to manage the Physical servers, i.e., Virtualization Technology. In Cloud Computing, the data centers host numerous Virtual Machines (VMs) on top of the Servers. Due to the rapid growth of Educational platforms, the workload of the VM is computationally getting increased. IT resources are provisioned over the network in the Cloud Educational platforms to execute the jobs. Since the data generated from the client-side is dynamic, it is not easy to allocate the computational resources efficiently. So to enhance the energy efficiency and to provide the resources in an optimized way, a VM Scheduling mechanism with Hybrid Genetic Algorithm and Modified Particle Swarm Optimization (GA-MPSO) is proposed in this work to achieve QoS parameters like reduced Energy consumption, SLA violation, and cost reduction over the heterogeneous environments. The Hybrid GA-MPSO predicts the optimal range and improves the best range of scheduling the Virtual resources to VMs from Physical Machines (PMs). The proposed approach, when compared to other VM scheduling algorithms, it intensifies the energy consumption to 105KWH, SLA violation rate of 0.08%, reduces the migrations count to 2122, and consumes the overall cost of 2567.68$. The different scheduling methods for VMs are evaluated against the results, which shows that the Hybrid GA-MPSO method is far better than the existing algorithms.

Keywords—virtual machine scheduling, cloud environment, optimizing resources, hybrid GA-MPSO

1 Introduction

Cloud computing [1] is a significant domain expanding gradually as the number of educational platforms is rapidly increasing in the IT industry regarding computing resources over the internet channel. It enables the usage of a high amount of storage, networks, platform, and applications to provide different services. To provide cloud computing services, it uses the advantages of virtual kind of resources. The cloud infrastructure gives an unlimited range of efficient scheduling of virtual resources as the size increases. It substantially stores resourceful data, and the energy consumed in the data centers is high; therefore, energy-efficient data centers should be initiated, impacting global warming. Cloud Computing should have an intelligent mechanism for analyzing and managing cloud computing resources. In Cloud, VM is allocated on the Physical Machines. If the resources are underutilized, then the physical machine resources are also computationally wasted. To reduce the wastage of physical machine resources, optimized Virtual Machine Management (VMM) plays a significant role. VM Scheduling must be done intelligently by analyzing size, memory, CPU utilization, energy, and SLA violation. These are essential steps to deciding on VM Scheduling [2].

In Cloud Computing, clients' requests are sent over the network; Cloud Brokers process these requests and allocate the resources on the Physical Machines as Virtual Machines to respond to every client by providing it like IaaS, as shown in Figure 1. This massive number of VM shares the physical resources as it initiates the virtualization in Cloud System and VM consumes the resources of Physical Machines [3]. To find the optimization and other VM Management, VM Scheduling has been proposed. It aggregates the resources in a heuristic manner [28] and provides a certain amount of resources deterministically. VM sets hosts' resources based on CPU, network bandwidth, disk specification, and memory. In VM scheduling, must intelligently deploy the VM on PMs by optimizing the power consumption and maximizing the utilization of resources by lowering the SLA violation. It utilizes the hardware capability, which reduces the cost of the administration. In VM scheduling, computing is tedious as many users continuously request resources. The VM scheduling algorithms affect the overall performance by determining the throughput. As the computing nodes are high, the Cloud is underutilized or over-utilized, which causes unbalanced load distributions. The different optimizations are required during VM Scheduling and while managing the VMs. Many existing VM Scheduling approaches fail to achieve all the performance metrics with less cost for the computation of overall operations. This motivates the researchers to work on this problem to effectively improve VM management for Allocation and coordinate with VMs [4]-[5].

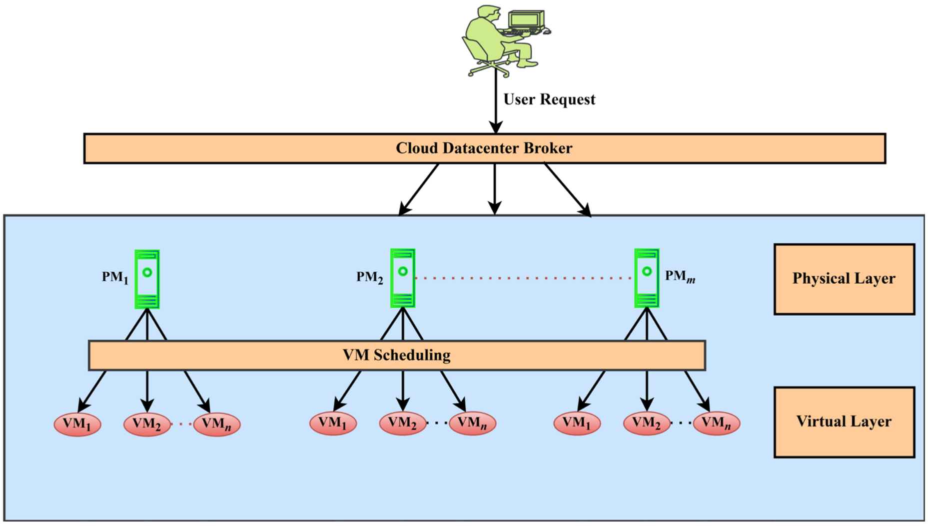

Fig. 1. The architecture of scheduling virtual machines

Optimized VM Scheduling reduces the VM migrations count, where it meets up with SLA and less energy consumption. The users have been defined with a non-viable range of placements in the Service Level Agreement. Due to the intelligence in VM Management, existing scheduling approaches waste a considerable portion of PM resources. Consequently, the power consumed by complete cloud technology is drastically increased; this may impact global warming by generating CO2 emissions. So intelligent VM scheduling approach optimizes the parameters of VMs assigned to PMs by reducing the idle PMs. The VM Scheduling uses the Virtual Machine Placement to map the computing resources between the physical and virtual machines. Insufficient utilization of computing resources can cause high-energy consumption with SLA violation [6].

Three essential tasks are to be carried out in the VM Scheduling are, as mentioned below.

1. To maintain the list of Processing elements on a particular host on its total capacity in a specific host with its full compute capacity in terms of MIPS.
2. Maintaining the mapping information between the processing elements and Virtual Machine for allocated MIPs.
3. Maintaining the list of VMs to migrate within or outside the host.

2 Related works

In [7] proposed, scheduling data processing in the big Cloud. As the cloud computing platforms are analyzed by collecting large amounts of data. VM is allocated using the VM scheduling algorithms for handling the vast data. The existing type of scheduling algorithms can waste the substantial resources of PM. The author proposed the VM relocation methodology, which significantly improves energy effectiveness. The proposed approach is improved using the Knapsack algorithm[8], which achieves the resource management for clustering of the Cloud.

They have developed a practical approach to cloud computing with VMs. In the IT industry, Cloud Computing is considered a boon. In this approach, the jobs generally require more time to execute, consuming more energy. Generally, the swapping of the situation is characteristically defined using the frameworks of the VM on blade servers. It manages the network by equipping the physical machine. Frameworks are defined using the different scheduling algorithms that cannot execute more than MIPS of the frameworks.

The optimized way to compute the data resources uses the virtual machine where a pool of servers is performed within the data center. In the network resources, the traffic-aware is balanced using the VMPPTB approach. It designs the processing time using the time-based placement type algorithm. The main advantage is optimized by using the locality aware with the traffic-aware approach for balancing. The multi-objective optimization is carried out simultaneously [9].

A VMP methodology [10] performs the VM in the cloud infrastructure. The Open stack platform had been initiated where the virtualization types resource scheduling platform. The physical resources such as memory, CPU utilization, and bandwidth are analyzed in the physical machine.

In [11], optimizes the performance of SLA, which controls the ownership of the cloud resource using the service where it initiates with the different services. It minimizes the number of physical hosts by supporting the VM by handling it in all the capacity requirements. However, VM migration overhead can cause issues in the VM placement ranges. The core aim is to decrease the performance losses which occur during the migration process by reducing the problems in the VM placement algorithm. It evaluates the existing type algorithms like ILP, FFD, which causes the constraints over the decisions at placement. These FFD heuristics are comparatively faster, generating the sub-optimal type solution, and valuable in real-time project decisions.

Comparative research has been conducted on several kinds of VM scheduling and Allocation methods. Companies demand various types of VM based on the requirements, and the cloud provider offers those facilities by the Service Level Agreement (SLA) to assure QoS. Cloud providers require an effective resource scheduling method to manage a high number of VM requests. Mainly Cloud Computing facilitates quick access to external and globally dispersed resources via Virtualization in Infrastructure as a Service [12].

In [13], used a technique to compute the number of iterations and equalize workloads. To enhance a virtual machine's works as intended for cloud computing in both homogeneous and heterogeneous settings, CloudSim has been used to model systems with various augmenting methods to compare their number of iterations and load balancing capacity. The results were good compared to that of other swarm intelligence approaches over the HABC scheduling performance of the cloud computing system.

A researcher suggested employing a Neuro-Fuzzy Inference with Black Widow Optimization (BWO) [14] to choose the best VM for each function with the least latency.

The recommended approach's principal purpose is to decrease the computing time, energy consumption, and activities cost while maximizing resource usage. The bulk of prior scheduling systems uses virtual machine (VM) instances that require more time to boot up and demand all available resources to complete tasks.

3 System model

Cloud computing services are being served through the internet medium for large Cloud Consumers. Different services are undertaken through the internet medium where it stores up the data, databases, servers, networking, and other software using pooling methodology. It has many different services, and to enhance speed, scalability, efficient continuous services, reduced power consumption, and without any Violations, Cloud has to develop efficient IT computing solutions for different clients and applications. For this, Cloud has to develop an optimized model to schedule the Virtual resources from the Physical resources during the VM Placement in such a way that it has to minimize the VM Migration. Figure 2 shows the flow of the VM Scheduling scenario in a Cloud technology.

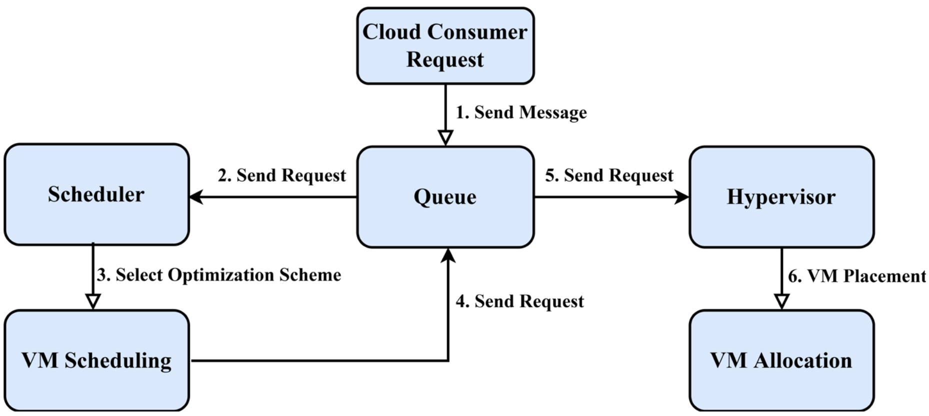

Fig. 2. The flow of VM scheduling in a cloud systems

3.1 Preliminary of the proposed system

In this, a System model is considered such that Cloud Environment comprises many Data Centers (DCs), and all these Data Center consists of different configuration Physical Machines. For example, let, a Data Center consisting of k PMs and a set of Physical Machines is considered as represented in Eqn. 1 and $|P|=m$.

$$P = \{PM_1, PM_2, \dots, PM_m\} \quad (1)$$

k^{th} Physical Machine, i.e. (PM_k) characterized by CPU, RAM, HDD, and Maximum Power Consumption resources as represented in Eqn. 2.

$$PM_k = [PM_k^{CPU}, PM_k^{ram}, PM_k^{hdd}, PM_k^{pmax}] \tag{2}$$

Where
PM_k^{CPU} – PM_k CPU resource,
PM_k^{ram} – PM_k ram resource,
PM_k^{hdd} – PM_k harddisk resource,
PM_k^{pmax} – PM_k maximum power consumption.

Each Physical Machine can host the n number Virtual Machines (VMs), V is a set of VMs, and |V|=n as represented in Eqn. 3.

$$V = \{ VM_1, VM_2, \ldots, VM_n\} \tag{3}$$

Each Virtual Machine *j* is consisting different resources like CPU, RAM, HDD, and power consumption as represented in Eqn. 4.

$$VM_j = [VM_j^{CPU}, VM_j^{ram}, VM_j^{hdd}, VM_j^{pmax}] \tag{4}$$

Where
VM_j^{CPU} – VM_j CPU resource,
VM_j^{ram} – VM_j ram resource,
VM_j^{hdd} – VM_j harddisk resource,
VM_j^{pmax} – VM_j maximum power consumption.

3.2 Problem formulation

Cloud Consumer sends the request for launching the Virtual Machine to execute the jobs on PMs on the Cloud Data Center. Consider Cloud Data Center consists of m PM, denoted as a set P and n number VMs to be host on these Physical Machines, which are represented as set V. In order to schedule the cloud resources to the VM, a proper selection of Physical Machine is essential. The identified Physical Machine details have to be sent to the hypervisor for the Placement of VM on Physical machines by satisfying QoS parameters like energy consumption, SLA, cost of downtime, migration. The optimization criteria are considered in the heterogeneous resources and the different capabilities to lower the power consumption of the PM by satisfying the SLA. Eqn. 5 can define the Energy Efficient Optimization (EEO) objective function:

$$EEO = min \sum_{k=1}^{k} \sum_{j=1}^{j} E_{ij}\, x_{ij} \tag{5}$$

E_{ij} : Energy consumed by PMj; x_{ij}: VM_i is scheduled on PM_j.

By satisfying the following constraints represented in Eqn. 6, 7, and 8:

$$\sum_{i=1}^{n} m_i^{cpu}\, x_{ij} \leq C_j^{cpu} \tag{6}$$

$$\sum_{i=1}^{n} m_i^{BW}\, x_{ij} \leq C_j^{BW} \tag{7}$$

$$\sum_{i=1}^{n} m_i^{ram}\, x_{ij} \leq C_j^{ram} \tag{8}$$

$m_i^{cpu}, m_i^{BW}, m_i^{ram}$: Maximum CPU-MIPS, network bandwidth, amount of memory.

3.3 Performance metrics

Proposed System Energy Consumption, SLA Violation, and VM Migration count parameters have been considered to analyze the proposed work with various existing algorithms.

Energy consumption. Most cloud providers focus on energy consumption since this is one of the primary parameters. Energy consumption can reduce the impact on resources in Cloud Systems. The optimization problem can reduce the wastage of the resources and maximize the resource utilization of the physical machines. As the physical devices get increased, the resources' cost increases. Using the Hybrid GA-MPSO, the energy transformation is feasible where it utilizes the resource of PM efficiently, which consumes less energy. By determining the best optimization strategy, the energy consumption can be decreased without any violation of Service Agreements. Power Consumption [15]-[16] of the Physical server in the Cloud Environment can be calculated using the Eqn. 9, and Total Energy Consumption (E) for a particular time is calculated using the Eqn. 10.

$$P(u) = k \cdot Pmax + (1 - k) * Pmax * u \quad (9)$$

Pmax denotes a host's maximum power in a running state; k denotes idle Physical Machine power consumption (in terms of %), and u denotes CPU utilization.

$$E = \int_{t_0}^{t_1} P(u(t))dt \quad (10)$$

$P(u(t))$: Probability of resource utilization over time u(t) between the time intervals(t_0, t_1).

SLA violation. SLA Violation [17] is an essential metric to analyze the performance to ensure the deviations in the system. The host's performance can be calculated using SLA violation and the total number of overloaded Physical hosts in the Datacenter. Eqn. 11 can be used to compute SLA Violation Time per Active Host (SLATAH), and Performance Degradation Caused by VM Migration can be calculated using Eqn. 12.

$$SLATAH = \frac{1}{N} \sum_{i=1}^{N} \frac{T_{fi}}{T_{ai}} \quad (11)$$

N: number of hosts; T_{fi}: total time for full utilization by the host; and T_{ai}: Total time that hosts are in the active mode.

$$PDCVM = \frac{1}{N} \sum_{i=1}^{N} \frac{P_{dj}}{P_{rj}} \quad (12)$$

N: number of VMs; *Pdj*: the performance degradation, *Prj*: Hosts CPU Requested by VM.

The main SLA Violation metric is created by combining the 2 previous metrics in Eqn. 13, as follows:

$$SLAV = SLATAH * PDM \tag{13}$$

Migration performance. The VM migration performance is generally used to improve resource utilization. The enormous computing scale can tolerate load balancing, fault tolerance, online type maintenance, performance metrics. Some factors include VM workload-based characteristics such as network transmission rate, memory size, VM workload characteristics, and other noisy rates.

4 Proposed Hybrid Genetic Algorithm-Modified Particle Swarm Optimization (GA-MPSO)

In Cloud Environment, Whenever the Cloud Consumer sends the request for the VM Scheduling on the Physical Server and the Virtual Machine Scheduling has to optimize the request in two levels: 1) Real-time data collection for VM selection for the regular time interval 2) Monitoring of Physical and Virtual Resources effectively.

The Hybrid GA-MPSO algorithm initially starts by generating a random set of populations. The population set defines each specific number of iterations within the algorithm parameters. In general, the initialization population passes through the GA algorithm and the first iterations portion. The number of iterations is defined as n, where the genetic Algorithm uses n/2 iterations. n/2 is used to decrease the excessive density by encoding the chromosomes within the solutions. Every function of the size of the population, other iterations are to be measured. Each of these parameters is adjusted according to the performance of their trial. The Hybrid GA-MPSO algorithm defines each set of iterations into equal halves of GA and PSO algorithms, respectively. As it uses the divide and conquers rule, the GA and PSO produce equivalent complexity where it is denoted as G (n) =2 x G(n/2) + T (n); where T (n) indicates the divide and conquer rule. It evaluates the multiple ranges of functions where each population member is sampled in the current state. Finally, it suggests the decrease in the iterations count that occurs. The GA algorithm uses the chromosomes, which use different operators such as mutation, crossover, and selection operators. Chromosomes are first sent to the PSO, and then to the iterations are defined for evaluation purpose. Each particle is minimized within the minimum fitness set of values, where each is represented in the form of workflow task scheduling.

Genetic Algorithm [25] uses a probabilistic optimization technique. In this chromosome, the biological evolution process is used. Here five critical steps are used i) The Initial population step, ii) The Fitness function step, iii) The Selection step iv) The Crossover step v) The Mutation step.

Algorithm 1 shows the Genetic Algorithm. An individual is defined by a set of parameters (variables) known as Genes in a genetic algorithm. A string represents an individual's set of genes in terms of an alphabet. The fitness function determines how to fit an individual, i.e., an individual's ability to compete with others. The fitness score determines the likelihood of an individual being chosen for reproduction.

The selection phase's goal is to find the healthiest individuals and permit them to pass those genes to the next generation. Two pairs of people (parents) are chosen based on their fitness scores. Some of the genes, particularly new offspring, can be exposed to a mutation with a small random probability. Individuals who are physically fit have an improved chance of being chosen for reproduction. The Genetic Algorithm is then said to have provided a set of results to our problem. If the population has converged, the Algorithm will end (does not yield offspring which are meaningfully different from the earlier generation).

```
Algorithm 1: Genetic Algorithm
Input: Hosts from Datacenter
Result: Overloaded Detection (True or False)
 1. START
 2. Generate the initial population
 3. Find the CPU and RAM resource consumption of each
    host.
 4. Find the average CPU and RAM resource consumption
    of hosts in the cluster.
 5. Find the utilization balance of CPU and RAM re-
    sources.
 6. Calculate the migration cost.
 7. Calculate the fitness value.
 8. REPEAT
 9. Selection phase to find the fittest.
 10.The crossover point is chosen randomly.
 11.Some of the bits can be flipped using mutation
 12.Calculate the fitness score
 13.UNTIL population has converged
 14.STOP
```

PSO [27] has been influenced by creatures' behaviour in groups, such as a gathering of birds that picks any dropped bits of food, which is an evolutionary programming technique. It's a computational technique for improving a problem by repeatedly improving a candidate grouping for a given amount. The PSO's primary goal is to discover the best outcome by collaborating and sharing data amidst particles or molecules is called a population. A particle is a section or part of a swarm that is a population. To find appropriate site regions, Swarm must fly over the hunt space. Each particle has a search area in which it searches for food, and each particle is created at random and contains both velocity and position. Every particle is aware of its own best position called Pbest and its best position within the group of particles called Gbest. In each iterative step, the location and velocity of an individual particle are updated.

Modified PSO [26] is a term that refers to enhanced variations of PSO that are currently used in VM scheduling. A few updates for velocity, exceeding global best optimum [18], limit control, and so on are included in this Algorithm. Modified PSO can reduce energy consumption and Minimize makespan time. Eqn. 14 is used to calculate the minimum energy consumption.

$$E(M) = \sum_{k=1}^{n} E_{ex}(M)_k + \sum_{i=1}^{n} E_{tr}(M)_i \quad (14)$$

To prevent the slow rate in convergence and difficulty in optimal results of the existing PSO algorithm, the M-PSO approach employs an altered inertia-weight technique to obtain the aim, as shown in Eqn.15, and the Fitness function has been represented in Eqn.16.

$$\omega = \left(\frac{\alpha\ x\ t_{max}}{t^{\gamma} + t_{max}}\right) + \beta \tag{15}$$

$$fitness(i) = \frac{1}{E(M)} \tag{16}$$

Where $E_{ex}(M)_k$: total execution consumption of resource k, $E_{tr}(M)_i$: total transfer consumption between task i, ω: inertia weight, t_{max}: maximum iteration, γ: acceleration factor, α, and β are constant parameters. The proposed method's main goal is to combine the SJFP-Smallest Job to Fastest Processor with the PSO approach. The balanced mapping is provided by this modified PSO algorithm, which assigns the job to the quickest processor.

Figure 3 demonstrates the process flow of the M-PSO. An M-PSO estimation can be used to achieve a globally optimal solution by minimizing both the cost and time of processing all tasks. The total amount of time it takes to complete all tasks is expressed as shown in Eqn. 17 and the Total cost for processing all jobs are represented in Eqn. 18.

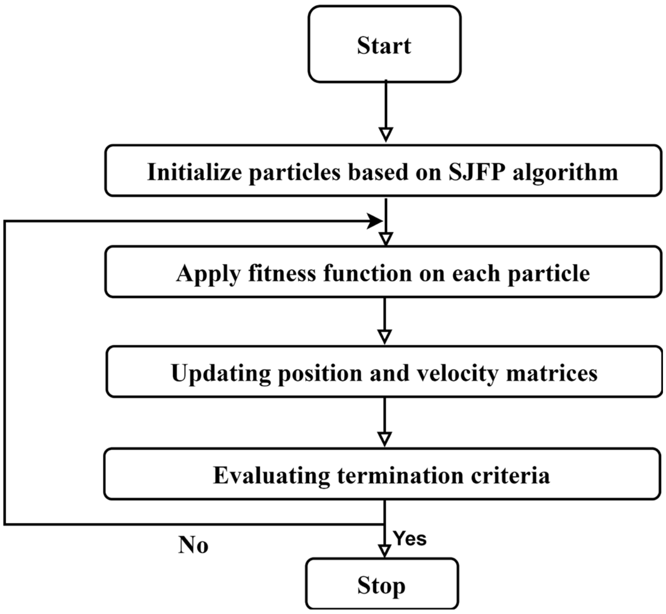

Fig. 3. The modified PSO

$$T_r = \sum_{i=1}^{m} T(r, i) \tag{17}$$

$$Cost_r = \sum_{r=1}^{m} T_r * ERC_r \tag{18}$$

Algorithm-2 shows the proposed Hybrid GA-MPSO algorithm for VM Scheduling. In this, both the Genetic and Modified Particle Swarm Optimization algorithm is combined to achieve the best performance.

Algorithm 2: Hybrid GA-MPSO Algorithm
Input: Randomly initialize PSO[i][j]
Result: G_{best} for Scheduling the VMs

1. Let PSO[i] be the position of the i^{th} particle of the PSO population
2. Let PSO[i][j] be the Physical Machine to which the jth VM in the ith particle is assigned
3. Let fitness[i] be the cost function of the ith particle according to (18)
4. Let p_fitness[i] be the local-best fitness for the best position visited by the ith particle
5. Initialize PSO[i][j] randomly from the set {1,2,…..k}
6. $P_{best}[i]$ through a copy of PSO[i] ∀i ≤ p
7. while #generation ≤ Max_Iter do
8. Find G_{best} | fitness[G_{best}] ≥ fitness[i] ∀i ≤ p
9. if PSO[i][j] not satisfy Eqn. 6-8 then
10. Generate random solution for the PSO[i][j]
11. end if
12. Selecting agents Using selection Tournament
13. Perform one-point crossover
14. Perform shift Mutation
15. for i ≤ p do
16. if fitness[i] > p_fitness[i] then
17. $P_{best}[i] = PSO[i]$
18. end if
19. end for
20. for i ≤ p do
21. Update $\omega(x)$ and PSO[i]
22. end for
23. Evaluate fitness[i]
24. end while

The technology minimizes energy usage by actively moving virtual computers in a cloud environment. It ensures that virtual machine migration takes as little time as possible. This effort leads to the efficient exploitation of existing resources. The use of PMs in the cloud environment results in energy-saving usage. It has been determined that virtual machines are alive, and effectively migration results in lower energy use.

5 Results and discussions

Implementing the algorithms of hybrid GA-MPSO for VM Scheduling algorithm using CloudSim[19], by considering the 800 PMs and 898-1516 VMs upon it by considering 10days traffic. SPECpower[20] data ss collected from HP ProLiant G4 and G5 servers. The workload is based on real-world system data from Planet Lab [21], considered for simulation on CloudSim. Table 1 shows the Number of Virtual Machine Counts for different trace workloads.

Table 1. The number of Virtual Machine counts for different workloads

Days	1	2	3	4	5	6	7	8	9	10
Workloads	20110303	20110306	20110309	20110322	20110325	20110403	20110409	20110411	20110412	20110420
Number of VMs	1052	898	1061	1516	1078	1463	1358	1233	1054	1033
Mean	12.31%	11.44%	10.70%	9.26%	10.56%	12.39%	11.12%	11.56%	11.54%	10.43%

The implementation is executed using the CloudSim simulator to identify that the hybrid GA-MPSO Algorithm is faster and performs in a bit of time based on customer demands. The allotted virtual machines must be placed on suitable host machines within the architecture to serve user requests in shorter time intervals effectively. Compared to other scheduling algorithms, where the penalties and cost of the VM get reduced and income increased due to the usage of the improved hybrid GA-MPSO algorithm approach. To get the optimal solution and cost-effectiveness, the VMs are scheduled in different phases with the hybrid algorithms to enhance the simplicity in the Cloud System. The comparative analysis of the VM scheduling algorithm has been done using cost and performance metrics. Compared to other scheduling algorithms, the hybrid GA-MPSO Algorithm minimizes the loss, income, and penalty of the Virtual Machine, as shown in Table 2.

Table 2. Cost comparative analysis of VM scheduling algorithm

SI.No.	Algorithm	Energy Consumption ($)	SLAV($)	Income($)	Overall Cost($)
1	GA-MPSO	2135.56	176.545	12398.59	2567.68
2	VMS-MCSA	2330.08	631.294	12398.59	3755.58
3	GM-DPSO	2868.74	732.07	12398.59	9529.85
4	PSACO	2688.44	200.95	12398.59	9509.21
5	LR-MMT	2604.3	1413.5	12398.59	8380.79
6	IQR-MC	3266.29	606.05	12398.59	9126.24

In this, a Hybrid GA-MPSO method is used to offer a Virtual Machine (VM) Scheduling mechanism. According to the overall findings collected, it is apparent that the suggested Algorithm performs the VM Scheduling with little energy consumption and that efficiency deterioration due to migration is less for the proposed method. Figure 4 shows the comparative Energy Consumption analysis of the proposed work with other

Algorithms according to the day-wise data, and it consumes less energy for all the 10days. Figure 5 shows the comparative SLA Violation analysis of proposed work with other Algorithms according to the day-wise data, and this results in minor SLA Violation for all the 10days. Finally, Figure 6 shows the comparative number of VM Migrations of proposed work with other Algorithms according to the day-wise data, and this results in fewer number VM Migrations for all the 10days.

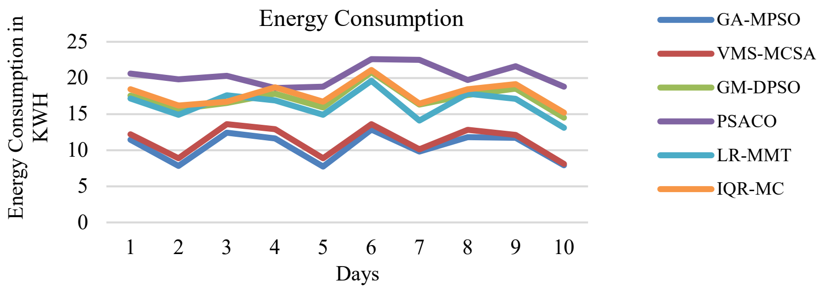

Fig. 4. Comparative energy consumption analysis of proposed work with other algorithms according to the day-wise data

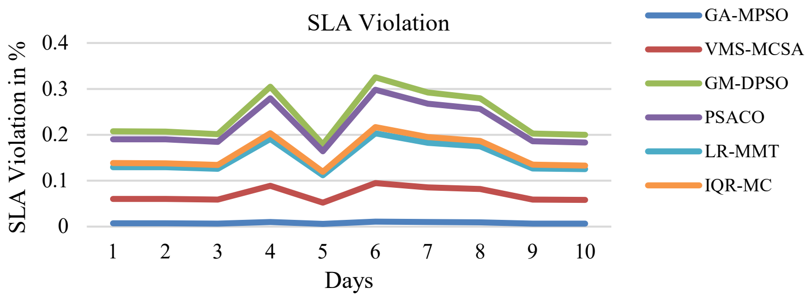

Fig. 5. Comparative SLA violation analysis of proposed work with other algorithms according to the day-wise data

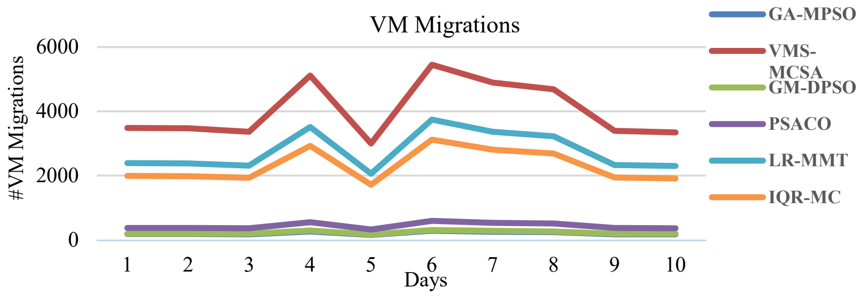

Fig. 6. The comparative number of VM migration analysis of proposed work with other algorithms according to the day-wise data

When the Hybrid Genetic Algorithm and Modified Particle Swarm Optimization algorithm were implemented in this work and resulted in better efficiency, compared to VMS-MCSA [22], GM-DPSO [23], PSACO [24], and standard algorithms like LR-MMT, IQR-MC. Table 3 shows the overall comparative analysis of the proposed work with other algorithms using all the performance metrics. Figure 7 shows the Comparative analysis of the overall energy consumption of the proposed Algorithm against other algorithms. The proposed work consumes energy 105.2KWH; this is better than different existing Algorithms. Figure 8 shows a Comparative analysis of the overall SLA Violation of the proposed Algorithm against other algorithms and the proposed work that violates the SLA of 0.08%, which is negligible compared to different existing Algorithms. Figure 9 shows the Comparative analysis of the overall VM Migration of the proposed Algorithm against other algorithms and the proposed work that yields fewer VM Migrations, i.e., 2122. This is very negligible compared to different existing Algorithms.

Table 3. Overall comparison of proposed algorithm with other existing algorithms

SI. No	Algorithm	Energy Consumption (KWH)	Number of VM Migration	SLA Violation (%)
1	GA-MPSO	105.2	2122	0.08%
2	VMS-MCSA	113.2	40223	0.70%
3	GM-DPSO	171.3	2303	2.40%
4	PSACO	203.3	4387	2.20%
5	LR-MMT	163.15	27632	1.50%
6	IQR-MC	177.1	23035	1.60%

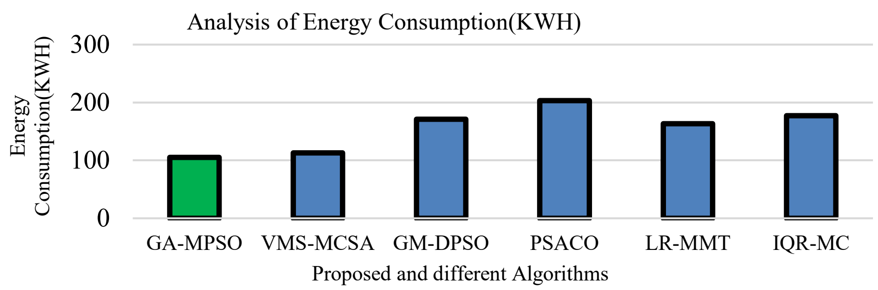

Fig. 7. Comparative analysis of overall energy consumption of proposed algorithm against other algorithms

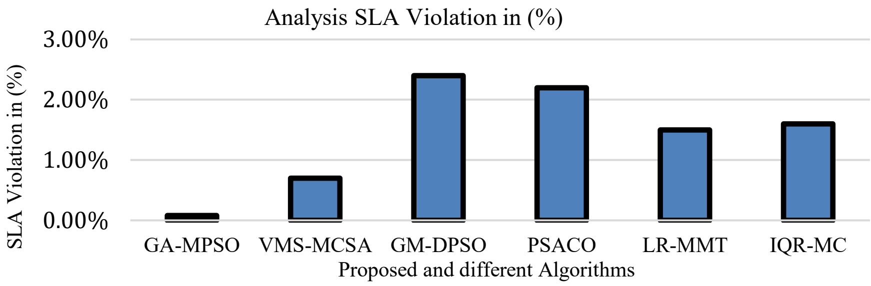

Fig. 8. Comparative analysis of overall SLA violation of proposed algorithm against other algorithms

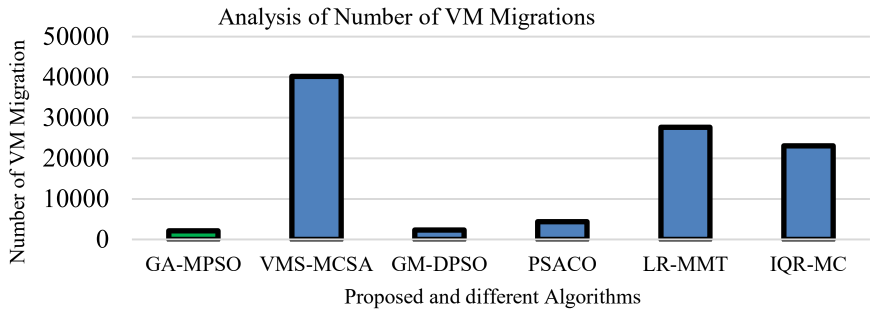

Fig. 9. Comparative analysis of overall VM migration of proposed algorithm against other algorithms

6 Conclusion

Cloud Computing faces difficulties in handling the resources effectively. This work targets the resources to utilize effective scheduling of the VMs on the Physical servers. This also benefits from various on-demand solutions and sharing resources in the Cloud Computing Environment. In this research work, a VM scheduling algorithm has been proposed for effectively managing the VMs in the data center that contains the Physical Machine resources. The Hybrid GA-MPSO method minimizes the processing time and cost of dependent activities, balances the load across heterogeneous cloud resources by considering reduced power consumption, minor SLA violation, and maintaining fewer virtual machine migrations. The different scheduling algorithms are compared according to their energy consumption, reduction, income, and cost expenditure for the VM scheduling. Other algorithms are evaluated to attain the results, which indicate that the Hybrid GA-MPSO algorithm is comparatively better than existing algorithms. Furthermore, the Hybrid GA-MPSO method reduces the overall execution time of the workloads, Energy consumption, the number of VM Migrations, and SLA Violation compared to the VMS-MCSA, GM-DPSO, PSACO, LR-MMT, IQR-MC algorithms. As per the obtained results, the proposed Hybrid GA-MPSO approach simulates with the

SLA violation rate of 0.08%, Power Consumption of 105.2 KWH, the VM migrations count being only 2122 and consumes the overall cost of 2567.68$ which is better compared to all the existing approaches by resulting most efficient solution for all the criterion.

7 References

[1] Wu, W., & Plakhtii, A. (2021). E-Learning Based on Cloud Computing. International Journal of Emerging Technologies in Learning (iJET), 16(10), pp. 4–17. https://doi.org/10.3991/ijet.v16i10.18579
[2] H. Xing, J. Zhu, R. Qu, P. Dai, S. Luo, and M. A. Iqbal, "An ACO for energy-efficient and traffic-aware virtual machine placement in cloud computing", Swarm and Evolutionary Computation, vol. 68. Elsevier BV, p. 101012, Feb. 2022. https://doi.org/10.1016/j.swevo.2021.101012
[3] Sun, H., Ni, W., & Zhao, P. (2020). Design of a Media Resource Management System for Colleges Based on Cloud Service. International Journal of Emerging Technologies in Learning (iJET), 15(21), pp. 231–245. https://doi.org/10.3991/ijet.v15i21.18195
[4] M. H. Ferdaus and M. Murshed, "Energy-Aware Virtual Machine Consolidation in IaaS Cloud Computing", Computer Communications and Networks. Springer International Publishing, pp. 179–208, 2014. https://doi.org/10.1007/978-3-319-10530-7_8
[5] M. K. Gupta and T. Amgoth, "Resource-aware virtual machine placement algorithm for IaaS cloud", The Journal of Supercomputing, vol. 74, no. 1. Springer Science and Business Media LLC, pp. 122–140, Jul. 26, 2017. https://doi.org/10.1007/s11227-017-2112-9
[6] T. Ciesielczyk et al., "An approach to reduce energy consumption and performance losses on heterogeneous servers using power capping", Journal of Scheduling, vol. 24, no. 5. Springer Science and Business Media LLC, pp. 489–505, May 20, 2020. https://doi.org/10.1007/s10951-020-00649-4
[7] Manasrah, Ahmad & Ali, Hanan. (2018). Workflow Scheduling Using Hybrid GA-PSO Algorithm in Cloud Computing, Wireless Communications and Mobile Computing, PP: 1-16, 2018. https://doi.org/10.1155/2018/1934784
[8] P. V. Kapse and R. C. Dharmik, "An effective approach of creation of virtual machine in cloud computing", 2017 International Conference on I-SMAC (IoT in Social, Mobile, Analytics and Cloud) (I-SMAC), 2017, pp. 145-147. https://doi.org/10.1109/I-SMAC.2017.8058326
[9] Mirobi, G.J., Arockiam, L. "DAVmS: Distance Aware Virtual Machine Scheduling approach for reducing the response time in cloud computing", J. Supercomput 77, 6664–6675 (2021). https://doi.org/10.1007/s11227-020-03563-w
[10] Hui Zhao, Q. Zheng, Weizhan Zhang, Y. Chen and Yunhui Huang, "Virtual machine placement based on the VM performance models in cloud", IEEE 34th International Performance Computing and Communications Conference, 2015, pp. 1-8. https://doi.org/10.1109/PCCC.2015.7410296
[11] A. Anand, J. Lakshmi and S. K. Nandy, "Virtual Machine Placement Optimization Supporting Performance SLAs," 2013 IEEE 5th International Conference on Cloud Computing Technology and Science, 2013, pp. 298-305. https://doi.org/10.1109/CloudCom.2013.46
[12] Karan D Prajapati, Pushpak Raval, Miren Karamta and M B Potdar, "Comparison of Virtual Machine Scheduling Algorithms in Cloud Computing", International Journal of Computer Applications, 83(15):12-14, December 2013. https://doi.org/10.5120/14523-2914

[13] B. Kruekaew and W. Kimpan, "Enhancing of Artificial Bee Colony Algorithm for Virtual Machine Scheduling and Load Balancing Problem in Cloud Computing," International Journal of Computational Intelligence Systems, vol. 13, no. 1. Springer Science and Business Media LLC, p. 496, 2020. https://doi.org/10.2991/ijcis.d.200410.002
[14] M. Nanjappan, G. Natesan, and P. Krishnadoss, "An Adaptive Neuro-Fuzzy Inference System and Black Widow Optimization Approach for Optimal Resource Utilization and Task Scheduling in a Cloud Environment", Wireless Personal Communications, vol.121, no.3, Springer Science and Business Media LLC, pp.1891–1916, Aug. 10, 2021. https://doi.org/10.1007/s11277-021-08744-1
[15] A. Beloglazov, J. Abawajy, and R. Buyya, "Energy-aware resource allocation heuristics for efficient management of data centers for Cloud computing", Future Generation Computer Systems, vol. 28, no. 5. Elsevier BV, pp. 755–768, May 2012. https://doi.org/10.1016/j.future.2011.04.017
[16] X. Fan, W.-D. Weber, and L. A. Barroso, "Power provisioning for a warehouse-sized computer," ACM SIGARCH Computer Architecture News, vol. 35, no. 2. Association for Computing Machinery (ACM), pp. 13–23, Jun. 09, 2007. https://doi.org/10.1145/1273440.1250665
[17] Xiong FU, Chen ZHOU, "Virtual machine selection and placement for dynamic consolidation in Cloud computing environment", Front. Comput. Sci., 2015, 9(2): 322–330. https://doi.org/10.1007/s11704-015-4286-8
[18] M. Masdari, F. Salehi, M. Jalali, and M. Bidaki, "A Survey of PSO-Based Scheduling Algorithms in Cloud Computing", Journal of Network and Systems Management, vol. 25, no. 1. Springer, pp. 122–158, May 14, 2016. https://doi.org/10.1007/s10922-016-9385-9
[19] R. N. Calheiros, R. Ranjan, A. Beloglazov, C. A. F. De Rose, and R. Buyya, "CloudSim: a toolkit for modelling and simulation of cloud computing environments and evaluation of resource provisioning algorithms", Software: Practice and Experience, vol. 41, no. 1. Wiley, pp. 23–50, Aug. 24, 2010. https://doi.org/10.1002/spe.995
[20] A. Beloglazov and R. Buyya, "Optimal online deterministic algorithms and adaptive heuristics for energy and performance efficient dynamic consolidation of virtual machines in Cloud data centers", Concurrency and Computation: Practice and Experience, vol. 24, no. 13. Wiley, pp. 1397–1420, Oct. 07, 2011. https://doi.org/10.1002/cpe.1867
[21] B. Chun et al., "PlanetLab," ACM SIGCOMM Computer Communication Review, vol. 33, no. 3. Association for Computing Machinery (ACM), pp. 3–12, Jul. 2003. https://doi.org/10.1145/956993.956995
[22] K. Ajmera and T. K. Tewari, "VMS-MCSA: virtual machine scheduling using modified clonal selection algorithm", Cluster Computing, vol. 24, no. 4. Springer Science and Business Media LLC, pp. 3531–3549, Jun. 29, 2021. https://doi.org/10.1007/s10586-021-03320-5
[23] Y. Shao, Q. Yang, Y. Gu, Y. Pan, Y. Zhou, and Z. Zhou, "A Dynamic Virtual Machine Resource Consolidation Strategy Based on a Gray Model and Improved Discrete Particle Swarm Optimization," IEEE Access, vol. 8, Institute of Electrical and Electronics Engineers (IEEE), pp. 228639–228654, 2020. https://doi.org/10.1109/ACCESS.2020.3046318
[24] Kumar Surjeet Chaudhury, Prof.(Dr.) Sabyasachi Pattnaik, Dr Ashanta Ranjan Routray, "A Particle Swarm and Ant Colony Optimization based Load Balancing and Virtual Machine Scheduling Algorithm for Cloud Computing Environment", Turkish Journal of Computer and Mathematics Education Vol.12 No. 11(2021), pp. 3885- 3898.
[25] Dilip Kumar, and Dr Tarni Mandal, "Bi-Objective Virtual Machine Placement using Hybrid of Genetic Algorithm and Particle Swarm Optimization in Cloud Data Center", International Journal of Applied Engineering Research, Vol. 12, No. 22 (2017) pp. 12044-12051.

[26] Z. Zhou, J. Chang, Z. Hu, J. Yu, and F. Li, "A modified PSO algorithm for task scheduling optimization in cloud computing", Concurrency and Computation: Practice and Experience, vol. 30, no. 24. Wiley, p. e4970, Sep. 21, 2018. https://doi.org/10.1002/cpe.4970
[27] A. Pradhan, S. K. Bisoy, and A. Das, "A survey on PSO based meta-heuristic scheduling mechanism in cloud computing environment", Journal of King Saud University-Computer and Information Sciences, Elsevier BV, Jan. 2021. https://doi.org/10.1016/j.jksuci.2021.01.003
[28] Supreeth S, & Kiran Kumari Patil. (2019). Virtual Machine Scheduling Strategies in Cloud Computing- A Review. International Journal on Emerging Technologies, 10(03), 181–188. https://doi.org/10.5281/zenodo.6144561

8 Authors

Mr. Supreeth S holds M. Tech. degree in Computer Science and Engineering from Visvesvaraya Technological University (VTU), Belgaum, and currently he is pursuing his Doctoral program (Ph. D.) in VTU and an Assistant Professor with the School of Computer Science and Engineering, REVA University, Bengaluru, India.

Dr. Kirankumari Patil holds Ph. D. in Computer Science and Engineering from DR. M.G.R Education & Research Institute University and currently working as Professor, RITM and Director, University-Industry Interaction Center (UIIC) at REVA University with 20 years of experience in mentoring, managing Software Product Design and Development Projects, Business Development and Business Incubation activities.

Article submitted 2022-01-02. Resubmitted 2022-02-15. Final acceptance 2022-02-15. Final version published as submitted by the authors.