ASIAN JOURNAL OF INFORMATION TECHNOLOGY
MEDWELL PUBLICATIONS

Improved Particle Swarm Optimization for Virtual Machine Selection in Cloud Datacenter

[1]R.B. Madhumala, [2]Harshvardhan Tiwari and [1]C. Devarajaverma
[1]Department of Computer Science, JAIN (Deemed to be University), Bangalore, India
[2]Department of Information Science and Engineering, JIT, Bangalore

Key words: Cloud computing, virtual machine optimization, particle swarm optimization, energy efficiency, resource allocation, nature inspired algorithms

Corresponding Author:
R.B. Madhumala
Department of Computer Science, JAIN (Deemed to be University), Bangalore, India

Page No.: 284-288
Volume: 19, Issue 12, 2020
ISSN: 1682-3915
Asian Journal of Information Technology

Abstract: To meet the ever-growing demand for the online computational resources, it is mandatory to have the best resource allocation algorithm to allocate the resources to its end users. Virtual machine placement is the key technology in improving the resource utilization and thereby reduces the power consumption. In this study, particle swarm optimization algorithm is used to address VM-PM placement problem. This can be addressed by reducing the number of physical machines over the cloud datacenters. In our study, we discuss how to improve the efficiency of particle swarm Intelligence by adapting efficient mechanism to reduce the power consumption in cloud data centers by maximizing the resource utilization. The obtained results shows that proposed Particle Swarm Optimization (PSO) provide the optimized solution compared to the existing algorithms.

INTRODUCTION

Cloud computing is a paradigm where the IT requirements are fulfilled on a subscription-based model, cloud computing enables users to use a portion of the computing resources, storage, RAM from a data center which will host all the above-mentioned resources. Virtualization is a technique where a fraction of cloud data center resources is reserved for a given user for a limited period.

Leasing the computational resources on demand is nothing new. Linear methods are good in allocating the resources but the time taken to allocate will increase exponentially as the number of clients requesting for the resources increase.

Though the artificial intelligence and machine learning algorithms are the best fit they suffer from the requirement that we need to have a huge amount of computational power and internal memory to efficiently allocate the resources.

Different optimization techniques are constructed for different optimization problems as no optimization technique which solves multidimensional problem. To reduce the time complexity and to increase the efficiency heuristic and meta-heuristic algorithms are used.

The number of people using cloud resources is increasing at an exponential rate this necessitates efficient algorithms for resource sharing and allocation, many researchers worked in this area to bring out optimization in cloud resource sharing and allocation. Figure 1 represents the basic architecture of VMs.

Our objective is to study all the existing algorithms and implement a new algorithm that will do the multidimensional optimization, less time consuming to

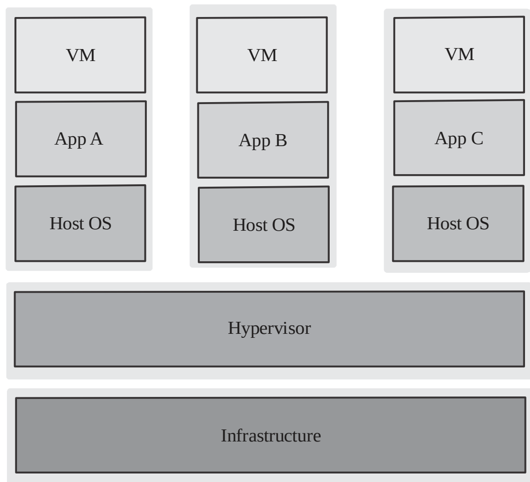

Fig. 1: Virtual machine architecture

reduce the number of running physical systems thereby increasing the power efficiency of the whole data center.

Particle Swarm Optimization (PSO): PSO is one of the nature-inspired population-based algorithms which utilize the swarm intelligence to find a better solution in the complete problem search space. PSO introduced by Kennedy and Eberhart[1], the PSO algorithm is having four main components which will decide the efficiency of the given algorithm, namely initial position, velocity and weight parameters and the fitness function. Here, in this study, we will discuss how to set the initial position and initial velocity, so that, the candidate solution obtained is the best one. To verify the authenticity of the arrived solution we use the fitness function and the fitness function ensures the PSO is optimized for the parameters we intended to. To solve the said problem we use PSO to where each particle maintains a local best and the global best solutions and after 'n' number of iterations, the global best solution is the selected physical machine where the virtual machine will be placed.

The main objective is to place the requested VMs in such a way to reduce the number of active physical machines and the total power consumption of the datacenter. Being an approximation algorithm PSO performs better when there are a lot of Virtual Machine (VMs) instances to be allocated on an active PM while satisfying the given objective by considering the energy-aware techniques used.

Literature reveiw: Optimizing resource sharing and allocation is an NP-hard problem as it has multidimensional properties if it was single dimensional problem Bin Packing algorithm would have solved the problem efficiently. In our problem statement, we consider computational elements, RAM, Bandwidth are the three major dimensions, the physical machine to be optimized for many researchers proposed different algorithms to solve the said problem and the notable ones are MBFD[2, 3] and MBFH[4].

Modified Best-Fit Decreasing (MBFD)[2,3] proposed by Beloglazov. A for VM placement problem by choosing the active node with minimum CPU capacity that maps to the current VM and while mapping checks for the availability and selects the smallest RAM from the cloud data center. Only the active nodes will be turned on and turn off the remaining nodes. MBFD increases the utilization of resources and reduces the power consumption but the algorithm fails to check the overloaded probabilities of VM before mapping with the active nodes in turn, it there is an increase in VM migrations and also it increases the SLA violations. One robust algorithm is needed to improve resource utilization by reducing energy consumption and also needs improvement in SLA violations.

Srikantaiah *et al*.[4] introduced the Modified Best Fit Heuristic algorithm [MBFH][4] to improve the energy efficiency in data centers by optimizing the VM allocation. Energy efficiency is calculated using the current selection and optimal selection within the data center. The energy consumed and resources utilized mainly focuses on the CPU cycles and storage.

Blondin, J., Particle swarm optimization in this study true velocity which is the difference between two successive particle positions is found. Few authors even proposed the VM Placement Optimization solutions based on Fuzzy logic, nature- inspired algorithms such as PSO, ACO and ABC, etc. and the genetic algorithms. Out of all these algorithms on the careful comparison, we decided to use PSO with custom initial particles, number of iterations and the fitness function. The results seem to be promising and they are provided in the result section using nice visual charts.

Mi *et al*.[5] proposed a genetic algorithm-based approach, namely GABA to adaptively self-reconfigure the VMs in cloud data centers consisting of heterogeneous nodes. Kanagavelu *et al*.[6] developed a fast heuristic algorithm called Greedy Virtual Machine Placement with Two Path Routing (GVMTPR) that is based on some constraints.

In Ant Colony Optimization, the pheromone trails will guide other ants to the food source and enable them to find the shortest paths between their nest and food sources[7]. Based on this Ant Colony Optimization (ACO) heuristics was proposed by Dorigo and Gambardellay[8]. Some extensions of ACO algorithms are presented in the literature such as Ant System (AS)[9], Ant Colony System (ACS)[8] and MAX-MIN Ant System (MMAS).

MATERIALS AND METHODS

As per the citation index, PSO is the popular SI based technique. PSO has high global convergence performance, requires primitive mathematical operators and a really few parameters to adjust. These are the most reasons for PSO to be popular. Previous testing found the implementation of PSO to be effective with several sorts of problems and tons of applications in various disciples. Cloud resources can be optimized by finding the optimal solutions for the raised problems to achieve this robust method is needed. Virtualization is the key technology that provides a cost-effective system by maximizing the utilization of cloud resources as well as by improving efficiency. Following are the steps involved:

- Select a VM from the VM list and For each VM, select the candidate solutions which fit the resource requirements for the VM
- Provide these candidate solutions to the PSO algorithm for optimization (Fig. 2)
- PSO algorithm returns the best fit among the given candidate solutions
- Check the solution and reduce the iteration parameter by repeating the experiment
- (Number of iteration parameters is found by trial and error method (Only experimental))
- Map the returned PM to the requested VM

VM-PM mapping process: In VM-PM Mapping, instead of selecting the available PMs, here, we selects only set of PMs which match the required demands of VM. Based on this strategy primary PM candidate list will be prepared with heterogeneity of resources.

The selected PMs which is called as PM candidate list. This PM candidate list will be given as input to the Particle Swarm Optimization (PSO) algorithm. In each iteration PSO checks for the availability of resources, based on the demand VM-PM mapping will be done. At each time the number active PMs will be reduced which indicates that decreasing the power consumption of VM-PM mapping and also increases the maximum utilization of resources.

The time complexity of PSO is given as O (pnlog(n)) And the time complexity for finding the initial position of candidate solutions is n2 (1 For loop to find the candidate solution to apply to PSO). The time complexity of the proposed algorithm is n2 X O (pnlog(n)).

The main intension of the selection and allocation of VM is to solve the energy by switching off the underutilized servers. Figure 3 illustrates VM allocation is done based on the number of Processing Elements

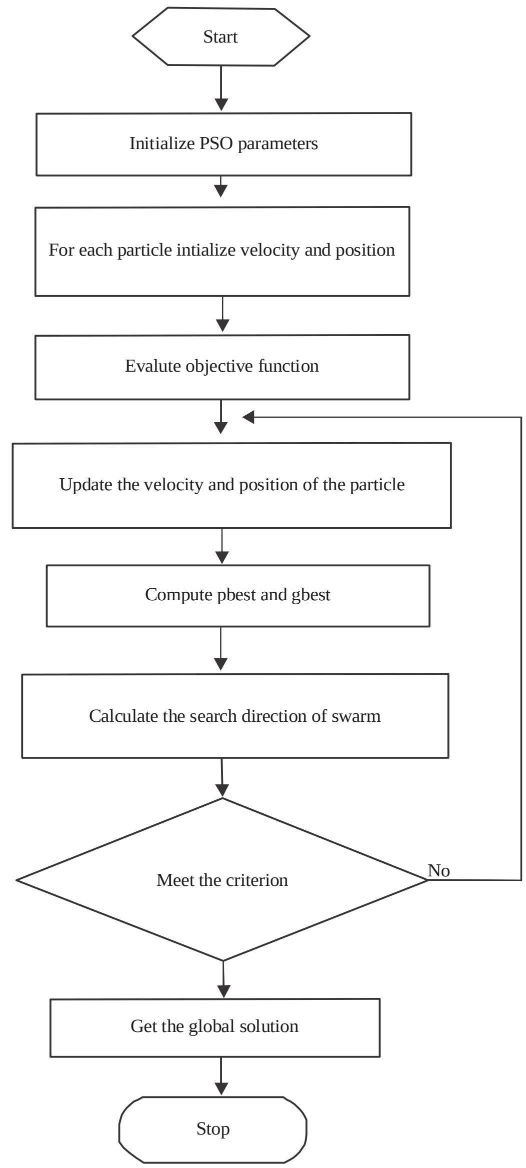

Fig. 2: PSO flowchart

(PEs) used Ram Utilization and the Bandwidth (BW) consumed over the host. Figure 3 shows list of cloud users represented as $\{CU_1, CU_2, CU_3, ..., CU_m\}$ and Virtual Machines as $\{VM_1, VM_2, VM_3, ..., VM_n\}$ and PE represents the Processing Elements.

Initially, VMs are created based on the available physical resources. As the demand increases resources will be allocated dynamically based on the availability of PEs, RAM and BW. We call this a new VM allocation policy which includes efficient mapping of VM to PM. The obtained results are evaluated with the existing policies.

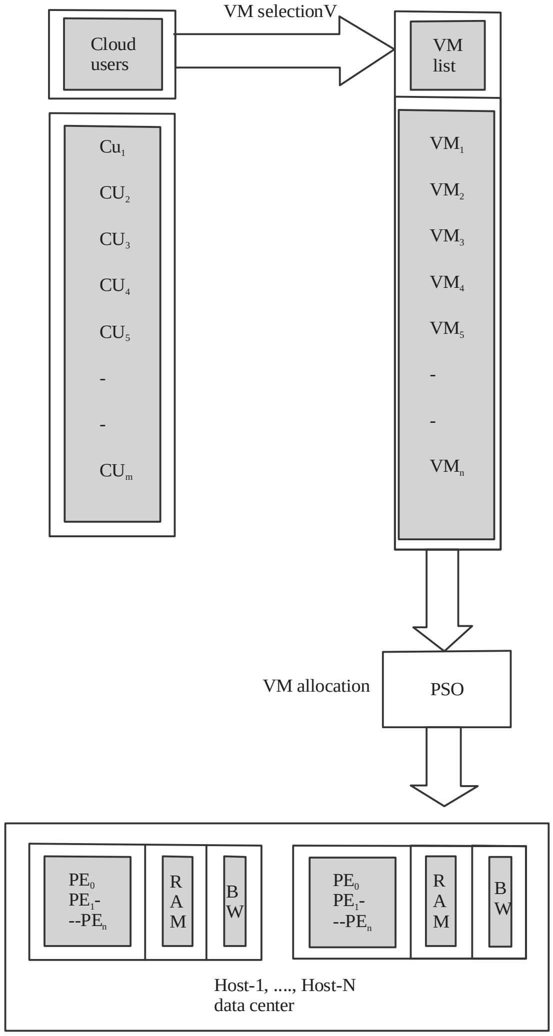

Fig. 3: VM-PM mapping process

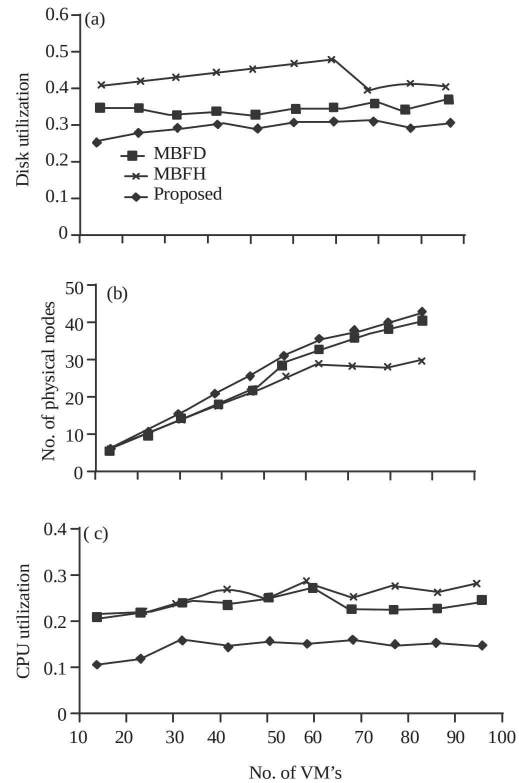

Fig. 4(a-c): (a) Memory utilization, (b) CPU utilization and (c) Physical node representation

RESULTS AND DISCUSSION

The experimental results are shown in this section, we used cloudsim platform to evaluate the cloud resources. We have done a comparison of memory utilization efficiency of MBFD[2, 3], MBFH[4] and our proposed algorithm is plotted below. We can observe from (Fig. 4a) that our proposed algorithm performs better than the other two algorithms MBFD[2,3], MBFH [4] in terms memory utilization.

In the second experiment (Fig. 4b) shows the CPU utilization of the proposed algorithm with the other two algorithms and the results are plotted. The results look promising as we increase the number of Vms.

In our last experiment, i.e. (Fig. 4c) we compared the number of running physical machines as the number of VMs increased in steps of 10. From the results, we observe our algorithm performs better as we increase the number of VMs and the other two are good when the number of VMs is less.

CONCLUSION

Our proposed algorithms perform better when there is a considerable number of VMs in the system and the same is depicted in the graphs provided, though there is a need to increase the total number of running physical machines at the times when there are few numbers of VMs, our algorithms perform better in all other aspects and this research can be extended in future to reduce the number of running physical machine by combining other methods.

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