International Journal of Mathematics and
Computer Science, **16**(2021), no. 2, 677–685

A Reliable Frame Work for Virtual Machine Selection in Cloud Datacenter Using Particle Swarm Optimization

Madhumala RB[1], **Harshvardhan Tiwari**[2], **C. Devarajaverma**[1]

[1]Department of CSE
JAIN (Deemed to be University)
Bangalore, Karnataka, India

[2]CIIRC-Jyothy Institute of Technology
Thathaguni, Karnataka 560082, India

email: madhumala8887@gmail.com

(Received September 10, 2020, Accepted November 6, 2020)

Abstract

Efficient resource allocation through Virtual Machine placement in a cloud data center is the ever-growing demand. Due to the variability in the cloud environment Virtual Machine, placement techniques must be optimized continuously. In this paper, we propose a Modified Particle Swarm Optimization (PSO) algorithm to get the Best Virtual Machine-Physical Machine mapping, where the proposed algorithm gives more importance to Energy Aware Hosts. We aim to decrease the count of active physical machines so that energy consumption is reduced to a minimum. The decreased count of active physical machines indicates improved resource allocation and decrease in the total energy consumed by the cloud data center. The obtained results show that the proposed algorithm performs better compared to other existing algorithms.

Key words and phrases: Cloud computing, Virtual Machine optimization, Particle Swarm Optimization, Energy efficiency, Resource Allocation.
AMS (MOS) Subject Classification: 68W50.
ISSN 1814-0432, 2021, http://ijmcs.future-in-tech.net

1 Introduction

Cloud computing is one of the popular options for people and business for a number of reasons such as cost savings, resource management, increased productivity, increase in energy savings, and speed. Resource allocation is one of the biggest challenges in cloud datacenter due to heterogeneity of resources. As a result of these tremendous applications over the cloud datacenter, optimization of the resources over the cloud datacenter is a great challenge. One such key technology is the cloud virtualization technology, where virtual machines are mapped to physical machines. Many optimization techniques are proposed by many researches, based on the different methodologies, few use heuristics while others use meta heuristics, where virtual machines are mapped to physical machines.

Many optimization techniques have been proposed by many researchers, based on the different methodologies. Few use heuristics while others used meta heuristics, where the algorithms must be in a position to solve both single as well as multi dimensional problems. In the previous decades, many global optimization methods have been proposed due to the nature of the inspired environment. Many traditional heuristic algorithms were proposed for an efficient Virtual machine selection problem. We mention notable ones such as First-Fit, Best-Fit and Modified-Best-Fit. VM Placement Optimization solutions are based on Fuzzy logic, Artificial Intelligence, Genetic Algorithms (GA). Out of all these algorithms, we decided to use Particle Swarm Optimization (PSO) with custom initial particles, number of iterations, and a fitness function.

2 Related work

The PSO technique was proposed by kennedy and Eberhart in 1995 [1] and was inspired from bird flocks social and biological behavior which they used to search for food sources. The individuals in nature are referred to as particles that move in the search space to find the global best position which can be applied to minimize (or maximize) a given problem. In this paper, we will discuss how to set the initial position and initial velocity so that the candidate solution obtained is the best one. PSO is optimized for the parameters we intended to. To solve the said problem we use PSO, where each particle maintains a local best and the global best solutions occur after 'n' iterations.

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. In 2014, Beloglazov and Buyya implemented a framework Dynamic VM consolidation for Open Stack cloud [2]. Open Stack is the well known commonly used open source cloud platform management tool. Open Stack architecture contains mainly four components as host overload detection, host under load detection, VM selection and VM placement policy. This open source platform is called the Modified Best Fit Decreasing algorithm.

The algorithm selects a minimum number of active servers. FFD [2] has no mechanism to handle heterogeneous servers. MBFD [3], also designed for the same framework, is only designed for the current utilization of servers. The idle power of the server is not taken into consideration [4]. To overcome this disadvantage, Moges et al. [4] proposed EnergyAware VM placement framework and introduced a new heuristic medium-fit modification in the algorithm results to improve power consumption and used heterogeneous servers for VM optimization.

Khaoula BraikI et al. [5] developed a Multi-objective Virtual Machine placement algorithm by using PSO by addressing the problem of maximizing the VM-PM mapping ratio by minimizing the energy utilization and explaining how to pack the computing resources efficiently in the cloud datacenter by using a lower number of PMs thereby reducing energy consumption. Wang et al. [6] investigated the applications and used heterogeneous virtual machines by redefining the PSO parameters and operators to maximize resource utilization over the cloud datacenter. PSO checks for the availability of resources based on the demand VM-PM mapping for power aware VM placement in which the VM optimization through the power efficient node[7].

3 Problem Formulation

3.1 Problem Statement

Resource allocation becomes a key problem which needs to be resolved, as unreasonable resources allocation can cause more energy consumption in cloud data center and degrades the performance of the overall system. We formulate the problem of Virtual machine Placement and propose Energy Efficient Particle Swarm Optimization. We apply the main technique to minimize power consumption and reduce the number of active physical machines and switching off the idle machines. The proposed algorithm periodically monitors the load of resources (CPU, disk storage and network interface) and makes decisions on switching nodes on or off to minimize the overall power consumption while providing the expected performance.

In PSO, every particle is associated with position and velocity with the movement of the particle in the problem space being updated each time. In our proposed method, the VM placement problem represents the multi-dimensional problem aiming to optimize the total energy consumed, total CPU cycles, RAM and the Bandwidth.

$V_{id} = V_{id} + C_1 * Rnd_1 (0, 1) * (VMpb_{id} - PM_{id}) + C_2 * Rnd_2 (0, 1) *$ $(VMgb - PM_{id}) - - - - - - - (1)$

$PM_{id} = PM_{id} + V_{id}, - - - - (2)$ where Equation (1) represents the updated Velocity and Equation (2) represents the updated position of the particle in the given problem space. w is the inertia factor which controls the past and the current speed of the particle where a smaller value of inertia improves the convergence speed, $c1c2$ are the social components provides local as well as global solutions, $r1r2$ are random numbers between 0 and 1, particle movement represents current position, personal best position of the particle and global best position of the entire swarm.

3.2 Proposed Solution

PSO is one of the Nature-inspired population-based algorithms which is a meta-heuristic optimization technique that finds maxima or minima of functions in the possible region. The following equations represent Modified PSO Parameters in the problem space. The Virtual Machine placement can be seen as a bin packing problem with variable bin sizes and prices. The bins refer to the Physical Machines, items are represented as Virtual Machine that have to be allocated. These bin sizes are the available CPU capacities of the Machines. Prices correspond to the power consumption by the nodes. As the bin packing problem is NP-hard, an ordinal method is not appropriate to solve it in an acceptable complexity. As a result, meta-heuristic methods are suggested.

In our proposed method, the meta-heuristic algorithm is chosen to find new Virtual Machine placement for all candidates of the Virtual Machine. In Figure 1, Energy Efficient Particle Swarm Optimization (EEPSO) accepts the Physical Machine list and the Virtual Machine list and classifies Hosts into Energy Aware Hosts and Non Energy Aware Hosts; meanwhile checks if sufficient resources are available in energy aware hosts and then allocates the Virtual Machine to Energy Aware Host, if Virtual Machine is not allocated to non energy aware host. Repeat the process for all available Virtual Machines in the Virtual Machine list.

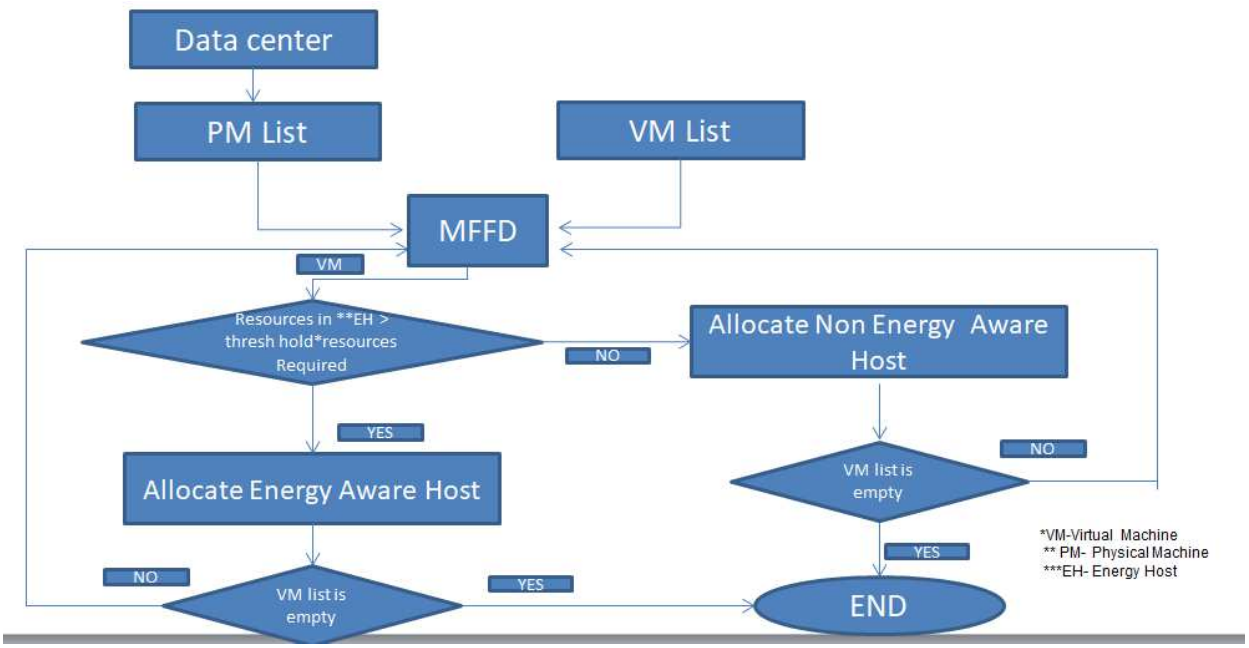

Figure 1: Energy Efficient PSO

The PSO algorithm converges faster than other global optimization problems with the main advantage being an inbuilt memory [7]. Therefore, each particle keeps track of its coordinates in the problem space which are associated with the optimal solution (fitness) it has achieved so far.

$$Mips\_Utilization = MIPS\_Utilized/MIPS\_Available - - - - (3)$$

$$RAM\_Utilization = RAM\_Utilized/RAM\_Available - - - - (4)$$

$$BW\_Utilization = BW\_Utilized/BW\_Available - - - - (5)$$

$$PSO\_Fitness = (Mips\_Utilization + RAM\_Utilization + BW\_Utilization)/3 - - (6)$$

The main objective is to select a method that returns an optimal solution to the given problem. The main technique applied to minimize power consumption is to reduce the number of active physical machines and switching off the idle machines. The proposed algorithm periodically monitors the load of resources (CPU, disk storage and network interface) and makes decisions on switching nodes on or off to minimize the overall power consumption while providing the expected performance.

4 Results and Discussions

4.1 Simulation Environment

We have used Cloudsim toolkit for simulation [8]. The Energy Efficient Particle Swarm Optimization (EEPSO) algorithm is evaluated using Cloud simulation toolkit which allows making use of customized polices for resource allocation over the cloud datacenter. We evaluate the performance ratio of the proposed algorithm with FFD[2] and MBFD[3] heuristic algorithms. For the performance evaluation we consider the same set of Virtual Machines and Physical Machines for all the algorithms. We simulate the heterogeneous servers over the cloud resources such as CPU, BW and Memory. The experimental results are shown in this section, where we used the Cloudsim platform to evaluate the cloud resources.

4.2 Performance Evaluation

In the proposed algorithm, results along the X-axis represent the VMs and those along the Y-axis represent the metrics considered in the proposed system. From figure 2a, we can observe that the proposed algorithm requires less physical machines to host all the virtual machines. As we can see from the chart, the performance is well aligned with other algorithms when VM size is less than 400 but when VM size increases, PSO Optimization kicks in and improves the efficiency much more than the existing algorithms. Figure 2b shows that our proposed algorithm improves the power consumption in the data center when compared with FFD [2] and MBFD [3]. Figure 2c explains CPU utilization. Resource wastage performance is given in figure 2d. In the proposed algorithm resource wastage is less when compared to the other algorithms and is balanced well in utilizing the resources.

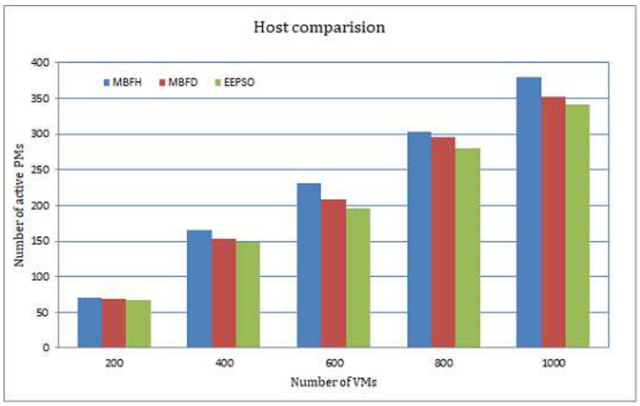

Figure 2a

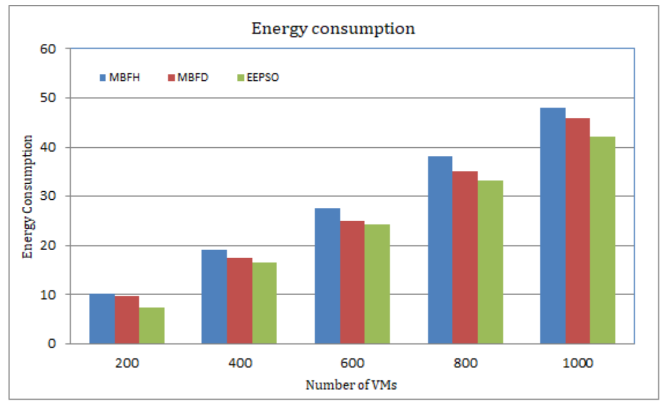

Figure 2b

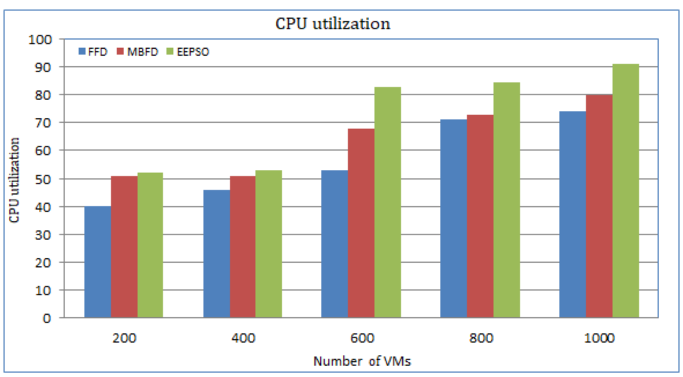

Figure 2c

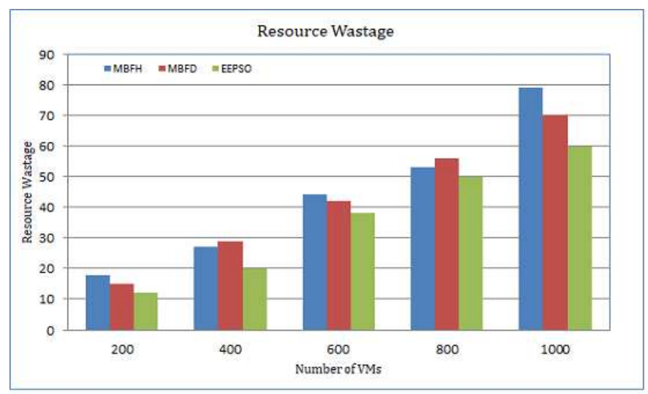

Figure 2d

5 Conclusion

Virtual Machine optimization maximizes the resource utilization and minimizes the energy consumption. In our proposed algorithm, we introduced an optimal solution for the Virtual Machine placement problem by minimizing the energy component and maximizing the resource utilization over the cloud user customized services. We compared our proposed algorithm with other popular algorithms such as FFD and MBFD and it turned out that our algorithm performed better in energy efficiency by reducing the number of Physical Machines. In future work, we intend to combine other heuristic methods to improve performance.

References

[1] Eberhart R. Kennedy, Particle Swarm Optimization, IEEE International Conference on Neural Networks, **4,** (1995).

[2] A. Beloglazov, R. Buyya, Energy Efficient Allocation of Virtual Machines in Cloud Data Centers, 10th IEEE/ACM International Conference on Cluster, Cloud and Grid Computing, Melbourne, (2010).

[3] A. Beloglazov, J. Abawajy, R. Buyya, Energy-aware resource allocation heuristics for efficient management of data centers for cloud computing, Future Generation Computer, Systems, **28,** no. 5, (2012), 755–768.

[4] Fikru Moges, Surafel Abebe, Energy-aware VM placement algo- rithms for the OpenStack Neat consolidation framework, Journal of Cloud Computing, **8,** (2019), 10.1186/s13677-019-0126-y.

[5] K. Braiki, H. Youssef, Multi-Objective Virtual Machine Placement Algorithm Based on Particle Swarm Optimization, 14th International Wireless Communications and Mobile Computing Conference, Limassol, (2018), 279–284.

[6] S. Wang, Z. Liu, Z. Zheng, Q. Sun, F. Yang, Particle Swarm Optimization for Energy-Aware Virtual Machine optimization in Virtualized Data Centers, International Conference on Parallel and Distributed Systems, Seoul, (2013), 102–109, doi: 10.1109/ICPADS.2013.26

[7] R. B. Madhumala, H. Tiwari, Analysis of Virtual Machine Placement and Optimization Using Swarm Intelligence Algorithms. In: A. Haldo-rai, A. Ramu, S. Khan, (eds), Business Intelligence for Enterprise Internet of Things, EAI/Springer Innovations in Communication and Computing, (2020), Springer, Cham., https://link.springer.com/chapter/10.1007.

[8] R. Calheiros, R. Ranjan, A. Beloglazov et al, CloudSim:a toolkit for modeling and simulation of cloud computing environments, **41,** no. 1, (2011), 23–50.