A Novel Virtual Machine Placement Algorithm Using an Energy-Aware Meta-Heuristics Approach

Loveleena Mukhija[1] and Rohit Sachdeva[2]
[1]Department of Computer Science, Punjabi University, Punjab, India
[2]Department of Computer Science, M. M. Modi College Punjabi University, Punjab, India
E-mail: loveleena298@gmail.com, rsachu.147@gmail.com

Abstract - The paramount concern associated with the Virtual Machine Placement (VMP) relates to the mapping of Virtual Machine (VMs) to the Physical Machine's (PMs). This mapping goal is to utilize the PMs to their maximum potential. In order to attain the full proficiency from the mapping process it is required not to impede already active instances of Virtual machine. Incompetence in mapping process substantially results in resource wastage and increase in energy consumption and consequentially increasing the overall functional cost at the data canter. A meta-heuristic based algorithm for virtual machine placement is recommended to redress the aforementioned issues. A cr-Cuckoo algorithm is proposed which integrates the concept of correlation and Cuckoo Search. The work given here is contrasted with varied familiar algorithm of the domain. The acquired results exhibit a distinguished reduction in the consumption of power and count of migrations by VMs and violation in SLA.
Keywords: Cuckoo Search, VMP, Meta-Heuristic, Energy Aware

I. INTRODUCTION

The emergence of computing in Cloud has evolved as utility model by providing underlying users with the valuable services. The services of cloud are harnessed by the entities such as network architect designers, developers, enterprises or the end users. The computing services availed by the users are in the order of Infrastructure as a Service (IaaS), Platform as a service (PaaS), and Software as a Service (SaaS) respectively. The cloud computing services has reprieved its users from load of increasing enormous infrastructure costs. Users are required to pay nominal expense as their usage [1].

Virtualisation is the fundamental technology accompanied in cloud computing scenario [2]. This technique has enabled multiplexing of hardware resources and allowed varied operating systems to run simultaneously on the same host or server the virtualization technique follows abstraction and mechanism by isolating different from each other the technique has enabled sharing of physical resources by creating virtual instances known as virtual machines VMs. The software responsible for creating VMs

is known as hypervisor. Moreover, the hypervisor is responsible for scheduling the virtual resources.

Scheduling of resources is the vital challenge in the virtualized cloud scenario. Efficient scheduling of resources can enhance the advantage of elasticity trait of cloud computing. Resources can be scheduled at the initial state or can be dynamically scheduled. Moreover, cloud follows the dynamic nature thus initial or static scheduling can lead to under or over provisioning of resources. Under or over provisioning of resources can consequently result in increase in energy consumption and increase in SLA violation respectively [3][4].

Virtual machine placement is one of the dominant component of studying or allocating resources in cloud computing. The virtual machine placement has been as mapping problem which is subject to certain optimisation objectives should stop to allocate virtual message to with respect to certain constraints. With the given constraints and the restrictions accent VMP can achieve subjective such as deduction in energy consumption and efficient resource utilization.

In this paper cr-Cuckoo search algorithm is proposed Cuckoo search with the concept of correlation is presented as the main algorithm the algorithm categorized entire PMS into clusters and then suitably allocates the virtual machines the main idea of the proposed algorithm is to provide the near optimal solution for placement problem will stop the proposed algorithm considers few quality of service parameters.

II. REVIEW OF LITERATURE

Extensive research has been carried out for the virtual machine placement in the cloud computing. Traditionally Heuristic algorithms such as the First Fit, Best Fit, Modified Best Fit Decreasing (MBFD) and Power Aware Best Fit Decreasing (PABFD) [5] have been widely used. Most of the prevalent methodologies are employing meta-heuristic approaches to resolve the placement problem of virtual machines.

Kaaouache *et al.,* proposed the genetic based algorithm for VMP [6]. Wu et al. presented the simulated annealing (SA) [7], Ali and Lee have given the biogeography-based optimisation technique (BBO) [8] and Wang et al. gave Particle Swarm optimization [9] considering energy-efficiency for VMP.

Although the work presented earlier taken energy efficiency but to have optimise solution did not consider the live migration. Few authors [10-13] have incorporated the swarm intelligence algorithms but considered the VMP as a single objective problem.

Xiong *et al.,* [14] has taken the VMP as the multidimensional problem and employed the PSO algorithm considering multiple objectives such as energy efficiency and reduced resource wastage.

In [15], [16] and [17] authors employed genetic algorithm to resolve VMP considering it as multi-objective problem. Liu *et al.,* used al. for replacement of VMs and to handle the energy consumption and load balancing for resources. Although there exist numerous VMP approaches with the different optimization objective to resolve the VMP. Also, there is a trade-off between the energy consumption and the overall performance, and this is one of the challenging concerns to be handled.

Moreover, the problem is optimization based problem. Also, it has found form the comprehensive review of the literature that a near optimal solution can be taken out for the same. Thus, our work focus on considering the VMP problem as multi-dimensional and finding the near optimal solution by incorporating an effective meta heuristic algorithm. The work presented here employs Cuckoo search based algorithm to resolve the VMP problem considering energy efficiency, number of migrations and SLA violation as a quality of service Parameters.

III. PROPOSED WORK

To attain the efficient utilization of physical resources at the data centre the optimal placement of virtual machines is the foremost aspect. By managing resources efficiently, it facilitates in decreasing energy requirements and also satisfying service level agreement. The utilization of resources and consumption of energy are complimentary to each other. Under or overutilization of resources result in escalating energy consumption.

Therefore, optimal placement of virtual machine as a part of resource utilization plays an eminent role. This section presents the modelling of VMP process and proposes cr-cuckoo algorithm to solve the problem by employing the meta heuristic based Cuckoo search algorithm.

Step 1: Introductory Assignment

In this step unassigned virtual machines are assigned to the varied hosts.in this scenario demands by the host is considered before assigning. Moreover, VMs check whether demand of resources and power requirement can be met by the host. The power requirement of each PM is carried out and then the traditional MBFD algorithm is employed to sort the PMs on the basis of power requirement. Finally, the VMs are allocated to the host with the least power requirement.

Algorithm 1 presents the incorporated MBFD algorithm at this phase.

Algorithm 1 MBFD

- Input Parameters: List of Hosts, List of VMs
- Output: List of VMs allocated to PMs
- Step 1: Start
- Step 2: Sort list of VMs in Decreasing order based on their utilization of CPU.
- Step 3: Calculate consumption of power for each VM in the list of VMs
- Step 4: MinimumPower←MAX
- Step 5: AllocatedHost←NULL
- Step 6: For I in the list of host
- Step 7: check for sufficient resources for VM
- Step 8: Calculate Power Consumption of all the hosts with the VMs.
- Step 9: if Consumed Power < threshold value, then assign the host to allocated host list
- AllocatedHost←host
- minpower ←Power
- Step 10: If the allocated host is not empty or null then VM is assigned.

Step 2: Hotspot Detection

After the initial assignment of VMs to the PMs it's probable to get some PMs as overloaded. This phase detects the overloaded nodes which are also termed as hot spot. One of the simple ways to define the hotspot in a static way is the Threshold (THR). Threshold policy based on the CPU utilization can be used to analyse the nodes.

Step 3: VM Selection

This phase is followed after detection of the hotspot and in this few VMs need to be selected to migrate from the hotspot. There are several selection methods that are employed, including the Maximum Correlation Policy (MC), Minimum Migration Time (MMT), Minimum Utilisation (MU), and Random Selection (RS).

Step 4: Finding the Target PM

With the help of meta-heuristic cuckoo search algorithm, the target PM is searched to allocate the migrated VMs. The meta-heuristic bio inspired based Cuckoo search algorithm is, created by Xin-She Yang and Suash Deb in the year 2009. The algorithm serves an inspired from the cuckoos and their peculiar way of reproduction and laying their eggs of Cuckoos.

Analogous to the search for the optimal nest for their eggs the search here is conducted to place the migrated VMS to the physical machines. The algorithm for the same is written below. cr-Cuckoo Search Algorithm. The inputs to the algorithm are (i) list of VMs and (ii) list of hosts, and (iii) list of sorted VMs by MBFD algorithm. Initially, the parameters for CS, like number of eggs (VMs), number of variables (CPU, RAM), VM count and size has been initiated. It takes into account whether the CPU utilisation is below the lower level, which shows that the PM is under loaded, or whether it is beyond the upper threshold, which indicates that the host is overloaded and is also known as a hotspot.

In that case its some VMs need to be migrated based on Minimum migration time policy. Cuckoo Search is used to find the target PM when reallocating the transferred VMS. The entire population of PMs are divided into two clusters and a threshold value is calculated with the help of K means. The overloaded and under-loaded PMs are distinguished so while migration the load can be decreased from an overloaded node and can be increased for the under-loaded respectively.

The correlation factor is computed in the fitness function of nest threshold with these increased and decreased load values for the nest. Finally on the basis of the computed values Euclidean distance values are created and reward matrix is generated and if the total reward are there then VMs are added to the migration list else they are rejected for the VM migration.

Algorithm 2: cr-Cuckoo

Input: Get the list of VMs after sorting based on MBFD and the list of allocated PMs.
Two lists respectively PMList, VMList and
Output: Reallocated VMs to the PMs Taking PM as nests and eggs as the virtual machines
Step1:Initial assignment of VM to PMs based on the MBFD.
Step2 calculating the average threshold value of CPU utilization CPU_U of the hosts.
Step 3: If the CPU_U value is found to be below the lower threshold value then check.
If CPU_U>upper threshold value:
call the nodes hotspot.
Few of its VMs need to be migrated.
Step 4: Apply the VM selection policy.
For the VMs to be moved from the hotspot node, select Minimum Migration Time Policy.
Step 5: Divide the entire hotspot nodes list in two clusters.
Step 6: Apply K-means to get two cluster based on the load.
Step 7: Apply cuckoo search for placing the VMs.
Step 8: The search is initiated based on the concept of random walk known as Levy flights.
Step 9: On the basis of correlation physical machine is selected out of the one of the computed cluster.
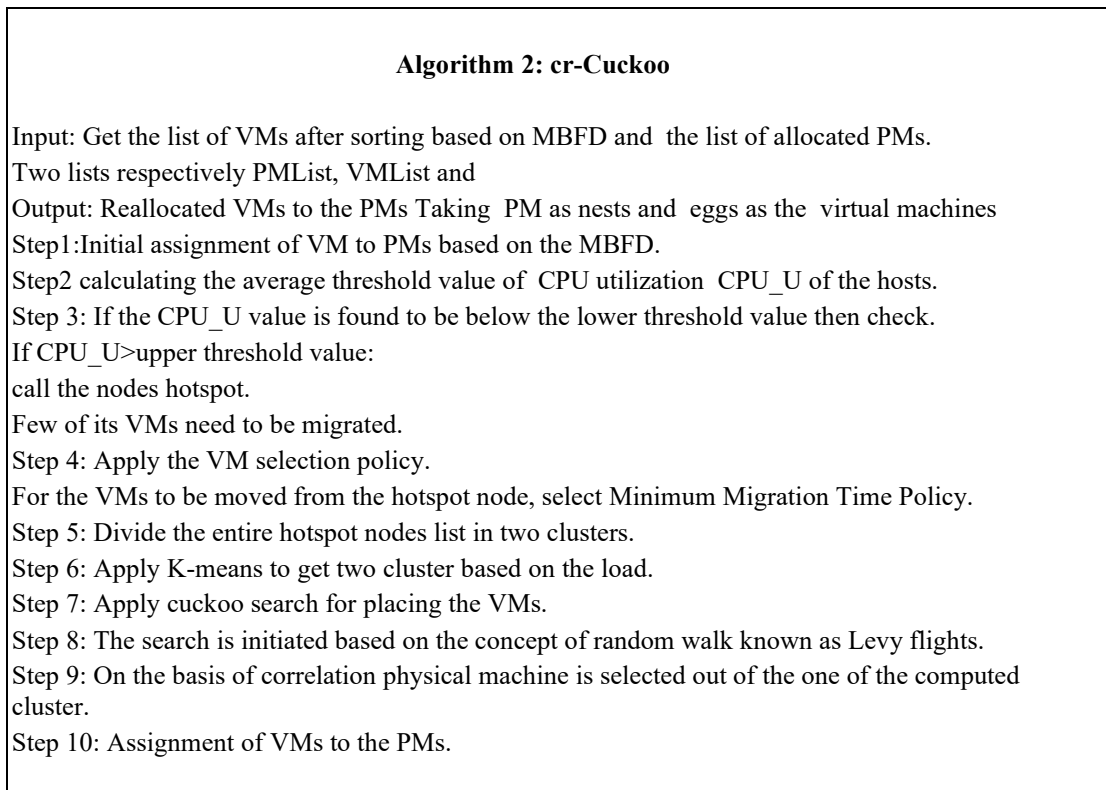Step 10: Assignment of VMs to the PMs.

Figure 1 depicts a concise flow diagram illustrating the proposed work.

The entire scenario of the proposed algorithm is comprehensively represented in the figure 2.
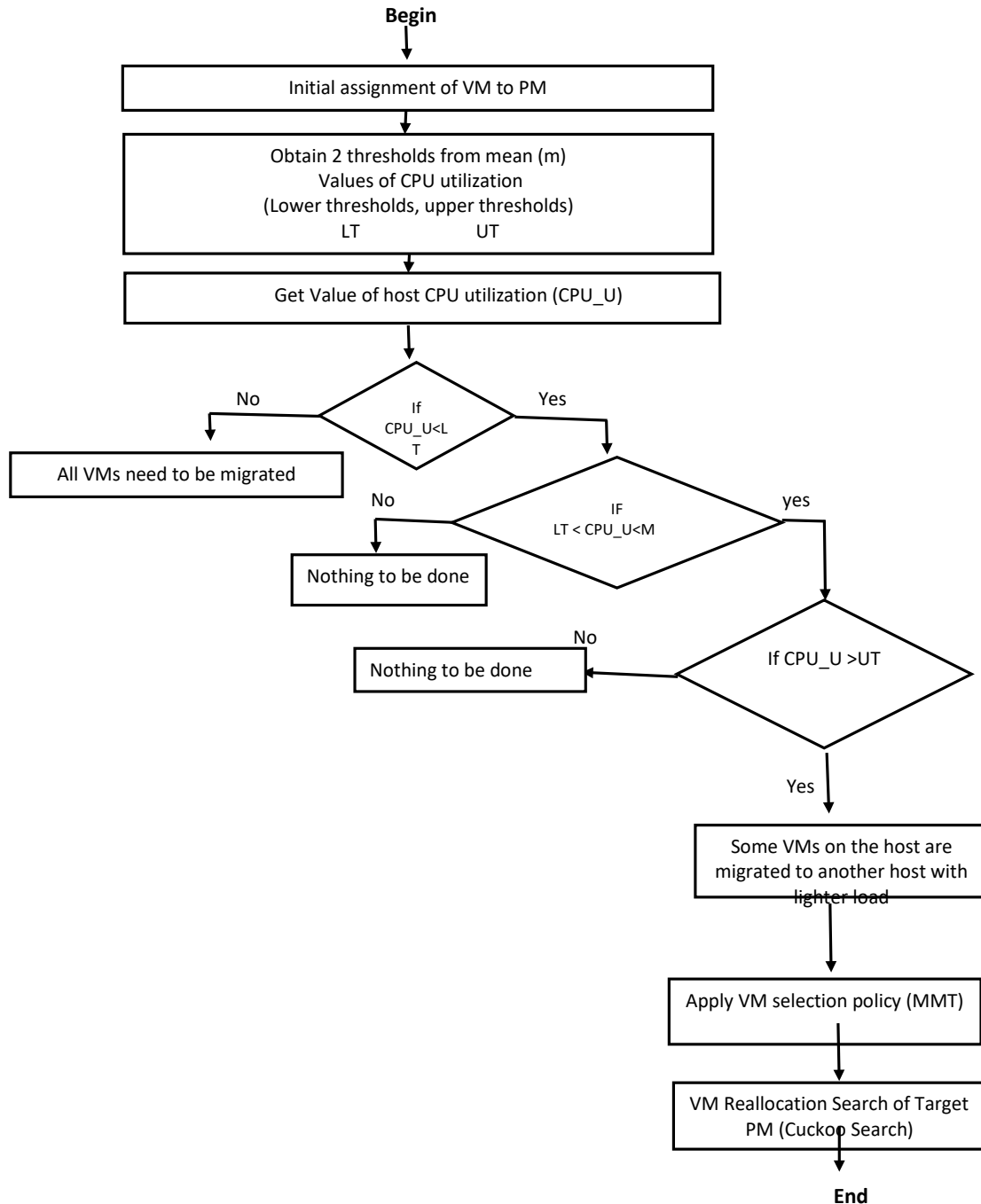
Begin

Initial assignment of VM to PM

Obtain 2 thresholds from mean (m)
Values of CPU utilization
(Lower thresholds, upper thresholds)
LT   UT

Get Value of host CPU utilization (CPU_U)

If CPU_U<LT

No → All VMs need to be migrated

Yes →

IF LT < CPU_U<M

No → Nothing to be done

yes →

If CPU_U >UT

No → Nothing to be done

Yes ↓

Some VMs on the host are migrated to another host with lighter load

Apply VM selection policy (MMT)

VM Reallocation Search of Target PM (Cuckoo Search)

End

Fig. 1 Flow Diagram

IV. PERFORMANCE EVALUATION AND DISCUSSION

The effectiveness of the suggested algorithm has been taken into account with respect to three qualities of service parameters namely power consumption, number of migrations and SLA-Violation (SLA-V). Although the SLA-Violation (SLA-V) parameter is associated with the above stated both parameters directly.

The proposed approach is validated by comparing it with the existing algorithms given by the authors Nashaat *et al.,* and Berlaskar *et al.,* [18][19]. The three qualities of service parameters have their own significance in the data center environment.

Power consumption is the important parameter for achieving energy efficiency and to attain green computing.
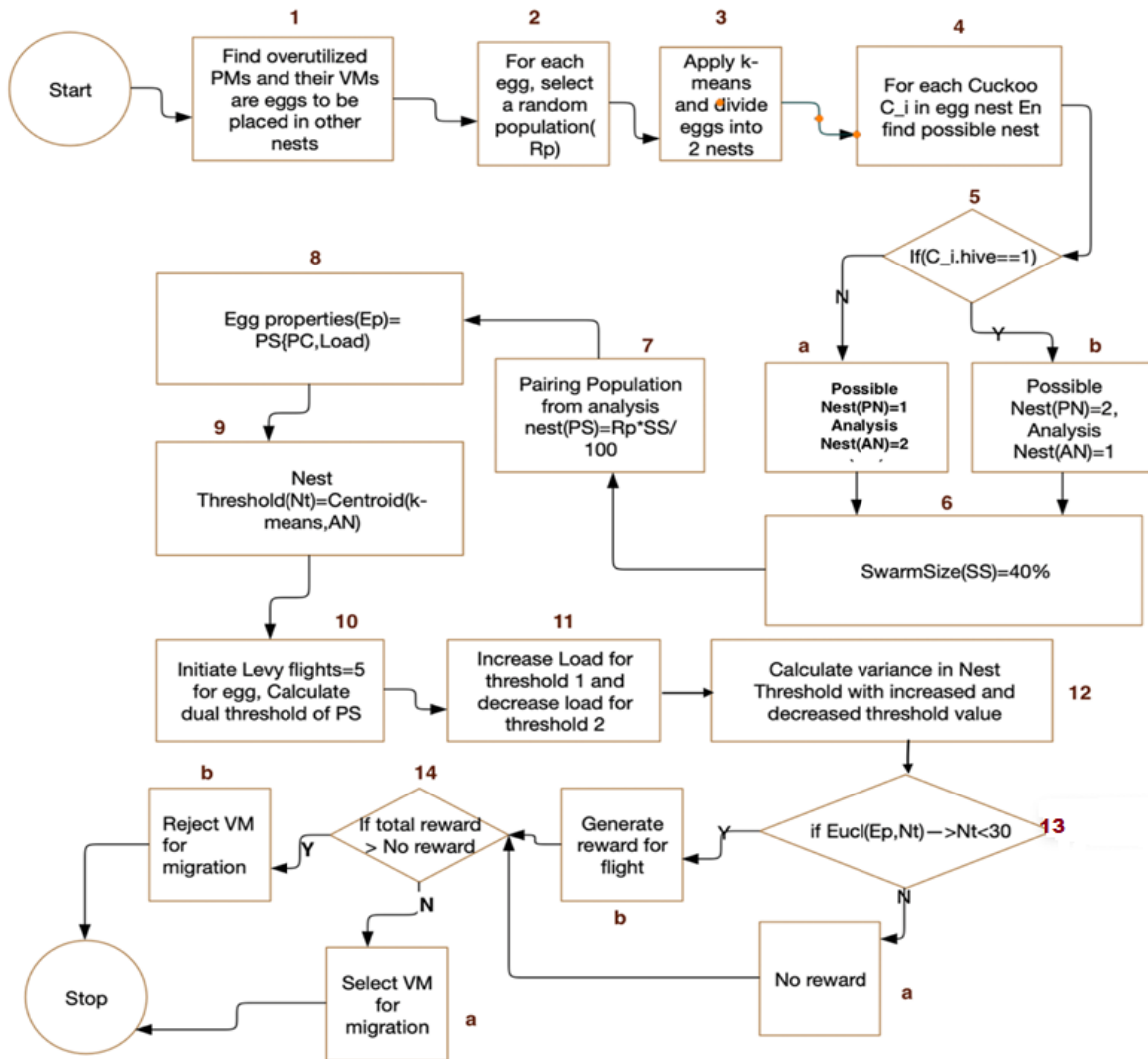
Fig. 2 Proposed Work

Broadly, it is calculated by dividing the total amount of power entering the data center with power consumed through the installed equipment's there. The other parameter number of migrations relates with the migration of Virtual machines while executing the applications. Migration is pivotal in the dynamic cloud environment but on the flip side it can increase the cost related to resource provisioning, increasing response time and in turn Rise in SLA violation.

SLA Violation states the violation in the mutual agreement between the cloud service vendors along with the user. Moreover, it is associated with the other quality of service parameters like energy consumption and the number of migration like SLA violation with respect to energy consumption is calculate taking average threshold of energy in the datacenter with the energy consumed above the average threshold as stated in the equation 1 given.

$$SLA\text{-}V = \frac{T_b^{energy\,extra}}{T_b^{Threshold}} \quad (1)$$

The total power utilised by all hosts in the data centre is taken into account when calculating power consumption and each host's power consumption is computed using equation 2.

$$\text{PC Host} = (\text{PC allocated Host-PC idle Host})* \text{CPU utilization} + \text{PC idle Host} \quad (2)$$

PC allocated Host: Power Consumption by allocated Host
PC idle Host: Power Consumption by Idle Host
CPU utilization refers to the CPU utilization of servers.

And the total consumption of power at the data centre is equal to sum total of the power consumed by all the hosts given in equation 3.

$$\text{Tpc} = \sum_{i=1}^{n} PCHost(F,t) \quad (3)$$

The given algorithm is assessed by taking the range of the virtual instances. The valuation of the same is explicated in the graph Fig 3. which states the outperformance of the proposed approach in comparison with the other approaches.
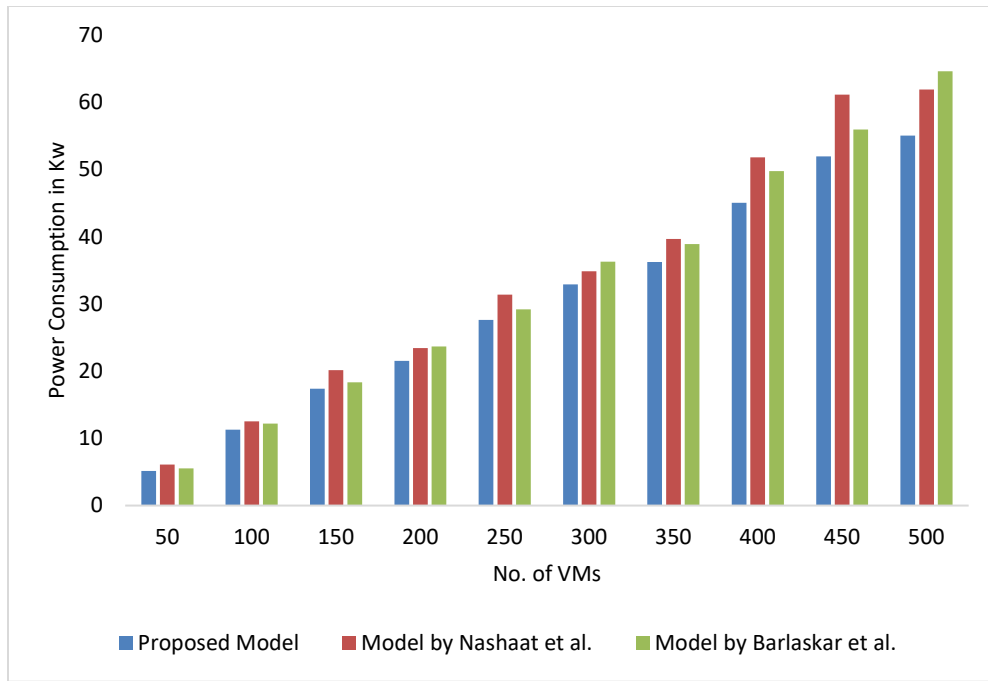
Fig. 3 Performance analysis based on power consumption

Moreover, the given approach is evaluated on the number of migration parameter which is represented in the form of graph (Fig. 4) and also the work is compared on the parameter of service level agreement (Fig 5). The graphical results strikingly present the outperformance of the approach.
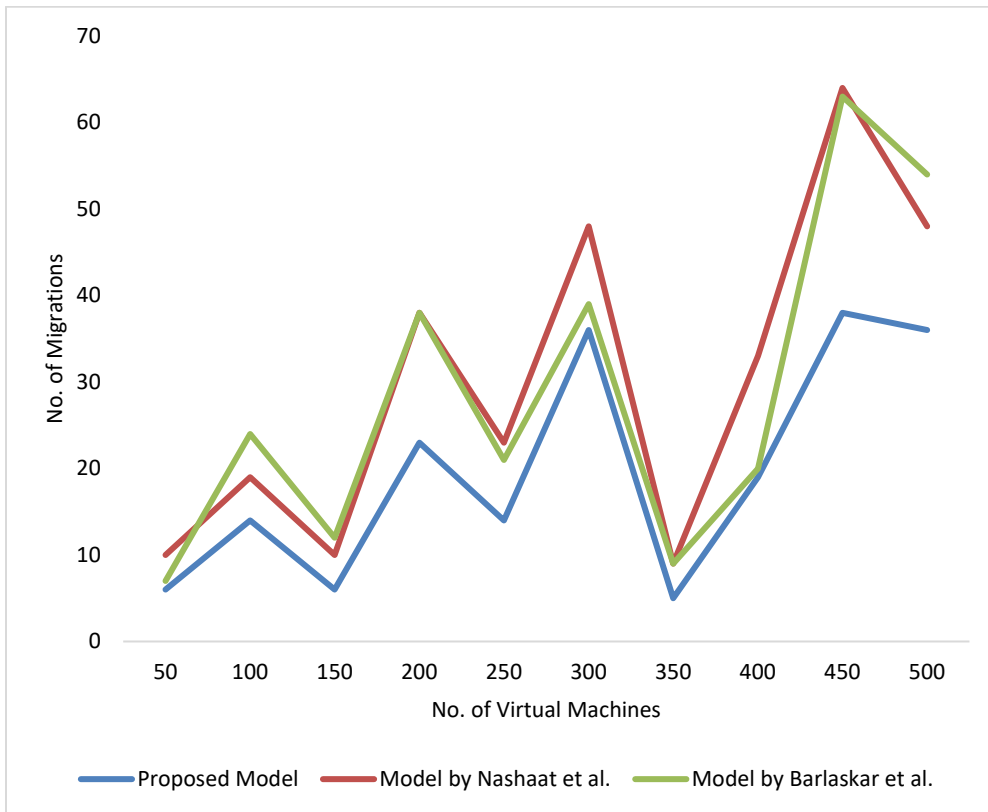

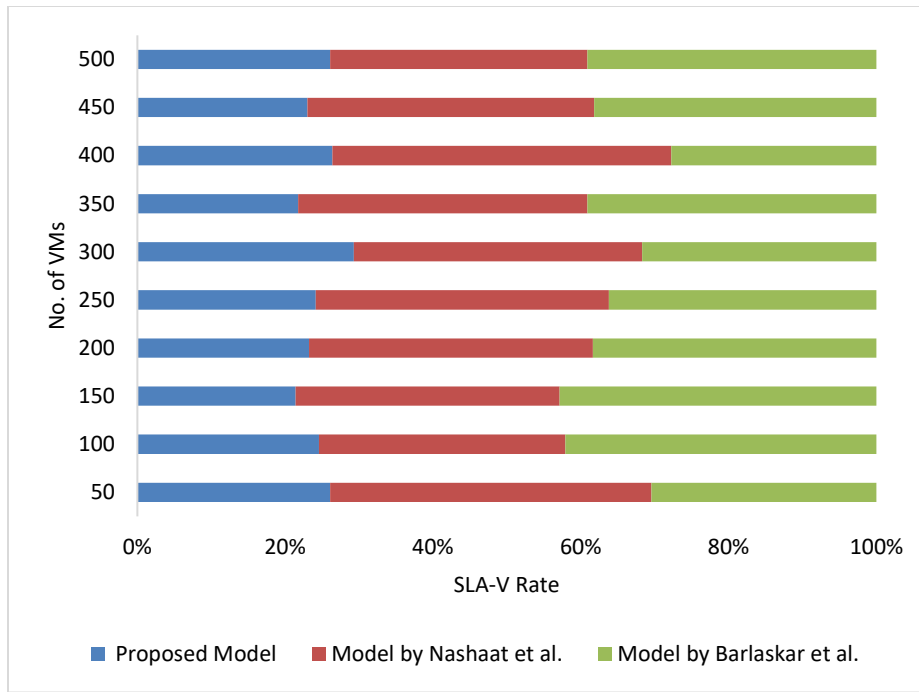Fig. 3 Performance Analysis based on no. of Migrations

Fig. 5 Performance Analysis based on SLA-V

V. CONCLUSION

The advent of virtualization, the deployment of virtual instances over servers, has proved to be a boon as it has increased the efficiency of the cloud data environment manifold [20][21]. Thus, VMP has been taken as the hot research area to achieve efficiency goals. The placement problem of virtual instances is considered as the problem relating to the packing of bins and is associated with multiple objectives. The problem is moreover relates to numerous optimisation objectives along with the certain restrictions. The optimisation concern is to decrease consumption of power, migrations, and count of SLA violations at the data centre while maximising load balancing. The proposed optimization algorithm effectively optimizes virtual machine placement and migrations. For instances of 50 to 500 virtual machines, the performance has been evaluated, where for 500 virtual machines, the power consumption is 55.0660916 kW, SLA-V is 0.00208696, and the number of migrations is 36. The experimental findings reveal that the cr-Cuckoo algorithm outstrips the two heuristic algorithms in lieu of energy economy and placement strategy in an acceptable time frame. The reason for this is the capacity of the suggested technique to determine the optimal host for virtual machine migration without compromising the energy consumption factor. According to the graphical representation, the mean number of virtual machines (VMs) that were migrated for the MBFD, FF, and the proposed technique are 34.1, 16.45, and 8.4, correspondingly. Hence, it can be noticed that the proposed approach results in a decrease of 75.3% in the migration of virtual machines (VMs) compared to the existing MBFD strategy, and a reduction of 51.76% compared to the FF approach.

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