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VM Selection and Allocation Policy to Optimize VM Migration in Cloud Environment

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Abstract*: *Cloud computing, a metered based technology provides the services using virtualized technology over the internet. In the cloud environment, to improve the performance (such as utilization of the resources, energy minimization) extreme number of virtual machines (VMs) can be installed on the servers as per their resource capacity. In this way, servers can be overloaded. Overloaded servers consume more energythan normal status servers. VM migration (VMM) is an efficient technique to become a server in a normal state. VMM technique is used to consolidate the resources to increase resource utilization (RU) and reduceenergy usage. In the VMM technique, selection of VM such as which VM is migrated from one server to another server and allocation of VM on servers is an important aspect. Appropriate VM selection declines the numeral of VMMs and increasesenergy efficiency. Appropriate VM allocation declines the server to become overloaded. In this paper, the VM selection and allocation strategy is presented. CloudSim toolkit is used to verify the strength of proposed VM selection and allocation algorithm. Proposed VM Selection algorithm (MaMT) performs better than existing MiMT algorithm in terms of total energy consumption, number of hosts shut down, number of VMM, and average Service Level Agreement (SLA) violation rate. MaMT algorithm with resource aware provisioning (RAP) and MiMT+RAP algorithm combines both VM selection and allocation policies. RAP algorithm used both energy and RU parameters while allocating VM to the server.MaMTreduces the energy consumption up to 7.25% and reduces the SLA violation rate up-to 2.6% in comparison to MiMT algorithm. When VM selection and allocation policies combines together than more system performance is improved. MaMT+RAPreduces the energy consumption up to6.76% and reduces the SLA violation rate up-to 0.22% in comparison to MaMT algorithm.MiMT+RAPreduces the energy consumption up to15.23% and reduces the SLA violation rate up-to 0.95% in comparison to MiMT algorithm.

Index Terms*: *Cloud computing, energy efficiency, resource provisioning, resource selection, virtualization, VMM.

I. INTRODUCTION

Cloud computing, a metered based technology provides the services using virtualized technology over the internet [1-3]. Cloud environment provides enormous benefits such as low upfront cost, use from anywhere and from any device etc. Due to various benefits, the demand for cloud-based amenities has increased nowadays. To accomplish the rising requisition for cloud-based services with high performance, the cloud service provider organizations are increasing the number of data centers at a rapid rate. The data center includes network cables, server, lightning, and air conditioner etc. which consumes high electricity and emit a large amount of carbon-di-oxide (CO_2) which increase the environmental hazards such as global warming [4-6]. For example, in 2014 [7], seventy billion kilowatts per hour (kWh) energy is expended by datacenters in U.S. Approximately 80-116 Metric Megatons of CO_2 can be emittedby a medium scale datacenter [8].

To increase the energy consumption, low resource utilization is one of the main cause. For example, 5000 production servers (server and host terms are used interchangeably) are monitored for six months and it is observed that server utilization is mainly between 10% to 50% [9]. To increase the resource utilization (RU) and energy efficiency, virtualization technique is used. Using virtualization technique, on a server, multiple virtual machines (VMs) can be deployed to increase RU and energy efficiency. Low utilized servers can be put to energy saving modes (such as shut down, hibernate etc.) which impressively reduce energy consumption. VM live migration [5,6] helps to consolidate the VMs on a least numeral of servers to increase RU and energy efficiency. In the VM migration (VMM) process, selection of the VM which is migrated from one server to another is an important aspect. Appropriate VM selection algorithm declines the numeral of VMM and surge energy efficiency. In this paper, the VM selection algorithm (MaMT) is presented. MaMT algorithm considers the Random-Access Memory (RAM) of the VM while selecting the VM for migration. For migration which VM has maximum RAM is selected. VM allocation policy also have significant impact on energy consumption. Efficient VM allocation policy maximize the usage of the serer resources. It reduces the chances to become server overloaded which impressively effect number of VMM and energy consumption. CloudSim toolkit is used to verify the strength of the proposed VM selection and allocation algorithm in terms of number of VMMs, total energy consumption, number of hosts shutdown, and average Service Level Agreement (SLA) violation rate.

The key contributions of the presented paper are as follows:

- MaMT algorithmsare proposed to selectthe appropriate VM for migration purpose.

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- MaMT makes use of memory occupied by the VM to attain energy efficiency.
- MaMT+RAP, MiMT+RAP VM selection policies with integration of VM allocation policies.
- MaMT+RAP, MiMT+RAP, consider the servers' RU while allocating VM to the servers.
- The achievability of proposed algorithms has been presented by implementing in CloudSim simulator [10].
- The efficiency of MaMT algorithm is exhibited by comparing withMiMT [11]. An enrichment in average energy consumption is reduced by about 7.25%.The efficiency of MaMT+RAP algorithm is exhibited by comparing it by MaMTand on average 6.76% energy consumption is reduced. MiMT+RAP reduced up-to 15.23% energy usage in comparison to MiMT.

Organization of this paper is as follows: Section II depicts the related work. Section III illustrates proposed system model. Section IV depicts the proposed VM selection algorithm. Section V proposed VM allocation algorithm. Section VI depicts the experimental setup. Section VII depicts the results and discussion. The last section presents the conclusion and future scope.

II. RELATED WORK

Beloglazov et al. [11] presented VM consolidate techniques which are dynamic in nature to optimize energy usage. In this, MiMT algorithm is proposed for VM selection from an overloaded server. MiMT algorithm select that VM which has minimum memory. Therefore, more than one VM can be needed to migrate from the overloaded server to another server to put the server in the normal state. In this way, the number of VMMs, average SLA violation rate, and energy consumption is increased. Beloglazov et al. [12] presented VM assignment and VM selection algorithms, using dynamic threshold parameters. MiMT VM selection policy is presented to diminish the numeral of VMMs. The best fit algorithm is modified for placement of VMs. Default algorithms presented in the CloudSim toolkit is used to check the strength of the proposed algorithmin terms of a numeral of VMMs. Chowdhury et al. [13] proposed the secondworst fit decreasing algorithm. This algorithm isa modified version of the existing VM assignmenti.e. modified first fit decreasing algorithm. These algorithms are compared with base algorithms which are built-in CloudSimtoolkit. Result shows that Local Regression (LR) VM dynamic consolidation technique with MiMT (VM selection technique) performs better. Monil et al. [14] altered the existingVM selection algorithms. Presented algorithm use therecent usage history of VMs' resources (Central processing unit i.e. CPU).VM never be selected for migration if their resources in a constant pattern. Because it is presumed that in future this VM also use their resources in the same pattern and other server can be overload if this VM is migrated. This technique performs better than built-in CloudSim algorithms. To diminish the numeral of VMM, the workload-based network scheduling algorithm is presented [15]. Communication cost, network congestion, etc. are avoided to reduce VMM. Critical ($\text{job accomplished} > 70\%$) and non-critical ($\text{job accomplished} < 70\%$) are two sections that are used to diminish the numeral of VMM. In this algorithm, firstly, select thatVMs which are in non-critical section for migration. This helps to maximize the RU and minimize energy consumption. Ifnon-critical section does not have any VM, VMs from critical sections are migrated. Chaabouni et al. [16] proposed a dynamic load detection algorithm to provide upper and lower threshold limits dynamically. Standard deviation (SD) and median absolute deviation (MAD) methods are used to compute the higher and lower threshold boundary. Results are compared with LR with MiMT, dynamic voltage and frequency scaling (DVFS), and MAD with MiMT. Proposed algorithm performs better than the existing algorithm and saves around 40% energy usage.Ferreto et al. [17], proposed consolidation techniques (such as Linear programming (LP) and heuristic (HE)) with migration control to diminish the numeral of VMM. VMs which does not have a stable pattern of resource demandis selected for the migration process. There are three versions of LP and HE such as DC with migration control,Dynamic consolidation (DC), and static consolidation (SC). DC performs better in comparison toother two algorithms in terms of total number of active servers.

III. PROPOSED SYSTEM MODEL

In this paper, a large but limited number of servers are considered. The serveris characterized by their assets such as CPU performance, number of cores,bandwidth, memory, etc. Fraction of these server resourcesareassigned to VMs as per the workload demand. At the run time, VMs are dynamically allocated/deallocated based on the workload demand. VMs are migrated if any server is overloaded to put the server in a normal state. All the VMs are migrated from the underloaded server and shut-down this server in order to minimize energy consumption. Upper threshold ($threshold_{upper}$) limit and lower threshold ($threshold_{lower}$) limit is used to detect the servers' status.$threshold_{upper}$ limit defines the maximum utilization of the server and $threshold_{lower}$ defines the minimum utilization of the server. Server is in normal state, if server utilization lies between upper and lower threshold boundary.Equation (1) is used the the to checkthe server status and described as:

$$Server\ Status = \begin{cases} Underloaded, if\ server_{utilization} < threshold_{lower} \\ Overloaded, if\ server_{utilization} < threshold_{upper} \\ Normal, \qquad Otherwise \end{cases} \quad (1)$$

Fig. 1 describes the proposed VM selection policy which is used in this paper. After an interval of time, server status is checked. If server is underloaded, then check thatentire VMs of the server can be migrated. If yes, then migrate entire VMs and shut down the server to save the energy. If server status is overloaded, then select the appropriate VM for migration. After migration VM server status is checked again until the server is in a normal state. If server status is normal, then no migration is performed.

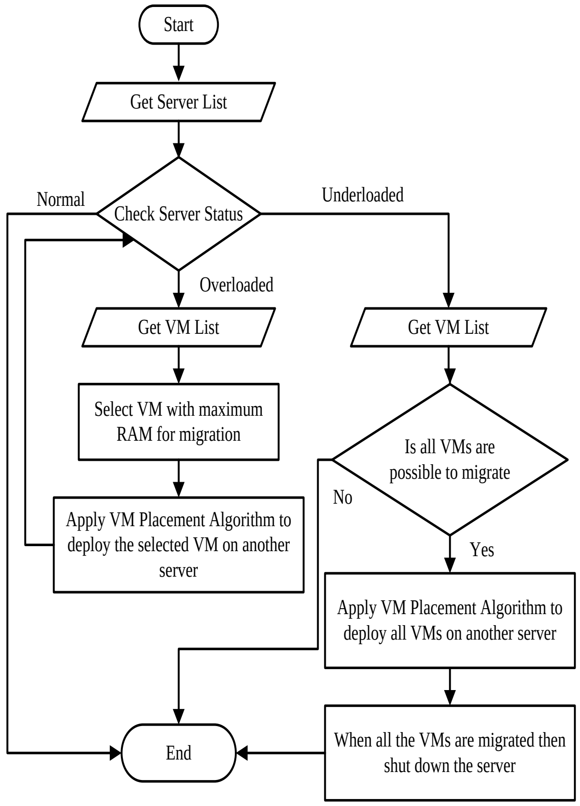

Fig. 1: Flow Chart of Proposed VM selection Policy

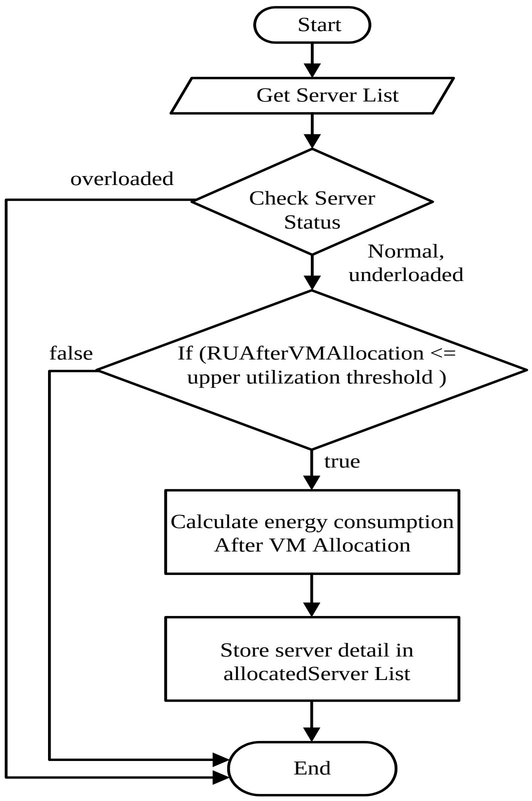

Fig.2: Flow Chart of Proposed VM allocation Policy

Fig. 2 describes the proposed VM allocation policy which is used in this paper. When any VM is selected for the migration from overloaded or underloaded server, then that VM needs to be allocated to any other server whose status is normal. VM allocation policy select that server whose energy consumption is less, and utilization does not exceed the upper utilization threshold value after allocation of the VM. This strategy helps to reduce number of servers to become overloaded which significantly reduce number of VMM. Reduction in number of VMM also helps to reduce the energy consumption. After checking all the servers if allocatedServer list is not empty than select that server whose energy consumption is low than all other servers,

IV. PROPOSED VM SELECTION ALGORITHM (MAMT)

In this section, the VM selection algorithm (MaMT) for VMM process is explained. This algorithm uses the memory assets of the VM to determine the selection of the VM for migration. This algorithm is proposed to diminish the energy consumption, numeral of VMM, and SLA violation rate.

Pseudocode (Algorithm 1) tries to find the VM for the migration process to order to increase energy efficiency. Initialize the VMM list to a null and max-metric variable to the minimum value (see line 1 and 2). This algorithm checks all the VMs of the server. If VM is already in the migration process, then continue to find the next VM (see line 4 and 5). If VM is not in the migration process, then select the VM which has the highest memory at that instant of time (see lines 8-11).

Algorithm 1: Pseudocode to select the VM for VMM process
Input: list of servers and VMs
Output: Select the VM for migration

```
1.  vmToMigrate ← null;
2.  maxMetric ← minValue;
3.  for each VM in the server S_k
4.     if VM is already in migration then
5.        continue;
6.     endif
7.     metric ← RAM of VM;
8.     if metric > maxMetric then
9.        maxMetric ← metric;
10.       vmToMigrate ← VM;
11.    endif
12. end for
```

A. Time Complexity of MaMTPseudocode

Theorem I: The time complexity of MaMT is measuredas $O(N_v N_s)$, where$N_s$is number of servers, $Nv$is number of VMs.

Proof: The time complexity to eliteappropriate VM for migration is $O(N_v)$ (lines 3-12). This algorithm repeats for all the active servers. Thus, time complexity of MaMT algorithm is $O(N_v N_s)$.

V. PROPOSED VM ALLOCATION ALGORITHM (RAP)

In this section, the VM allocation algorithm (MaMT) for VMM process is explained. This algorithm uses RU and energy consumption to determine the selection of server for VM allocation.

This algorithm is proposed to diminish the energy consumption, numeral of VMM, and SLA violation rate.

Pseudocode (Algorithm 2) tries to discover server for VM allocation process to order to increase energy efficiency. Initialize the allocatedServer list to a null and max-metric variable to the minimum value (see line 1 and 2). This algorithm checks all the VMs of the server. If VM is already in the migration process, then continue to find the next VM (see line 4 and 5). If VM is not in the migration process, then select the VM which has the highest memory at that instant of time (see lines 8-11).

Algorithm 2: Pseudocode for VM allocation
Input: list of servers and VMs for allocation
Output: Select the server for VM allocation

```
1.  for each VM
2.  allocatedServer ← null;
3.    for each server S_k
4.       if server status is normal or underloaded then
5.         if RU after VM allocation <= upper
           utilization threshold value then
6.           calculate energy consumption of server
             after allocation;
7.           allocatedServer ← S_k
8.         endif
9.       endif
10.   end for
11.   if allocatedServer is not empty then
12.     Allocate VM that server whose energy
        consumption is less than other servers
13.   endif
14. end for
```

A. Time Complexity of RAPpseudocode

Theorem II: The time complexity of RAP is measuredas $O(N_v N_s)$, whereN_s *and* is number of servers, $N_v$is number of VMs.

Proof: The time complexity to elite the appropriateserver for VM allocation $O(N_s)$ (lines 3-10). Time complexity for selecting appropriate server from the allocatedServer list depends on the list size. It is always less than number of active servers. This algorithm repeats for all the selected VMs. Thus, time complexity of this algorithm is $O(N_v N_s)$

VI. EXPERIMENTAL SETUP

CloudSim toolkit [10] is used to evaluate presented MaMT,MaMT+RAP, and MiMT+RAP algorithm. PlantLab workload is used to evaluate these parameters. Two types of servers are considered such as HP ProLiant ML110 G4 and HP ProLiant ML110 G5 [11,18]. Total 800 number of servers are considered. Four types (extra-large, large, micro, and small) are considered such. Total 1052 number of VMs are considered. The quantity of VMs is equally divided between these four types of VMs.

To detect the server status various dynamic load detection strategies are used such as Linear regression (LR), Inter – Quartile range (IQR), threshold (THR), local regression robust (LRR), and median absolute deviation (MAD). If server status is overloaded, then presented MaMTalgorithm is used to select the VM for migration so that server comes under the normal status. If server status is underloaded, then tries to migrate entire VMs and shut-down this server to save the energy consumption.

Energy consumption in kilowatt-hours, the numeral of VMM, numeral of hosts shutdowns, and average SLA violation in percentage parameters are used to evaluate the performance presented algorithm. These parameters [18] are described below:

A. Energy Consumption

Energy consumption defines the total energy is used to execute the workload on the hosts. CPU, memory, bandwidth etc. resources use the energy to execute the workload. Like paper [4, 18], energy consumption of only CPU is considered. Equation 2 describes the total energy consumptionas:

$$TEC = \sum_{i=1}^{n} k_i * E_i + (1 - k_i) * E_i * U_i \qquad (2)$$

Where TEC is total energy consumption, $n$is numberal of active servers, k_i is the fraction of the energy consumption when server is in idle state, $E_i$is the outermost energy consumption when server utilization is 100%.

B. Number of VMM

This parameter is used to calculate total VMM performed throughout the simulation.

C. Number of server shutdowns

This parameter is used to calculate total number of server shutdowns throughout the simulation.

D. Average SLA violation rate

This parameter is used to calculate average SLA destruction owed to VMM. Because VM is unreachable, during VMM process.

VII. RESULT AND DISCUSSION

PlanetLab workload is used to check the performance of the presented algorithms.

Fig.3illustrates TEC of MaMT, MiMT, MaMT+RAP, and MiMT+RAP algorithm. In comparison of MiMT, MaMT consumes less energy. MaMT select that VM which has the highest RAM for migration operation. In the MiMT, more than one VMs are migrated to become the server in normal condition. But in the proposed algorithm, one migration is needed at that time to become a server in a normal state. Therefore, energy consumption of MaMT is diminished. Around7.25%, energy consumption is diminished in comparison ofMiMT. When VM allocation policy is integrated with VM selection policy then further energy consumption is reduced. This is because VM allocation policy minimize the chances to become the server overloaded. In this way further number of VMM are decreased which helps to improve the energy efficiency. Fig. 3 clearly shows that improvements. The efficiency of MaMT+RAP algorithm is exhibited by comparing it by MaMTand on average 6.76% energy consumption is reduced. MiMT+RAP reduced up-to 15.23% energy usage in comparison to MiMT.

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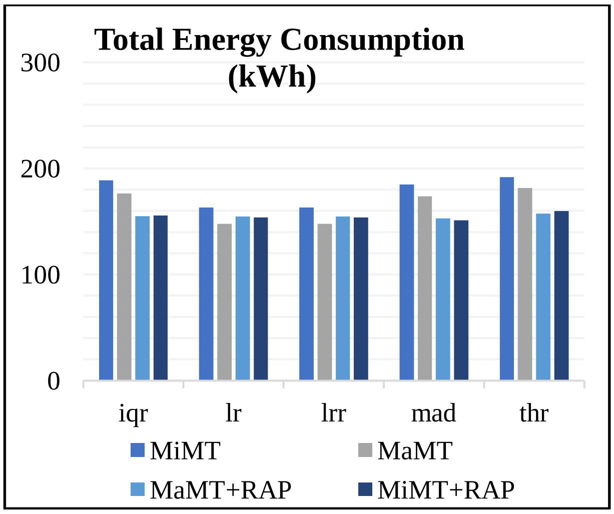

Fig. 3: Total energy consumption in kWh

Fig. 4illustrates total number of VMMs are donethroughout the simulation. Number of VMMs in MaMT isreduced in contrasttoMiMT. If server is overloaded, then VMM method is called. At a time only one VM is migrated in the proposed VM selection algorithm. Thus, in MaMT,number of VMMis less in comparison toMiMT. In the presented algorithm, on an average 16.17% number of VMMs are reduced. When VM allocation policy is integrated with VM selection policy then further number of VMM is reduced. This is because VM allocation policy minimize the chances to become the server overloaded. Fig. 4 clearly shows that improvements. The efficiency of MaMT+RAP is exhibited by comparing it by MaMTand on average 83.6% number of VMMs are reduced. MiMT+RAP reduced up-to 74.4% VMMs in comparison to MiMT.

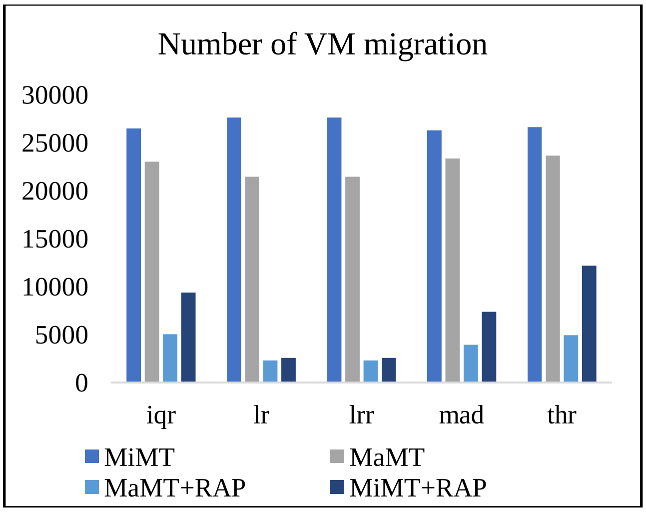

Fig. 4: Number of VMMs

Fig.5illustrates total number of hosts' shutdowns done throughout the simulation. Number of host shutdowns are reduced in presented algorithms. Reducing the number of VMM also decline number of host shutdowns. On an average, 13.14% number of hosts shutdowns are declined in contrast of MiMT . In MaMT+RAP on an average 77.35% host shutdowns are reduced in comparison to MaMT. MiMT+RAP reduced about 70.91% host shutdowns in comparison to MiMT algorithm.

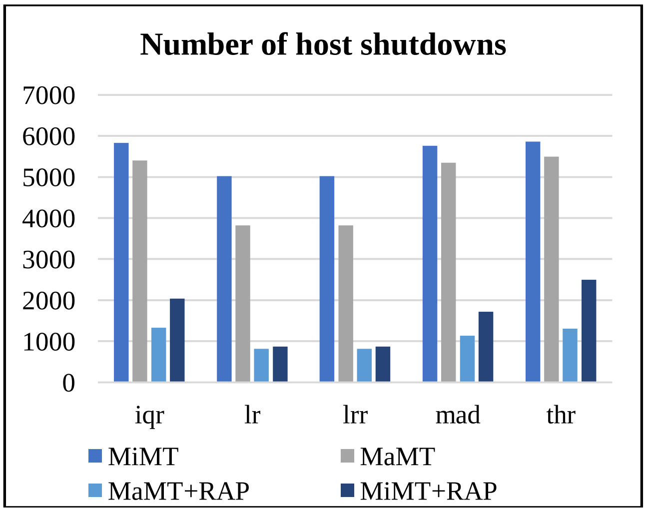

Fig.5: Number of host shutdowns

Fig.6illustrates SLA violation throughout the simulation. SLA violation of MaMTisreduced as compare to MiMT. Around 2.6% SLA violation rate is declined as compare to MiMT.The efficiency of MaMT+RAPis exhibited by comparing it by MaMTand on average 0.22% average SLA violation rate is reduced. MiMT+RAP reduced up-to 0.95% average SLA violation rate in comparison to MiMT.

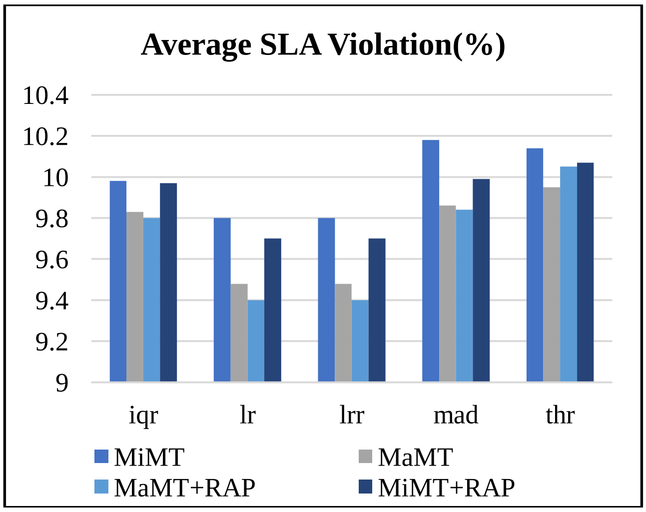

Fig.6: Average SLA Violation in %

VIII. CONCLUSION

In this paper, presented algorithm increase the system performance in terms of energy efficiency, number of VMM, number of hosts shutdowns, and average SLA violation rate. In this paper, for VMM purpose, appropriate VM is selected to become the host in a normal state. This algorithm tries to diminish the numeral of VMM for becoming a host in a normal state. Thus, MaMT algorithm improve the system performance. in comparison to MiMT algorithm.System performance is further reduced by wisely allocating the VMs to the servers.

Efficient VM allocation policy reduce the causes to become server overloaded which significantly decrease the number of VMM. On an average, MaMT algorithm reduced 7.25% energy consumption, 16.17% number of VMMs, 13.14% number of hosts shut down in comparison to MiMT. MaMT+RAP reduces up-to 6.76% energy consumption, 83.6% number of VMMs, 77.35% host shutdowns, 0.22% average SLA violation rate in comparison to MaMT algorithm. MiMT+RAP reduces about 15.23% energy usage, 74.4% VMMs, 70.91 % host shutdowns, 0.95% average SLA violation rate in comparison to MiMT. In the future, future usage load of the server is predicted. New VM selection and allocation strategies are used to extend the presented work.

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