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Energy optimization using virtual machine migration for power aware

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Abstract. Using cloud computing, the cloud service can be delivered to the user via an internet connection. A major concept in cloud computing is virtualization, which allows for the dynamic sharing of physical resources. The deployment of virtual machines (VMs) in the cloud is a difficult problem since they are placed on top of real machines in the data center. A good VM placement policy should increase resource utilization and also provide energy optimization, as saving energy has become crucial due to the high demand for the cloud and its data centers consuming high power. In this work, an approach is made to optimize the energy consumption during VM migration called, Power-Aware Energy Optimized VM Migration (PAEOVMM). The approach uses the maxPower of the host to allocate VM to the host. Our proposed approach is analyzed using CloudSim. As per the simulation results, PAEOVVM performs better in energy consumption than existing baseline CloudSim algorithm. PAEOVVM performs improvement in energy consumption on an average of 27-40%.

Keywords: cloud computing, servers, power consumption, energy consumption, service virtualization, virtual machines, virtual machine migration, data centers, energy-awareness.

1. Introduction

Cloud computing is one of emerging technologies in today's IT world because of its nature of elasticity, pay and use, flexibility, and easy to manage. As the demand to shift the computing to cloud is increasing so is energy consumption of data centers [1]. In Live VM migration. The VM is migrated from one physical machine to another while it is still running. It is possible to separate hardware and software considerations with live OS migration and create a single unified management domain for clustered gear [1]. Some of the common reasons why organizations choose to move their data centers to the cloud are as follows:

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Global market expansion: Expanding the organization's customer base may require its servers to be present in different countries. The public cloud platform provides this flexibility to deploy the data center into various cloud servers located in different countries.

Location and privatization requirements for regulatory compliance: A compliance requirement may mandate the presence of the IT infrastructure across certain geographical locations or enforce the need for a non-shareable infrastructure. For example, an HIPAA-compliant hosting environment requires a non-shareable environment. The cloud provides the flexibility to have data centers at various cloud regions where the data centers are hosted. **Renewal of software licenses**: Some of the software that the organizations use have huge license costs. When these licenses are due to expire, purchasing new licenses is expensive and the IT budget may not be able to accommodate this. It is therefore wise to use the application that is hosted in the cloud, which can be used at nominal costs. **Hardware upgrade and its costs**: A growing organization may need to upgrade its hardware from time to time, so as to accommodate the business requirements. Instead of spending large funds on purchasing new hardware, organizations prefer to migrate their IT environment to the cloud. **Datacenter lease expiration**: Many organizations lease their data center from vendors. When the lease is due to expire, it is wise to migrate the data center to the cloud. The majority of organizations have moved to the cloud in part due to the above-mentioned advantages. In recent years, this shift has caused data centers to consume more and more power [2]. To reduce this heavy power consumption, one of the virtualization technologies used is the migration of virtual machines from one overloaded server to another less overloaded server. A virtual machine can be migrated in two ways: live migration and cold migration. In cold migration, the VM is shut down before being transferred to another server; in live migration, the VM runs while being transferred [3]. Allocating virtual machines to the correct server during the migration process is one of the most challenging tasks. As part of the migration, This article discusses allocating virtual machines based on the maxPower of the host or server. All the PE's on the server add up to the maxPower of the host A random workload with varying VM and PM sizes is used to compare the proposed method to the baseline algorithms [13]. PAEOVMM uses the power of the server to cut down on energy consumption of server because power of the server would be the best way to figure out how much energy the server uses. According to the structure of this work, the following are the significant contributions:

1. PAEOVMM outperforms baseline algorithms in terms of efficiency when it comes to balancing energy consumption with service level agreements (SLAs).
2. Energy SLA Violation (ESV), is reduced.
3. PAEOVMM's effectiveness in reducing power consumption, the number of VM migrations, and the number of hosts have been demonstrated in experiments.
4. It has been proposed to reduce energy consumption in data centers by using a power-aware VM deployment technique called PAEOVMM.

The rest of the paper is divided into the following sections. Part-2 gives a survey on related works. Part-3 explains the proposed methodology and algorithm, then Part-4, Experimental setup and results. Finally, Part-5 Conclusion.

2. Related work

Yizhang.et.al explores an innovative idea of energy and deadline aware with a non-migration scheduling algorithm, a heuristics algorithm. The author tries to avoid virtual machine migration by postponing of the task which are deadlines with less priority [4]. Buyya. et.al propose a green cloud computing solution to reduce operation cost, and energy, the solution uses a heuristics energy-aware allocation of the virtual machine to the host [2] Tuan le work surveys weaknesses and strengths of state of art live migration techniques and identifies the key points to implement migration based on workload characteristics [5]. Debabrota. et.al proposed an algorithm called Megh, which models the energy-and-performance efficient resource management during live migration as a Markov decision process and solves it using functional approximation schemes and further suggests implementation of Megh in real-life data centers [6]. Mehran Tarohomi. et.al implements cloud resource management

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with live migration of virtual machines to reduce power consumption. The resource management is done based on the future load prediction of the host [7]. Youseef et.al developed an approach to reduce the energy consumption of the host by considering performance -the to-power ratio of data center workload utilization assigned to a lower threshold and hence try to reduce the no of virtual machine migrations [8]. Xiao jun ruan. et.al proposes a strategy called PPRGear, which calculates on the server side the CPU power consumed by java operations during a certain period of time divided by the active power consumption in that period and hence achieves optimizing power consumption [8]. This research was conducted by A cloud modeling toolkit called CloudSim was used by Tanvir Alam Siddique et al to examine six well-known task scheduling techniques. In spite of the fact that the algorithms are out of date, they are still used today. Based on the number of tasks assigned and virtual machines, performance measures differ. An evaluation and comparison of the performance of various algorithms were conducted to identify which algorithm was most suitable for a given set of conditions. [9] Power consumption and service quality are improved by adding algorithms that are on basis of bin packing problem solutions. Mohammad Masdari et al. concluded that VM migrations could be predicted. They are expected to reduce costs and improve the efficiency of cloud DCs, according to study findings. The classification of predictive migration methods is based on the forecast algorithms they are based on, along with their advantages, disadvantages, and contributions. In the first part, it describes virtualization and how virtual machines can be migrated. It also shows how the VM migration approaches avoid performance degradation during the migration by using prediction algorithms [10]. To conclude the work done so far considers mainly of CPU threshold of the hosts for optimization of the power consumption or the present or predicted workload for optimization. Much work is not concentrated on the maxPower of the host. This work tries to implement an algorithm based on the maxPower of the host, which includes the power consumed by all the processing elements of the host.

3. Proposed methodology

3.1. Problem statement

In the cloud data center, we formed nN number of physical servers like N1, N2, N3, ……, NnN . Number of VMs for Nj PM = pj = |Nj |, 1 ⩽ j ⩽ nN.

Let, the value of “bNSj” indicates the status of Nj PM. Pj means, the number of VMs on jth server.

$$\text{bNSj} = (1) - \text{ if Nj is an active PM; } (0) - \text{Otherwise} \tag{1}$$

$$\text{M in}\{\ \textstyle\sum_{j=1}^{nN} \text{bNSj}\} \tag{2}$$

For resource utilization of Nj indicated as R (Nj)

$$\boldsymbol{Max}\left\{\sum_{j=1}^{nN} R(Nj) \times bNSj — \sum_{j=1}^{nN} bNSj\right\} \tag{3}$$

The migration status of the kth VM, indicated as like bVMksd, Finally, the total number of VMs, $VM_{tn} = \sum_{j=1}^{nN} \sum_{i=1}^{pj} 1$

bVM_{ksd} = here, assign 1 where s ≠ d, otherwise 0.

$$\text{Min}\left\{\sum_{k=1}^{VM\,tn} bv\,Mksd\right\} \tag{4}$$

The maximum resource capacity of VMs does not change during server consolidation. Here, a few basic level steps to form our algorithm, these are: Step1: Identify if the host is overloaded. Step 2: Select the virtual. achines (VMs) to be transferred from the overburdened host. Step3: Find the host to which selected VMs are to be migrated by PAEOVMM method. Step4: Execute the migration process.

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This algorithm chooses better hosts if their power is greater than the other host's. In case both the hosts have same power then host with a lower CPU is selected

3.2. Power model

The work is implemented by using maxPower of the host. Maxpower is the maximum power formed by the collection of all the processing elements of the host such as CPU, RAM, Storage Unit, and NIC, whereas the baseline algorithm considers power of the host. The energy model of PAEOVMM can be formulated as

$P_{max} = P_{idle+} P_{processing\ elements}$ where P_{idle} is considered to be constant (5)

PAEOVMM considers the powermodel of the host when the workload is 100%. By consolidating all servers, PAEOVMM algorithm allows for the migration of as many virtual machines as possible. Each iteration involves selecting the host to which the virtual machine has to be assigned based on the maximum power of the host and remaining power of the host after virtual machine allocation in the previous iteration. The algorithms consider the power model HP Proliant ML 110G4 or HP Proliant ML110G5 when the workload is 100%. PAEOVMM proves to outperform the baseline algorithms because the allocation is done when the workload is maximum.

4. Experiment and results

To simulate the technique, we used Cloud Sim, a well-known tool for creating computer models of cloud computing environments. Cloud Sim is written in java and has java classes for different cloud components. It supports the testing of power-aware algorithms. Our approach uses the power VM Allocation Abstract class and overrides find Host for VM method. The work is compared with the baseline algorithms proposed by Beloglazov and Buyya [11] using Planet Lab workload data. To select and allocate suitable virtual machines for migration, we selected Iqr Mc and Mmt [11]. Based on Beloglazov and Buyya's results, these algorithms are the best among the others. IqrMc analyzes historical CPU utilization using a robust statistic interquartile range. To migrate virtual machines, it chooses the ones that correlate most closely with the CPU [12]. To determine if the host is overloaded, LrMmt uses a method derived from Cleveland. If a host is over-utilized, LrMmt selects a virtual machine that takes the least time to migrate.

4.1. Experiment setup

The proposed algorithm is compared with the baseline algorithm defined in CloudSim. The parameter and their configurations used in the simulation are as follows:

Table 1. Parameters and Configurations.

Parameters	Configurations
Type of Hosts	HP Proliant ML110G4(2*1800MIPS 4GB)
	HP Proliant ML 110G5(2*2660 MIPS 4GB)
Workloads	Planetlab (10 days of traces)
Host counts	400, 800 of each type of hosts
Type of VMs	1000 MIPS
	1500 MIPS
	2000 MIPS
	2500 MIPS

4.2. Performance metrics for evaluation

We have applied the evaluation metrics as follows. The energy evaluation metrics suggested by the author are (1) SLA violation time per active host (SLATAH) (2) Performance degradation due to migration (PDM) (3) SLAV Violation (SLAV) (4) Energy Consumption (EC) (5) Energy and SLA Violation (ESV) (6) Number of VM migrations.

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[4] SLATAH measures the quality of service of the running PM, SLATAH can be formulated as

$$\text{SLATAH} = \frac{1}{\text{N}\sum_{j=1}^{n}\frac{Tsi}{Tai}} - \tag{6}$$

If there are N hosts, then Tsi is the total time that the host was used at 100%, resulting in a SLA breach. Tai is the sum of the active state of the host I. (serving VMs).

[2] Performance due to migration (PDM) is overall performance degradation by VM due to migration. It can be measured as

$$\text{PDM} = \frac{1}{\text{M}\sum_{j-1}^{M}\frac{Cdj}{Crj}} \tag{7}$$

Whereas the VM's estimated decrease in performance due to migration is Cdj, the total CPU capacity needed by VMj over the course of its lifetime is Crj[]. During the entire VM migration, Cdj is predicted to consume 10% of MIPS' CPU power.

[5] SLAV Violation: The level of SLA breaches in the system can be characterized by both SLATAH and PDM. Author [13] proposes a hybrid metric that include both host overloading and VM migration performance loss.

$$\text{SLAV} = \text{SLATAH} * \text{PDM} \tag{8}$$

[6] ESV: Energy consumption and SLA is defined as

$$\text{ESV} = \text{EC} * \text{SLAV} \tag{9}$$

[7] EC (Energy consumption) It is the energy used by the data centers in a single day

[8] Number of VM Migration: Will give number of VM's migrated during a single day. The simulations were analyzed by using Panetlab traces for 10 days.

Table 2. Workload characteristics.

Date	No of VM's
20110303	1052
20110306	898
20110309	1061
20110322	1516
20110325	1078
20110403	1463
20110409	1358
20110411	1233
20110412	1054
20110420	1033

4.3. Result analysis

Here, Figure-1 to figure-2 shows the parametric comparisons of irq_mmt_1.5, irq_mc_1.5 and PAEOVMM_irq_mc_1.5 In the nutshell we can conclude that our proposed methodology PAEOVMM, they shows an average reduction of 300-400 number of virtual machine migrations fig4 shows 27-40% of reduction in energy consumption, and comparatively show 0.3-0.6% of reduction in SLA. Reduction in SLAV. Also. it shows 15-31%, reduction in ESV, we can realize the PDM of PAEOVMM_irq_mc_1.5 is much reduced when compared to irq_mc_1.5 and irq_mmt_1.5 because PAEOVMM has less number of virtual machine migrations compared to other two methods. It is clear that the improvement in SLA violations for PAOVMM because of PAOVMM has less number of migration hence the chances of service degradation is less compared to irq_mc_1.5 and irq_mmt_1.5 and hence a reduction in SLA violation and improvement in QOS. Cloud providers can reduce energy consumption and resource use by dynamically consolidating virtual machines (VMs) utilizing live migration and putting idle nodes into sleep mode. Customers expect high-quality service, which necessitates balancing the need for excellent energy performance with the need to avoid

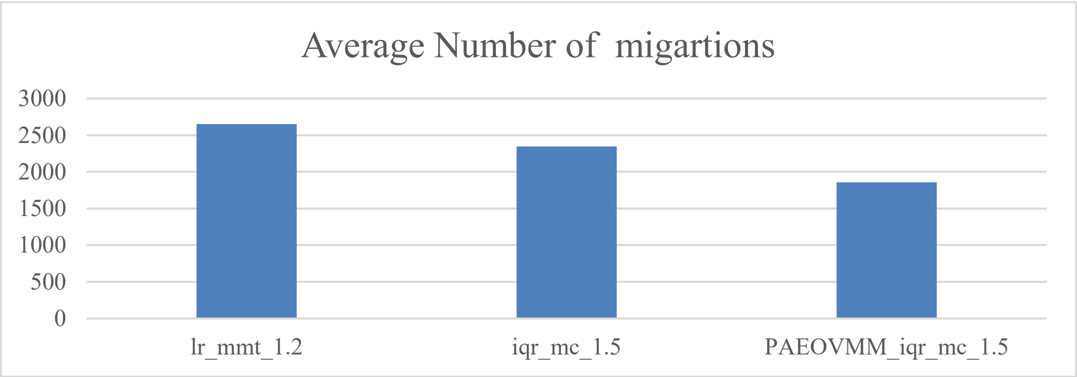

Figure 1. Average number of virtual machine migrations.

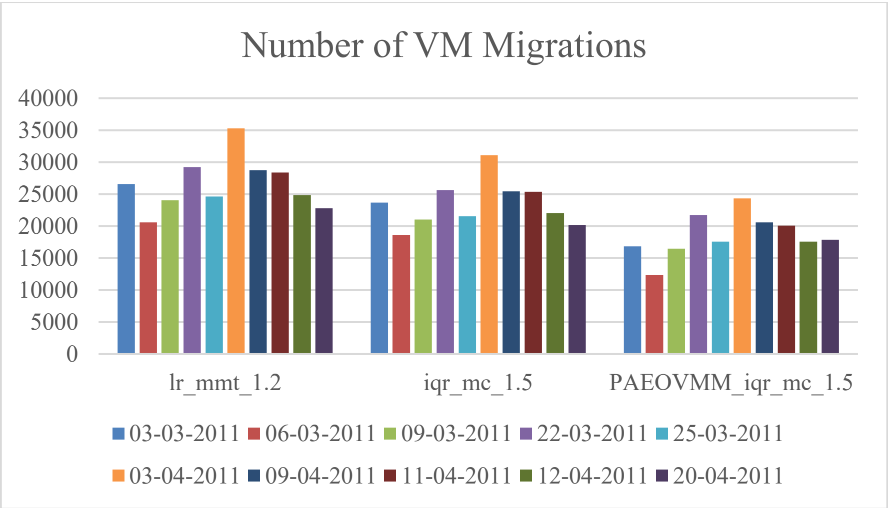

Figure 2. Number of migrations.

5. Conclusion and future work

As cloud computing is a very new and evolving field, there are few standard inputs or benchmarks to use for comparative analysis. This work allocates VMs based on the power of the host using our PAEOVMM methodology. In comparison with baseline algorithms, the PAEOVMM algorithm has shown a significant reduction in power consumption, SLA violations, and VM migrations. PAEOVMM outperforms the baseline algorithms as it considers the maxPower of the host which is the power of the host at 100% workload. As a future work, PAEOVMM can be analyzed for energy optimization considering the bandwidth and RAM of the host machine during live migration.

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