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Research Article

Load Migration Algorithm Using Green Computing in Cloud Environment

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Abstract

Due to continual growth of cloud users, quality of service declining and workload increasing rapidly of cloud based data centers. They consist of dozens of virtual machines that provides various services. By using green computing we try to make best use of resource efficiency in eco- friendly manner. Deliver superior Quality of Service, efficient resource utilization, better management of users and reduce time and energy can be done by VM balancing and migration. In data centers VM has huge amount of traffic and generate harmful radiation as outcome.

In this paper, we go through all existing VM balancing and migration methods with respect to their pros and cons and examined VM migration technique by simulation taking CPU consumption, Memory, time taken as parameters.

Keywords: Load Migration Algorithm; Green Computing; Cloud Environment; Virtual Machine (VM)

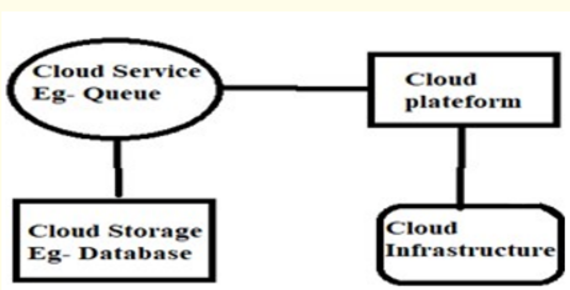


Figure 1: Cloud computing environment.

Introduction

Due to demand for internet habits and the digitalization of entire world has boosted the concept of implementing extensive Data Centers. Cloud computing can be categorized as a new prototype for the dynamic provisioning of computing services sustained by data centers that generally employ Virtual Machine (VM) technologies for environment remoteness purposes. The purpose of cloud data center is to assure best internet facility for all users. There are three basic service modules in the Cloud Computing, Software as Service (SaaS), Platform as a Service (PaaS), and Infrastructure as a Service (IaaS). Nowadays many organizations are go thronging the benefits of Cloud Computing, they build out private clouds using various tools such as VMware or OpenStack and create online services for their consumers.

A recent John Gunther report stated: "Green computing, has the potential to renovate a large part of the IT industry, creating software even more attractive as a service in eco-friendly Manner". Green Computing in cloud environment offers significant benefit to IT companies by relieving them from the necessity in setting up basic hardware and software infrastructures generate more heat emission, and thus enabling more effort on innovation and creating commercial value for their services.

However, a usual data center consumes as much energy as 35,000 houses. As energy costs are increasing while availability diminishes, it's essential to transfer the emphasis from enhancing data center resource management for effective performance to enhancing them for energy Efficiency, though sustaining high service level performance Therefore, Green Computing providers need to implement procedures to certify that their return side is not intensely reduced due to high energy expenses. For instance, the UK government has established The UK Data Center Council to address the rising energy consumption of data centers in green environment.

To addressing future progress of cloud services and drive Green Cloud computing, data center assets need to be achieved in an energy-efficient manner. In particular, Cloud resources need to be assigned not only to fulfil Quality of Service requirements but also to decrease energy consumption.

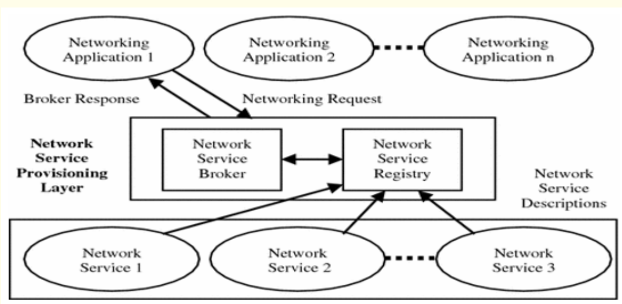


Figure 2: Concept of virtualization.

Objective of the Study

The main objective of this work are:

- Describe an architectural structure and principles for energy effective Green computing in Cloud Environment.
- Examine energy-aware resource provisioning and distribution algorithms that provision data center resources to client applications in a way that improves the energy efficiency of a data center, without violating the negotiated SLAs.
- Develop algorithms for energy-efficient mapping of VMs to suitable Cloud resources in addition to dynamic consolidation of VM resource panels.
- Explore open research challenges in energy-efficient resource management for virtualized Cloud data centers to facilitate advancements of the state-of-the-art operational Cloud environments.

Related work

One of the first works, in which power management has been applied at the data center level, has been done by Pinero [1]. In this work the authors have proposed a technique for minimization of power consumption in a heterogeneous cluster of computing nodes serving multiple web- applications. The proposed algorithm periodically monitors the load of resources (CPU, disk storage and network interface) and makes decisions on switching nodes on/off to minimize the overall power consumption, while providing the expected performance.

Beloglazov have considered the problem of energy-efficient management of homogeneous resources in Internet hosting centers [2]. The main challenge is to determine the resource demand of each application at its current request load level and to allocate resources in the most efficient way. The authors have noted that the management algorithm is fast when the workload is stable, but turns out to be relatively expensive during significant changes in the workload.

Kong [3] have investigated the problem of power efficient resource management in a single web application environment with fixed SLAs (response time) and load balancing handled by the application. The main idea of the policy is to estimate the total CPU frequency required to provide the necessary response time, conclude the optimal number of physical nodes and set the proportional frequency to all the nodes.

Goudarzi [4] and Schwan have deliberate power management techniques in the perspective of virtualized data centers, which has not been done formerly The idea is to emulate hardware scaling by provided that less resource time for a VM using the Virtual Machine Monitor's (VMM) scheduling proficiency. The authors have suggested an architecture where the resource management is divided into local and global guidelines.

Buyya [5] have investigated the problem of power management for a data center environment by combining and coordinating five varied power management policies. The authors explored the problem in terms of control theory and applied a feedback control loop to organize the controllers' actions. This results in the suitability for enterprise environments, but not for Cloud computing providers, where more widespread support for SLAs is essential.

Patel [6] have defined the problem of power management in virtualized heterogeneous environments as a sequential optimization and addressed it using Limited Look ahead Control (LLC). The objective is to maximize the resource provider's profit by minimizing both power consumption and SLA violation.

Jayasinghe [7] have studied the problem of request scheduling for multi-tiered web-applications in virtualized heterogeneous systems to minimize energy consumption, while meeting performance requirements. The authors have examined the effect of presentation degradation due to high utilization of different resources when the workload is associated.

Proposed an approach for the problem of power-efficient allocation of VMs in virtualized heterogeneous computing environments by Huang [8]. They have leveraged the min, max and shares parameters of VMM, which represent minimum, maximum and proportion of the CPU allocated to VMs distribution the same resource.

Esfandiarpur [9] have formulated the problem of power-aware dynamic placement of applications in virtualized heterogeneous systems as continuous optimization: at each time frame the placement of VMs is optimized to minimize power consumption and maximize performance. The proposed algorithms, on the contrary to our approach, do not handle strict SLA requirements: SLAs can be violated due to variability of the workload.

Recently, a numeral of research works have been done on the thermal-efficient resource management in data centers. The studies have shown that the software-driven thermal management and temperature-aware workload placement bring additional energy savings. However, the problem of thermal management in the situation of virtualized data centers has not been investigated. Moreover, to the best of our knowledge.

Green cloud architecture

Architectural framework

Clouds aim to determination the design of the next generation data centers by architecting them as networks of virtual services (hardware, database, user-interface, application logic) so that operators can access and deploy applications from anywhere in the world on demand at competitive costs depending on their QoS requirements.

There are basically four main entities involved:

- Consumers/brokers: Cloud consumers or their brokers submit service requests from anywhere in the world to the Cloud. It is important to notice that there can be a difference between Cloud consumers and users of organized services. For instance, a consumer can be a company deploying a web-application, which presents varying workload according to the number of 'users' accessing it.
- Green service allocator: Acts as the border between the Cloud infrastructure and consumers. It requires the interaction of the following components to provision the energy-efficient resource management
- VMs: Multiple VMs can be dynamically started and stopped on a single physical machine according to incoming requests, hence providing the flexibility of organizing various partitions of resources on the same physical machine to different requirements of service requests.
- Physical machines: The underlying physical computing servers provide the hardware infrastructure for creating virtualized resources to meet service demands.

Algorithm: Load Migration

Input:hostList,vmList Output:allocationofVMs vmList.sortDecreasingUtilization() foreach vm in vmList do minPower←MAX allocatedHost←NULL foreach host in hostList do if host has enough resource for vm then power←estimatePower(host,vm) if power>minPower then allocatedHost←host minPower←power if allocatedHost=NULL then allocate vm to allocatedHost

return.

Power model

Power model is used to prevent the energy consumption rate during the allocation and migration of VMs in cloud computing environment. It is the precise amount of energy which is going to be utilized in order to allocation and migration of VMs. According to this model, the following types of energies are deliberated:

- Ea- This is the amount of energy that is required in allocation
- Em- This is the amount of energy that is required in the migration of VMs.

The energy or power consumed by nodes in the data server is primarily calculated by the CPU, memory, disk storage and network interface. As compared to other resources CPU consume more power and hence this work is mainly focused on to manage the power consumed by CPU. The CPU utilization is unswervingly proportional to the overall system load. Mathematically power model is defined below:

$(v) = n \times Pmax + (1 - n) \times Pmax \times v\ Pmax$ ………… 4.1.1

P_{max} - Signifies maximum power consumed in case of fully utilized server. n - Signifies the fraction of power consumed by idle server. v - Signifies the CPU utilization.

Energy-aware allocation of data center resources

Recent developments in virtualization have ensued in its proliferation across data centers. By supporting the movement of VMs between physical nodes, it enables dynamic migration of VMs according to the performance requirements.

Currently, resource allocation in a Cloud data center aims to provide high performance while meeting SLAs, without focusing on allocating VMs to minimize energy consumption. To explore both performance and energy efficiency, three crucial concerns must be addressed. All these issues necessitate effective consolidation policies that can minimize energy consumption without admitting the user-specified QoS requirements.

VM selection

The optimization of the current VM allocation is carried out in two steps: at the first step we select VMs that need to be migrated, at the second step the preferred VMs are placed on the hosts using the MBFD algorithm. To regulate when and which VMs should be migrated, we introduce three double-threshold VM selection policies. The basic idea is to set upper and lower utilization thresholds for hosts and keep the entire utilization of the CPU by all the VMs allocated to the host between these thresholds.

The aim is to preserve free resources in order to prevent SLA violations due to the consolidation in cases when the utilization by VMs increases. The difference between the old and new placements systems a set of VMs that have to be reallocated. The new placement is achieved using live migration of VMs. In the following sections we discuss the proposed VM selection policies.

The minimization of migrations policy

The Minimization of Migrations (MM) policy selects the minimum number of VMs needed to migrate from a host to lower the CPU utilization below the upper utilization threshold if the upper threshold is violated. Let V_j be a set of VMs currently allocated to the host *j*.

The pseudo-code for the MM algorithm for the over-utilization case is presented. The algorithm sorts the gradient of VMs in the decreasing order of the CPU utilization. Then, it repeatedly looks through the list of VMs and finds a VM that is the best to migrate from the host. The algorithm stops when the new utilization of the host is below the upper utilization threshold. The complexity of the algorithm is proportional to the product of the number of over utilized hosts and the number of VMs allocated to these hosts.

Performance analysis

In this section, we discuss a performance analysis of the energy-aware allocation heuristics presented. In our experiments, we calculate the time needed to achieve a live relocation of a VM as the size of its memory divided by the available network bandwidth. This is defensible as to enable live migration, the images and data of VMs must be kept on a Network Attached Storage (NAS); and therefore, copying the VM's storage is not compulsory. Live migration creates an extra CPU load; however, it has been shown that the performance upstairs is low.

Performance metrics

In order to associate the efficiency of the algorithms we use numerous metrics to appraise their performance. The first metric is the total energy consumption by the physical resources of a data center caused by the application assignments. The second performance metric is called the SLA violation percentage, or simply the SLA violations, which is defined as the percentage of SLA violation events relatively to the total number of the processed time frames. We define that an SLA violation arises when a given VM cannot get the quantity of Million Instructions per Second (MIPS) that are requested. This can happen in cases when VMs sharing the same multitude require a CPU performance that cannot be provided due to the consolidation.

Experiment setup

As the targeted system is a generic Cloud computing environment, i.e. IaaS, it is essential to estimate it on a large-scale virtualized data center infrastructure. However, it is extremely difficult to conduct repeatable large-scale experiments on a real infrastructure, which is required to evaluate and compare the proposed resource management algorithms. Therefore, to ensure the repeatability of experiments, simulations have been chosen as a way to appraise the performance of the proposed heuristics.

We have simulated a data center comprising 100 heterogeneous physical nodes. Each node is modeled to have one CPU core with the performance equivalent to 1000, 2000 or 3000 MIPS, 8 GB of RAM and 1 TB of storage. The users submit requests for provisioning of 290 heterogeneous VMs that fill the full capacity of the simulated data center.

Simulation results

For the benchmark experimental results we have recycled the Non Power-Aware (NPA) policy. This policy does not apply any power responsive optimizations and implies that all hosts run at 100% CPU utilization and consume maximum power all the time.

To evaluate the double-threshold policies it is necessary to determine the best values for the thresholds in terms of the energy consumption and QoS delivered. We have chosen the MM policy to deportment the analysis of the utilization thresholds. We have simulated the MM policy varying the absolute values of the lower and upper thresholds as well as the interval between them. First of all, it is important to determine which threshold has higher influence on the energy consumption.

The results showing the mean energy consumption achieved using the MM policy for different values of the lower utilization threshold and the interval between the thresholds are presented.

In summary, all the evaluated policies reason approximately the same energy consumption and average value of SLA violation.

The results shows that the dynamic reordering of VMs according to the current CPU utilization can bring higher energy savings in comparison to static resource allocation policies. According to the *T*-test, for the simulated situation the MM 50% - 90% policy leads to 0.48 kwh less energy consumption on average than ST 60% with approximately the same level of SLA violations with 95% CI. Moreover, the MM policy leads to more than 10 times less VM migrations than ST 60%.

According to our model, the service provider pays a penalty to the client in cases of SLA violations. The actual penalty amount depends on the contract terms negotiated between the provider and the client. Moreover, the performance requirements set as the SLAs for our experiments imply the 100% performance delivery. In a real world environment, the provider can define in the contract terms the allowed mean performance degradation of 1% - 5%, and thus avoiding the penalty if the performance degradation does not exceed the specified value.

We have composed the data on the numeral of times the hosts have been switched to the sleep mode caused by the proposed MM algorithm during the simulations. The distribution of the number of transitions obtained from 10 simulation runs is depicted.

The data show that the mean time before a host is switched to the sleep mode is 20.1s with 95% CI. In other words, for our experiment setup and the workload generated, on average a host switches to the sleep mode after approximately 20s of being active. This value is effective for real-world systems, as modern servers allow low-latency transitions to the sleep mode consuming low power. Meissner., *et al*. have shown that a typical blade server consuming 450W in the fully utilized state consumes approximately 10.4 W in the sleep mode, while the transition delay is 300 ms.

Experiments and Analysis

Tool used

For the implementation of above technique some hardware and software are required. With the help of these resources we will implement the research work.

Performance metrics

During the placement process of VMs, the Virtual machines are assigned to their respective host according to the resources (CPU utilization, Memory) as per MBFD algorithm. After that, VMs are migrated from over-utilized host towards under-utilized host; number of migrations would be less by using MM technique with kernel purpose. With the reduced number of migrations, energy consumption and SLA violation would be less. Following performance metrics would be used for the evaluation of the proposed work.

Hardware	Intel Core2Duo Processor 32-bit/64-bit CPU 100GB Hard Disk 1GB RAM
Software	NetBeans (IDE), Cloud Sim Libraries
Platform	Windows 7 or above
Language	Java

Table 1: Hardware/Software to be used.

Example 1

Let's consider two host machines and five virtual machines.

No. of Host	1	1	5	4
Memory Consumption	2 Hz	1 Hz	4 Hz	3 Hz

Table 2: Host memory power consumption.

Let us consider 2 host machine.

VM_Id	VM_power	CPU utilization	Memory req.
1	2	2.12Hz	5 Hz
2	3.1	3.14 Hz	4 Hz
3	2	2.15 Hz	3 Hz
4	1	3.12 Hz	2 Hz
5	5	1.16 Hz	1 Hz

Table 3: Virtual memory power consumption.

Sort VM's according to CPU Utilization, in the decreasing order.

CPU util.	3.14 Hz	3.12 Hz	2.15 Hz	2.12 Hz	1.16 Hz
VM's	2	4	3	1	5

Table 4: Virtual machine sorting.

Take every VM in the list

Here, I[st] VM would be VM no. 2

Min power = max;

Take max anything, say 50; Min power = 50;

Allocated host = Null; (No Host allocated)

For each host in the host list (there are 2 hosts)

Hosts Memory = 15

Memory> Vm Requirement

(15 > 4) where, 4 is VM requirement

Power consumption = (3.1 + 4) = 7.1

Where, 3.1 = VM_power

Now, if (Power < Min power)

Min power = 50;

Allocation Table:

VM_ID Host_Id VM_power 2 1 7.1

SLA violation

SLA stands for "Service Level Agreement". It is an assurance to service provider to the user. SLA can be known as violation e.g. if the job ought to be scheduled and it is nonscheduled.

$$SLA\,violation = \sum_{i=1}^{p} SLA_v \text{ (host, VM)} \quad \text{............ 1.1.2}$$

P= Total iterations.

Number of migration

VM Migration includes the Cost of RAM and Hard disk, so it is a costly operation. It also includes the CPU use, link bandwidth, downtime of services and total migration time, so our main aim is to reduce the number of Migrations.

$$Total\ number\ of\ migrations = \sum_{i=1}^{j} mig(h_{ost}, VM) \ \ldots\ldots\ldots\ldots\ldots\ldots 1.1.3$$

J= Total iterations

Energy consumption

$$Energy\ consumption = \sum_{VM_e} + \sum h_{ost_e} \ldots\ldots 1.1.4$$

VM_e – Signifies the energy of VM $host_e$.

It is defined as the total energy consumed by each server within the system. Mathematically it can be represented as

ost_e - Signifies the energy of host

Parameters explanation

After analysis, the results are evaluated based on some parameters. These parameters are explained below:

- Allocation Error rate AE = $t1 - t2\ td$

Where t1 is test weight and t2 is the new weight. td is the total test data.

Allocation Strength SSR = $t2\ AE$

- Where t2 is new weight and AE is encryption error rate.

Result and Analysis

During the placement process of VMs, the Virtual machines are allocated to their respective host according to the resources (CPU utilization, Memory) as per MBFD algorithm. After that, VMs are migrated from over-utilized host towards under-utilized host; number of migrations would be less by using MM technique. With the reduced number of migrations, energy consumption and SLA violation would be less. Number of migrations is calculated for the proposed work.

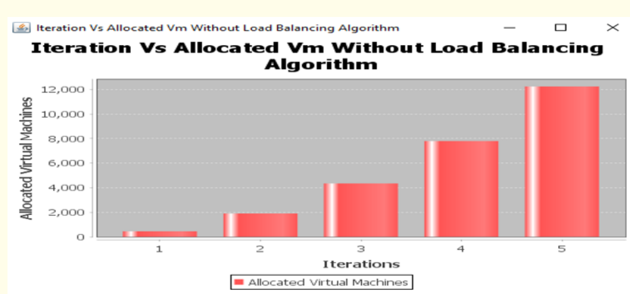


Figure 3: Iteration vs allocated Vm without load balancing.

The above figure represents the CPU utilization of VMs in case of CPU utilization Without Load balancing. The CPU utilization is created randomly in order to know the capacity of individual VMs.

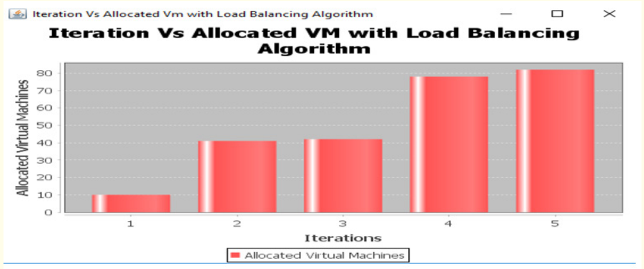
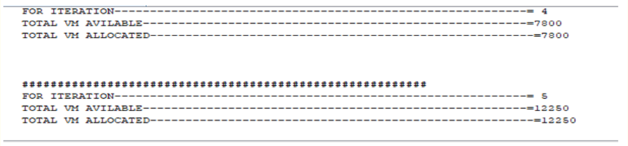


Figure 4: Iteration vs allocated Vm with load balancing.

The above figure represents the CPU utilization of VMs in case of CPU utilization with Load balancing. The CPU utilization is created randomly in order to know the capacity of individual VMs.



```
FOR ITERATION--------------------------------------------------------= 4
TOTAL VM AVILABLE----------------------------------------------------=7800
TOTAL VM ALLOCATED---------------------------------------------------=7800


##########################################################
FOR ITERATION--------------------------------------------------------= 5
TOTAL VM AVILABLE----------------------------------------------------=12250
TOTAL VM ALLOCATED---------------------------------------------------=12250
```

Figure 5: Iteration and allocating Vm.

Concluding Remarks and Future Directions

This work developments the Cloud computing field in two ways. First, it plays a significant role in the reduction of data center energy consumption expenses, and thus helps to develop a strong and competitive Cloud computing industry. Second, consumers are increasingly becoming conscious about the environment. A recent study shows that data centers represent a large and rapidly growing energy consumption sector of the economy and a significant source of CO_2 emissions. The experiment results have exposed that this approach leads to a substantial decrease of energy consumption in Cloud data centers in comparison to static resource allocation techniques. We are aiming at putting in a strong thrust on open challenges acknowledged in this paper in orderenhance the energy-efficient management of Cloud computing environments.

The research work is planned to be followed by the development of a software platform that supports the energy-efficient management and allocation of Cloud data center resources. In order to reduce the cost of software engineering, we will extensively reuse existing Cloud middleware and associated technologies.

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