International Journal of Engineering and Advanced Technology (IJEAT)
ISSN: 2249-8958 (Online), Volume-8 Issue-6, August, 2019

Efficient Resource Utilization Based on Energy Management in Cloud Data Center

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Abstract*: *Efficient resource utilization plays a vital role in cloud computing since the shared computational power of the resources is offered on demand. During dynamic resource allocation sometimes a server may be over utilized or underutilized thus leading to excess of energy consumption in the data centers. So the proposed system calculates the over utilization and underutilization of a CPU and RAM usage and also considers the network bandwidth usage to reduce power consumption in the cloud data center. Hence, a novel method is used for minimizing power consumption in the data center

Index Terms*: *CPU, network bandwidth, power consumption, RAM, resource utilization.

I. INTRODUCTION

The resource utilization is very important concept in cloud computing environment since workload keep changing dynamically in server. But it is not possible to provide additional servers manually when workload increases. The virtualization concept involves minimized infrastructural need. The virtual environment entails the creation of multiple Virtual Machines (VMs) on a unique physical node. The running of virtual machines minimizes the resource's idle time, thus preventing the resource from being under-utilized (Lei Yu et al. 2014).

The dynamic workload allocation is used to utilize minimum amount of resources for energy saving. Whenever the workload demand decreases, the underutilized servers are switched off (low power mode). The equal distribution of workload among nodes prevents over utilization and underutilization of nodes. This equal distribution is used to reduce energy consumption. Virtualization concept has been used in cloud data center in order to improve its energy efficiency. The virtual machine migration is used to transfer a VM across physical machines, has been considered as an important approach for achieve better energy efficiency of cloud data center. The virtual machine migration can be categorized into two types: regular migration and live migration. The regular migration moves a VM from one host to another by pausing the source, copying its content, and then resuming it on the destination. On the other hand the live migration does the same without pausing the source. It efficiently manages the workload allocation and improves the data center efficiency.

The VM migration helps to provide additional server when the workload increases. Virtual selection is used to select the VM for migration based on CPU utilization, RAM utilization and bandwidth usage. Virtual machine migration is moving the VM from one physical machine to another. It is used for server consolidation, load balancing, fault management, system maintenance and energy consumption. Also, resources are allocated efficiently to each VM to handle the workload dynamically. Each VM periodically checks the workload fluctuation according to the user requirement. Thus, Virtual Machine Migration accommodates the changing workloads automatically. Sometimes a server may become over utilized and during this time, it is difficult to determine which and how many VMs are to be chosen for migration to an appropriate server (Octavio Gutierrez et al. 2015). VM allocation is dependent on CPU usage, RAM usage and bandwidth usage. Each resource will update their utilization after completing a task. So the proper VM selection, VM migration and VM allocation techniques are important for energy management.

Revised Manuscript Received on October 30, 2019.

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II. STATE OF ART

The Virtual Machine Migration (VMM) is the process of relocating a VM to another physical machine without shutting down the VM in a single cloud data center or multiple data centers. Live VM migration is done for three reasons: workload balancing, resource allocation, and reducing power consumption. Live migration for load balancing is done on two types of VMs: under loaded VM and overloaded VM. An under loaded VM is that VM which is underutilizing its CPU capacity. All type of VMs is migrated to that host whose capacity is large enough to occupy them. Then the remaining node is switched off to save power. An overloaded VM is one which has already across its utilization capacity. Here, the live migration is done to move the workload from one VM to other VM for workload balancing (Richa Sinha et al. 2011).

In a cloud data center, CPU utilization levels are monitored continuously. If there is any variation in the utilization levels, dynamic load balancing is implemented. Migration takes place from an overloaded host to another host with time varying workloads in the virtualized cloud data centers (Octavio et al. 2015).

The dynamic VM allocation sometimes leads to variation in the CPU utilization levels. Moreover, the VM selection is very difficult for resource management. The more resource requirements affect the VMs allocation process in the data center. Generally, appropriate VM selection is needed to minimize the live migration effort (Mayank Mishra et al. 2012).

Also, energy efficient VM migration is used to decrease the power consumption. Power is rate of performing some work in a specific period of time. The reduction of power consumption reduces infrastructure provisioning cost (Jyothi Sekhar et al. 2012). The power consumption of a cloud data center depends on the utilization of the servers and their cooling systems. Generally, servers consume maximum power at their underutilization level.

DVFS (Dynamic Voltage Frequency Scaling) technique is reduced the power consumption in the cloud data center. DVFS uses combinations of different frequency and voltage to run the processors for minimizing the power consumption. This technique dynamically changes the frequency and voltage of the processors. The frequency value is adjusted for over load or under load processor according to the threshold value. This is an improved method to reduce the power consumption in the distributed cloud environment (Kritika Sharma &Raman Maini 2015).

The virtualized cloud datacenter consumes less energy when compared to a data center. Live migration in a virtualized data center manages the maximum resources with minimum energy consumption. A properly utilized node consumes less energy when compared to over utilized and underutilized nodes (Octavio Gutierrez et al. 2015).

A VM migration heuristic methodology is used to select the migrating VMs. The heuristic methodologies are of three types. The first type is the CPU based migration heuristic. The migrated VM selection is based on the Highest CPU Usage (HCPU) or Lowest CPU Usage (LCPU). The second type is Memory based migration heuristic. The migrated VM selection is based on the Highest Memory Usage (HMEM) or Lowest Memory Usage (LMEM). The last type is a combination based migration heuristic. The migrated VM selection is depends on both CPU and Memory usage. There are four combinations in this: HCPU-HMEM, HCPU-LMEM, LCPU-HMEM, and LCPU- LMEM (Octavio Gutierrez et al. 2015).

Memory based migration heuristic is further divided into two categories such as pre-copy migration and post-copy migration. The pre-copy approach consists of warm-up phase and stop-and-copy phase. In warm-up phase, the memory pages are copied from source to destination while the VM is still running on the source. Finally, copy all pages from the source to the destination. In stop and copy phase, it stop the VM and copied the remaining pages to the destination and VM will be resumed in the destination (Divya Kapil et al. 2012).

The problem in pre-copy approach is sending the same pages lot of times whenever pages are modified, which increases the total migration time and down time. So the upcoming level of pre-copy approach divides the pages into normal and high dirty page (modified page). This approach is based a threshold value. If a page is altered more than that of the threshold value, it is considered as high dirty page otherwise normal page. The high dirty pages are sent at the last iteration (Praveen Jain et al. 2016).

III. PROPOSED APPROACH

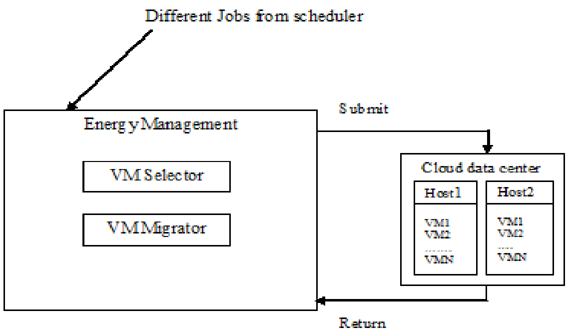

Figure1:Structure of Energy Management

Energy management is used to alter the VMs placement in the cloud data center dynamically and reduce the energy consumption correspondingly. This module consists of two components namely: VM Selector and VM Migrator. VM Selector is used to select the VM based on the Maximum Utilization (MU), Minimum Utilization (MinU) and Random Selection (RS) parameter values. The MU is determined depends on the maximum usage of CPU, RAM and bandwidth. The MinU is determined depends on the lowest usage of CPU, RAM and bandwidth. The Random Selection is used to randomly select a VM.

VM Migrator is used to perform VM migration based on the VM Selection being made. There is a possibility that few physical machines which consume less power and efficient VM provisioning for job management. Depends on the availability of these VMs, jobs are migrated from one VM to another using migration technique.

A.VM Selection

Virtualization is a significant procedure of distributed computing to run various working frameworks all the while on the equivalent physical machine. The VM selection is based on the following algorithm. Once a VM is chosen for migration, VM allocation is dependent on the CPU usage, RAM usage and bandwidth usage. Each resource will update their utilization details once a task is completed.

Algorithm for VM Selection

Step 1: Check if the VM is selecting a CPU based migration.
Select the VM with low CPU utilized node.
Step 2: Check if the VM is selecting a RAM based migration
Select the VM with low memory utilized node.
Step 3: Check if the VM is selecting a bandwidth based migration.
Select the VM with low bandwidth utilized node.
Step 4: Otherwise select a combined migration.
Step 5: Sort the CPU usage, RAM usage.
Step 6: Select the VM with low utilized CPU, RAM and bandwidth node.

The CPU-based relocation selects the VMs to be moved dependent on their CPU use. The source host can be designed to choose the VM with either the Highest CPU Usage (HCU) or the Lowest CPU Usage (LCU) for movement. By movement, the VM with the Highest CPU Usage; an over-burden host may rapidly decrease its load. Be that as it may, the goal host might be before long over-burden by facilitating a VM with generous registering necessities.

Then again, by relocation the VM with the Lowest CPU Usage; an over-burden host may require more VM movements to decrease its load. Be that as it may, increasingly potential goal hosts can be found and the VM may not be relocated again because of its low figuring necessities.

The memory-based movement heuristics chooses the VMs to be relocated dependent on their memory use. The source host can be arranged to choose the VM with either the Highest Memory Usage (HMU) or the Lowest Memory Usage (LMU) for relocation. The method of reasoning behind the memory-based relocation is like the basis of the CPU-based movement.

The consolidated movement chooses the VMs to be moved dependent on both memory and CPU use. There are four joined movement techniques: HCU-HMU, HCU-LMU, LCU-HMU, and LCU-LMU.

The HCU-LMU relocation strategy chooses the VM with the most elevated CPU use and the least memory use. This is dictated by arranging the VMs put in a host in the rising request as per their CPU utilization. At that point, a CPU weight of k is doled out to the VM in the k^{th} position of the arranged rundown. Thusly, the VM with the most noteworthy CPU use has the heaviest weight. While later, the VMs are arranged in diving request as indicated by their memory use and a memory weight of k is allotted to the VM in the k^{th} position of the arranged rundown. In doing as such, the VM with the most reduced memory utilization has the heaviest weight. At long last, the VM with the most astounding aggregate of CPU weight and memory weight is chosen for movement.

The HCU-HMU, LCU-HMU, and LCUPU-LMU migration methods are implemented similarly to the HCU-LMU migration method.

B.VM Migration

Virtual machine movement is a valuable device in server farms. VMs can be moved starting with one physical machine then onto the next for accomplishing burden adjusting and vitality productivity in cloud server farms. One of the approaches to quantify the effectiveness of a cloud server farm is to gauge the use rate. The Pre-copy technique is used for VM migration to migrate the workload to the target machine, and the VM may still execute at the host machine. The VM transfers all memory pages to the destination and then finally transfer the modified pages. After completing the VM migration, the source VM goes down and restarts the target machine.

VM Live relocation is the path toward moving a running virtual machine or application between two unmistakable hosts or physical machines without disengaging the source VM or application. Memory, Network and limit accessibility of the virtual machines are traded from the first visitor machine to the goal machine.

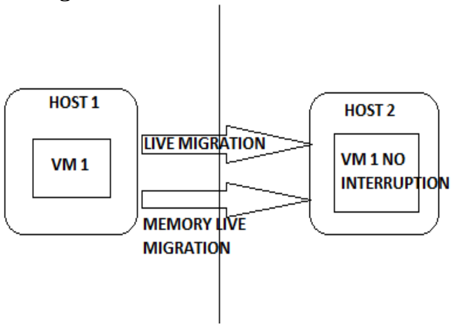

Figure 2: VM Migration

Utilizing virtual machine movement accomplishes:

- ✓ Load adjusting among the assets by appropriating by and large outstanding burden.
- ✓ Minimizes vitality utilization by improving asset usage of assets.
- ✓ Improves the accessibility of the assets and keeps away from disappointments. Utilizing a heap adjusting relocation method, can appropriate burden over the physical servers in a server farm. Dynamic outstanding burden in cloud server farm oversees by live relocation of VMs.

Algorithm for VM Migration

Input: sourceVM, destinationVM and migration bit
Output: VM Migration based max rate
Step 1: Select the sourceVM and destinationVM
Step 2: Set max_rate=0.8GHZ
Step 3: Assign VM1=sourceVM, VM2=destinationVM
Step 4: For all load in VM1
    Set the migration bit for VM1
  End for
Step 5: While transfer_rate<max_rate do Transfer load from VM1 to VM2
\End while

There are two states in the VM migration, i.e. overload, and under load. The overload state represents that PM CPU utilization is larger than the Threshold of CPU capacity. The under load state represents that PM CPU utilization is lesser than the Threshold of CPU capacity.

The conditions of VM are defined as

{Overload, if CPU_Ui,j > Threshold
Underload, if CPU_Ui,j < Threshold}

C.VM Allocation

Virtual machine (VM) allocation process involves the following points:

1. Identifying basic hosts: over-burden host and underutilized host.
2. Selecting VMs for movements: relocate VMs far from an over-burden host.
3. Reallocating those relocated VMs onto underutilized host(s).

IV. IMPLEMENTATION MODEL

The computing architecture model is planned with a merchant class that makes another cloudlets list from the cloudlets rundown presented by the clients, wherein the intermediary itself makes another cloudlets rundown and request the equivalent as indicated by the VM choice. At that point the cloudlet with the due date will be put on the facade of the rundown, and after that the cloudlets will be relegated to has from this new cloudlets rundown utilizing the coded sendNow() strategy which is in charge of allotting the cloudlets to has in the dealer usage on first started things out served arrangement which is given in the CloudSim programming.

The overloaded host migrates from one virtual machine to another virtual machine to save energy in the host. However, the selection of virtual machine mitigation relies on minimal temperature difference.

Tom Guerout et al. (2013) presented a dynamic voltage frequency scaling for energy management depends on CPU threshold. This model checks whether the CPU load is above or below threshold. If it is above threshold, increase the frequency. Otherwise decrease the frequency. The power model utilized at fixed recurrence is:

$$P = (1-\alpha)\ CPU_{idle} + CPU_{full} \quad (1)$$

where α is the CPU burden, CPU_{idle} and CPU_{full} are the power devoured by the CPU at 0% and 100% of use, individually. The power model used at various recurrence is represented in Equation (2)

$$P = \int (1-\alpha)\ CPUu \quad (2)$$

where α is the CPU load at different frequency, CPUu is the power consumed by the CPU utilization, respectively. CloudSim simulator is a framework to simulate and model application performance. The CPU picked can work in six recurrence levels. According to the architecture, execution time varies for different frequencies for different workloads. The frequency determines the execution time of the tasks in the queue.

A.General model based on CPU, RAM and bandwidth

The energy model of CPU is a simple linear regression, but the energy consumption of CPU is not linear based on its utilization. The CPU utilization is independent variable.

$$y_i = \beta_0 + \beta_1 x_1 + \beta_2 x_2 + \beta_3 x_3 + z_i \quad i = 1, \ldots, 3. \quad (3)$$

Where y_i is the observed energy consumption, x_1 is the CPU utilization, x_2 is the RAM utilization, x_3 is the bandwidth utilization, β_i (i=0,..3) is the coefficient of regression model, and z_i is the random error that cannot be observed.

V. RESULTS

The following steps are used for frequency selection.

Step 1: The working recurrence of a processor is chosen dependent on the real outstanding task at hand alongside the due date. There might be more than one recurrence that will finish the activity in a specific dead line. The model picks just the base recurrence.

The total energy consumed by the processor is the cumulative power consumption over the total execution time. The energy consumption is calculated by the following formula (Vikas Malik & Barde 2015).

$$E = \int_{t=0}^{n} p(t) \quad . \quad (4)$$

Here E is the vitality devoured, P is the power expended at time t and t ranges from 0 to add up to time of execution. The CPU execution is spoken to by methods for MIPS (Millions Instructions for each Second). For this situation E=27 KW.

Step 2: The next step involves checking whether the equivalent job can be allocated to more than one virtual machine so that the total energy consumed is minimum and the time of execution falls within the deadline.

If the condition is true, then 50 percentage of the job is migrated to another virtual machine and both the virtual machines would be executing the similar job.

The outcomes demonstrate that for various job sizes, there is a considerable amount of minimization in energy utilization. Simulations conducted with Job lengths from 100MB to 50,000MB show that the virtual machine model has decreased the energy consumption in the cloud data center. Using migration model, the proportionality between job length and energy consumed is considerably less and hence energy consumption reduces even more for task with higher dead line.

From Table 1 is to relate power consumption of different job length and the Figure 3 depicts the Power consumption of different job length.

Table 1: Power Consumption of different job length

Job Length(MB)	Energy(W)
Small(100MB)	6
Medium (5000MB)	16
Large(11000MB)	32

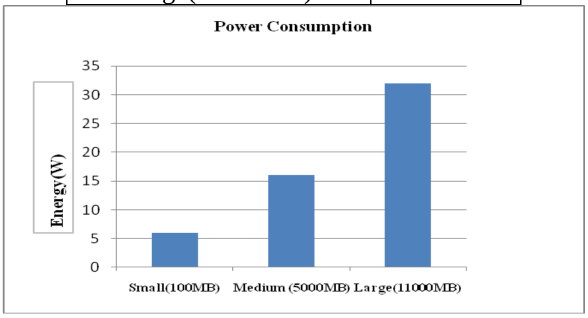

Figure 3: Power Consumption of different job length

Figure 4 shows the relationship between the various times such as average start, average finish, and start and finish time with respect to cloud ID. From the graph, it is understood that the slope is maintained at zero level upto 50 cloud ID and thereafter there is positive slope up to 90 and proceeds with a steep increase up to 3000 sec.

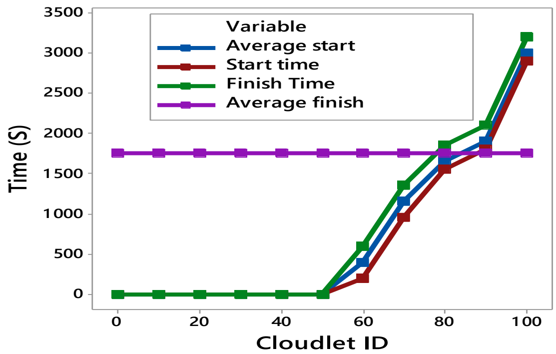

Figure 4: Execution Time of different jobs

VI. CONCLUSION

A competent resource management practice plays an imperative role in cloud computing. To achieve an efficient resource usage in cloud computing the proposed method varies the processor frequency based on energy model and, reduces the energy consumption in the data center based on the operating frequency of processor. Performance analyses of different scenarios are considered and from the result it concludes that different frequencies reduce energy consumption comparatively. Furthermore the performance can be increased by applying various migrations techniques according to the user requirements. In addition, the combination of methods in terms of CPU usage, memory usage and bandwidth usage can reduce more energy under different environmental job conditions. This can be further improvised by combining the concepts of both power-aware and energy-aware scheduling algorithms to minimize both energy and temperature and further improve VM image minimization to make the next generation cloud computing systems to be more efficient.

ACKNOWLEDGEMENT

I would like to thank my family, friends and colleagues, for their nonstop inspiration and support.

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