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Optimal Utilization based VM Consolidation Technique for Green Cloud Computing

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Abstract-The need of Cloud data centers for hosting pervasive and high performance computing applications is rapidly increasing and these results in increased energy consumptions and increased carbon footprints to the environment. Dynamic VM consolidation suggests switching of VMs on the least number of physical machines (PMs) using live VM migration, in accordance with the current resource usage and requirements. In this paper, we propose an optimal utilization based VM consolidation approach inside the data centers for Green Cloud Computing environments. Firstly, the need of VM consolidation is established then few such techniques are surveyed. Then the key steps of proposed approach and framework is presented. The performance evaluation of the proposed approach is done on CloudSim toolkit. The results demonstrate that the proposed approach also guarantee optimal energy consumption while maintaining QoS and SLAs.

Keywords-Green Cloud Computing; VM Consolidation; Quality of Service (QoS); Service Level Agreement (SLA); Energy Aware; Energy efficiency, Power Aware.

I. INTRODUCTION

Cloud Computing (CC) offers services for sharing resources, services and information among the people and organizations across the globe and such pervasive applications are hosted by large-scaledata centers.CC becomes a new paradigm for dynamic provisioning of various services [1].These data centres hosting cloud applications consume huge amounts of energy, leading to huge operational cost and greenhouse gas emission [2]. The potential reasons of high energy consumption are mentioned: 1.The amount of computing resources as per the application requirements. 2. The power inefficiencyof the hardware. 3. The inefficient use of resources. 4. The cooling systems. The energy costs would add 75% to the overall cost of operating a data center [3].To understand the cloud computing architecture and the level at which virtualization is applied. The live virtual machine (VM) migration dynamically consolidates VMs to the least number of physical nodes in accordance with the current resource requirements [4].The work is focused on studying the performance of dynamic VM consolidation policies for energy and performance efficiency, and employs optimal utilization metric to propose a new VM consolidation policy for Green Cloud data centers. The dynamic VM consolidation policies and frameworks involve a simple problem of determining the over-utilized and under-utilized host. Then the VMs are selected to migrate from these hosts to others, so that the idle hosts get turned off or switched to sleep mode to minimize the energy consumption without violating the SLAs.The existing solutions for dynamic consolidation have not fully considered the application heterogeneity of both workload and machine hardware found at cloud data centers. So, it becomes difficult for the traditional schemes to make a reliable, deterministic estimate of resource demands. In this work, Virtual machine consolidation in Green cloud data center has been studied in different aspects including the energy consumption and SLAs.The proposed work is compared with few other benchmark policies like Dynamic Voltage & Frequency Scaling (DVFS) for performance evaluation.

The rest of the paper is organized as follows: Section-2, represents the related works in this field of study (Literature Review).The existing mechanisms are also discussed in this section. Then, we present the key steps of proposed approach along with framework in Section-3.The performance metrics and effect of our approach by performance evaluation experiments is shown in Section 4. Finally we conclude our paper in Section 5.

II. RELATED WORK

With an huge growth of virtual computing environments such as Clouds the context has been shifted to data centers. The authors' in [5] propose an admission control and scheduling mechanism which maximize the resource utilization, profit and also ensure QoS requirements of users to met specified SLAs.

AnandMotwani et al. [6] investigated "SLA and Energy-Efficient Dynamic Virtual Machine (VM) Consolidation techniques" that meets Quality of Service expectations and Service Level Agreements (SLA) requirements. The analysis is based on various heuristics at hosts using real workload traces of more than one thousand VMs. A comparative analysis and results are also presented using CloudSim toolkit.

The authors [7] addressed architectural principles for energy-efficient management of Clouds; energy-efficient resource allocation and scheduling policies considering QoS expectations and power characteristics of the devices; The approach

is evaluated using the CloudSim toolkit showing high potential for the improvement of energy efficiency under dynamic workload scenarios.
Beloglazov and Buyya [8] have proposed a novel technique for dynamic consolidation of VMs based on accustomed (adaptive) utilization thresholds, which make surea high level of meeting the Energy Service Level Agreements Violation (SLAV) is less than 1%. It used workload traces from more than a thousand PlanetLab servers.

III. PROPOSED WORK

A. The System Model

The system model measured for experiment's objective fulfilment and for comparison purpose is an IaaS environment represented by a huge-scale data center consisting of M heterogeneous physical nodes as presented in [10,11, 12, 6] .The global manager resides on the master node has many responsibilities including (i) Consumer Profiling, (ii)Green Service Allocation: It includes negotiations with the consumers/brokers to finalize the SLAs between the provider and users depending on the consumer's QoS requirements and energy saving schemes.(iii) Collection of statistics from the local managers to maintain system's resource utilization. (iv)To issueVM migration commands to optimize the VM placement. (v) Accounting etc.

B. Proposed VM Consolidation Framework

In this work, optimal utilization thresholds are used when VM are selected for migration purpose. The design of proposed VM consolidation framework is shown in Figure 2. The proposed framework is different at VM selection technique is applied used. The name given to Overload and Under-load Detection Algorithm is "Adaptive Threshold" and the name specified to VM selection policy is "Optimal Utilization".

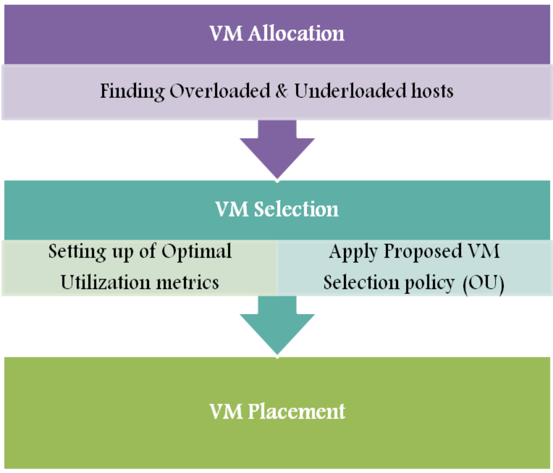

Figure 2: Proposed VM Consolidation Framework

C. Proposed "Optimal Utilization" VM Selection Policy

The "Optimal Utilization" VM selection policy selects the VM for migration on the basis of two metrics: one is "Minimum Utilization" and other is "Minimum Migration Time". It chooses the VM for migration that satisfies either of the conditions formalized in (3.1) and (3.2). The "Total Utilization Of Cpu" represents the utilization formed by all cloudlets running on this VM in MIPS while "Total Mips" presents VM capacity in MIPS.

$$\frac{\text{Total Utilization Of Cpu (Mips)}}{\text{Total Mips}} \quad (3.1)$$

$$\frac{\text{RAM utilized by VM}}{\text{Spare Network Bandwidth for host}} \leq \frac{\text{RAM currently utilized by VM}}{\text{Spare Network Bandwidth for host}} \quad (3.2)$$

IV. PERFORMANCE EVALUATION

A. Performance Metrics

The performance evaluation is done on following parameters

1) Total Energy Consumption: It denotes the total energy consumption by physical servers of a data center caused by application workloads. Energy consumption is calculated according to the power model and energy consumption model as described in [7, 8, 10], which describe the power consumption as a function of the CPU utilization P(u) as shown in equation (4.1) and total energy consumption by a server as defined in equation (4.2), where Pmax is the maximum power consumed; k is the fraction of power consumed by an idle server; and u is the CPU utilization.

$$P(u)=k.Pmax+(1-k)Pmax.u=Pmax.(0.7+0.3.u) \quad (4.1)$$

$$E = \int_t P(u(t))dt \quad (4.2)$$

2) Combined Energy and SLA Violation: The objective is to minimize the energy consumption while maintaining the level of SLA violation, so we used a combined metric as described in [9]:

ESV = E .(SLAV)

Where ESV is combined Energy and SLA Violation.

3) Number of VM Migrations: Live VM migration puts negative impact on performance of applications running in a VM. So it is one of the important metric for measuring performance of our policy and it should be less.

B. Simulation Setup

The simulation platform CloudSim 3.0.2 is chosen for experimentation purposes. It is a popular tool for large scale cloud simulations. The simulation has been performed by defining 800 hosts (physical servers) of two types and 898 VMs in a data center.The details of simulation parameters are shown in Table 1.The methods of VM Allocation (determination of over-utilized and under-utilized hosts), and VM selection policies (to migrate VMs), can be combined to form various strategies. Here we combined the following: (i) Static Threshold (Thr) + Minimum Utilization (Mu) called as [ThrMu] (ii) Median Absolute Deviation (Mad) + Minimum Utilization (Mu) called [MadMu]. We compared the policies mentioned above with “AdtOu”.

TABLE I GENERAL SIMULATION PARAMETERS

Simulation Variables	Value
No. of Hosts	800
Host Types and configurations	Type -1: 2 CPU cores, 1860 Million Instructions Per Second per core (MIPS/core), 4GB RAM, 1GB storage, 1Gbps Network Bandwidth.
	Type -2: 2 CPU cores, 2660 MIPS/core,4GB RAM, 1GB storage, 1Gbps Network Bandwidth
No. of VMs. (PlanetLab Workload)	898 (“2010306”)Each VM is randomly assigned a workload trace from real workload data.
VM Types	4 VM Types: each requires 1 CPU core with maximum of 2500, 2000, 1000, 500 MIPS respectively, and870, 1740, 1740, 613 RAM respectively, 100Mbps network bandwidth and 2.5 GB of storage.
VM Allocation	Adaptive Threshold (Adt), Static Threshold (Thr), Median Absolute Deviation (Mad)
Utilization measurement interval	900 seconds,
Simulation Time	86400 seconds

C. Result Analysis

Table 2, shows the comparisons between benchmark policy Dvfs, ThrMu, MadMu and proposed policyAdtOu. The Figure 3 through 5 shows visualization of performance comparisons in graphical form. The results shown are as per the performance metrics discussed in section IV.

TABLE 2 COMPARISON OF DVFS, THRMU, MADMU AND ADTOU.

Parameters	Dvfs	MadMu	ThrMu	Proposed AdtOu
Energy Consumption (kWh)	685.22	212.99	211.41	206.98
SLA	0	10.02	10.06	9.98
No. of VM migrations	0	2417	2310	2259

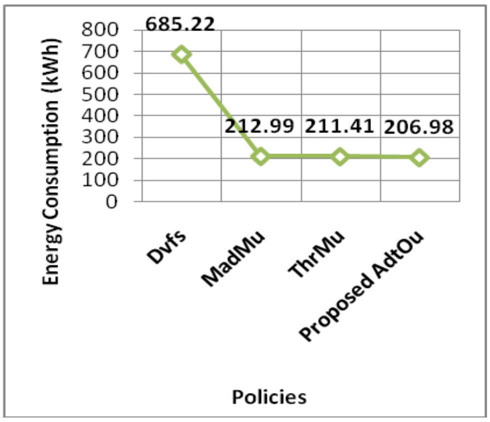

Figure 3: Comparison of Number of Energy Consumption (kWh)

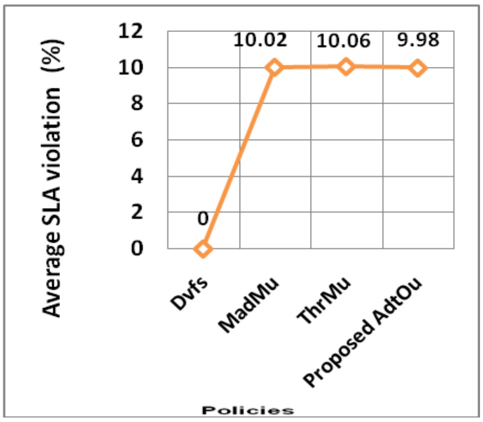

Figure 4: SLAV Comparison

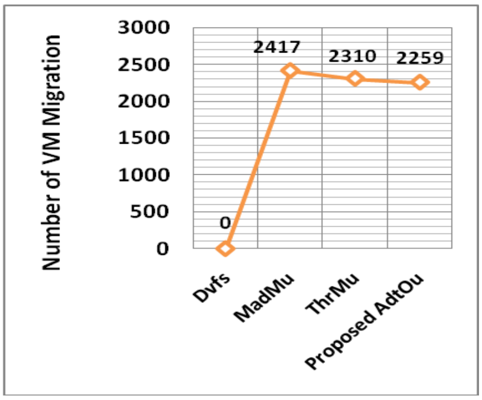

Figure 5: Comparison of Number of VM migrations

V. CONCLUSION AND FUTURE WORK

VM Consolidation techniques are of prime importance for resource allocation in a Cloud data center and also for optimal power consumption. This work mainly focused on green cloud computing and present: (a) survey on few VM consolidation techniques with (b) A proposed novel Optimal Utilization based Virtual Machine Consolidation Technique for Green Cloud Computing(c) comparison of proposed policy with existing policies. Our Proposed policy outperformed when compared with Dynamic voltage frequency scaling and several combinations of Static and Adaptive Threshold based policies i.e. host overload and under-load detection and 'Minimum Utilization' i.e. VM selection policies. Here we presented the comparisons with the following policies (i) ThrMu, (ii) MadMu. The proposed policy showed a substantial improvement from Energy efficiency; QoS; SLA assurance perspective. The proposed policies can be further combined with other energy efficient techniques and tested for performance. The proposed framework would be further implemented and tested with real cloud environment, having small number of hosts and VMs.

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