Energy-Aware Migration Of Virtual Machine In Cloud Computing

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Abstract- *Energy efficiency has grown into a latest exploration area of virtualized cloud computing paradigm. The increase in the number and the size of the cloud data centers has propagated the need for energy efficiency. An extensively practiced technology in cloud computing is live virtual machine migration and is thus focused in this work to save energy. This paper proposes an energy-aware virtual machine migration technique for cloud computing. The proposed technique migrates the maximally loaded virtual machine to the least loaded active node while maintaining the performance and energy efficiency of the data centers. The efficacy of the proposed technique is exhibited by comparing it with other techniques using the CloudSim simulator. An enhancement in the average energy consumption of about 44.39 % has been attained by reducing an average of 72.34 % of migrations and saving 34.36 % of hosts, thereby, making the data center more energy-aware.*

Keywords- Cloud computing, Energy awareness, Virtualization, Virtual Machine (VM) migration

I. INTRODUCTION

Cloud computing [1] characterizes a vital step in computing by offering shared computational power of the resources on demand [10]. Being grounded on the fundamental concept of virtualization [2], it has significantly transformed the manner of delivering the IT services with minimized infrastructural requirements. The virtual environment involves the creation of multiple VMs (or virtual servers) on a single physical node. In actual context, the multiple operating systems (OSs) can run on a single OS underlying the same hardware platform. The running of virtual servers minimizes the resource idle time, thus preventing the resource under-utilization [16, 17]. Additionally, the reduction in the amount of required hardware lowers the power needed for operation which consequently cuts down the energy demand. The diminution in the energy demand by the ICT (Information and Communication Technology) sector is highly appreciated in the current scenario of rising energy crisis. Energy efficiency [3] has thus gained prominence in the ICT data centers that host massive servers resulting in the induced upsurge of energy consumption levels [13].

The emergence of cloud computing and the virtualization support offered by it, has further corroborated the efforts for realizing energy efficient computing. It has been observed that the virtualized cloud data centers require lesser energy as compared to the non-virtualized ICT data centers. The composed distribution of the workload among the nodes prevents node over-utilization that would have otherwise occurred. The optimally utilized nodes consume less energy as compared to the nodes that are over-utilized or under-utilized [18]. The under-utilization of a node indicates that the node is sitting idle while the over-utilization of a node means it is running tasks beyond its capability. The concept of dynamically and transparently migrating the VMs from one host to the other, to find the best target host is known as Live migration [11]. Apart from this, the key benefit of VM migration is the identification of hotspots in the data centers [12]. The over-utilized nodes are the hot-spots and their identification helps to lower the energy consumption by migrating their load to the less utilized nodes, leading to green cloud data centers.

The contribution of our work is as follows:

- An energy-aware meta-heuristic technique that performs live migration of the VMs from one active node to the other active node.
- Our approach makes use of a bio-inspired Firefly optimization technique to achieve energy efficiency in cloud data centers.
- The energy-efficiency has been maximized through the optimum migration of VMs, thereby improving the resource utilization levels.
- This approach also sustains scalability to the large number of heterogeneous cloud nodes.
- The achievability of the proposed technique has been shown by executing it in the CloudSim simulator.
- The efficacy of the proposed technique is exhibited by comparing it with other techniques. An enhancement in the average energy consumption of about 44.39 % has been attained by reducing an average of 72.34 % of migrations and saving 34.36 % of hosts.

II. RELATED WORK

A lot of research is being conducted in the area of cloud computing to reduce the power consumption in the data centers as surveyed. Many different techniques to overcome the power wastage have been proposed and devised with and without VMmigration. Live VMmigration is being vigorously investigated since long and numerous techniques have been developed to migrate a running VM from one active node to the other active node. It has been observed to be an influential technique for efficiently managing the data center energy. Most of the prevailing VM migration methodologies for energy management in cloud data centers are not straight forward, as primarily they involve VM consolidation or VM placement approaches at the higher level of implementation.
This section briefly discusses such techniques. Feller et al. [30] have put forward a scalable and autonomic VMs management framework that uses a centralized ACO-based VM consolidation algorithm to locally consolidate the VMs. Tarighi et al. [24] have offered a fuzzy decision making based VM migration scheduling algorithm, that discovers the maximally loaded servers and takes a migration decision by using TOPSIS (Technique for Order Preference by Similarity to Ideal Solution) approach. Wood et al. [25, 26] have suggested two gray-box and blackbox approaches for virtualized cluster to diminish the hotspots by monitoring and detecting hotspots and then allowing the live migration of VMs. Marzolla et al. [32] have projected a VM consolidation protocol based on a coarse-grained gossip that apply local VM consolidation by migrating the VMs from the smallest laden node to the greatest laden node. All the above mentioned techniques have considered VM migration in one or the other way, but there is no reflection of energy savings. Thereby, these techniques differ from our proposed approach, which principally aims to achieve energy savings with the help of VM migration in the cloud data centers.

Nathuji et al. [45] have designed architecture for the management of the energy in the virtualized data centers by using VM live migration to consolidate multiple VMs on a single server. Tolia et al. [29] have practiced a short-term VM migration for consolidating workloads and to put the under-utilized servers in the sleep mode. Lim et al. [27] have presented a way of consolidating VMs onto a lesser number of hosts by dynamically migrating virtual machines to save energy in a virtualized environment. A multiobjective profit-oriented algorithm to place VMs has been proposed by Goiri et al. [38]. Performance in terms of SLA violations, energy efficiency and overheads of virtualization has been considered in this algorithm. Ghribi et al. [13] have offered a combination of an exact VM allocation algorithm and an exact VM migration algorithm for reducing the number of nodes and hence to save energy in cloud data centers.

Verma et al. [28, 34] have proposed a framework that examines the VM placement algorithms by considering the energy and the migration costs as well as the performance benefit in a virtualized sever cluster, to maximize performance and to minimize energy consumption. Mehta and Neogi [40] have presented a ReCon tool to dynamically consolidate servers in data centers. The VMs are mapped to the servers by considering the static and the dynamic costs of physical servers, the cost of VM migration, and the resource consumption data from the history. The work cited in [13, 27–29, 34, 38, 40, 45], does not consider energy consumption done by memory unlike our FFO-EVMM technique which in addition to the CPU energy consumption offers energy optimization at the memory level as well. In other words, it tries to handle the impact of time-space parameters in terms of the consumed energy.

An approach for VM consolidation has been offered by Cardosa et al. [37] that agree to the highest and lowest resource requirements of the VMs to achieve energy-efficiency. Resource utilization is improved and energy consumption is reduced by consolidating several VMs onto a single server. Effectual energy-aware heuristics to allocate VMs dynamically have been advocated by Beloglazov et al. [17, 35, 36].

These heuristics practice live migration of VMs to minimize energy consumption by reducing the number of used nodes and without having required the knowledge of VMs applications [44, 61]. A solution for VM placement and consolidation that is grounded on Bernoulli trials has been proposed by Mastroianni et al. [31] by considering energy and migration cost.

Vu et al. [43] have projected a VM placement algorithm that enhances the performance of communication by decreasing the overall cost of the virtual machine traffic and saves energy by increasing the utilization of the CPUs. Sekhar et al. [46] have designed an energy efficient VM live migration technique based on greedy heuristics to curtail the consumed energy in cloud data centers. Jung et al. [50] have established a framework to optimize the energy consumption by using the live VM migration for consolidating virtual servers and by switching-off the idle servers in cloud data centers.

Bila et al. [49] have offered a technique that partially migrates the VMs that are idle and are running on the desktops of the users to a consolidation server to reduce overall consumed energy. Graubner et al. [39] have extended the Eucalyptus cloud management framework to incorporate the support for live migration and consolidation. Xiaoli et al. [42] have presented an energy-aware VM placement algorithm for making cloud data centers more energy-efficient by increasing resource utilization. The resource utilization as well as the energy cost in migrations have been considered in their approach. Unlike our technique, none of the techniques listed in this paragraph, deals with CPU and memory utilization for lowering the energy consumption. Also, they attempt to diminish the consumed energy without considering the hosts and the VM migrations whereas FFO-EVMM cuts down the used energy accomplished by saving the number of nodes and by lowering the number of migrations.

The technique mentioned in [33] mainly targets the reduction in the number of active nodes and the number of VM migrations to cut down the consumed energy in the overall data center. The FFO-EVMM also minimizes the number of nodes and VM migrations but it individually computes the energy consumption of VM and node thereby keeping a track of the energy consumption of each and every VM and node in the cloud data center. The purpose behind computing the individual node and VM energy is to analyze the workload handling capacity of the node. The workload handling capacity of the node can be considered as the capability of a node to process the types of workloads while keeping the energy consumption under a set threshold. Our preexisting work for the FFO-EVMM technique is the resource utilization technique described in [6] deals with two different types of workloads- CPU-intensive and memory-intensive. It is important to carefully consolidate variable workloads in order to avoid contention of resources. The contention among resources can cause performance degradation and hence energy wastage. The FFO-EVMM also provides workload scalability such that a large number of workloads can be processed without violating the energy constraints. The authors in [35] advocate different energy aware heuristics for dynamically allocating VMs in accordance with the current resource utilization. The live migration of VMs is practiced to set aside the free resources that are then switched to the sleep mode, hence cutting down the energy consumption done by them when in idle mode. The main focus for preserving the free resources is to lower the SLA violations and to improve the energy-efficiency of the data center. These heuristics run on varied underlying infrastructure and assorted VMs while maintaining the SLA constraints imposed by the users. They have primarily attempted to optimize the energy consumption done by the processor while missing out the energy consumption done by the memory. The memory is one of the most vital elements of emphasis in the power and energy usage optimization in the current scenario. Based on the investigation of the existing works, it can be inferred that most of the techniques have focused on energy management largely through VM consolidation and VM placement. Likewise, the proposed technique focuses majorly on the improvement in the performance and energy consumption levels through VM migration. Additionally, our technique is based on the bio-inspired FFO technique. With the rising diversity and complexity of large-scale distributed computing services, there is a necessity to design more scalable, heterogeneous and sustainable computing techniques that can conjointly deal with the other issues such as heterogeneity and growing energy crisis as well. Thus, apart from the underlying infrastructure support available through cloud computing in this case), it is important to explore and adopt new paradigms.

Currently, many researchers are focusing and implementing the biologically inspired computing as a preferable paradigm to handle these issues with proficiency and without the augmented complication. In spite of the several inherent challenges encountered while surviving in an enormous, dynamic, incredibly diverse, and highly complex environment, the biological organisms evolve, self-organize, self-repair, navigate, and flourish. This is possible with their local knowledge and without any centralized control. This prompted the research community to discover and learn lessons from the biological systems such as Ant Colony Optimization (ACO) [20, 22], Artificial Bee Colony (ABC) [21], Bacterial Foraging Optimization (BFO) [62], Particle swarm optimization (PSO) [4] techniques.

Firefly Optimization (FFO) Algorithm

The Firefly Optimization (FFO) algorithm has been designed by Xin-She Yang in the late 2007 and 2008 at Cambridge University [4, 5, 7]. It is centred on the flashing features of fireflies and uses the subsequent three idealized procedures: (1) One firefly is attracted to the other fireflies irrespective of their sex as all fireflies are unisex, (2) The attractiveness is proportionate to the brightness, thus they both decrease as their distance increases and for any two flashing fireflies, the less brighter one will travel near the brighter one. If no firefly is brighter than a specific firefly, it moves arbitrarily and (3). The brightness of a firefly is regulated by the landscape of the objective function to be optimized.

Proposed FireFly Optimization—Energy-Aware Virtual Machine Migration (FFO-EVMM) Technique

The prior work related to the scheduling aspect of the proposed technique has already been done and is available in our previously published work [6]. The previous work proposed an energy-aware resource utilization model which is shown in Fig. 1.

The model facilitates the energy-aware scheduling decisions by properly and efficiently managing the cloud resources. It further uses an Artificial Bee

Colony (ABC) based energy-aware resource utilization technique to provide the required resources to the users' applications in a way to improve the resource utilization levels and to diminish the energy consumption in the cloud data centers without degrading the performance. The energy saving is also done by keeping the idle nodes in a sleep mode. Also, the energy-aware decisions are based on the past resource utilization and energy consumption data. Therefore, it can be said that the model enhances the utility levels of the server resources, reduces the energy consumption and hence the heat dissipation in the cloud data centers, thus contributing directly to the green computing. Its problem formulation, energy model, mathematical explication and the detailed working are given in our previously published work [6].

The present work proposes an energy-aware virtual machine migration technique for cloud computing that is based on the flashing behavior of fireflies. This technique tries to migrate the most loaded VM from an active node which satisfies a minimum criteria for energy consumption, to another active node that consumes the least energy. It consists of four main parts,

A) Selection of source node,
B) Selection of VMs,
C) Selection of destination node and
D) Distance updated values.

III. CONCLUSION AND FUTURE WORK

Currently, many researchers are focusing and implementing the biologically inspired computing as a preferable paradigm to handle heterogeneity and growing energy crisis with proficiency and without the augmented complication. Likewise, for our work, we have chosen biological behaviour of firefly insects and have devised FFO-based migration technique. The criteria for choosing it are its faster convergence speed and global optimization attainment. Furthermore, it exploits the concept of curtailing the overall upsurge in the incremental power due to the new VM migrations and has never been used previously for VM migration approach. In the scenario of energy consumption by VM migration, a linear model based on

FFO is formulated that runs an FFO algorithm which is able to solve the energy consumption issue with the attraction property of fireflies. The capability of fireflies to get attracted towards the brighter fireflies is the basis for considering the FFO.

The proposed approach can be used as an effective solution for VM Migrations in cloud environment where a large number of nodes are available with the energy restrictions. Improvement in the results with respect to the existing approaches—ACO & FFD, proves the efficacy of the proposed algorithms with higher scalability and lower number of host usage. The proposed technique is better in achieving the energy efficiency as compared to the other techniques as it saves an average of 44.39 % of energy by saving an average of 34.36 % of hosts and by reducing an average of 72.34 % of migrations. Thus, this technique reduces the energy consumption of cloud data centers by saving the nodes and the number of migrations, thereby contributing towards the green computing. Future work is targeted to study the robustness of FFO-EVMM technique and further expand its performance by verifying it in an existent cloud computing environment like Aneka [55] or some private, public or hybrid cloud. Besides, this technique will additionally be used to design an energy-aware load balancing technique for cloud computing. That load balancing technique will experimentally be investigated for performance and efficiency using a real environment.

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