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Energy Management Techniques for Cloud Based Environment

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ABSTRACT

Cloud Computing has the facility to transform a large part of information technology into services in which computer resources are virtualized and made available as a utility service. From here comes the importance of scheduling virtual resources to get the maximum utilization of physical resources. The growth in server's power consumption is increased continuously; and many researchers proposed, if this pattern repeats continuously, then the power consumption cost of a server over its lifespan would be higher than its hardware prices. The power consumption troubles more for clusters, grids, and clouds, which encompass numerous thousand heterogeneous servers. Continuous efforts have been done to reduce the electricity consumption of these massive-scale infrastructures. To identify the challenges and required future enhancements in the field of efficient energy consumption in Cloud Computing, it is necessary to synthesize and categorize the research and development done so far. In this paper, the authors prepare taxonomy of huge energy consumption problems and its related solutions. The authors cover all aspects of energy consumption by Cloud Datacenters and analyze many more research papers to find out the better solution for efficient energy consumption. Keywords: Cloud computing, Collocated virtual machines, Live migration, Load balancing, Resource scheduling

Keywords : Energy-efficiency, Virtualization; DVFS, VM Consolidation, VM-Migration Cloud Datacenters, VM-Allocation

I. INTRODUCTION

In the fast growing global business environment, maintaining rapid application development in the information technology sector has been cumbersome. Expediting the software deployment strategies by reducing the time and effort requires the application of a recent trend called Cloud computing. Cloud computing is everywhere, in the simplest terms it can be defined as storing and accessing data and programs over the Internet instead of your computer's hard-drive. Cloud is just a metaphor of the Internet. All the applications in cloud computing are provided as services each time and every time it is demanded. Thus the services including application storage, network, server and other services can be utilized effectively and efficiently. This results in enormous savings with respect to time and cost.

Most of the quality of services parameters including execution time, cost, scalability, reliability, energy and load balancing have been achieved to a remarkably satisfying level with the help of cloud computing. In cloud computing, customer may be provided with numerous virtualized resources to utilize; it is not possible for anyone to allocate the jobs manually. Hence, to allocate the resources to the virtual machine layer, the load balancing algorithm becomes essential. In cloud systems, all hardware infrastructure elements are virtualized into virtual entities to deliver Infrastructure as a Service (IaaS) cloud model. Cloud operating system (OS), networking, and storage systems are also virtualized to deliver Platform as a Service (PaaS) cloud model. In addition, software programs, applications, and different OSs are implemented in a cloud to deliver Software as a Service (SaaS) cloud model [1]. Virtualization is considered the main enabling technology of cloud computing.

It is a technique that allows running different OSs simultaneously on one physical machine (PM). These OSs are isolated from each other and from the underlying physical infrastructure by means of a special middleware abstraction called virtual machine (VM) as shown in Fig. 1. The piece of software that is responsible for creating, running, and managing these multiple VMs on PM or a pool of PMs is called hypervisor or VM kernel (VMkernel). It provides a mechanism for mapping VMs to physical resources transparently from the cloud users. So, VMkernel can be considered as a scheduler that manages VM access to the physical resources.

Scheduling the allocation of the physical and virtual resources is considered the most important challenge in virtual and cloud systems. Resource allocation process has two major levels: the physical resource allocation in the infrastructure level and the virtual resource allocation in the task or application level [2, 3]. The resource allocation in infrastructure level mainly depends on VM placement whether for the first startup time of the system or by changing its place according to the available physical resources during the system running [4]. In the first startup time for the system, the VM is placed on a selected PM and gets its required resources from the PM's physical resources. In the second case, while there is a need to change the placement of VM from one PM to another, migration techniques are needed.

Rest sections of the paper are as follows. In section II, related works have been discussed. Section III gives taxonomy of various energy efficient techniques and discussion on these techniques is mentioned in section IV. Section V concludes the paper.

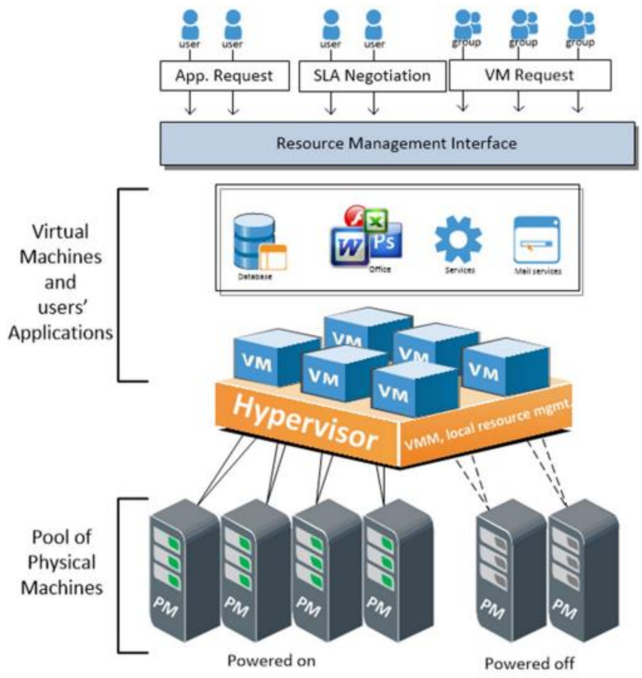

Fig. 1 Virtualization architecture

II. RELATED WORK

Cloud computing has changed the IT industry by providing an elastic on-demand allocation of computational resources comprising processors, storage & networks which is accompanied by creation, modification, and enhancement of large-scale systems consisting of cluster, grids and Cloud datacenters. This system leads to a lot of energy consumption and significant Co2emissions. Due to the increased quantity of computational resources, the energy bills come as the second largest items in the budgets of Cloud service providers. Many researchers have been worked to enhance the effective energy utilization in Cloud datacenters and proposed many algorithms related to virtual machine migration, consolidation, and VM allocation. Various task scheduling parameters in Cloud Computing have been discussed in [8] [9], energy-efficiency is more concern parameter of today's research community. In [10], the author gives an absolute review of currently alive techniques for energy regulation and reliability. To improve the availability for the cloud services, energy-aware resource provisioning strategy is identified simultaneously minimizing its energy consumption. Several challenges and research gaps for future research and developments for a trade-off between energy regulation and reliability are also identified. Another review paper [11] summed up with a few existing energy scheduling algorithms taken up in a cloud environment also the energy saving percentage in present energy-efficient scheduling algorithms. The results reveal the best energy saving proportion level can be attained by using DVFS and DNS both. In [12], the author discussed the double role of Cloud Computing as a huge power consumer and as an energy saving method with compare to traditional computing systems. This paper gives a comprehensive and relative study of several energy efficient methods in Cloud Computing. The power consumption of ICT equipment is discussed in [13]. The authors give a classification of power and system performance based efficient methods for grid, cluster and Cloud datacenters. This survey is different from other surveys because it discussed both aspects of power consumption and system performance of ICT equipment. In this paper, the author also presents a taxonomy of energy-efficient techniques and discussed various methods, concerning energy efficiency and other related parameters of Cloud Computing.

III. TAXONOMY OF ENERGY-EFFICIENT TECHNIQUES

Energy conscious scheduling such as DVFS, energy efficient load balancing, virtualization, resource consolidation, and migration are mostly reviewed for knowledge and practical implementations. Many researchers worked for efficient power consumption in Cloud Computing. In this paper author categories, these techniques in different ways and describes the method, improvements, and limitation of these techniques. Fig. 1 presents the taxonomy of various energy efficient techniques. The author further discusses all these techniques one by one and gives a detailed description and study of these algorithms in table-1.

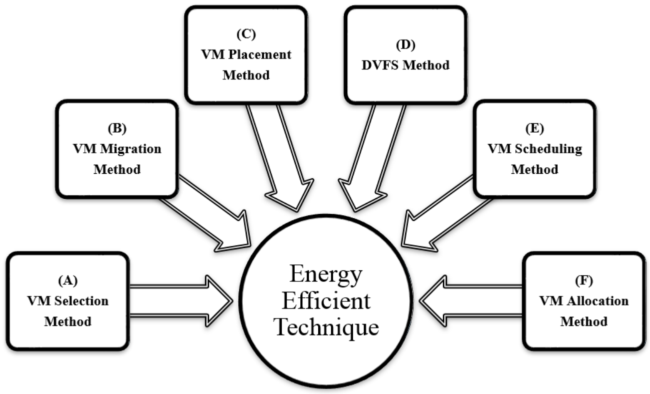

Fig. 2. Taxonomy of Energy-Efficient techniques for Cloud Computing

A) Virtual Machine (VM) Selection Methods

Random VM selection: A uniform distributed discrete random variable is used to select the virtual machine from the overloaded server for migration [14]. Minimum migration time: Migration time of the virtual machine is considered as the ratio of the quantity of RAM utilization of virtual machine to the server's bandwidth that hosted virtual machine. In this method of VM selection for migration, a VM having minimum migration time is select for migration in comparison to other VMs [15] [16]. Minimum utilization: Physical resource utilization by the virtual machine is considered as the ratio of the volume of resource utilized by the virtual machine due to user's tasks allocated to that VM and total MIPS allocated to that VM. And in this method [15] a VM which has minimum utilization has to be select for migration. Least VM in CPU utilization first: In this method of VM selection [17], a VM which has share least CPU time with other virtual machines (VMs) allocated to the same server has been selected for migration. Maximum correlation: Multiple correlation coefficients [18] are used to calculate the correlation among the virtual machines hosted on the same server.

B) Virtual Machine (VM) Placement Methods

For developing Cloud datacenters, energy consumption is the main concern. Several methods and techniques have been proposed to reduce energy consumption, but these techniques are mainly having more VM migration and less resource utilization. In [20], the authors proposed a VM placement technique based on a heuristic greedy algorithm. In this algorithm, the author develops a VM deployment and live migration model to improve resource utilization and decrease power consumption. The heuristic algorithm predicts the workload and mapped CPU-intensive workload and memory-intensive workload to the same physical server to reduce energy usage by the different servers and balancing the workload. In [21], the author developed a statistical mathematical framework for VM placement, which integrates complete virtualization expenses in the dynamic migration process. The proposed dynamic virtual machine placement method enables VM request scheduling and lives migration to reduce the active server participation so as to reduce the power consumptions in Cloud datacenters. The author proposed a VM allocation method [22], based on minimum virtual machine migration. Three strategies named fixed double threshold, double resource threshold and dynamic double threshold are developed. Each strategy is used in both phases. In the first phase, VM selection is made and selected VM is placed on a physical datacenter in the second phase. The result shows that these lower and upper bound resource utilization threshold policies are better than the single threshold technique. These methods determine less power consumption, a smaller number of SLA violations and a minimum number of VM migrations. The main concern of Cloud service provider is to answer two questions, where to place VMs initially and where to transfer VMs, when VM-movements are required. VM migration is helpful to reduce datacenter overloading and reduce active servers' involvement for effective resource utilization and power saving. It is important to detect overloaded servers efficiently for better performance and minimum service cost of Cloud system. In [23], a logistic regression and median absolute derivation methods are used to propose a general detection algorithm for the overloaded server. Any VM placement and migration algorithms can detect overloaded server with this detection algorithm.

C) Virtual Machine (VM) Migration Methods

An energy consumption model is proposed in [25], which is based on the statistical method and can estimate the VM power consumption with the error rate of 3%-6%. In this method, a workload threshold is set for each server, and if a server exceeds its workload threshold then the VM will be migrated from that overloaded server to another server to reduce the energy consumption by the overloaded server. This method can achieve an effective reduction in power consumption without violating the QoS. A linear integer programming model and bin packaging model are used in [26], to develop two exact algorithms for VMs placement and consolidation for reducing power consumption and VM migration cost and compared with the heuristic based best-fit algorithm. The results show that the combination of these two algorithms contributes to a significant reduction in power consumption.

In [22], the authors have proposed three policies for VM placement and migration. When the number of VM placement increased o server then due to overload the VM migration is required. Which server has to be select for VM migration is dependent on these policies named FDT, DRT, and DDT. These are three different methods for selection of the server for migration according to the threshold set by these policies.

D) DVFS-Aware Consolidation Methods

More than 43 million ton of Co2emission per year and about 2% of the world's power production has been consumed by the Cloud datacenters. In [27], the author proposed two methods, one for efficient power consumption based on DVFS technique and second for VM consolidation. The first method is used to determine performance degradation with power consumption and gives a DVFS-aware workload management which saves energy up to 39.14% for dynamic workload situations. The second VM consolidation method is also determined dynamic frequency while allocating workload to achieve QoS. There are different types of physical machines are available in Cloud datacenters. This machine heterogeneity consumes more energy when workloads have been scheduled on them. A job consolidation algorithm with DVFS technique is proposed in [28], for efficient resource utilization in hetero-genetic Cloud Physical machines. The proposed algorithm will replace jobs efficiently to reduce energy consumption.

E) Virtual Machine (VM) Scheduling Methods

The author proposed an online scheduling algorithm for IaaS Cloud model for reduction in energy consumption [29]. The algorithm works for heterogeneous machines and different workload scenario to achieve a better quality of service. One way to reduce energy consumption in Cloud datacenters is to shut down physical servers which are idle. In [30], an energy-aware virtual machine scheduling algorithm has been proposed named as dynamic round robin algorithm. The results showed that the algorithm saves 43.7% energy and 60% of physical machine usage compared with other scheduling algorithms. The authors suggest a model [31] for energy consumption estimation, which considered the running tasks created by virtual machine for estimation of each VM's power consumption. The suggested model also schedules the VMs to confirm the energy cost of each VM. Most of the energy efficient methods use VM migration technique but in [32], the author proposed an energy-aware virtual machine scheduling algorithm EMinTRE-LFT, which is based on the concept i.e., decrease in power consumption is directly equivalent to minimization in the completion time of all physical servers. The author used OpenStack Nova scheduler for simulation and compares it with other algorithms. The Cloud scheduling algorithms face many challenges due to the dynamic and unpredictable nature of Cloud user's request. In [33], the author proposed an algorithm which does not require any prior knowledge of user's request. The author conducted a mathematical analysis to find the balance between energy consumption and system performance. A real-time dynamic scheduling algorithm is proposed in [34], which schedule distributed application in a distributed system to reduce the power consumption. The proposed algorithm uses heuristics and resource allocation techniques to get the optimal solution. It minimizes the power consumption and task execution time with order dependent setup between tasks for VM and power setup for different Cloud designs.

F) Virtual Machine (VM) Allocation Methods

The authors proposed an interior search based virtual machine allocation algorithm for efficient energy consumption and proper resource utilization in [35]. The model and simulation of the proposed algorithm are tested on CloudSim and compared the amount of energy consumption with the Genetic Algorithm (GA) and Best-fit Decreasing (BFD) algorithm. Cloud provider allocates VMs to the customer's application according to their demand, and these VMs are assigned to the physical machines. Many resource allocation methods use VMs resource utilization history for efficient resource allocation. In paper [36], the author proposed a QoS-aware virtual machine allocation method based on resource utilization history to improve the level of quality of services and reduce energy consumption. Cloud datacenters provide services to Cloud applications which consume a huge amount of energy and produce carbon emission. To overcome from this issue, the author proposed an energy-aware VM allocation algorithm in [14], that provision and schedule Cloud datacenter resources to the user's tasks in an efficient manner that reduces energy consumption level of datacenters and improve the quality of service. Many researchers worked for energy efficiency in Cloud Computing, but some researchers are working for energy efficiency in a specific type of Datacenters. In paper [37], the author proposed an efficient power consumption algorithm for video streaming datacenters. They proposed a method for VM management with the power-law feature. It predicts the future resource usage of VM, according to the popularity of video and arranges sufficient resources for that VM and shut down the idle servers on the datacenters to reduce power consumption. The results showed that this algorithm reduced more power consumption compared with Nash and Best-fit algorithm.

IV. CONCLUSION

Increment in power utilization is the emerging problem in today's computing world. Hike of applications related to complicated data have introduced the establishment of big datacenters which raised the energy need. From the above study of energy efficient techniques, we can say that, most of the work to reduce energy consumption in datacenters is done using VM-migration and VM-scheduling methods. Some researchers proposed multi-objective algorithms, which are mostly cover SLA, QoS and resource utilization with efficient energy consumption in Cloud datacenters. Less work has been done for heterogeneous physical machines, which needs some attention from research community. In this paper, the author presents taxonomy of energy efficient techniques for Cloud Computing. Various algorithms have been studied and their finding and improved parameters are listed in the table. This paper can help readers to find merits and limitations of proposed energy efficient algorithms **present** in the literature.

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