Achieving Energy Aware Mechanism in Cloud Computing Environment

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Abstract Cloud Computing is an emerging technology and it provides pay-per-use computing model over the Internet without giving hassle of resource management to the users. With the increasing demand and usage of Cloud applications worldwide, the issues of energy consumption, carbon emission and operational cost require special attention. Many researchers have tried to address these issues in different facets. In this paper, we first explore few research carried out in the direction of energy efficiency. We further propose (a) architecture for energy-aware mechanism in Cloud and (b) pre-processing approach by considering Virtual Machine (VM) allocation and consolidation techniques as key factors to achieving energy efficiency in Cloud Computing.

Keywords Cloud computing · Energy efficiency · Energy aware architecture · Allocation · Consolidation for VMs

1 Introduction

Availability of high-speed internet computing and large scale computational power at processor level has lead us to think a completely new model of computation viz. Cloud Computing where resources such as Processors, Memory, Storage etc. are used on rental basis and payment is made in pay-per-use form.

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National Institute of standards and Technology [NIST] [1] categorizes the computing resources into networks, servers, storage, applications and services. These resources are provisioned to demanding users and cost to the users is calculated on the basis of the resource-usage. Further, the provisioning is elastic i.e. resources may be added if required and removed when not required. Additionally, based on the type of services offered, NIST classifies three service models viz. Infrastructure-as-a-Service (IaaS), Platform-as-a-Service (PaaS) and Software-as-a-Service (SaaS). Based on territorial deployment concerns, NIST lists four deployment models viz. Private, Public, Hybrid and Community model.

Traditionally, the concept of Cloud Computing is implemented by a group of data centers managed and operated by Cloud service providers. These data centers are equipped with large number of processing elements and huge amount of other resources such as memory, storage, and bandwidth etc. The power consumed by these computational resources is significant and has attracted the attention of many researchers. In 2012, total power consumption to the data center is around of 38 Giga Watt [GW] and that is equal to 63 % and more than the power consumption of 2011. And that is sufficient for fulfilling the energy requirement of all residential households of United Kingdom [2].

The fundamental technology which makes the idea of Cloud computing practically possible is *virtualization*. It creates virtual instances of a physical server and these instances are offered as a service to the user on a shared basis. These instances are often known as Virtual Machines (VMs). Physically, every host (sometimes known as server or node) consists of many VMs. And many such hosts comprise a data center. To address the issue of energy consumption, it is suggested to keep minimal number of host live (active or running) at any given point of time. To achieve this, one may need to migrate few VMs from one host to another based on certain criteria. Hence, VM migration can be used to address the issue of energy consumption.

In this paper, we aim to focus on the issue of reducing energy consumption by considering the communication cost between user and service provider using geographical location as one of the factors. Moreover, after selection of data center with lowest communication cost, we intend to reduce number of running hosts by applying existing VM consolidation and migration techniques.

The rest of paper is organized as follows. In Sect. 2, we explore various research carried out in the direction of energy efficiency. We also analyze strength and limitation of the approaches. We have compared few researches based on the criterion they have used to achieve energy efficiency. In Sect. 3, we present our proposed work with neat architecture, flow-diagram and algorithm. We further show the possible incorporation of VM selection and placement techniques in our proposed work. In Sect. 4, we conclude our research with mentioning our forthcoming plan of action to implement and validate the proposed mechanism.

2 Related Work

In increasing demand for internet based services, in that large amount of process as like computational data, resource management and network based communications that are significantly contribute to energy consumption. And Cloud computing is a multidirectional solution to make process and network communication easier. In [3] authors presented, the analysis a comprehensive energy consumption to consider both public and private cloud. And which includes the energy consumption in transmission and switching also data storage and data processing. And they assess three services to consume energy, namely the storage as a service; software as a service and at last service is processing as a service. In cloud switching and transmission process that represents a significant percentage to the total energy consumption in cloud computing services for storage at high and medium usage rates. These analyses tell that Cloud computing offers to save energy through mostly use virtualization and server consolidation techniques.

Energy aware cloud service provisioning approach [4] used an energy consumption model with the component part called a Trigger engine. And this engine will be used Pre-processed data [PPD] for the automatic live migration process of virtual machines to preserve the energy consumption in green cloud computing environment.

The wide recognition of cloud services and a wide spectrum and combined application can be increasingly deployed in the data center in cloud, communication in DCs is ever compact [5, 6]. As the Data center network is more complex, and switches and cables are major issues for energy consumption in data centers.

In IT companies, data centers are basic necessary for the function of communications, academic, business, government system. But data centers have concerns because they produce high energy consumption [7]. The Environment Protection Agency [EPA] report to the high amount of energy consumption is increasingly in last 5 years and their cost is $7.4 billion annually [8]. Impact of huge energy consumption for environmental is causing concern because the carbon emission of ICT is growing rapidly. In 2006, it was estimated 2 % of global carbon emission, and it equivalent to the emission of the industry [9]. In 2007, Carbon emission is 14 % of ICT for data centers and this is projected to be 18 % in 2020 [10].

The majorities of research work it provides a range of hardware and software solution the problem of energy consumption and minimize the carbon emission in the cloud. Turning on and shutting down the servers and putting them to sleep are some simple method for energy saving and that used for servers in clouds. In that use two common and popular technique are Dynamic Voltage and Frequency Scaling (DVFS) [11] and second is Dynamic Power Management (DPM) [12]. DVFS technique use for arrange the CPU power accordingly there offered load and use virtualization techniques for better resource utilization. Virtualization technique is reducing the energy consumption using live migration [13] and resource consolidation techniques. And DPM scheme use for down the power for whole servers,

Table 1 Comparison of energy Models

Author/year component	Arthi T/Shahul Hamead H 2013	Bharti wadhwa/Amandeep 2014	Ting Yang/Young Choon Lee 2014	Anton Beloglazow, Rajkumar Buyya 2012	Fransic Owusu/Colin Pattinson 2012
Compute [server]	✓	✓	✓	✓	✓
Allocation and migration		✓	✓	✓	
CPU utilization	✓	✓	✓	✓	✓
VMLivemigration	✓				
VM scheduling algorithm		✓		✓	
Energy consumption	✓	✓	✓	✓	✓

and also include their memory, buses and disks, which is make a technique more energy efficient.

The movement of virtual machines between physical nodes in data centers, and it is enables to dynamic migration of VMs according to the requirements of performance. When provided resources are not use VMs that time VMs can be resized logically and consolidate minimum number of physical nodes. While idle nodes can be turn off in sleep mode to eject them and reduce the total energy consumption for data center [14]. In heterogeneous infrastructure the formulated algorithm can be used for VM allocation and migration process. These techniques are not depend on type of VM request and not required application information and which is run on that VMs. And that can be handle strict SLA and heterogeneous VMs.

In virtual machines scheduling algorithm [15] presents a combination of the two methods. Allocation algorithm used for allocate the jobs and a migration algorithm for optimal migration of VMs. These techniques use linear integer program and that is noticeable and significant amount of energy save and it is depend on the load of the system. In [16] proposed Energy and Carbon Efficient VM Placement and Migration techniques, is use the VM allocation and migration process in federated cloud datacenters and also consider carbon footprint rate of different datacenters.

We see the various research techniques to attain the energy consumption and reduce power consumption. But some researcher tried to only reduce the energy consumption for different data centers to considering only allocation and migration techniques, but they do not reduce the communication cost. So we tried in our work to reduce the communication cost between users and service providers in cloud that will be reduce the energy consumption.

We proposed a new approach, called Energy aware mechanism in Cloud computing Environment, which is unique from the above described techniques as we have tried to optimize the problem of energy consumption and carbon emission in the cloud data centers having Pre-processing phase in that also use allocation and migration techniques to achieve maximum energy efficiency based on geographical location. Table 1 describes comparison of energy model and their approaches will be described above.

3 Proposed Approach

In this section, our contribution is Energy Aware Architecture to related cloud computing environment. And this is differ from the above mentioned techniques and we have tried to optimize the problem of Energy Consumption in the cloud data centers having Pre-Processing Phase. And this phase uses the allocation and migration technique to achieve maximum energy consumption (Fig. 1).

The cloud based services use the users via a service request processor. Users data and organization software data are store on server site based on remote location. Service request processes are manage (submission and handle) all requests for service to the server. Customized the processes to call the customer needs, and this

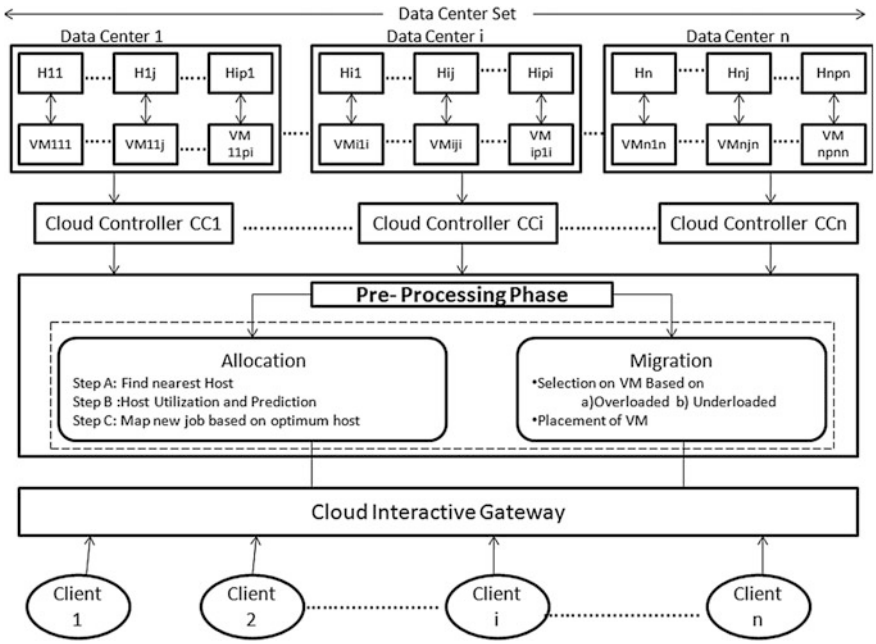

Fig. 1 Energy aware architecture [4]

process is depend on type and complexity of the customer request. An administration tool is cloud controller, and it maps the resources like services, storage to server node. And it includes centrally data and take the decision correspondence.

In server virtualization process a many users share a single server in that process, that why increase the service utilization and that time reduce the number of server and it is required for processing. And also user not need and not required any information of the task and workloads for performed by another user, utilize the server when task will be complete and they are only user on that server. During the time of less requirement server enter into sleep mode that time reduce the idle servers and reduce the energy efficiency. The Energy Consumption to reflect to profit utilization of server, consolidation of Pre-processing data is performed. Figure 2 presents our proposed mechanism.

In Pre-Processing Phase the allocation process can be designed into three phase as follow:

(1) First phase: In step (A) Fig. 2, each data centers is the distributed cloud architecture. And we find the nearest host and data centers for based on their Geo-Graphical location.
(2) Second phase: In step (B) Fig. 2, based on selected host in step A Calculate the (B.1) Current Host Utilization, for better resource utilization. (B.2) Predicted Load. Predict the host loads of every data center using the two prediction algorithm are (B.2.1) Short-Term Prediction and second is (B.2.2) Long-Term

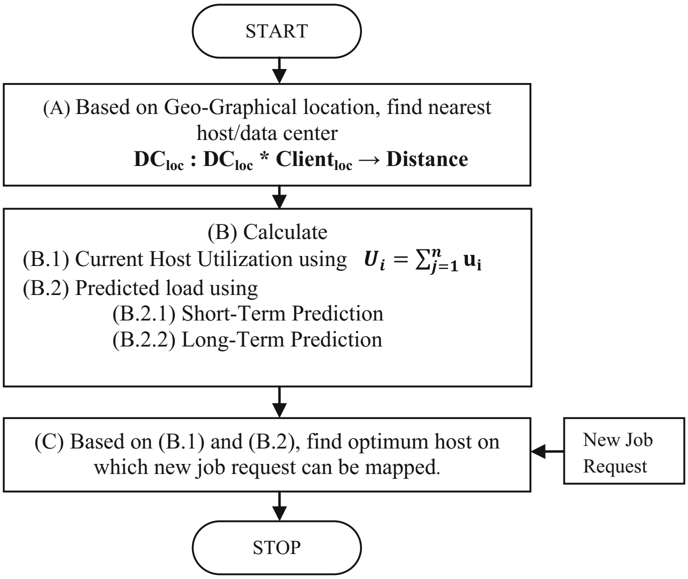

Fig. 2 Proposed mechanism

prediction. And selection of right prediction is depending on two factors (1) Time of the prediction and (2) Type of the data. And in computer system short-term prediction is the range of minute or hours and long-term prediction is the range of days, week or month.

(3) Last phase: To find optimum host in step (C) Fig. 2, we use the following equation to calculate threshold values for every host selected in step B. $T = \{T_{H1}, T_{H2}, T_{H3} \ldots T_{Hn}\}$

$$T_H = (1 - \lambda)C + \lambda P \tag{1}$$

where

T_H Threshold value
λ Constant ranging from 0 to 1
C Current host utilization
P Predicted host utilization

To find optimum host, we believe that the value of threshold should vary between two bounds viz. upper bound and lower bound. Host with threshold less than lower bound tend to go underutilized and host with threshold more than upper bound tend to go overutilized. Hence, we selected only those host whose threshold lies between these ranges:

$$\text{Optimum Host} = \text{MIN}_{T_{lower}}^{T_{upper}}\{T\} \quad (2)$$

Where set of threshold values for each selected host T = $\{T_{H1}, T_{H2}, T_{H3} \ldots T_{Hn}\}$

T_{upper} Upper bound threshold value
T_{lower} Lower bound threshold value

We further assume that detection of overloaded or underloaded hosts may be carried out using already available techniques. Based on this detection, selected VMs can be migrated using one of the existing VM migration approaches:

1. Selection of Virtual Machine
2. Placement of Virtual Machine based on Selected VM

1. Selection of Virtual Machine
   For current virtual machine the optimization process for allocation is work on two steps: (1) Select the VMs that need to be migrated, (2) Choose VMs and put on the hosts use the MBFD algorithm in [18]. When and which VMs can be migrated that is depend on the policies for VM selection. Basic thing is define the upper and lower utilization threshold values for hosts and keep the total utilization for CPU, and on host all VMs allocated between threshold values. Selection process will be use Minimization of Migration (MM) policy.
2. Placement of Virtual Machine based on Selected VM
   Virtual Machine allocation process problem can be divided in [17] two part: the (1) Insert a new requests for VM provisioning and placing the VMs on hosts, (2) Optimization of the current VM allocation. In modification, the Modified Best Fit Decreasing (MBFD) algorithms, short all VMs in decreasing order of their current CPU utilizations, and every VM can be allocate host and that supply the least of increasing order of energy consumption due to allocation. This is allowing for leveraging the heterogeneity of resources chooses based on energy efficient aware nodes first.

4 Conclusion and Future Work

In this research, we identified energy consumption as one of the key issues to be addressed and we analysed various approaches leading toward energy efficiency in cloud environment. Broadly divided into two phases, we select nearest data center to reduce communication cost in first phase for selection of hosts. In second phase, using appropriate VM selection and migration techniques, we have minimized number of active running server to reduce energy consumed. Our research is at elementary level and in future, we wise to implement the proposal and validate the results against our claim.

References

1. P. Mell and T. Grance.: The NIST definition of cloud computing (draft), NIST special publication. vol. 800, p. 145.
2. R. Brown et. al.: Report to congress on server and data center energy efficiency: Public law 109-431, Lawrence Berkeley National Laboratory, 2008.
3. Green cloud Computing. Balancing Energy in processing, Storage and transport. Jayant Baliga W.A. Ayre, Kerry Hinton, and Rodney S. Tucker, Fellow IEEE, January 2011.
4. Arthi T, Shahul Hamead H.: Energy Aware Cloud Service Provisioning Approach For Green Computing Environment, in International Conference on Energy Efficient Technologies for Sustainability(ICEETS), Nagercoil, April, 2013, pp. 139–144.
5. Y. Han, S-S. Seo, C. Hwang, J-H. Yoo, and J.W.-K Homg.: Flow-level traffic matrix generation for various data center networks. Network IEEE Operations and Management Symposium (NOMS), pp. 1–6, 2014.
6. O. Fatmi, D. Pan.: Distributed multipath routing for data center networks based on stochastic traffic modeling, in Proceedings of the 2014 IEEE 11th International Conference on Networking, Sensing and Control (ICNSC), pp. 536–541,2014.
7. J. Loper and S. Parr. Energy efficiency in Data Centers: a new policy frontier. January 2007. [online]. Available: http://www.fypower.org/pdf/ASE_DataCenter_EE.pdf. [Accessed 10 May 2011].
8. U.S. Environmental Protection Agency.: Report to Congress on server and Data Center energy efficiency. U.S. Environmental Protection Agency, Washington, 2007.
9. Kaplan, James M; Forrest, William; Kindler, Noah.: Revolutionising Data center Efficiency. McKinsey and Company, London, 2008.
10. The Climate Group.: SMART 2020: Enabling the low carbon economy in the information age. The Climate Group, New York, 2008.
11. L. Shang, L.-S. Peh, and N. K. Jha.: Dynamic voltage scaling with links for power optimization of interconnection networks, in the 9th International Symposium on High-Performance Computer Architecture (HPCA 2003), Anaheim, California, USA, 2003, pp. 91–102.
12. L. Benini, A. Bogliolo, and G. De Micheli.: a survey of design techniques for system-level dynamic power management. IEEE Transaction on Very Large Scale Integration(VLSI), San Jose, CA, April 2010.
13. C. Clark, K. Fraser, S. Hand, J. G. Hansen, E. Jul, C. Limpach, I. Pratt, and A. Warfield.: Live migration of virtual machines. In The 2nd Symposium on Networked Systems Design and Implementation (NSDI 2005), Boston, Massachusetts, USA, 2005, pp. 273–286.
14. Anton Beloglazov, Jemal Abawajy, Rajkumar Buyya.: Energy-aware resource allocation heuristics for efficient management of datacenters for Cloud computing. In Future Generation Computer Systems, 2012, pp. 755–768.
15. Chaima Ghribi, Makhlouf Hadji, Djamal Zeghlache.: Energy Efficient VM Scheduling for Cloud Data Centers: Exact allocation and migration algorithms. In 13th IEEE/ACM International Symposium on Cluster, Cloud, and Grid Computing, 2013, pp. 671–678.
16. Bharti Wadhwa, Amandeep Verma.: Energy saving approaches for Green Cloud Computing: A review. In Proc. of Recent Advances in Engineering and Computational Sciences, March 2014, pp. 1–6.
17. Anton Beloglazov, Jemal Abawajy, Rajkumar Buyya.: Energy-aware resource allocation heuristics for efficient management of data centers for Cloud computing. ELSEVIER 2012.
18. Anton Beloglazov, Jemal Abawajy, Rajkumar Buyya “Energy-aware resource allocation heuristics for efficient management of data centers for Cloud computing” ELSEVIER 2012