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Energy-Efficient Virtual Machine Allocation Technique Using Interior Search Algorithm for Cloud Datacenter

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***Abstract*-- Cloud Computing is revolutionizing how Computing power is generated and consumed over the Internet on a pay-per- use basis over the past few years. The broader acceptance of Cloud technologies has led to the establishment of datacenters. Over the years, high energy consumption by datacenters has become a major interest as a result of increasing demands of resources and services by enterprise and scientific applications. Consequently, datacenter infrastructure turns out to be not only expensive to sustain, but also unfavorable to the surrounding environment due to their huge carbon emission. Thus, energy efficient virtual machine allocation techniques are required to overcome high energy consumption due to improper resource allocation within the data centers. This paper proposes Energy-Efficient Virtual Machine allocation technique using Interior Search Algorithm (ISA) that reduces the datacenter energy consumption and resource underutilization. The results shows that, the energy consumption of GA and BFD is 90% - 95% as compare to the proposed EE-IS which around 65%. On average 30% of energy has been save using EE-IS as well the utilization of the resources which has also improved.**

Keywords--Virtual Machine; Cloud Datacenter; Resource Allocation; Energy-Efficiency; Interior Search Algorithm

I. INTRODUCTION

Cloud computing is a universal term used for the delivery of hosted services and resources connected with Internet that are pre-packaged using virtualization technology. The technology allows the creation of duplicate servers or computer system known as virtual machine (VM). The concept of utilizing Cloud Computing allows companies, industries, and organization to have their Computing resources as a utility that is acquired on pay-per-use basis instead of building and keeping computing infrastructures in their premises. The broader acceptance of Cloud Computing domain and virtualization technologies contributes to the formation of large-scale data centers that provide cloud services. These services are being offered in different ways and at different level of the Cloud datacenters as shown in Fig 1.

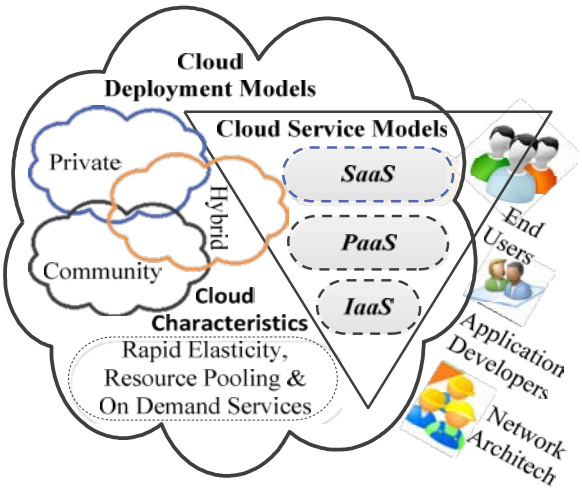

Fig. 1. Classification and Model of Cloud Computing [3]

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The Cloud services are classified as Infrastructure as a Service (IaaS), Software as a service (SaaS), and Platform as a Service (PaaS) [1, 2]. The benefits of using Cloud Computing are enamors. They includes; pay per-use, instant on-demand self-service provisioning, rapid elasticity and resource pooling. The concept of resource allocation (RA) has a meaningful impact on datacenter, specifically in pay-per-use deployments model which include public, private, community and hybrid Cloud. These models resource usage are charged by the service or application provider. However, over the years, high energy consumption by Cloud datacenters become a major interest as a result of increasing demands of resources and services by enterprise and scientific applications. This lead to inefficient usage of the infrastructure, poor scheduling policies, and resource utilization which are the reason for high energy consumption in datacenters. Various resource scheduling techniques that are considered to be energy-efficient using classical metaheuristics algorithms has been designed [4-6] to prevent underutilization of resource, that are liable for arousing the high energy consumption [3]. Therefore, energy efficiency remains an issue for Cloud datacenters management and service providers. Among the means to address this problem is to reduce the potentialities of the Cloud datacenters due to the used of virtualization technology [1]. The virtualization which is one of the enabling technology of cloud computing allows administrators of the Cloud to initiate VM Instances over a physical machine (PM). By this, physical resources demand will be less than before, thus the resource utilization of resources is improved. However, the method improves the situation, but it is often not adequate, due to the dynamicity and heterogeneity of the Cloud environment. Kaur and Chana [7] in their survey point out unsolved Cloud Computing challenges because of their underlying problem such as resource utilization, central access, and location-awareness. This study focus on resource utilization and energy consumption due to the fact that efficient resource management for IaaS in Cloud datacenter offers the benefits of reduction in energy consumption and resource under/over utilizationThis paper proposes Virtual Machine allocation technique using Interior Search Algorithm (ISA) that reduces the datacenter energy consumption and resource underutilization.

II. Related Work

Virtualization is an essential and important aspect of Cloud Computing. The benefit of a virtualizing Cloud datacenter environment is to allows better resource utilization that are available in physical machine [8]. Li, et al. [9] proposed an approach called EnaCloud that support dynamic placement of live running applications in datacenter. The authors uses bin-packing problem by taking into consideration of the applications energy consumption. Another energy-conscious algorithm has been designed to efficiently and heuristically schedule application that guarantees server virtualization. In this technique, the VMs encapsulate applications, and VM live migration was implemented for reducing energy consumption [11]. Rodero, et al. [5] successfully develop energy-efficient resource provisioning scheme that helps in centralizing and clustering of VM-based allocation. Likewise, Deore, et al. [10] developed a scheduling scheme that is consider to be energy- efficient. Similarly, another migration technique for energy- aware allocation and consolidation of cloud resources to minimize overall consumption of energy in datacenters has been proposed by Ghribi, et al. [11].

A GA-based Hybrid Optimization (GAHO) model for green cloud computing to establish energy-efficient datacenters is proposed by Rocha and Cardozo [12]. Sharma and Reddy [6] combined DVFS and GA to reduce the energy consumption of a datacenter, increased resource utilization and convergence of the solutions. Moganarangan, et al. [13] propose a Hybrid Algorithm (HA) for reducing energy consumption and makespan in cloud datacenters. The algorithm combines ACO and Cuckoo Search Algorithms (CSA) to reduce the energy consumption of datacenter. Therefore, Cloud service providers have to consider high energy consumption and inefficient resource utilization by the datacenters.

III. Energy-Efficient Resource Allocation in Cloud Datacenter

In this section the energy-efficient resource allocation technique methods are discussed. The variables of the methods which include the proposed system architecture, Energy- Efficient Interior Search (EE-IS) with their assumption and corresponding models are explained.

A. Architecture

The need to manage various applications in Cloud datacenter, generate the relevant challenge of on-demand provisioning of resources and allocation of different changing workloads [5, 14]. Fig 2 illustrate the energy-efficient architecture of VM allocation for Cloud datacenter. It shows how the user request are handle by the broker to the Cloud and finally to the datacenter. The users request are submitted to the Cloud broker first, then the broker will return result to the user based on their need capacity and performance management of the available datacenters that the broker subscribes.

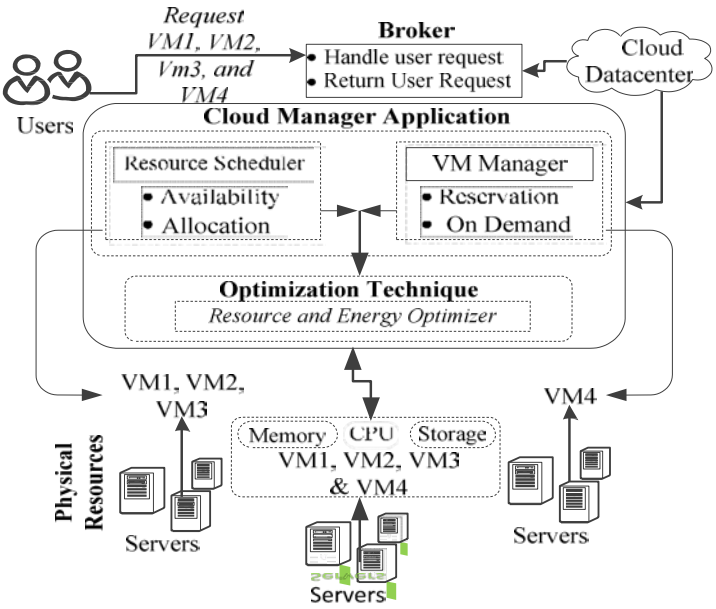

Fig 2. The Proposed System Architecture

When the broker's request reach the datacenter, the cloud manager will now look at the request and also makes a decision after comparing the request on the VM manager module and resource scheduler module. These two modules will identify whether the characteristics of the resource which include reservation, on demand, availability and allocation. The acceptance of any request is determine by the Cloud manager through the system availability. This method has not solve the problem of the inefficiency of the resource allocation policy that resulted into poor resource utilization and energy management in cloud datacenters. However, our method has taken into consideration of the aforementioned problem and introduces a new optimization technique using ISA to solve the problem.

B. Energy-Efficient Interior Search

The ISA was recently proposed by Gandomi [15] to solve global optimization problems. This algorithm used and implemented by various researchers such as [15-17] to settle complex and multi-dimensional optimization problem. The ISA operational performance has been confirmed using accepted benchmarking technique. The summary obtained from ISA evolutionary line, shows that the algorithm has the readiness, flexibility, capability and efficiency of being adaptable to solve different types of problems in different NP-hard situations. ISA elements are divided into two classes which include composition and mirror group. The composition class of elements becomes different in order to obtain more attractive solutions. The mirror group are normally placed between the fittest element and mirrors elements to find improved perfect view. Below is the detail description of the ISA algorithm.

Algorithm: Energy-Efficient Interior Search (EE-IS)

1. Start.
2. Define solution Boundary between lower bound **(*LB*)** and upper bound **(*UB*)** and find their fitness value
3. ***Procedure*** Generate Initial population and set Iteration Limits
4. ***Procedure*** Compute the Fitness Function of all the Solutions
5. Is the Value of the Solution Less than Parameter *a*?
6. ***If*** yes ***then*** Elements Goes into Mirror Group
7. Compute Position of Mirror Element and Find Fitness Value.
8. ***Else*** Element Goes Into Composition Group
9. ***Procedure*** Evaluate New Value Within the Range of Solutions
10. Is the Fitness Value Better Than Previous?
11. ***If*** Yes, Replace Old Value with the new Value
12. ***End If***
13. ***Else*** keep the old Value
14. ***End Procedure***

Every optimization technique and algorithms possess important components known as tuning parameters which can be used before in the process of simulation or any implementation environment. More than two parameters are turned using metaheuristics algorithms. But ISA uses only one parameter which α that is use for turning and is varied from 0 to 1. The result obtained from this algorithm are competitive compare with other well-known algorithms that already exist for constrained optimization.

C. Modeling of Energy-Efficient Resource Allocation

The problem of resource allocation in Cloud Computing is linked to other scheduling issue. Finding an optimal solution in allocating, planning and assignment of available resources of Cloud datacenter is the aim of this research. Therefore, we assume that datacenters consist of large number of servers known as PM connected with other related components. Each PM have a fixed size of memory, CPU and storage. As an initial step, clients or users may require Cloud services. This can be translated into sending a request to the Cloud through broker

The send requests has to be treated by the datacenter manager, which in turn may lead to reservation of certain number of VMs as requested by the user. The VMs can be identical or different depending on the application requirement. Cloud provider offers different class of VMs for their users or client to choose from. These classes differ in specification in terms of memory, CPU units and storage of each Computing resource Consequently, each of the requested VMs is allocated on PM of the datacenter resource. The system model process request sent by the users based on the following assumption;

- Cloudlet – A task that actually runs in VM.
- Datacenter: Set of physical machine that runs VM.
- Datacenter Broker: This broker is an agent of VM requests
- Host: Manages the VMs with the help of hypervisor.
- VM: A software representation of a physical
- Every VM must be hosted by host.
- Each VM and host are independent.

Mathematically, the resource allocation model can be formulated as given by Eq. (1).

$$\sum_{x=1}^{Z,n}(PC_i + PD_i + PM_i) \times T_i \rightarrow U_i^j \qquad (1)$$

The cloud datacenter assign m number of virtual resources $V = (V1,V2,V3,....Vm)$ onto n available physical resources of the datacenter with the limited resource capacity such as $P = (Pc1,Pc2,Pc3,....Pcn)$, $P = (Pd1,Pd2,Pd3,....Pdn)$ and $P = (Pm1,Pm2,Pm3,....Pmn)$ to the users of the Cloud services $U = (U1,U2,U3,....Un)$ such that the fitness of j objective function $F = (F1,F2,F3,....Fz)$ are maximized subject to .

1) Minimizing Energy Consumption

The first aim of this research is to minimize the energy consumed by datacenter based on the strength requirement for the execution of cloudlets and also user request made to Cloud datacenter environment [1]. Simply, it is the total electricity power used to run the host or PMs in datacenters as expressed in Eq. (2)

$$Energy\ Cons = \sum_{resource\ i} \int_{Str_{Time}}^{Fnh_{Time}} E_i(F,T) \quad (2)$$

The energy consumption of given resource *i* at a time *T* with placement *F*. The E_i represents the energy that is consumed by the resource *i* from its starting time to finishing time of utilization.

2) Maximizing Resource Utiliztion

Resource Utilization Model: is used to measure the actual amount of resources consumed by the datacenters. Therefore, Cloud manager has to find a way to efficiently allocate the users request from the available pool of resources in the datacenter [18]. The resource utilization of the physical host can be expressed as given by Eq. (3).

$$Resource\ Utiliz = \frac{\sum_{resource\ i} Execution_{time}}{Makespan\ or\ Maxtask^i(Execution_{time})} \qquad (3)$$

Where makespan is the highest completion time once the resources are allocated to users and execution time is the difference between the requests starting time with finishing time.

VI. PERFORMANCE EVALUATION

The proposed VM allocation technique is implemented using the Cloudsim version 3.0.3. [18]. The Cloudsim is run with the Eclipse lunar IDE release version 4.0.

TABLE 1. EXPERIMENTAL PARAMETER SETTING

S/NO	Parameter Setting				
	Technique	***No OF Host***	***No of VMs***	***No of Users***	***VMM***
1	EE-IS	25	180	10	Xen
2	GA	25	180	10	Xen
3	BFD	25	180	10	Xen

The algorithm is implemented on an Intel CoreTM i5 processor, 2GHz processor speed, 1 terabyte hard disc drive and 8 gigabyte memory. Table 1 present the parameter settings of the scheduling techniques. The results of the proposed technique are compared with the existing algorithm GAPA [4] and base line scheduling algorithm such as best-fit decreasing (BFD) with Genetic Algorithm (GA) on the basis of total energy consumption and resource utilization that are show Fig 3 below.

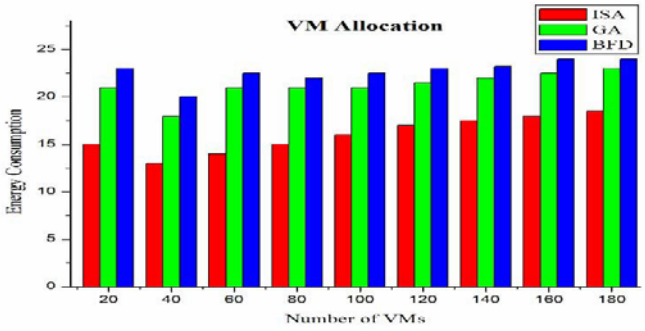

Fig. 3. Energy consumption of EE-IS, GA and BFD for VM Allocation

V. CONCLUSION

In this paper we proposed energy-efficient VM allocation technique using ISA with aim of reducing datacenter energy consumption and improved the resource utilization of the physical resources. The models and Algorithm's pseudo code have been elaborated. Cloudsim environment has been used as testbed to simulate our algorithm. We show that our technique is more efficient in terms of energy consumption and resource utilization after it has been compared with GA and BFD. The results shows that, the energy consumption of GA and BFD is 90% - 95% as compare to the proposed EE-IS which around 65%. On average 30% of energy has been save using EE-IS as well, the utilization of the resources which has also improved.

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