International Journal on Applications in Engineering and Technology
Volume 10 : Issue 2 : May 2024, pp 36 – 41 www.aetsjournal.com
ISSN (Online) : 2455 - 0523

Energy efficient scheduling for cloud data centers using heuristic based migration

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Abstract: - – Cloud computing has now become extremely fast spread in the various fields of research, industry and computing in that of the recent years. Being a part of the services that are offered there are identified some new possibilities for building applications and also for providing some services to that of the end user by means of virtualization by the internet. The energy efficiency is that global challenge in today's world and virtualization will provide a promising approach for re- dividing the hardware and also the software more than the physical servers in their multiple applications which will be able to run on a similar physical server even while having different resources. Both the Heuristic and the metaheuristic-based techniques have proven to have achieved some near-optimal solutions in a reasonable time frame for various complex problems. In this work, a shuffled frog leaping algorithm (SFLA) has been proposed for enhancing the total time of execution, the number of migration and the consumption of energy than that of the previous work that is based on the particle swarm optimization (PSO) algorithm. The results show that the total simulation time (s) taken by the data center when the actual number of VMs is 100 using the SFLA is less and it achieves much better performance than the mechanism using PSO by about 17.8%.

Key words: Energy efficiency • Virtualization • Virtual machines (VMs) • Particle swarm optimization (PSO) and shuffled frog leaping algorithm (SFLA)

I. INTRODUCTION

Cloud computing has proven to be a hot topic in recent times and has been quickly developing. Cloud computing has provided a computation as well as storage services that has been made available as a subscription-based service for a pay-as-you-go mode to the customers [1]. These services have been divided into three types which are: infrastructure as a service (IaaS), the platform as a service (PaaS), and the software as a service (SaaS). The users will be able to avail the services based on the pay-as-you-use mode with no geographical restrictions. This is a convenient, necessary and a shared resource for network computing along with a dynamic configuration that includes the network, the storage, the service and the application. The providers of Cloud service will have to consider the cloud services and their convenience with minimal emphasis on the facilities of hardware for extending the potential of computing for computer centers. So there are different cloud users that will enjoy different capabilities both easily and also efficiently. The actual core of this cloud computing environment will be the cloud data center that normally consists of many highly configured hardware facilities. This computing capability of the data center will be the main indicator that is considered by the cloud service providers. With the number of large data centers, the consumption of energy by data centers is also on the increase which can affect the environment [2].

There are more such data centers that lead to a higher consumption of energy and so the consumption capacity of the data centers and their huge energy con- sumption is considered for addressing the optimization issue of resource management for the data centers. The Green computing is perhaps the only method that can enhance the efficiency of operation of data centers and also bring down the damage that has been made to the envi- ronment. The center designers should consider using effi- ciently the computing resources based on the premise that this system continues to maintain some excellent services for computing vast energy. The cost of energy for the data centers are increasing rapidly and the costs can further double and may also exceed the purchase costs in the later years for the server hardware. Additionally, the cooling costs for such data centers will also continue to be on the rise owing to the ever- increasing consumption of power by the servers that leads to an increase in the heat dissipation. So, the model in cloud computing will be expected to become the infrastructure for the next generation because of its efficiency of energy. The actual amount of the energy that is consumed by any server will vary based on the workload. There are many such studies for predicting or controlling the consumption of server power that is based on the assumption that this power consumption of any processor has been determined mainly by the utilization of the processor. But the consumption of energy will be based on the utilization of the power or the time of execution that is not accurate for the billing of the energy costs.

The Server vendors have now started to inte- grate the power measurement and the hardware for moni- toring the power consumption of the server [3]. By means of employing an integrated power measurement hardware, energy consumption in any server is measured accurately. But an integrated meter of power will measure the con- sumption of power of the entire server system at the same time the energy based billing systems of these cloud services will need the energy consumption for all the VMs. Cloud users will request VMs from that of a data center by means of specifying the demands of resources (demands relating to the CPU, the memory, and the storage), the platform, along with the VM's duration and when the data center receives such user requests can allocate the VM to that of a server and also reserve all the needed resources on this server. The server can also host many such VMs that depend on the server capacity and as the consumption of energy is now becoming a major factor in cost, along with an environmental issue with the data centers it may be critical to allocate the VMs to their servers to bring down consumption of energy [4].

The reduction of energy that is used in the cloud com- puting is one critical issue which is in a sustainable society. There are many such existing approaches for the reduction of energy and for using in the data centers however there are some new approaches that are required for cases of cloud computing energy management. This type of energy management cycle contains four different phases: the monitoring, the calculation, the analysis and action. For the purpose of analyzing the effective actions and their data, the monitoring as well as the analysis of the phases that have to be important. In case of the monitoring phase, there are many other types of data sources that have also been monitored and the monitoring of the data by a unified interface has been found to be quite effective than the several other kinds of data in many other ways. This is not only the monitoring of data by also a unified interface of data access along with that of a standardized format of data that are all considered important. In the phase of analysis, there are several types of data that have been used as the inputs for the purpose of seeking correlations. The main purpose of the system of energy management for that of cloud computing will be the support of the phases of the different management cycles and for that of the monitoring phase this system will need the monitoring of the various types of sensors as most such sensors will be deployed in the different data centers. Such sensor data is also obtained by means of using a unified interface that has been provided by the layer of data management. The consumption of energy and the emissions are further cal- culated from the data collected in the phase of calculation. In case of the analysis phase, this system will provide the optimizations that are specific to cloud computing. This will determine an appropriate allocation of the VM to the servers in a multiple data centers. These VMs have been reallocated in accordance to the allocation that is optimized in their action phase.

For this work, a cloud energy man- agement system has been developed and this is used in conjunction with the sensor management functions that are along with an optimized tool of VM allocation for mini- mizing the energy and its consumption in the multimedia centers. Luo et al. [2] presented a study on the Infrastructure as a Service model, in which custom virtual machines (VMs) were launched in their appropriate servers of the data centers. This scheme will not only ensure the quality of service (by the service level agreements) and also achieve a maximum amount of energy saving. Taking that data center host into consideration it makes use of the exact algorithm for solving the problem of resource allocation a modified shuffled frog leaping algorithm along with improved optimization has been employed to solve this. The results of the experiment had demonstrated that this scheme of resource management has exhibited some per- formance in case of green cloud computing. Kim et al.

[3] made a suggestion of a model to estimate the consumption of a virtual machine without a dedicated hardware for measurement. The model will estimate this energy consumption for a virtual machine in the in-pro- cessor events that are generated by this virtual machine. On the basis of the estimation model, there was a virtual machine that was proposed for scheduling the algorithm to provide the resources in accordance to the energy budget of each of such virtual machines. These suggested schemes will be implemented in a Xen virtualization system, the evaluation of which will show that the schemes suggested and also provide consumption of energy with the errors of lower than about 5% of the total consumption of energy. Xie et al. [4] further made a study on the allocation problem of the VM in which a set of VMs along with a set of servers in one data center in which each of the VMs will have a resource demand (like the CPU, the memory, and the storage) with a starting time as well as a finishing time, and with each server having a resource capacity.

These servers will be nonhomogeneous and the problem of such a proposed concern will be to allocate these VMs onto ser- vers to ensure that the resource demands of the VMs are brought down. This problem has been formulated as one Boolean integer linear programming issue. There is a heuristic algorithm that is proposed for solving this prob- lem. There are extensive simulations that are conducted for demonstrating the proposed method that can save signifi- cantly the consumption of energy in the data centers. To consider this into account a migration overhead in the decision making of the migration is considered. Liu et al. [8] further investigated design methodologies for quantitatively predicting the performance of migration and the cost of energy.

To analyze the key parameters affecting the cost of migration from theory to practice two applica- tion-oblivious models for predicting the cost by making use of a learned knowledge on the workloads as a hypervisor (called VMM level) is also used. This will be the first of its kind for estimating the live migration cost of the VM for both performance and energy in that of a quantitative approach. Evaluate these models by using five represen- tative workloads on that of a Xen virtualized environment. The results of the experiment results showed that this refined model yields much higher than 90% of the accuracy of prediction compared to that of the measured cost. The Model-guided decisions will significantly bring down the cost of migration by more than at least 72.9% at energy savings of about 73.6%. Liaqat et al. [9] further surveyed the VM migration methods as well as the applications. Some of the open research issues are highlighted for representing the future challenges within this domain.

There is a queue that is based on the migration model proposed and also discussed for migrating efficiently the VM memory pages. Pacini et al. [6] also made a study on the private Clouds for executing the scientific experiments that were coming from the multiple users, which are where the work focuses on infrastructure as a service (IaaS) model in which the custom virtual machines (VM) that are launched in case of the appropriate hosts that are available in a Cloud. Then, by correctly scheduling the Cloud hosts which will be quite important and also necessary to be developed as an effi- cient scheduling strategy to allocate appropriately the VMs to their physical resources. Here, the scheduling will, however, be challenging owing to its inherent NP-com- pleteness. The main metrics of performance will be to study the number of Cloud users that will be able to serve the number of the VMs in the online scheduling scenarios. Besides, the actual number of the intra-cloud network messages will be sent and evaluated. The simulated experiments will be performed by using the CloudSim and also a job data from the real scientific problems prove that proposed scheduler will succeed in balancing these studied metrics when compared to the schedulers that are based on the Random assignment and their Genetic Algorithms. Bin packing [5] is that classical combinatorial problem in optimization that has been extensively studied. In case of the classical bin packing issue for a given set of items, the main objective will be to pack such items within a mini- mum number of bins to ensure that the total size of these items in each of the bins will not exceed the capacity. A Dynamic bin packing (DBP) is that generalization of such problems of bin packing. In case of the DBP issue, each item will have a size, a time of arrival and a time of departure. This item will stay from its arrival to its departure the objective of this being is to pack these items inside the bins for minimizing the number of bins used. Swarm intelligence (SI) has been getting an increasing attention among the researchers and is being referred to as the behavior emerging from the swarms of social insects that ill collectively solve issues.

So the researchers have now proposed the algorithms that are used for optimization issues that are combinatorial [6]. Furthermore, the scheduling in the SI has been proposed and an intelligent method called the modified shuffled frog leaping algorithm (SFLA) has been applied efficiently and rapidly to com- plete a dynamic allocation of the VMs [7]. Chen and Huang [10] further analyzed this current sit- uation of cloud computing to introduce the shuffled frog leaping algorithm. It aims to fall within the local optimum with a fast speed of convergence in which an artificial vector machine had been introduced to the subgroups of this algorithm. This improved shuffled frog leaping algo- rithm has effectively avoided from falling within the local optimum and also shortens the time of such global searching and the optimum. There is a classic function that proves the performance of this algorithm that had been improved to a great extent and the CloudSim platform will demonstrates the efficiency of the improved system into the tasks of processing and make the allocation of resources in that of the cloud computing and also very effective. The work also proposed a SFLA algorithm for a virtual machine migration in that of cloud computing. In Sect. 2 the details of the work methodology are described. Sec- tion 3 elaborates results and Sect. 4 gives the conclusion.

II Methodology

A detailed VM migration, a first fit algorithm, the PSO and the SFLA are presented in this section to compare and enhance the total time of execution, the number of migration and the consumption of energy in the cloud computing. The algorithms are evaluated to achieve a proper load balancing of the virtual machine to meet the requirements of the user with seamless service by using the virtual migration approach.

2.1 Virtual machine migration

The migration of the virtual-machine has been defined as that movement of this VM from one host to that of another. The time taken for migration by every task will be to migrate among the virtual machines win that of the cloud computing [11]. So, in order to achieve a proper load bal- ancing, this cloud data center will dynamically migrate as well as deploy the virtual machine for meeting the needs of the user without any disruption of the service that is being delivered to users. There are several techniques of migra- tion that are available for the migration of the virtual machine from one host to the other like the pre-copy, the post copy the adaptive compression, the least recent used (LRU) and the splay tree, the check point recovery trace and finally the replay method. This migration process will also help in the supporting of other services like the server consolidation, the online maintenance, the proactive fault tolerance and finally the load balancing. Additionally, it reduces the cost of usage and can perform a resource allo- cation that is fast.

Aside from that, the high energy con-Virtual machine migration sumption and its solution will not just be the quantity of the computing resources and their inefficiency of the power of hardware and also their inefficient usage of such resources.

2.2 First fit algorithm

In case of the bin packing process, there is a bin that is opened when it actually receives the first item. When all items in the bin depart, the bin gets closed. At any such time, the actual total size of all these active items in the open bin has been referred to as a bin level. Each time there is a new item that arrives there will be one or more open bins which will be able to accommodate a new item. The First Fit will place the item inside the bin that is opened first. In case no open bin can accommodate a new item, this new bin will be opened for receiving this item.

2.3 Particle swarm optimization (PSO)

A particle swarm optimization (PSO) is one hot topic for research in recent years. It has been proposed by Kennedy and Eberhart (1995) inspired by group behavior research results based on birds. The PSO makes use of the stochastic method for generating a feasible population that will accelerate the speed of convergence for the PSO. This will shift the individual to a better region based on the fitness level of each particle. A general term ‘‘particle’’ has been used for representing the birds, the bees or any other type of individual that will exhibit a social behavior of a group and will also interact with one another [12]. Under the PSO, there are multiple candidate solutions that are called particles which coexist and also indirectly collaborate simultaneously. Every par- ticle ‘‘flies’’ within the problem and its search space searching for an optimal landing position. Every particle will adjust the position within the search space based on the flying experience from time to time and for the flying experience of its neighbors and also its own (or sometimes also the colleagues). Furthermore, the particles will essentially be described using two traits which are the particle position for defining the location of the particle and the particle velocity that defines the direction as to how fast the particle will be able to improve the levels of fitness. The fitness of any particle is that number which will rep- resent how close any particle will be to the optimal point when compared to that of the other particles in this space. A basic PSO algorithm that can bring down an objective function f (x) of any variable vector x that is defined on an n-dimensional space, will make use of a swarm of m par- ticles and each i particle in the swarm will be connected with that of a position in an n-dimensional search space. Likewise, the velocity will also be an n-dimensional vector.

In accordance to the velocity equation, the particle will decide as to where the next move will be and keeping its experience in consideration that being a memory of the best past position and the experience of the particle that is most successful in the swarm. The new particle and its position will be determined by means of adding the cur- rent position to the particle and the new velocity gets computed.

PSO algorithm

1: Set particle dimension as equal to the size of ready tasks in $\{t\}_i \in T$

2: Initialize particles position randomly from PC =1, ..., j and velocity v_i randomly.

3: For each particle, calculate its fitness value. 4: If the fitness value is better than the previous best pbest, set the current fitness value as the new pbest.

5: After Steps 3 and 4 for all particles, select the best particle as gbest.

6: For all particles, calculate velocity and update their positions.

7: If the stopping criteria or maximum iteration is not satisfied, repeat from Step 3.

2.4 Shuffled frog leaping algorithm (SFLA)

The shuffled frog leaping algorithm (SFLA) is that kind of a collaborative search method that is based on a population natural, which has been produced by means of enlightening the natural biological imitation [13]. The SFLA makes use of the abstract model in the virtual population. A basic idea is derived using a local search and exchange of global information. The individual that is best will leap out of the local and using the shuffle strategy it will conduct one global exchange of such local information. This algorithm is based on the population and is a random search algo- rithm that has been inspired by the memetics. Here, the population for a particular solution that is defined by a set of frogs which have been partitioned into many commu- nities that are called the memeplexes. Each such frog belonging to the memeplexes will be performing a local search.

Inside each such memeplex, the behavior of the individual form is influenced by the behavior of the remaining frogs and this can evolve by means of a process of such a memetic evolution. Once a certain number of memetics and their steps in evolution are forced to be mixed together with new memeplexes that are formed through shuffling [14]. This local search along with the shuffling processes will continue until the criteria of con- vergence are satisfied. The SFLA flowchart has been shown in Fig. 1. The main steps in the Shuffled Frog Leap Algorithm are as below:

- Initial population: The individual frogs will be equiv- alent to that of the GA chromosomes, and will represent one set of solutions.
- Sorting and distribution: The frogs get sorted in a descending order that is based on fitness values and the frogs are distributed to subsets called the memeplex, and the whole population gets divided into the m memeplexes, each of them containing n number of frogs.

The Cloud computing aims at provision of the leasing and of the server capabilities that are scalable for the vir- tualized services to the end users. But the data centers and their hosing cloud applications will consume large amounts of electrical energy and this continues the contribution of high costs of operation and the carbon footprints. The Cloud computing solutions which are not able to minimize the cost of operation will also be able to reduce the impact of the environment to this. The model of the cloud service in which the VMs have been launched within their appropriate servers that are available within the data cen- ters.

There is a complete data center scheme of resource management that has been presented here in this work. This scheme also ensures quality of service of users (by means of service level agreements) and this will also be able to achieve a maximum amount of energy saving along with the goals of cloud computing. Keeping the data center host that has tens of thousands in numbers and size into consideration the using of the exact algorithm will solve the problem of resource allocation that is very difficult and for this the SFLA with an improved extremal optimization had been employed for this work in order to solve the VM's problem of dynamic allocation. The algorithm has Fig. 1 Flowchart of SFLA best convergence results and has a better quality of solution compared to that of the other methods like the PSO. The time taken for computation and the characteristics of convergence are also quite fast. The results of the experi- ment have demonstrated that this proposed resource man- agement scheme has been exhibiting an excellent performance in the data center of cloud computing.

III Results and discussion

We have simulated a data center comprising 100, 300, 500 VM. Each VM is modeled to have one CPU core with the performance equivalent to 1000, 2000 or 3000 MIPS, 4 GB of RAM and 512 Mb storage. Figures 2, 3 and 4 shows the total simulation time (s), energy consumption (KWH) and the number of migration respectively. Figure 2 shows that the total simulation time (s) for SFLA performs better than the first fit by 5.43% and better than PSO by 17.8% when the number of VM is 100. Again, the total simulation time (sec) for SFLA performs better than the first fit by 13.91% and better than PSO by 26.8% when the number of VM is 300. Also, the total simulation time (s) for SFLA performs better than the first fit by 7.19% and better than PSO by 29.3% when the number of VM is 500. It is observed that the SFLA is more efficient. Figure 3 shows that the energy consumption (KWH) for SFLA performs better than the first fit by 21.05% and better than PSO by 13.69% when the number of VM is 100. Again, the energy consumption (KWH) for SFLA performs better than the first fit by 16.95% and better than PSO by 5.41% when the number of VM is 300. Also, the energy consumption (KWH) for SFLA performs better than the first fit by 12.29% and better than PSO by 8% when the number of VM is 500. The proposed SFLA has the least energy consumption while scheduling in cloud. Figure 4 shows that the number of migration for SFLA performs better than the first fit by 29.41% and better than PSO by 12.9% when the number of VM is 100. Again, the number of migration for SFLA performs better than the first fit by 22.68% and better than PSO by 10.99% when the number of VM is 300. Also, the number of migration for SFLA performs better than the first fit by 16.67% and better than PSO by 13.85% when the number of VM is 500. The proposed SFLA helps in reducing the number of migrations.

II. DOCKER

Containers, or Linux Containers, are a technology that allows us to isolate certain kernel processes and trick them into thinking they're the only ones running in a completely new computer.Different from Virtual Machinesa container can share the kernel of the operating system while only having their different binaries/libraries loaded with them.In other words, you don't need to have whole different OS (called **guest OS**) installed inside your host OS. You can have several containers running within a single OS without having several different guest OS's installed.Docker packages an application and all its dependencies in a virtual container that can run on any Linux server. This is why we call them containers. Because they have all the necessary dependencies contained in a single piece of software.

IV Conclusion

Cloud computing is that cost-effective model of service delivery that will make IT management and its mainte- nance easy; it can further rapidly adapt to the changing business needs. In order to enhance its total execution time, the number of migration as well as energy consumption, the SFLA is being proposed. The results have shown that this total simulation time (s) for the SFLA performs much better than that of the first fit by about 5.43% and better than the PSO by about 17.8% when the actual number of VMs is 100.

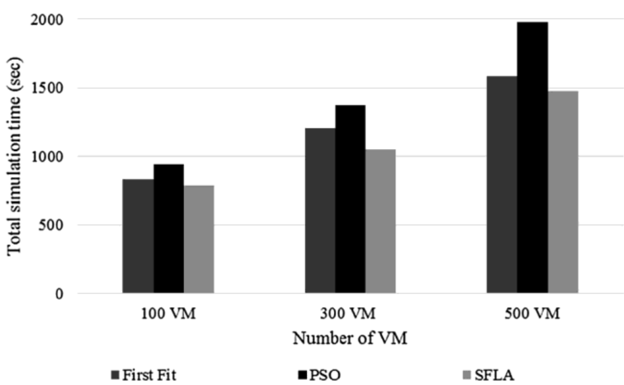

Fig. 3 Energy consumption (KWH)

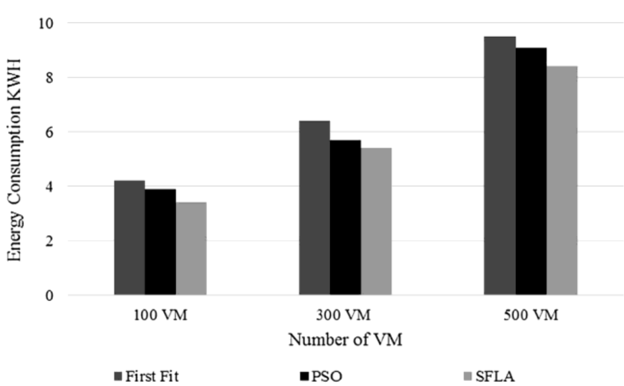

Fig. 4 Number of migration

Again the entire time of simulation (s) for the SFLA performs much better than that of the first fit by about 13.91% and better than the PSO by about 26.8% when the actual number of the VMs is 300. Also, the total time of simulation (s) for the SFLA performs much better than that of the first fit by about 7.19% and better than the PSO by about 29.3% when the number of the VMs is 500.

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